Condor Version 6.1.17 Manual

Condor Team, University of Wisconsin–Madison

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For more information:
Condor Team
Attention: Professor Miron Livny
7367 Computer Sciences
1210 W. Dayton St.
Madison, WI 53706-1685
miron@cs.wisc.edu
http://www.cs.wisc.edu/˜miron/miron.html

CHAPTER

ONE

Overview

This chapter provides a basic, high-level overview of Condor, including Condor's major features and limitations. Because Condor is a system to implement a High-Throughput Computing environment, this section begins defining what is meant by High-Throughput Computing.

1.1 What is High-Throughput Computing (HTC) ?

For many research and engineering projects, the quality of the research or the product is heavily dependent upon the quantity of computing cycles available. It is not uncommon to find problems that require weeks or months of computation to solve. Scientists and engineers engaged in this sort of work need a computing environment that delivers large amounts of computational power over a long period of time. Such an environment is called a High-Throughput Computing (HTC) environment.
In contrast, High Performance Computing (HPC) environments deliver a tremendous amount of compute power over a short period of time. HPC environments are often measured in terms of FLoating point Operations per Second (FLOPS). A growing community is not concerned about FLOPS, as their problems are of a much larger scale. These people are concerned with floating point operations per month or per year. They are more interested in how many jobs they can complete over a long period of time instead of how fast an individual job can complete.

1.2 HTC and Distributed Ownership

The key to HTC is to efficiently harness the use of all available resources. Years ago, the engineering and scientific community relied on large centralized mainframe and/or big-iron supercomputers to do computational work. A large number of individuals and groups needed to pool their financial resources to afford such a machine. Users had to wait for their turn on the mainframe, and they only had a certain amount of time allocated to them. While this environment was inconvenient for users, it was very efficient, because the mainframe was busy nearly all the time.

As computers became smaller, faster, and cheaper, users moved away from centralized mainframes and purchased personal desktop workstations and PCs. An individual or small group could afford a computing resource that was available whenever they wanted it. The personal computer was usually far slower than the large centralized machine, but it was worthwhile due to its exclusive access. Now, instead of one giant computer for a large institution, there might be hundreds or thousands of personal computers. This is an environment of distributed ownership, where individuals throughout an organization own their own resources. The total computational power of the institution as a whole might rise dramatically as the result of such a change, but because of distributed ownership, individuals could not capitalize on the institutional growth of computing power. And while distributed ownership is more convenient for the users, it is much less efficient. Many personal desktop machines sit idle for very long periods of time while their owners are busy doing other things (such as being away at lunch, in meetings, or at home sleeping).

1.3 What is Condor ?

Condor is a software system that creates a High-Throughput Computing (HTC) environment by effectively harnessing the power of a cluster of UNIX or NT workstations on a network. Although Condor can manage a dedicated cluster of workstations, a key appeal of Condor is its ability to effectively harness non-dedicated, preexisting resources in a distributed ownership setting such as machines sitting on people's desks in offices and labs.

1.3.1 A Hunter of Available Workstations

Instead of running a CPU-intensive job in the background on their own workstation, a user submits their job to Condor. Condor finds an available machine on the network and begins running the job on that machine. When Condor detects that a machine running a Condor job is no longer available (perhaps because the owner of the machine came back from lunch and started typing on the keyboard), Condor checkpoints the job and migrates it over the network to a different machine which would otherwise be idle. Condor restarts the job on the new machine to continue from precisely where it left off. If no machine on the network is currently available, then the job is stored in a queue on disk until a machine becomes available.

As an example, a compute job that typically takes 5 hours to run is submitted to Condor. Condor may start running the job on Machine A, but after 3 hours Condor detects activity on the keyboard. Condor will checkpoint the job and migrates it to Machine B. After two hours on Machine B, the job completes (notifying the submitter via e-mail).

Perhaps this 5 hour compute job must be run 250 different times (perhaps on 250 different data sets). In this case, Condor can be a real time saver. With one command, all 250 runs are submitted to Condor. Depending upon the number of machines in the organization's Condor pool, there could be dozens or even hundreds of otherwise idle machines running the job at any given moment.

Condor makes it easy to maximize the number of machines which can run a job. Because Condor does not require participating machines to share file systems (via NFS or AFS for example), machines across the entire enterprise can run a job, including machines in different administrative domains. Condor does not require an account (login) on machines where it runs a job. Condor can do this because of its *remote system call* technology, which traps operating system calls for such operations as reading or writing from disk files and sends them back over the network to be performed on the machine where the job was submitted.

1.3.2 Effective Resource Management

In addition to migrating jobs to available machines, Condor provides sophisticated and distributed resource management. Match-making resource owners with resource consumers is the cornerstone of a successful HTC environment. Unlike many other compute cluster resource management systems which attach properties to the job queues themselves (resulting in user confusion over which queue to use as well as administrative hassle in constantly adding and editing queue properties to satisfy user demands), Condor implements a clean design called *ClassAds*.

ClassAds work in a fashion similar to the newspaper classified advertising want-ads. All machines in the Condor pool advertise their resource properties, such as available RAM memory, CPU type and speed, virtual memory size, physical location, current load average, and many other static and dynamic properties, into a *resource offer* ad. Likewise, when submitting a job, users can specify a *resource request* ad which defines both the required and a desired set of properties to run the job. Similarly, a resource offer ad can define requirements and preferences. Condor acts as a broker by matching and ranking resource offer ads with resource request ads, making certain that all requirements in both ads are satisfied. During this match-making process, Condor also takes several layers of priority values into consideration: the priority the user assigned to the resource request ad, the priority of the user which submitted the ad, and desire of machines in the pool to accept certain types of ads over others.

1.4 Distinguishing Features

Checkpoint and Migration. Users of Condor may be assured that their jobs will eventually complete even in an opportunistic computing environment. If a user submits a job to Condor which runs on another's workstation, but the job is not finished when the workstation owner returns, the job can be checkpointed. The job continues by migrating to another machine. It makes progress toward its completion by the checkpoint and migration feature. Condor's periodic checkpoint feature periodically checkpoints a job even in lieu of migration in order to safeguard the accumulated computation time on a job from being lost in the event of a system failure such as the machine being shutdown or a crash.

Remote System Calls. Despite running jobs on remote machines, the Condor standard universe execution mode preserves the local execution environment via remote system calls. Users do not have to worry about making data files available to remote workstations or even obtaining a login account on remote workstations before Condor executes their programs there. The program behaves under Condor as if it were running as the user that submitted the job on the workstation where it was originally submitted, no matter on which machine it really ends up executing on.

No Changes Necessary to User's Source Code. No special programming is required to use Condor. Condor is able to run normal non-interactive UNIX or NT programs. The checkpoint and migration of programs by Condor is transparent and automatic, as is the use of remote system calls. If these facilities are desired, the user only re-links the program. The code is not compiled or changed.

Sensitive to the Desires of Workstation Owners. The owner of a workstation has complete priority over the workstation, by default. A workstation owner is generally happy to let others compute on the workstation while it is idle, but wants the workstation back promptly upon returning. The owner does not want to take special action to regain control. Condor handles this automatically.

ClassAds. The ClassAd mechanism in Condor provides an extremely flexible, expressive framework for matchmaking resource requests with resource offers. One result is that users can easily request practically any resource, both in terms of job requirements and job desires. For example, a user can require that a job run on a machine with 64 Mbytes of RAM, but state a preference for 128 Mbytes if available. Likewise, a workstation can state a preference in a resource offer to run jobs from a specified set of users, and it can require that there be no interactive workstation activity detectable between 9 am and 5 pm before starting a job. Job requirements/preferences and resource availability constraints can be described in terms of powerful expressions, resulting in Condor's adaptation to nearly any desired policy.

1.5 Current Limitations

Limitations on Jobs which can Checkpointed Although Condor can schedule and run any type of process, Condor does have some limitations on jobs that it can transparently checkpoint and migrate:

1. Multi-process jobs are not allowed. This includes system calls such as `fork()`, `exec()`, and `system()`.
2. Interprocess communication is not allowed. This includes pipes, semaphores, and shared memory.
3. Network communication must be brief. A job *may* make network connections using system calls such as `socket()`, but a network connection left open for long periods will delay checkpointing and migration.
4. Sending or receiving the SIGUSR2 or SIGTSTP signals is not allowed. Condor reserves these signals for its own use. Sending or receiving all other signals *is* allowed.

5. Alarms, timers, and sleeping are not allowed. This includes system calls such as `alarm()`, `getitimer()`, and `sleep()`.
6. Multiple kernel-level threads are not allowed. However, multiple user-level threads *are* allowed.
7. Memory mapped files are not allowed. This includes system calls such as `mmap()` and `munmap()`.
8. File locks are allowed, but not retained between checkpoints.
9. All files must be opened read-only or write-only. A file opened for both reading and writing will cause trouble if a job must be rolled back to an old checkpoint image. For compatibility reasons, a file opened for both reading and writing will result in a warning but not an error.
10. A fair amount of disk space must be available on the submitting machine for storing a job's checkpoint images. A checkpoint image is approximately equal to the virtual memory consumed by a job while it runs. If disk space is short, a special *checkpoint server* can be designated for storing all the checkpoint images for a pool.
11. On Digital Unix (OSF/1), HP-UX, and Linux, your job must be statically linked. Dynamic linking is allowed on all other platforms.

Note: these limitations *only* apply to jobs which Condor has been asked to transparently checkpoint. If job checkpointing is not desired, the limitations above do not apply.

Security Implications. Condor does a significant amount of work to prevent security hazards, but loopholes are known to exist. Condor can be instructed to run user programs only as the UNIX user nobody, a user login which traditionally has very restricted access. But even with access solely as user nobody, a sufficiently malicious individual could do such things as fill up /tmp (which is world writable) and/or gain read access to world readable files. Furthermore, where the security of machines in the pool is a high concern, only machines where the UNIX user root on that machine can be trusted should be admitted into the pool. Condor provides the administrator with IP-based security mechanisms to enforce this.

Jobs Need to be Re-linked to get Checkpointing and Remote System Calls Although typically no source code changes are required, Condor requires that the jobs be re-linked with the Condor libraries to take advantage of checkpointing and remote system calls. This often precludes commercial software binaries from taking advantage of these services because commercial packages rarely make their object code available. Condor's other services are still available for these commercial packages.

1.6 Availability

Condor is currently available as a free download from the Internet via the World Wide Web at URL http://www.cs.wisc.edu/condor/downloads. Binary distributions of Condor version 6.x are available for the platforms detailed in Table 1.1. A platform is an architecture/operating system combination. Condor binaries are available most major versions of UNIX, as well as Windows NT.

In the table, *clipped* means that Condor does not support checkpointing or remote system calls on the given platform. This means that *standard* jobs are not supported, only *vanilla* jobs. See section 2.4.1 on page 12 for more details on job universes within Condor and their abilities and limitations.

The Condor source code is no longer available for public download from the Internet. If you desire the Condor source code, please contact the Condor Team in order to discuss it further (see Section 1.7, on page 6).

Architecture	*Operating System*
Hewlett Packard PA-RISC (both PA7000 and PA8000 series)	HPUX 10.20
Sun SPARC Sun4m,c, Sun UltraSPARC	Solaris 2.5.x, 2.6, 2.7
Silicon Graphics MIPS (R4400, R4600, R8000, R10000)	IRIX 6.2, 6.3, 6.4
	IRIX 6.5
Intel x86	RedHat Linux 5.2, 6.x
	Solaris 2.5.x, 2.6, 2.7
	Windows NT 4.0 (“clipped”)
Digital ALPHA	OSF/1 (Digital Unix) 4.x
	Linux 2.0.x, Linux 2.2.x (“clipped”)

Table 1.1: Condor Version 6.1.17 supported platforms

NOTE: Other Linux distributions (Debian, etc.) may work, but are not tested or supported.

1.7 Contact Information

The latest software releases, publications/papers regarding Condor and other High-Throughput Computing research can be found at the official web site for Condor at http://www.cs.wisc.edu/condor.

In addition, there is an e-mail list at mailto:condor-world@cs.wisc.edu. The Condor Team uses this e-mail list to announce new releases of Condor and other major Condor-related news items. Membership into condor-world is automated by MajorDomo software. To subscribe or unsubscribe from the the list, follow the instructions at http://www.cs.wisc.edu/condor/condor-world/condor-world.html. Because many of us receive too much e-mail as it is, you’ll be happy to know that the condor-world e-mail listgroup is moderated and only major announcements of wide interest are distributed.

Finally, you can reach the Condor Team directly. The Condor Team is comprised of the developers and administrators of Condor at the University of Wisconsin-Madison. Condor questions, comments, pleas for help, and requests for commercial contract consultation or support are all welcome; just send Internet e-mail to mailto:condor-admin@cs.wisc.edu. Please include your name, organization, and telephone number in your message. If you are having trouble with Condor, please help us troubleshoot by including as much pertinent information as you can, including snippets of Condor log files.

CHAPTER

TWO

Users' Manual

2.1 Welcome to Condor

Presenting Condor Version 6.1.17! Condor is developed by the Condor Team at the University of Wisconsin-Madison (UW-Madison), and was first installed as a production system in the UW-Madison Computer Sciences department nearly 10 years ago. This Condor pool has since served as a major source of computing cycles to UW faculty and students. For many, it has revolutionized the role computing plays in their research. An increase of one, and sometimes even two, orders of magnitude in the computing throughput of a research organization can have a profound impact on its size, complexity, and scope. Over the years, the Condor Team has established collaborations with scientists from around the world and has provided them with access to surplus cycles (one of whom has consumed 100 CPU years!). Today, our department's pool consists of more than 700 desktop UNIX workstations. On a typical day, our pool delivers more than 500 CPU days to UW researchers. Additional Condor pools have been established over the years across our campus and the world. Groups of researchers, engineers, and scientists have used Condor to establish compute pools ranging in size from a handful to hundreds of workstations. We hope that Condor will help revolutionize your compute environment as well.

2.2 What does Condor do?

In a nutshell, Condor is a specialized batch system for managing compute-intensive jobs. Like most batch systems, Condor provides a queueing mechanism, scheduling policy, priority scheme, and resource classifications. Users submit their compute jobs to Condor, Condor puts the jobs in a queue, runs them, and then informs the user as to the result.

Batch systems normally operate only with dedicated machines. Often termed compute servers, these dedicated machines are typically owned by one organization and dedicated to the sole purpose of running compute jobs. Condor can schedule jobs on dedicated machines. But unlike traditional batch systems, Condor is also designed to effectively utilize non-dedicated machines to run jobs. By being told to only run compute jobs on machines which are currently not being used (no keyboard activity, no load average, no active telnet users, etc), Condor can effectively harness otherwise idle machines throughout a pool of machines. This is important because often times the amount of compute power represented by the aggregate total of all the non-dedicated desktop workstations sitting on people's desks throughout the organization is far greater than the compute power of a dedicated central resource.

Condor has several unique capabilities at its disposal which are geared towards effectively utilizing non-dedicated resources that are not owned or managed by a centralized resource. These include transparent process checkpoint and migration, remote system calls, and ClassAds. Read section 1.3 for a general discussion of these features before reading any further.

2.3 Condor Matchmaking with ClassAds

Before you learn about how to submit a job, it is important to understand how Condor allocates resources. Understanding the unique framework by which Condor matches submitted jobs with machines is the key to getting the most from Condor's scheduling algorithm.

Condor simplifies job submission by acting as a matchmaker of ClassAds. Condor's ClassAds are analogous to the classified advertising section of the newspaper. Sellers advertise specifics about what they have to sell, hoping to attract a buyer. Buyers may advertise specifics about what they wish to purchase. Both buyers and sellers list constraints that need to be satisfied. For instance, a buyer has a maximum spending limit, and a seller requires a minimum purchase price. Furthermore, both want to rank requests to their own advantage. Certainly a seller would rank one offer of $50 dollars higher than a different offer of $25. In Condor, users submitting jobs can be thought of as buyers of compute resources and machine owners are sellers.

All machines in a Condor pool advertise their attributes, such as available RAM memory, CPU type and speed, virtual memory size, current load average, along with other static and dynamic properties. This machine ClassAd also advertises under what conditions it is willing to run a Condor job and what type of job it would prefer. These policy attributes can reflect the individual terms and preferences by which all the different owners have graciously allowed their machine to be part of the Condor pool. You may advertise that your machine is only willing to run jobs at night and when there is no keyboard activity on your machine. In addition, you may advertise a preference (rank) for running jobs submitted by you or one of your co-workers.

Likewise, when submitting a job, you specify a ClassAd with your requirements and preferences. The ClassAd includes the type of machine you wish to use. For instance, perhaps you are looking for the fastest floating point performance available. You want Condor to rank available machines based upon floating point performance. Or, perhaps you care only that the machine has a minimum of 128 Mbytes of RAM. Or, perhaps you will take any machine you can get! These job attributes and requirements are bundled up into a job ClassAd.

Condor plays the role of a matchmaker by continuously reading all the job ClassAds and all the machine ClassAds, matching and ranking job ads with machine ads. Condor makes certain that all requirements in both ClassAds are satisfied.

2.3.1 Inspecting Machine ClassAds with condor_status

Once Condor is installed, you will get a feel for what a machine ClassAd does by trying the *condor_status* command. Try the *condor_status* command to get a summary of information from ClassAds about the resources available in your pool. Type *condor_status* and hit enter to see a summary similar to the following:

```
Name       Arch     OpSys        State      Activity   Loa-
dAv Mem  ActvtyTime

adriana.cs INTEL    SOLARIS251   Claimed    Busy       1.000  64    0+01:10:00
alfred.cs. INTEL    SOLARIS251   Claimed    Busy       1.000  64    0+00:40:00
amul.cs.wi SUN4u    SOLARIS251   Owner      Idle       1.000  128   0+06:20:04
anfrom.cs. SUN4x    SOLARIS251   Claimed    Busy       1.000  32    0+05:16:22
anthrax.cs INTEL    SOLARIS251   Claimed    Busy       0.285  64    0+00:00:00
astro.cs.w INTEL    SOLARIS251   Claimed    Busy       0.949  64    0+05:30:00
aura.cs.wi SUN4u    SOLARIS251   Owner      Idle       1.043  128   0+14:40:15
```

...

The *condor_status* command has options that summarize machine ads in a variety of ways. For example,

condor_status -available shows only machines which are willing to run jobs now.

condor_status -run shows only machines which are currently running jobs.

condor_status -l lists the machine ClassAds for all machines in the pool.

Refer to the *condor_status* command reference page located on page 300 for a complete description of *condor_status* command.

Figure 2.1 shows the complete machine ad for a single workstation: alfred.cs.wisc.edu. Some of the listed attributes are used by Condor for scheduling. Other attributes are for information purposes. An important point is that *any* of the attributes in a machine ad can be utilized at job submission time as part of a request or preference on what machine to use. Additional attributes can be easily added. For example, your site administrator can add a physical location attribute to your machine ClassAds.

```
MyType = "Machine"
TargetType = "Job"
Name = "alfred.cs.wisc.edu"
Machine = "alfred.cs.wisc.edu"
StartdIpAddr = "<128.105.83.11:32780>"
Arch = "INTEL"
OpSys = "SOLARIS251"
UidDomain = "cs.wisc.edu"
FileSystemDomain = "cs.wisc.edu"
State = "Unclaimed"
EnteredCurrentState = 892191963
Activity = "Idle"
EnteredCurrentActivity = 892191062
VirtualMemory = 185264
Disk = 35259
KFlops = 19992
Mips = 201
LoadAvg = 0.019531
CondorLoadAvg = 0.000000
KeyboardIdle = 5124
ConsoleIdle = 27592
Cpus = 1
Memory = 64
AFSCell = "cs.wisc.edu"
START = LoadAvg - CondorLoadAvg <= 0.300000 && KeyboardI-
dle > 15 * 60
Requirements = TRUE
Rank = Owner == "johndoe" || Owner == "friendofjohn"
CurrentRank =  - 1.000000
LastHeardFrom = 892191963
```

Figure 2.1: Sample output from *condor_status -l alfred*

2.4 Road-map for running jobs with Condor

The road to using Condor effectively is a short one. The basics are quickly and easily learned.

Here are all the steps needed to run a job using Condor.

Code Preparation. A job run under Condor must be able to run as a background batch job. Condor runs the program unattended and in the background. A program that runs in the background will not be able to do interactive input and output. Condor can redirect console output (stdout and stderr) and keyboard input (stdin) to and from files for you. Create any needed files that contain the proper keystrokes needed for program input. Make certain the program will run correctly with the files.

The Condor Universe. Condor has five runtime environments (called a *universe*) from which to choose. Of the five, two are likely choices when learning to submit a job to Condor: the standard universe and the vanilla universe. The standard universe allows a job running under Condor to handle system calls by returning them to the machine where the job was submitted. The standard universe also provides the mechanisms necessary to take a checkpoint and migrate a partially completed job, should the machine on which the job is executing become unavailable. To use the standard universe, it is necessary to relinking the program with the Condor library using the *condor_compile* command. The manual page on page 305 has details.

The vanilla universe provides a way to run jobs that cannot be ?. It depends on a shared file system for access to input and output files, and there is no way to take a checkpoint or migrate a job executed under the vanilla universe.

Choose a universe under which to run the Condor program, and re-link the program if necessary.

Submit description file. Controlling the details of a job submission is a submit description file. The file contains information about the job such as what executable to run, the files to use for keyboard and screen data, the platform type required to run the program, and where to send e-mail when the job completes. You can also tell Condor how many times to run a program; it is simple to run the same program multiple times with multiple data sets.

Write a submit description file to go with the job, using the examples provided in section 2.5.1 for guidance.

Submit the Job. Submit the program to Condor with the *condor_submit* command.

Once submitted, Condor does the rest toward running the job. Monitor the job's progress with the *condor_q* and *condor_status* commands. You may modify the order in which Condor will run your jobs with *condor_prio*. If desired, Condor can even inform you in a log file every time your job is checkpointed and/or migrated to a different machine.

When your program completes, Condor will tell you (by e-mail, if preferred) the exit status of your program and various statistics about its performances, including time used and I/O performed. If you are using a log file for the job(which is recommended) the exit status will be recorded in the log file. You can remove a job from the queue prematurely with *condor_rm*.

2.4.1 Choosing a Condor Universe

A *universe* in Condor defines an execution environment. Condor Version 6.1.17 supports five different universes for user jobs:

- Standard
- Vanilla
- PVM
- MPI

- Globus

The `Universe` attribute is specified in the submit description file. If the universe is not specified, then it will default to `standard`.

The `standard` universe provides migration and reliability, but has some restrictions on the programs that can be run. The `vanilla` universe provides fewer services, but has very few restrictions. The `PVM` universe is for programs written to the Parallel Virtual Machine interface. See section 2.8 for more about PVM and Condor. The `MPI` universe is for programs written to the MPICH interface. See section 2.9 for more about MPI and Condor. The Globus universe allows users to submit Globus jobs through the Condor interface. See http://www.globus.org for more about Globus.

Standard Universe

In the standard universe, Condor provides *checkpointing* and *remote system calls*. These features make a job more reliable and allow it uniform access to resources from anywhere in the pool. To prepare a program as a standard universe job, it must be re-linked with *condor_compile*. Most programs can be prepared as a standard universe job, but there are a few restrictions.

Condor checkpoints a job at regular intervals. A *checkpoint image* is like a snapshot of the current state of a job. If a job must be migrated from one machine to another, Condor makes a checkpoint image, copies the image to the new machine, and restarts the job *right where it left off*. If a machine should crash or fail while it is running a job, Condor can restart the job on a new machine from the most recent checkpoint image. In this way, jobs can run for months or years even in the face of occasional computer failures.

Remote system calls make a job perceive that it is executing on its home machine, even though it may execute on many different machines over its lifetime. When your job runs on a remote machine, a second process, called a *condor_shadow* runs on the machine where you submitted the job. Whenever your job attempts a system call, the *condor_shadow* performs it instead and sends the results back. So, if your job attempts to open a file that is stored only on the submitting machine, the *condor_shadow* will find it and send the data to the machine where your job happens to be running.

To convert your program into a standard universe job, you must use *condor_compile* to re-link it with the Condor libraries. Simply put *condor_compile* in front of your usual link command. You do not need to modify the program's source code, but you do need access to its un-linked object files. A commercial program that is packaged as a single executable file cannot be converted into a standard universe job.

For example, if you normally link your job by executing:

```
% cc main.o tools.o -o program
```

Then you can re-link your job for Condor with:

```
% condor_compile cc main.o tools.o -o program
```

There are a few restrictions on standard universe jobs:

1. Multi-process jobs are not allowed. This includes system calls such as `fork()`, `exec()`, and `system()`.
2. Interprocess communication is not allowed. This includes pipes, semaphores, and shared memory.
3. Network communication must be brief. A job *may* make network connections using system calls such as `socket()`, but a network connection left open for long periods will delay checkpointing and migration.
4. Sending or receiving the SIGUSR2 or SIGTSTP signals is not allowed. Condor reserves these signals for its own use. Sending or receiving all other signals *is* allowed.
5. Alarms, timers, and sleeping are not allowed. This includes system calls such as `alarm()`, `getitimer()`, and `sleep()`.
6. Multiple kernel-level threads are not allowed. However, multiple user-level threads *are* allowed.
7. Memory mapped files are not allowed. This includes system calls such as `mmap()` and `munmap()`.
8. File locks are allowed, but not retained between checkpoints.
9. All files must be opened read-only or write-only. A file opened for both reading and writing will cause trouble if a job must be rolled back to an old checkpoint image. For compatibility reasons, a file opened for both reading and writing will result in a warning but not an error.
10. A fair amount of disk space must be available on the submitting machine for storing a job's checkpoint images. A checkpoint image is approximately equal to the virtual memory consumed by a job while it runs. If disk space is short, a special *checkpoint server* can be designated for storing all the checkpoint images for a pool.
11. On Digital Unix (OSF/1), HP-UX, and Linux, your job must be statically linked. Dynamic linking is allowed on all other platforms.

Vanilla Universe

The vanilla universe in Condor is intended for programs which cannot be successfully re-linked. Shell scripts are another case where the vanilla universe is useful. Unfortunately, jobs run under the vanilla universe cannot checkpoint or use remote system calls. This has unfortunate consequences for a job that is partially completed when the remote machine running a job must be returned to its owner. Condor has only two choices. It can suspend the job, hoping to complete it at a later time, or it can give up and restart the job *from the beginning* on another machine in the pool.

Notice:

In UNIX, jobs submitted as vanilla universe jobs can only rely on an external mechanism for accessing data files from different machines such as NFS or AFS. The job *must* be able to access your data files on any machine on which it could potentially run. As an example, suppose your work machine is blackbird.cs.wisc.edu and your job requires a particular data file `/u/p/s/psilord/data.txt`. You wish to submit to Condor from this machine and the job can potentially run on cardinal.cs.wisc.edu. If the job runs on that machine, it must have `/u/p/s/psilord/data.txt` available through either NFS or AFS for your job to run correctly.
Condor deals with this restriction of the vanilla universe by the `FileSystemDomain` and `UidDomain` machine ClassAd attributes that reflect the reality of the pool's disk mounting structure. If you have a large pool spanning multiple `UidDomain` and/or `FileSystemDomain`s then you must specify your `requirements` to use the correct `UidDomain` and/or `FileSystemDomain`s that your jobs need to access your data files.
However, under Windows NT, the vanilla universe *does not* require a shared file system due to the Condor File Transfer mechanism. Please see chapter 5 for more details about Condor NT.

PVM

The PVM universe allows programs written to the Parallel Virtual Machine interface to be used within the opportunistic Condor environment. Please see section 2.8 for more details.

MPI

The MPI universe allows programs written to the MPICH interface to be used within the opportunistic Condor environment. Please see section 2.9 for more details.

Globus Universe

The Globus universe in Condor is intended to provide the standard Condor interface to users who wish to start Globus system jobs from Condor. Each job queued in the job submission file is translated into a Globus RSL string and used as the arguments to the *globusrun* program. The manual page for *condor_submit* has detailed descriptions for the Globus-related attributes.

2.5 Submitting a Job to Condor

A job is submitted for execution to Condor using the *condor_submit* command. *condor_submit* takes as an argument the name of a file called a submit description file. This file contains commands and keywords to direct the queuing of jobs. In the submit description file, Condor finds everything it needs to know about the job. Items such as the name of the executable to run, the initial working directory, and command-line arguments to the program all go into the submit description file. *condor_submit* creates a job ClassAd based upon the information, and Condor works toward running the job.

The contents of a submit file can save time for Condor users. It is easy to submit multiple runs of a program to Condor. To run the same program 500 times on 500 different input data sets, arrange your data files accordingly so that each run reads its own input, and each run writes its own output. Each individual run may have its own initial working directory, stdin, stdout, stderr, command-line arguments, and shell environment. A program that directly opens its own files will read the file names to use either from stdin or from the command line. A program that opens a static filename every time will need to use a separate subdirectory for the output of each run.

The *condor_submit* manual page is on page 305 and contains a complete and full description of how to use *condor_submit*.

2.5.1 Sample submit description files

In addition to the examples of submit description files given in the *condor_submit* manual page, here are a few more.

Example 1

Example 1 is the simplest submit description file possible. It queues up one copy of the program *foo*(which had been created by *condor_compile*) for execution by Condor. Since no platform is specified, Condor will use its default, which is to run the job on a machine which has the same architecture and operating system as the machine from which it was submitted. No `input`, `output`, and `error` commands are given in the submit description file, so the files `stdin`, `stdout`, and `stderr` will all refer to `/dev/null`. The program may produce output by explicitly opening a file and writing to it. A log file, `foo.log`, will also be produced that contains events the job had during its lifetime inside of Condor. When the job finishes, its exit conditions will be noted in the log file. It is recommended that you always have a log file so you know what happened to your jobs.

```
####################
#
# Example 1
# Simple condor job description file
#
####################

Executable     = foo
Log            = foo.log
Queue
```

Example 2

Example 2 queues two copies of the program *mathematica*. The first copy will run in directory `run_1`, and the second will run in directory `run_2`. For both queued copies, `stdin` will be `test.data`, `stdout` will be `loop.out`, and `stderr` will be `loop.error`. There will be two sets of files written, as the files are each written to their own directories. This is a convenient way to organize data if you have a large group of Condor jobs to run. The example file shows program submission of *mathematica* as a vanilla universe job. This may be necessary if the source and/or object code to program *mathematica* is not available.

```
####################
#
# Example 2: demonstrate use of multiple
# directories for data organization.
#
####################

Executable     = mathematica
Universe = vanilla
input   = test.data
output  = loop.out
error   = loop.error
Log     = loop.log

Initialdir     = run_1
Queue

Initialdir     = run_2
Queue
```

Example 3

The submit description file for Example 3 queues 150 runs of program *foo* which has been compiled and linked for Silicon Graphics workstations running IRIX 6.5. This job requires Condor to run the program on machines which have greater than 32 megabytes of physical memory, and expresses a preference to run the program on machines with more than 64 megabytes, if such machines are available. It also advises Condor that it will use up to 28 megabytes of memory when running. Each of the 150 runs of the program is given its own process number, starting with process number 0. So, files `stdin`, `stdout`, and `stderr` will refer to `in.0`, `out.0`, and `err.0` for the first run of the program, `in.1`, `out.1`, and `err.1` for the second run of the program, and so forth. A log file containing entries about when and where Condor runs, checkpoints, and migrates processes for the 150 queued programs will be written into file `foo.log`.

```
####################
```

```
#
# Example 3: Show off some fancy features including
# use of pre-defined macros and logging.
#
####################

Executable     = foo
Requirements   = Memory >= 32 && OpSys == "IRIX65" && Arch =="SGI"
Rank  = Memory >= 64
Image_Size     = 28 Meg

Error   = err.$(Process)
Input   = in.$(Process)
Output  = out.$(Process)
Log = foo.log

Queue 150
```

2.5.2 About Requirements and Rank

The `requirements` and `rank` commands in the submit description file are powerful and flexible. Using them effectively requires care, and this section presents those details.

Both `requirements` and `rank` need to be specified as valid Condor ClassAd expressions, however, default values are set by the *condor_submit* program if these aren't defined in the submit description file. From the *condor_submit* manual page and the above examples, you see that writing ClassAd expressions is intuitive, especially if you are familiar with the programming language C. There are some pretty nifty expressions you can write with ClassAds. A complete description of ClassAds and their expressions can be found in section 4.1 on page 177.

All of the commands in the submit description file are case insensitive, *except* for the ClassAd attribute string values. ClassAds attribute names are case insensitive, but ClassAd string values are always *case sensitive*. The correct specification for an architecture is

```
        requirements = arch == "ALPHA"
```

so an accidental specification of

```
        requirements = arch == "alpha"
```

will not work due to the incorrect case.

The allowed ClassAd attributes are those that appear in a machine or a job ClassAd. To see all of the machine ClassAd attributes for all machines in the Condor pool, run *condor_status -l*. The *-l* argument to *condor_status* means to display all the complete machine ClassAds. The job ClassAds, if there jobs in the queue, can be seen with the *condor_q -l* command. This will show you all the available attributes you can play with.

To help you out with what these attributes all signify, descriptions follow for the attributes which will be common to every machine ClassAd. Remember that because ClassAds are flexible, the machine ads in your pool may include additional attributes specific to your site's installation and policies.

ClassAd Machine Attributes

`Activity` : String which describes Condor job activity on the machine. Can have one of the following values:

- **`"Idle"`** : There is no job activity
- **`"Busy"`** : A job is busy running
- **`"Suspended"`** : A job is currently suspended
- **`"Vacating"`** : A job is currently checkpointing
- **`"Killing"`** : A job is currently being killed
- **`"Benchmarking"`** : The startd is running benchmarks

`Arch` : String with the architecture of the machine. Typically one of the following:

- **`"INTEL"`** : Intel x86 CPU (Pentium, Xeon, etc).
- **`"ALPHA"`** : Digital Alpha CPU
- **`"SGI"`** : Silicon Graphics MIPS CPU
- **`"SUN4u"`** : Sun UltraSparc CPU
- **`"SUN4x"`** : A Sun Sparc CPU other than an UltraSparc, i.e. sun4m or sun4c CPU found in older Sparc workstations such as the Sparc 10, Sparc 20, IPC, IPX, etc.
- **`"HPPA1"`** : Hewlett Packard PA-RISC 1.x CPU (i.e. PA-RISC 7000 series CPU) based workstation
- **`"HPPA2"`** : Hewlett Packard PA-RISC 2.x CPU (i.e. PA-RISC 8000 series CPU) based workstation

`ClockDay` : The day of the week, where 0 = Sunday, 1 = Monday, . . ., 6 = Saturday.

`ClockMin` : The number of minutes passed since midnight.

`CondorLoadAvg` : The portion of the load average generated by Condor (either from remote jobs or running benchmarks).

`ConsoleIdle` : The number of seconds since activity on the system console keyboard or console mouse has last been detected.

`Cpus` : Number of CPUs in this machine, i.e. 1 = single CPU machine, 2 = dual CPUs, etc.

CurrentRank : A float which represents this machine owner's affinity for running the Condor job which it is currently hosting. If not currently hosting a Condor job, `CurrentRank` is -1.0.

Disk : The amount of disk space on this machine available for the job in kbytes (e.g. 23000 = 23 megabytes). Specifically, this is the amount of disk space available in the directory specified in the Condor configuration files by the `EXECUTE` macro, minus any space reserved with the `RESERVED_DISK` macro.

EnteredCurrentActivity : Time at which the machine entered the current Activity (see `Activity` entry above). On all platforms (including NT), this is measured in the number of seconds since the UNIX epoch (00:00:00 UTC, Jan 1, 1970).

FileSystemDomain : A "domain" name configured by the Condor administrator which describes a cluster of machines which all access the same, uniformly-mounted, networked file systems usually via NFS or AFS. This is useful for Vanilla universe jobs which require remote file access.

KeyboardIdle : The number of seconds since activity on any keyboard or mouse associated with this machine has last been detected. Unlike `ConsoleIdle`, `KeyboardIdle` also takes activity on pseudo-terminals into account (i.e. virtual "keyboard" activity from telnet and rlogin sessions as well). Note that `KeyboardIdle` will always be equal to or less than `ConsoleIdle`.

KFlops : Relative floating point performance as determined via a Linpack benchmark.

LastHeardFrom : Time when the Condor central manager last received a status update from this machine. Expressed as seconds since the epoch (integer value). Note: This attribute is only inserted by the central manager once it receives the ClassAd. It is not present in the *condor_startd* copy of the ClassAd. Therefore, you could not use this attribute in defining *condor_startd* expressions (and you would not want to).

LoadAvg : A floating point number with the machine's current load average.

Machine : A string with the machine's fully qualified hostname.

Memory : The amount of RAM in megabytes.

Mips : Relative integer performance as determined via a Dhrystone benchmark.

MyType : The ClassAd type; always set to the literal string `"Machine"`.

Name : The name of this resource; typically the same value as the `Machine` attribute, but could be customized by the site administrator. On SMP machines, the *condor_startd* will divide the CPUs up into separate virtual machines, each with with a unique name. These names will be of the form "vm#@full.hostname", for example, "vm1@vulture.cs.wisc.edu", which signifies virtual machine 1 from vulture.cs.wisc.edu.

OpSys : String describing the operating system running on this machine. For Condor Version 6.1.17 typically one of the following:

- **`"HPUX10"`** : for HPUX 10.20
- **`"IRIX6"`** : for IRIX 6.2, 6.3, or 6.4
- **`"LINUX"`** : for LINUX 2.0.x or LINUX 2.2.x kernel systems
- **`"OSF1"`** : for Digital Unix 4.x
- **`"SOLARIS251"`**
- **`"SOLARIS26"`**

`Requirements` : A boolean, which when evaluated within the context of the machine ClassAd and a job ClassAd, must evaluate to TRUE before Condor will allow the job to use this machine.

`StartdIpAddr` : String with the IP and port address of the *condor_startd* daemon which is publishing this machine ClassAd.

`State` : String which publishes the machine's Condor state. Can be:

- **`"Owner"`** : The machine owner is using the machine, and it is unavailable to Condor.
- **`"Unclaimed"`** : The machine is available to run Condor jobs, but a good match is either not available or not yet found.
- **`"Matched"`** : The Condor central manager has found a good match for this resource, but a Condor scheduler has not yet claimed it.
- **`"Claimed"`** : The machine is claimed by a remote *condor_schedd* and is probably running a job.
- **`"Preempting"`** : A Condor job is being preempted (possibly via checkpointing) in order to clear the machine for either a higher priority job or because the machine owner wants the machine back.

`TargetType` : Describes what type of ClassAd to match with. Always set to the string literal `"Job"`, because machine ClassAds always want to be matched with jobs, and vice-versa.

`UidDomain` : a domain name configured by the Condor administrator which describes a cluster of machines which all have the same `passwd` file entries, and therefore all have the same logins.

`VirtualMemory` : The amount of currently available virtual memory (swap space) expressed in kbytes.

ClassAd Job Attributes

`CkptArch` : String describing the architecture of the machine where this job last checkpointed. If the job has never checkpointed, this attribute is UNDEFINED.

`CkptOpSys` : String describing the operating system of the machine where this job last checkpointed. If the job has never checkpointed, this attribute is UNDEFINED.

ClusterId : Integer cluster identifier for this job. A "cluster" is a group of jobs that were submitted together. Each job has its own unique job identifier within the cluser, but shares a common cluster identifier.

ExecutableSize : Size of the executable in kbytes.

ImageSize : Estimate of the memory image size of the job in kbytes. The initial estimate may be specified in the job submit file. Otherwise, the initial value is equal to the size of the executable. When the job checkpoints, the ImageSize attribute is set to the size of the checkpoint file (since the checkpoint file contains the job's memory image).

JobPrio : Integer priority for this job, set by *condor_submit* or *condor_prio*. The default value is 0. The higher the number, the worse the priority.

JobStatus : Integer which indicates the current status of the job, where 1 = Idle, 2 = Running, 3 = Removed, 4 = Completed, and 5 = Held.

JobUniverse : Integer which indicates the job universe, where 1 = Standard, 4 = PVM, 5 = Vanilla, and 7 = Scheduler.

LastCkptServer : Hostname of the last checkpoint server used by this job. When a pool is using multiple checkpoint servers, this tells the job where to find its checkpoint file.

LastCkptTime : Time at which the job last performed a successful checkpoint. Measured in the number of seconds since the epoch (00:00:00 UTC, Jan 1, 1970).

LastVacateTime : Time at which the job was last evicted from a remote workstation. Measured in the number of seconds since the epoch (00:00:00 UTC, Jan 1, 1970).

NumCkpts : A count of the number of checkpoints written by this job during its lifetime.

NumRestarts : A count of the number of restarts from a checkpoint attempted by this job during its lifetime.

NiceUser : Boolean value which indicates whether this is a nice-user job.

Owner : String describing the user who submitted this job.

ProcId : Integer process identifier for this job. In a cluster of many jobs, each job will have the same ClusterId but will have a unique ProcId.

QDate : Time at which the job was submitted to the job queue. Measured in the number of seconds since the epoch (00:00:00 UTC, Jan 1, 1970).

JobStartDate : Time at which the job first began running. Measured in the number of seconds since the epoch (00:00:00 UTC, Jan 1, 1970).

2.5.3 Heterogeneous Submit: Execution on Differing Architectures

If executables are available for the different platforms of machines in the Condor pool, Condor can be allowed the choice of a larger number of machines when allocating a machine for a job. Modifications to the submit description file allow this choice of platforms.

A simplified example is a cross submission. An executable is available for one platform, but the submission is done from a different platform. Given the correct executable, the `requirements` command in the submit description file specifies the target architecture. For example, an executable compiled for a Sun 4, submitted from an Intel architecture running Linux would add the `requirement`

```
  requirements = Arch == "SUN4x" && OpSys == "SOLARIS251"
```

Without this `requirement`, *condor_submit* will assume that the program is to be executed on a machine with the same platform as the machine where the job is submitted.

Cross submission works for both `standard` and `vanilla` universes. The burden is on the user to both obtain and specify the correct executable for the target architecture. To list the architecture and operating systems of the machines in a pool, run *condor_status*.

2.5.4 Vanilla Universe Example for Execution on Differing Architectures

A more complex example of a heterogeneous submission occurs when a job may be executed on many different architectures to gain full use of a diverse architecture and operating system pool. If the executables are available for the different architectures, then a modification to the submit description file will allow Condor to choose an executable after an available machine is chosen.

A special-purpose MachineAd substitution macro can be used in the `executable`, `environment`, and `arguments` attributes in the submit description file. The macro has the form

```
  $$(MachineAdAttribute)
```

Note that this macro is ignored in all other submit description attributes. The $$() informs Condor to substitute the requested `MachineAdAttribute` from the machine where the job will be executed.

An example of the heterogeneous job submission has executables available for three platforms: LINUX Intel, Solaris26 Intel, and Irix 6.5 SGI machines. This example uses *povray* to render images using a popular free rendering engine.

The substitution macro chooses a specific executable after a platform for running the job is chosen. These executables must therefore be named based on the machine attributes that describe a platform. The executables named

```
  povray.LINUX.INTEL
```

```
povray.SOLARIS26.INTEL
povray.IRIX65.SGI
```

will work correctly for the macro

```
povray.$$(OpSys).$$(Arch)
```

The executables or links to executables with this name are placed into the initial working directory so that they may be found by Condor. A submit description file that queues three jobs for this example:

```
####################
#
# Example of heterogeneous submission
#
####################

universe     = vanilla
Executable   = povray.$$(OpSys).$$(Arch)
Log          = povray.log
Output       = povray.out.$(Process)
Error        = povray.err.$(Process)

Requirements = (Arch == "INTEL" && OpSys == "LINUX") || \
               (Arch == "INTEL" && OpSys =="SOLARIS26") || \
               (Arch == "SGI" && OpSys == "IRIX65")

Arguments    = +W1024 +H768 +Iimage1.pov
Queue

Arguments    = +W1024 +H768 +Iimage2.pov
Queue

Arguments    = +W1024 +H768 +Iimage3.pov
Queue
```

These jobs are submitted to the vanilla universe to assure that once a job is started on a specific platform, it will finish running on that platform. Switching platforms in the middle of job execution cannot work correctly.

There are two common errors made with the substitution macro. The first is the use of a non-existent `MachineAdAttribute`. If the specified `MachineAdAttribute` does not exist in the machine's ClassAd, then Condor will place the job in the machine state of hold until the problem is resolved.

The second common error occurs due to an incomplete job set up. For example, the submit description file given above specifies three available executables. If one is missing, Condor report back that an executable is missing when it happens to match the job with a resource that requires the missing binary.

2.5.5 Standard Universe Example for Execution on Differing Architectures

Jobs submitted to the standard universe may produce checkpoints. A checkpoint can then be used to start up and continue execution of a partially completed job. For a partially completed job, the checkpoint and the job are specific to a platform. If migrated to a different machine, correct execution requires that the platform must remain the same.

A more complex `requirements` expression tells Condor to migrate a partially completed job to another machine with the same platform.

```
  CkptRequirements = ((CkptArch == Arch) || (CkptArch =?= UNDE-
FINED)) && \
                      ((CkptOpSys == OpSys) || (CkptOp-
Sys =?= UNDEFINED))
  Requirements = ( (Arch == "INTEL" && OpSys == "LINUX") || \
                 (Arch == "INTEL" && OpSys =="SOLARIS26") || \
                 (Arch == "SGI" && OpSys == "IRIX65") ) && $(CkptRequirements)
```

The `Requirements` expression in the example uses a macro to add an additional expression, called `CkptRequirements`. The `CkptRequirements` expression guarantees correct operation in the two possible cases for a job. In the first case, the job has not produced a checkpoint. The ClassAd attributes `CkptArch` and `CkptOpSys` will be undefined, and therefore the meta operator (`=?=`) evaluates to true. In the second case, the job has produced a checkpoint. The Machine ClassAd is restricted to require further execution only on a machine of the same platform. The attributes `CkptArch` and `CkptOpSys` will be defined, ensuring that the platform chosen for further execution will be the same as the one used just before the checkpoint.

Note that this restriction of platforms also applies to platforms where the executables are binary compatible.

The complete submit description file for this example:

```
  ####################
  #
  # Example of heterogeneous submission
  #
  ####################

  universe     = standard
  Executable   = povray.$$(OpSys).$$(Arch)
  Log          = povray.log
  Output       = povray.out.$(Process)
  Error        = povray.err.$(Process)

  CkptRequirements = ((CkptArch == Arch) || (CkptArch =?= UNDE-
FINED)) && \
                      ((CkptOpSys == OpSys) || (CkptOp-
Sys =?= UNDEFINED))
  Requirements = ( (Arch == "INTEL" && OpSys == "LINUX") || \
                 (Arch == "INTEL" && OpSys =="SOLARIS26") || \
                 (Arch == "SGI" && OpSys == "IRIX65") ) && $(CkptRequirements)

  Arguments    = +W1024 +H768 +Iimage1.pov
  Queue

  Arguments    = +W1024 +H768 +Iimage2.pov
  Queue

  Arguments    = +W1024 +H768 +Iimage3.pov
  Queue
```

2.6 Managing a Condor Job

This section provides a brief summary of what can be done once jobs are submitted. The basic mechanisms for monitoring a job are introduced, but the commands are discussed briefly. You are encouraged to look at the man pages of the commands referred to (located in Chapter 8 beginning on page 248) for more information.

When jobs are submitted, Condor will attempt to find resources to run the jobs. A list of all those with jobs submitted may be obtained through *condor_status* with the *-submitters* option. An example of this would yield output similar to:

```
%  condor_status -submitters

Name                 Machine      Running IdleJobs HeldJobs

ballard@cs.wisc.edu  bluebird.c         0       11        0
nice-user.condor@cs. cardinal.c         6      504        0
wright@cs.wisc.edu   finch.cs.w         1        1        0
jbasney@cs.wisc.edu  perdita.cs         0        0        5

                           RunningJobs           Idle-
Jobs           HeldJobs
```

```
 ballard@cs.wisc.edu                  0                  11                  0
 jbasney@cs.wisc.edu                  0                   0                  5
nice-user.condor@cs.                  6                 504                  0
  wright@cs.wisc.edu                  1                   1                  0

               Total                  7                 516                  5
```

2.6.1 Checking on the progress of jobs

At any time, you can check on the status of your jobs with the *condor_q* command. This command displays the status of all queued jobs. An example of the output from *condor_q* is

```
%  condor_q

-- Submitter: froth.cs.wisc.edu : <128.105.73.44:33847> : froth.cs.wisc.edu
 ID      OWNER            SUBMITTED    CPU_USAGE ST PRI SIZE CMD
 125.0   jbasney         4/10 15:35   0+00:00:00 I  -
10 1.2  hello.remote
 127.0   raman           4/11 15:35   0+00:00:00 R  0   1.4  hello
 128.0   raman           4/11 15:35   0+00:02:33 I  0   1.4  hello

3 jobs; 2 idle, 1 running, 0 held
```

This output contains many columns of information about the queued jobs. The `ST` column (for status) shows the status of current jobs in the queue. An `R` in the status column means the the job is currently running. An `I` stands for idle. The job is not running right now, because it is waiting for a machine to become available. The status `H` is the hold state. In the hold state, the job will not be scheduled to run until it is released (see condor_hold and condor_release man pages). Older versions of Condor used a `U` in the status column to stand for unexpanded. In this state, a job has never checkpointed and when it starts running, it will start running from the beginning. Newer versions of Condor do not use the `U` state.

The `CPU_USAGE` time reported for a job is the time that has been committed to the job. It is not updated for a job until the job checkpoints. At that time, the job has made guaranteed forward progress. Depending upon how the site administrator configured the pool, several hours may pass between checkpoints, so do not worry if you do not observe the `CPU_USAGE` entry changing by the hour. Also note that this is actual CPU time as reported by the operating system; it is not time as measured by a wall clock.

Another useful method of tracking the progress of jobs is through the user log. If you have specified a `log` command in your submit file, the progress of the job may be followed by viewing the log file. Various events such as execution commencement, checkpoint, eviction and termination are logged in the file. Also logged is the time at which the event occurred.

When your job begins to run, Condor starts up a *condor_shadow* process on the submit machine. The shadow process is the mechanism by which the remotely executing jobs can access the environment from which it was submitted, such as input and output files.

It is normal for a machine which has submitted hundreds of jobs to have hundreds of shadows running on the machine. Since the text segments of all these processes is the same, the load on the submit machine is usually not significant. If, however, you notice degraded performance, you can limit the number of jobs that can run simultaneously through the `MAX_JOBS_RUNNING` configuration parameter. Please talk to your system administrator for the necessary configuration change.

You can also find all the machines that are running your job through the *condor_status* command. For example, to find all the machines that are running jobs submitted by "breach@cs.wisc.edu," type:

```
%  condor_status -constraint 'RemoteUser == "breach@cs.wisc.edu"'

Name       Arch     OpSys        State      Activity   Loa-
dAv Mem  ActvtyTime

alfred.cs. INTEL    SOLARIS251   Claimed    Busy       0.980  64    0+07:10:02
biron.cs.w INTEL    SOLARIS251   Claimed    Busy       1.000  128   0+01:10:00
cambridge. INTEL    SOLARIS251   Claimed    Busy       0.988  64    0+00:15:00
falcons.cs INTEL    SOLARIS251   Claimed    Busy       0.996  32    0+02:05:03
happy.cs.w INTEL    SOLARIS251   Claimed    Busy       0.988  128   0+03:05:00
istat03.st INTEL    SOLARIS251   Claimed    Busy       0.883  64    0+06:45:01
istat04.st INTEL    SOLARIS251   Claimed    Busy       0.988  64    0+00:10:00
istat09.st INTEL    SOLARIS251   Claimed    Busy       0.301  64    0+03:45:00
...
```

To find all the machines that are running any job at all, type:

```
%  condor_status -run

Name       Arch     OpSys        LoadAv Remo-
teUser           ClientMachine

adriana.cs INTEL    SOLARIS251   0.980  hepcon@cs.wisc.edu   chevre.cs.wisc.
alfred.cs. INTEL    SOLARIS251   0.980  breach@cs.wisc.edu   neufchatel.cs.w
amul.cs.wi SUN4u    SOLARIS251   1.000  nice-
user.condor@cs. chevre.cs.wisc.
anfrom.cs. SUN4x    SOLARIS251   1.023  ashoks@jules.ncsa.ui jules.ncsa.uiuc
anthrax.cs INTEL    SOLARIS251   0.285  hepcon@cs.wisc.edu   chevre.cs.wisc.
astro.cs.w INTEL    SOLARIS251   1.000  nice-
user.condor@cs. chevre.cs.wisc.
aura.cs.wi SUN4u    SOLARIS251   0.996  nice-
user.condor@cs. chevre.cs.wisc.
balder.cs. INTEL    SOLARIS251   1.000  nice-
```

```
user.condor@cs. chevre.cs.wisc.
bamba.cs.w INTEL    SOLARIS251   1.574  dmarino@cs.wisc.edu  riola.cs.wisc.e
bardolph.c INTEL    SOLARIS251   1.000  nice-
user.condor@cs. chevre.cs.wisc.
...
```

2.6.2 Removing a job from the queue

A job can be removed from the queue at any time by using the *condor_rm* command. If the job that is being removed is currently running, the job is killed without a checkpoint, and its queue entry is removed. The following example shows the queue of jobs before and after a job is removed.

```
%  condor_q

-- Submitter: froth.cs.wisc.edu : <128.105.73.44:33847> : froth.cs.wisc.edu
 ID      OWNER            SUBMITTED    CPU_USAGE ST PRI SIZE CMD
 125.0   jbasney         4/10 15:35   0+00:00:00 I  -
10 1.2  hello.remote
 132.0   raman           4/11 16:57   0+00:00:00 R  0   1.4  hello

2 jobs; 1 idle, 1 running, 0 held

%  condor_rm 132.0
Job 132.0 removed.

%  condor_q

-- Submitter: froth.cs.wisc.edu : <128.105.73.44:33847> : froth.cs.wisc.edu
 ID      OWNER            SUBMITTED    CPU_USAGE ST PRI SIZE CMD
 125.0   jbasney         4/10 15:35   0+00:00:00 I  -
10 1.2  hello.remote

1 jobs; 1 idle, 0 running, 0 held
```

2.6.3 Changing the priority of jobs

In addition to the priorities assigned to each user, Condor also provides each user with the capability of assigning priorities to each submitted job. These job priorities are local to each queue and range from -20 to +20, with higher values meaning better priority.

The default priority of a job is 0, but can be changed using the *condor_prio* command. For example, to change the priority of a job to -15,

```
%  condor_q raman
```

```
-- Submitter: froth.cs.wisc.edu : <128.105.73.44:33847> : froth.cs.wisc.edu
 ID      OWNER            SUBMITTED    CPU_USAGE ST PRI SIZE CMD
 126.0   raman           4/11 15:06   0+00:00:00 I  0   0.3  hello

1 jobs; 1 idle, 0 running, 0 held

%  condor_prio -p -15 126.0

%  condor_q raman

-- Submitter: froth.cs.wisc.edu : <128.105.73.44:33847> : froth.cs.wisc.edu
 ID      OWNER            SUBMITTED    CPU_USAGE ST PRI SIZE CMD
 126.0   raman           4/11 15:06   0+00:00:00 I  -15 0.3  hello

1 jobs; 1 idle, 0 running, 0 held
```

It is important to note that these *job* priorities are completely different from the *user* priorities assigned by Condor. Job priorities do not impact user priorities. They are only a mechanism for the user to identify the relative importance of jobs among all the jobs submitted by the user to that specific queue.

2.6.4 Why does the job not run?

Users sometimes find that their jobs do not run. There are several reasons why a specific job does not run. These reasons include failed job or machine constraints, bias due to preferences, insufficient priority, and the preemption throttle that is implemented by the *condor_negotiator* to prevent thrashing. Many of these reasons can be diagnosed by using the *-analyze* option of *condor_q*. For example, the following job submitted by user jbasney was found to have not run for several days.

```
% condor_q

-- Submitter: froth.cs.wisc.edu : <128.105.73.44:33847> : froth.cs.wisc.edu
 ID      OWNER            SUBMITTED    CPU_USAGE ST PRI SIZE CMD
 125.0   jbasney         4/10 15:35   0+00:00:00 I  -
10 1.2  hello.remote

1 jobs; 1 idle, 0 running, 0 held
```

Running *condor_q*'s analyzer provided the following information:

```
%  condor_q 125.0 -analyze

-- Submitter: froth.cs.wisc.edu : <128.105.73.44:33847> : froth.cs.wisc.edu
```

```
---
125.000:  Run analysis summary.  Of 323 resource offers,
          323 do not satisfy the request's constraints
            0 resource offer constraints are not satis-
fied by this request
            0 are serving equal or higher priority customers
            0 are serving more preferred customers
            0 cannot preempt because preemption has been held
            0 are available to service your request

WARNING:  Be advised:
   No resources matched request's constraints
   Check the Requirements expression below:

Requirements = Arch == "INTEL" && OpSys == "IRIX6" &&
  Disk >= ExecutableSize && VirtualMemory >= ImageSize
```

For this job, the `Requirements` expression specifies a platform that does not exist. Therefore, the expression always evaluates to false.

While the analyzer can diagnose most common problems, there are some situations that it cannot reliably detect due to the instantaneous and local nature of the information it uses to detect the problem. Thus, it may be that the analyzer reports that resources are available to service the request, but the job still does not run. In most of these situations, the delay is transient, and the job will run during the next negotiation cycle.

If the problem persists and the analyzer is unable to detect the situation, it may be that the job begins to run but immediately terminates due to some problem. Viewing the job's error and log files (specified in the submit command file) and Condor's `SHADOW_LOG` file may assist in tracking down the problem. If the cause is still unclear, please contact your system administrator.

2.6.5 Job Completion

When your Condor job completes(either through normal means or abnormal termination by signal), Condor will remove it from the job queue (i.e., it will no longer appear in the output of *condor_q*) and insert it into the job history file. You can examine the job history file with the *condor_history* command. If you specified a log file in your submit description file, then the job exit status will be recorded there as well.

By default, Condor will send you an email message when your job completes. You can modify this behavior with the *condor_submit* "notification" command. The message will include the exit status of your job (i.e., the argument your job passed to the exit system call when it completed) or notification that your job was killed by a signal. It will also include the following statistics (as appropriate) about your job:

Submitted at: when the job was submitted with *condor_submit*

Completed at: when the job completed

Real Time: elapsed time between when the job was submitted and when it completed (days hours:minutes:seconds)

Run Time: total time the job was running (i.e., real time minus queueing time)

Committed Time: total run time that contributed to job completion (i.e., run time minus the run time that was lost because the job was evicted without performing a checkpoint)

Remote User Time: total amount of committed time the job spent executing in user mode

Remote System Time: total amount of committed time the job spent executing in system mode

Total Remote Time: total committed CPU time for the job

Local User Time: total amount of time this job's *condor_shadow* (remote system call server) spent executing in user mode

Local System Time: total amount of time this job's *condor_shadow* spent executing in system mode

Total Local Time: total CPU usage for this job's *condor_shadow*

Leveraging Factor: the ratio of total remote time to total system time (a factor below 1.0 indicates that the job ran inefficiently, spending more CPU time performing remote system calls than actually executing on the remote machine)

Virtual Image Size: memory size of the job, computed when the job checkpoints

Checkpoints written: number of successful checkpoints performed by the job

Checkpoint restarts: number of times the job successfully restarted from a checkpoint

Network: total network usage by the job for checkpointing and remote system calls

Buffer Configuration: configuration of remote system call I/O buffers

Total I/O: total file I/O detected by the remote system call library

I/O by File: I/O statistics per file produced by the remote system call library

Remote System Calls: listing of all remote system calls performed (both Condor-specific and Unix system calls) with a count of the number of times each was performed

2.7 Priorities in Condor

Condor has two independent priority controls: *job* priorities and *user* priorities.

2.7.1 Job Priority

Job priorities allow the assignment of a priority level to each submitted Condor job in order to control order of execution. To set a job priority, use the *condor_prio* command — see the example in section 2.6.3, or the command reference page on page 272. Job priorities do not impact user priorities in any fashion. Job priorities range from -20 to +20, with -20 being the worst and with +20 being the best.

2.7.2 User priority

Machines are allocated to users based upon a user's priority. A lower numerical value for user priority means higher priority, so a user with priority 5 will get more resources than a user with priority 50. User priorities in Condor can be examined with the *condor_userprio* command (see page 320). Condor administrators can set and change individual user priorities with the same utility.

Condor continuously calculates the share of available machines that each user should be allocated. This share is inversely related to the ratio between user priorities. For example, a user with a priority of 10 will get twice as many machines as a user with a priority of 20. The priority of each individual user changes according to the number of resources the individual is using. Each user starts out with the best possible priority: 0.5. If the number of machines a user currently has is greater than the user priority, the user priority will worsen by numerically increasing over time. If the number of machines is less then the priority, the priority will improve by numerically decreasing over time. The long-term result is fair-share access across all users. The speed at which Condor adjusts the priorities is controlled with the configuration macro `PRIORITY_HALFLIFE` , an exponential half-life value. The default is one day. If a user that has user priority of 100 and is utilizing 100 machines removes all his/her jobs, one day later that user's priority will be 50, and two days later the priority will be 25.

Condor enforces that each user gets his/her fair share of machines according to user priority both when allocating machines which become available and by priority preemption of currently allocated machines. For instance, if a low priority user is utilizing all available machines and suddenly a higher priority user submits jobs, Condor will immediately checkpoint and vacate jobs belonging to the lower priority user. This will free up machines that Condor will then give over to the higher priority user. Condor will not starve the lower priority user; it will preempt only enough jobs so that the higher priority user's fair share can be realized (based upon the ratio between user priorities). To prevent thrashing of the system due to priority preemption, the Condor site administrator can define a `PREEMPTION_REQUIREMENTS` expression in Condor's configuration. The default expression that ships with Condor is configured to only preempt lower priority jobs that have run for at least one hour. So in the previous example, in the worse case it could take up to a maximum of one hour until the higher priority user receives his fair share of machines.

User priorities are keyed on "username@domain", for example "johndoe@cs.wisc.edu". The domain name to use, if any, is configured by the Condor site administrator. Thus, user priority and therefore resource allocation is not impacted by which machine the user submits from or even if the user submits jobs from multiple machines.

An extra feature is the ability to submit a job as a "nice" job (see page 308). Nice jobs artificially boost the user priority by one million just for the nice job. This effectively means that nice jobs will only run on machines that no other Condor job (that is, non-niced job) wants. In a similar fashion, a Condor administrator could set the user priority of any specific Condor user very high. If done, for example, with a guest account, the guest could only use cycles not wanted by other users of the system.

2.8 Parallel Applications in Condor: Condor-PVM

Applications that use PVM (Parallel Virtual Machine) may use Condor. PVM offers a set of message passing primitives for use in C and C++ language programs. The primitives, together with the PVM environment allow parallelism at the program level. Multiple processes may run on multiple machines, while communicating with each other. More information about PVM is available at http://www.epm.ornl.gov/pvm/.

Condor-PVM provides a framework to run PVM applications in Condor's opportunistic environment. Where PVM needs dedicated machines to run PVM applications, Condor does not. Condor can be used to dynamically construct PVM virtual machines from a Condor pool of machines.

In Condor-PVM, Condor acts as the resource manager for the PVM daemon. Whenever a PVM program asks for nodes (machines), the request is forwarded to Condor. Condor finds a machine in the Condor pool using usual mechanisms, and adds it to the virtual machine. If a machine needs to leave the pool, the PVM program is notified by normal PVM mechanisms.

NOTE: Condor-PVM is an optional Condor module. It is not automatically installed with Condor. To check and see if it has been installed at your site, enter the command:

```
        ls -l ‘condor_config_val PVMD‘
```

Please note the use of back ticks in the above command. They specify to run the *condor_config_val* program. If the result of this program shows the file `condor_pvmd` on your system, then the Condor-PVM module is installed. If not, ask your site administrator to download and install Condor-PVM from http://www.cs.wisc.edu/condor/downloads/.

2.8.1 Effective Usage: the Master-Worker Paradigm

There are several different parallel programming paradigms. One of the more common is the *master-worker* (or *pool of tasks*) arrangement. In a master-worker program model, one node acts as the controlling master for the parallel application and sends pieces of work out to worker nodes. The worker node does some computation, and it sends the result back to the master node. The master has a pool of work that needs to be done, so it assigns the next piece of work out to the next worker that becomes available.

Condor-PVM is designed to run PVM applications which follow the master-worker paradigm. Condor runs the master application on the machine where the job was submitted and will not preempt it. Workers are pulled in from the Condor pool as they become available.

Not all parallel programming paradigms lend themselves to Condor's opportunistic environment. In such an environment, any of the nodes could be preempted and disappear at any moment. The master-worker model does work well in this environment. The master keeps track of which piece of work it sends to each worker. The master node is informed of the addition and disappearance of nodes. If the master node is informed that a worker node has disappeared, the master places the unfinished work it had assigned to the disappearing node back into the pool of tasks. This work is sent again to the next available worker node. If the master notices that the number of workers has dropped below an acceptable level, it requests more workers (using `pvm_addhosts()`). Alternatively, the master requests a replacement node every time it is notified that a worker has gone away. The benefit of this paradigm is that the number of workers is not important and changes in the size of the virtual machine are easily handled.

A tool called *MW* has been developed to assist in the development of master-worker style applications for distributed, opportunistic environments like Condor. MW provides a C++ API which hides the complexities of managing a master-worker Condor-PVM application. We suggest that you consider modifying your PVM application to use MW instead of developing your own dynamic PVM master from scratch. Additional information about MW is available at http://www.cs.wisc.edu/condor/mw/.

2.8.2 Binary Compatibility and Runtime Differences

Condor-PVM does not define a new API (application program interface); programs use the existing resource management PVM calls such as `pvm_addhosts()` and `pvm_notify()`. Because of this, some master-worker PVM applications are ready to run under Condor-PVM with no changes at all. Regardless of using Condor-PVM or not, it is good master-worker design to handle the case of a disappearing worker node, and therefore many programmers have already constructed their master program with all the necessary fault tolerant logic.

Regular PVM and Condor-PVM are *binary compatible*. The same binary which runs under regular PVM will run under Condor, and vice-versa. There is no need to re-link for Condor-PVM. This permits easy application development (develop your PVM application interactively with the regular PVM console, XPVM, etc.) as well as binary sharing between Condor and some dedicated MPP systems.

This release of Condor-PVM is based on PVM 3.4.2. PVM versions 3.4.0 through 3.4.2 are all supported. The vast majority of the PVM library functions under Condor maintain the same semantics as in PVM 3.4.2, including messaging operations, group operations, and `pvm_catchout()`.

The following list is a summary of the changes and new features of PVM running within the Condor environment:

- Condor introduces the concept of machine class. A pool of machines is likely to contain machines of more than one platform. Under Condor-PVM, machines of different architectures belong to different machine classes. With the concept machine class, Condor can be told what type of machine to allocate. Machine classes are assigned integer values, starting with 0. A machine class is specified in a submit description file when the job is submitted to Condor.

- `pvm_addhosts()`. When an application adds a host machine, it calls `pvm_addhosts()`. The first argument to `pvm_addhosts()` is a string that specifies the machine class. For example, to specify class 0, a pointer to the string "0" is the first argument. Condor finds a machine that satisfies the requirements of class 0 and adds it to the PVM virtual machine.

  The function `pvm_addhosts()` does not block. It returns immediately, before hosts are added to the virtual machine. In a non-dedicated environment the amount of time it takes until a machine becomes available is not bound. A program should call `pvm_notify()` before calling `pvm_addhosts()`. When a host is added later, the program will be notified in the usual PVM fashion (with a `PvmHostAdd` notification message).

  After receiving a `PvmHostAdd` notification, the PVM master can unpack the following information about the added host: an integer specifying the TID of the new host, a string specifying the name of the new host, followed by a string specifying the machine class of the new host. The PVM master can then call `pvm_spawn()` to start a worker process on the new host, specifying this machine class as the architecture and using the appropriate executable path for this machine class. Note that the name of the host is given by the startd and may be of the form "vmN@hostname" on SMP machines.

- `pvm_notify()`. Under Condor, there are two additional possible notification types to the function `pvm_notify()`. They are `PvmHostSuspend` and `PvmHostResume`. The program calls `pvm_notify()` with a host tid and `PvmHostSuspend` (or `PvmHostResume`) as arguments, and the program will receive a notification for the event of a host being suspended. Note that a notification occurs only once for each request. As an example, a `PvmHostSuspend` notification request for tid 4 results in a single `PvmHostSuspend` message for tid 4. There will not be another `PvmHostSuspend` message for that tid without another notification request.

  The easiest way to handle this is the following: When a worker node starts up, set up a notification for `PvmHostSuspend` on its tid. When that node gets suspended, set up a `PvmHostResume` notification. When it resumes, set up a `PvmHostSuspend` notification.

  If your application uses the `PvmHostSuspend` and `PvmHostResume` notification types, you will need to modify your PVM distribution to support them as follows. First, go to your $(PVM_ROOT). In `include/pvm3.h`, add

  ```
  #define PvmHostSuspend  6   /* condor suspension */
  #define PvmHostResume   7   /* condor resumption */
  ```

  to the list of "pvm_notify kinds". In `src/lpvmgen.c`, in `pvm_notify()`, change

  ```
  } else {
          switch (what) {
          case PvmHostDelete:
          ....
  ```

to

```
} else {
        switch (what) {
        case PvmHostSuspend:  /* for condor */
        case PvmHostResume:   /* for condor */
        case PvmHostDelete:
        ....
```

And that's it. Re-compile, and you're done.

- `pvm_spawn()`. If the flag in `pvm_spawn()` is `PvmTaskArch`, then a machine class string should be used. If there is only one machine class in a virtual machine, "0" is the string for the desired architecture.

  Under Condor, only one PVM task spawned per node is currently allowed, due to Condor's machine load checks. Most Condor sites will suspend or vacate a job if the load on its machine is higher than a specified threshold. Having more than one PVM task per node pushes the load higher than the threshold.

  Also, Condor only supports starting one copy of the executable with each call to `pvm_spawn()` (i.e., the fifth argument must always be equal to one). To spawn multiple copies of an executable in Condor, you must call `pvm_spawn()` once for each copy.

  A good fault tolerant program will be able to deal with `pvm_spawn()` failing. It happens more often in opportunistic environments like Condor than in dedicated ones.

- `pvm_exit()`. If a PVM task calls `pvm_catchout()` during its run to catch the output of child tasks, `pvm_exit()` will attempt to gather the output of all child tasks before returning. Due to the dynamic nature of the virtual machine in Condor, this cleanup procedure (in the PVM library and daemon) is error-prone and should be avoided. So, any PVM tasks which call `pvm_catchout()` should be sure to call it again with a NULL argument to disable output collection before calling `pvm_exit()`.

2.8.3 Sample PVM submit file

PVM jobs are submitted to the PVM universe. The following is an example of a submit description file for a PVM job. This job has a master PVM program called `master.exe`.

```
###########################################################
# sample_submit
# Sample submit file for PVM jobs.
###########################################################

# The job is a PVM universe job.
universe = PVM
```

```
# The executable of the master PVM program is ‘‘master.exe’’.
executable = master.exe

input = "in.dat"
output = "out.dat"
error = "err.dat"

###################  Machine class 0  ##################

Requirements = (Arch == "INTEL") && (OpSys == "LINUX")

# We want at least 2 machines in class 0 before starting the
# program.  We can use up to 4 machines.
machine_count = 2..4
queue

###################  Machine class 1  ##################

Requirements = (Arch == "SUN4x") && (OpSys == "SOLARIS26")

# We need at least 1 machine in class 1 before starting the
# executable.  We can use up to 3 to start with.
machine_count = 1..3
queue

###################  Machine class 2  ##################

Requirements = (Arch == "INTEL") && (OpSys == "SOLARIS26")

# We don’t need any machines in this class at startup, but we can use
# up to 3.
machine_count = 0..3
queue

###############################################################
# note: the program will not be started until the least
#       requirements in all classes are satisfied.
###############################################################
```

In this sample submit file, the command `universe = PVM` specifies that the jobs should be submitted into PVM universe.

The command `executable = master.exe` tells Condor that the PVM master program is *master.exe*. This program will be started on the submitting machine. The workers should be spawned by this master program during execution.

The `input`, `output`, and `error` commands specify files that should be redirected to the standard in, out, and error of the PVM master program. Note that these files will not include output from worker processes unless the master calls `pvm_catchout()`.

This submit file also tells Condor that the virtual machine consists of three different classes of machine. Class 0 contains machines with INTEL processors running LINUX; class 1 contains machines with SUN4x (SPARC) processors running SOLARIS26; class 2 contains machines with INTEL processors running SOLARIS26.

By using `machine_count = <min>..<max>`, the submit file tells Condor that before the PVM master is started, there should be at least `<min>` number of machines of the current class. It also asks Condor to give it as many as `<max>` machines. During the execution of the program, the application may request more machines of each of the class by calling `pvm_addhosts()` with a string specifying the machine class. It is often useful to specify `<min>` of 0 for each class, so the PVM master will be started immediately when the first host from any machine class is allocated.

The `queue` command should be inserted after the specifications of each class.

2.9 Running MPICH jobs in Condor

In addition to PVM, Condor also supports the execution of parallel jobs that utilize MPI. Our current implementation supports the following features:

- There are no alterations to the MPICH implementation. You can directly use the version from Argonne National Labs.
- You do not have to re-compile or re-link your MPICH job. Just compile it using the regular *mpicc*. Note that you have to be using the ch_p4 subsystem provided by Argonne.
- The communication speed of the MPI nodes is not affected by running it under Condor.

However, there are some limitations to our current implementation.

2.9.1 Caveats

MPICH Your MPI job must be compiled with MPICH, Argonne National Labs' implementation of MPI. Specifically, you must use the "ch_p4" device for MPICH. For information on MPICH, see Argonne's web page at http://www-unix.mcs.anl.gov/mpi/mpich/. Your version of MPICH must not be compiled with the path to RSH hard-coded into the library (As a result of running configure as `./configure`-rsh=/path/to/your/rsh possilbly.) Condor provides a special version of rsh that it uses to start jobs.

Dedicated Resources You must make sure that your MPICH jobs will be running on machines that will not vacate the job before the job terminates naturally. (This is a limitation of MPICH and the MPI specification.) Unlike PVM (Section 2.8), the current MPICH implementation does not support dynamic resource management. That is, processes in the virtual machine may NOT join or leave the computation at any time. If you start an MPI job with 4 nodes, for example, none of those 4 nodes can be preempted by other Condor jobs or the machine's owner.

Scheduling We do not yet have a sophisticated scheduling algorithm in place for MPI jobs. If you set things up properly, there shouldn't be much of a problem. However, if there are several users trying to run MPI jobs on the same machines, it may be the case that no jobs will run at all and Condor's scheduling will deadlock. Writing a good scheduler for this environment is high on the priority list for Condor version 6.5.

"New" shadow and starter We have been developing new versions of the *condor_shadow* and the *condor_starter*. You have to use these new versions to run MPI jobs. For information on obtaining these binaries, see below.

Shared File System The machines where you want your MPI job to run must have a shared file system. There is no remote I/O for our MPI support like there is for our Standard Universe jobs.

Condor Version 6.1.15+ You must be running this version of the Condor distribution (or greater) in order to use this contrib module.

2.9.2 Getting the Binaries

There is now an MPI "contrib" module available with Condor. It can be found in the contrib section of the downloads. When you un-tar the tarfile, there will be three files:

- *condor_starter.v61*
- *condor_shadow.v61*
- *rsh*

The last item is named `rsh`, but it is not the *rsh* utility you're familiar with — it's a wrapper that is required for our implementation to function correctly. These three binaries should go in Condor's `sbin` directory, where many other files like them reside.

2.9.3 Configuring Condor

Now that you've got the necessary binaries, you'll have to configure Condor to use MPI. Insert the following lines in the main condor_config file:

```
ALTERNATE_STARTER_2 = $(SBIN)/condor_starter.v61
STARTER_2_IS_DC = TRUE
MPI_CONDOR_RSH_PATH = $(SBIN)
SHADOW_MPI = $(SBIN)/condor_shadow.v61
```

Reconfigure your pool by typing

```
condor_reconfig ‘condor_status -m‘
```

The -m argument tells *condor_status* to return just the names of all the running *condor_master* daemons in your pool. Note that you have to do this from a machine with administrator privileges.

2.9.4 Managing Dedicated Machines

There are several ways that you can set up a pool to run MPI jobs without interruption. We will cover two methods that will work, although more sophisticated solutions are possible. Familiarity with Startd policy configuration (Section 3.6) is necessary to understand the following examples.

For the first example, let's assume that you have a cluster of machines which do not have regular users on them. Let's also assume that these machines are solely dedicated to the use of Condor. The simplest way to set up your policy is as follows:

```
START        = TRUE
CONTINUE     = TRUE
SUSPEND      = FALSE
PREEMPT      = FALSE
KILL         = FALSE
```

With the above configuration, the machines will accept any Condor job, and the jobs will never be suspended, preempted, or killed. You will never have to worry about an MPI job (or any job, for that matter) being evicted from the machines.

For a more complex example, let us assume you have machines with sophisticated policies already in place, and you'd like the machines to manage MPI jobs differently. The following macros (which should be specified near other Startd policy support macros) allow you to accomplish the task easily.

```
MPI   = 8
IsMPI = (JobUniverse == $(MPI))
```

Now change your configuration from

```
START = /* your interesting policy here */
```

to

```
FORMER_START = /* your interesting policy here */
```

Similarly, the `CONTINUE` , `SUSPEND` , `PREEMPT` , and `KILL` expressions should be changed to macros named `FORMER_CONTINUE`, etc. The following configuration will ensure that MPI jobs are never suspended or evicted while implementing your former policy for all other jobs.

```
START = ( $(FORMER_START) )
CONTINUE = ( $(FORMER_CONTINUE) )
SUSPEND = ( $(FORMER_SUSPEND) && ((IsMPI) == FALSE ) )
PREEMPT = ( $(FORMER_PREEMPT) && ((IsMPI) == FALSE ) )
KILL = ( $(FORMER_KILL) && ((IsMPI) == FALSE ) )
```

Thus, Condor will never attempt to vacate an MPI job from a machine once it starts running on that machine. Some machine owners may not like this setup, so you may need to customize your configuration to suit your needs. The most important point to remember when creating your Startd policy is that MPI jobs are immediately killed if one or more nodes of the job leave the computation.

2.9.5 Submitting to Condor

Here is a minimal submit file to submit an MPI job to Condor. For more information on writing submit files, see Section 2.5.1.

```
universe = MPI
executable = your_mpi_program
machine_count = 4
queue
```

This tells Condor to start the executable named `your_mpi_program` on four machines. These four machines will be of the same architechture and operating system as the submitting machine. Note the `universe = MPI` line tells Condor that an MPICH job is being submitted.

Now let's try a more sophisticated submit file:

```
####################################################################
## submitfile                                                     ##
####################################################################
universe = MPI
executable = simplempi
log = logfile
input = infile.$(NODE)
output = outfile.$(NODE)
error = errfile.$(NODE)
machine_count = 4
queue
```

Notice the `$(NODE)` macro, which is expanded when the job starts so that it becomes equivalent to the MPI "id" of the MPICH job. The first process started becomes "0", the second is "1", etc. For example, let's say I prepared four input files, named `infile.0` through `infile.3`:

```
infile.0:
Hello number zero.

infile.1:
Hello number one.
```

etc. I then created a simple MPI job, named `simplempi.c`

```
/******************************************************************
 * simplempi.c
 ******************************************************************/
#include <stdio.h>
#include "mpi.h"

int main(argc,argv)
    int argc;
    char *argv[];
{
    int myid;
    char line[128];

    MPI_Init(&argc,&argv);
    MPI_Comm_rank(MPI_COMM_WORLD,&myid);

    fprintf ( stdout, "Printing to stdout...%d\n", myid );
    fprintf ( stderr, "Printing to stderr...%d\n", myid );
    fgets ( line, 128, stdin );
    fprintf ( stdout, "From stdin: %s", line );

    MPI_Finalize();
    return 0;
}
```

And to complete the demonstration, here's the `Makefile`:

```
###################################################################
## This is a very basic Makefile                                 ##
###################################################################

# Change this part to your mpicc, obviously....
CC          = /usr/local/bin/mpicc
```

```
CLINKER     = $(CC)

CFLAGS    = -g
EXECS     = simplempi

all: $(EXECS)

simplempi: simplempi.o
        $(CLINKER) -o simplempi simplempi.o -lm

.c.o:
        $(CC) $(CFLAGS) -c $*.c
```

Once `simplempi` is built, use *condor_submit* to submit your job. This job should finish pretty quickly once it finds machines to run on, and the results will be what you expect: 8 files will be created: `errfile.[0-3]` and `outfile.[0-3]`. For example, `outfile.0` will contain

```
Printing to stdout...0
From stdin: Hello number zero.
```

and `errfile.0` will contain

```
Printing to stderr...0
```

Of course, individual tasks may open other files; this example was constructed to demonstrate the `$(NODE)` feature and the setup of the expected `stdin`, `stdout`, and `stderr` files in the MPI universe.

2.10 Extending your Condor pool with Glidein

Condor works together with Globus software to provide the capability of submitting Condor jobs to remote computer systems. Globus software provides mechanisms to access and utilize remote resources.

condor_glidein is a program that can be used to add Globus resources to a Condor pool on a temporary basis. During this period, these resources are visible to users of the pool, but only the user that added the resources is allowed to use them. The machine in the Condor pool is referred to herein as the local node, while the resource added to the local Condor pool is referred to as the remote node.

These requirements are general to using any Globus resource:

1. An X.509 certificate issued by a Globus certificate authority.

2. Access to a Globus resource. You must be a valid Globus user and be mapped to a valid login account by the site's Globus administrator on every Globus resource that will be added to the local Condor pool using *condor_glidein*. More information can be found at http://www.globus.org
3. The environment variables `HOME` and either `GLOBUS_INSTALL_PATH` or `GLOBUS_DEPLOY_PATH` must be set.

2.10.1 *condor_glidein* Requirements

In order to use *condor_glidein* to add a Globus resource to the local Condor pool, there are several requirements beyond the general Globus requirements given above.

1. Use Globus v1.1 or better.
2. Be an authorized user of the local Condor pool.
3. The local Condor pool configuration file(s) must give `HOSTALLOW_WRITE` permission to every resource that will be added using *condor_glidein*. Wildcards are permitted in this specification. An example is of adding every machine at cs.wisc.edu by adding *.cs.wisc.edu to the `HOSTALLOW_WRITE` list. Recall that the changes take effect when all machines in the local pool are sent a reconfigure command.
4. The local Condor pool's configuration file(s) must set `GLOBUSRUN` to be the path of *globus-run* and `SHADOW_GLOBUS` to be the path of the *condor_shadow.globus*.
5. Included in the `PATH` must be the common user programs directory `/bin`, globus tools, and the Condor user program directory.
6. Have the environment variable `X509_USER_PROXY` set, pointing to a valid user proxy.

2.10.2 What *condor_glidein* Does

condor_glidein first checks that there is a valid proxy and that the necessary files are available to *condor_glidein*.

condor_glidein then contacts the Globus resource and checks for the presence of the necessary configuration files and Condor executables. If the executables are not present for the machine architecture, operating system version, and Condor version required, a server running at UW is contacted to transfer the needed executables.

When the files are correctly in place, Condor daemons are started. *condor_glidein* does this by creating a submit description file for *condor_submit*, which runs the *condor_master* under the Globus universe. This implies that execution of the *condor_master* is started on the Globus resource. The Condor daemons exit gracefully when no jobs run on the daemons for a configurable period of time. The default length of time is 20 minutes.

The Condor executables on the Globus resource contact the local pool and attempt to join the pool. The START expression for the *condor_startd* daemon requires that the username of the person running *condor_glidein* matches the username of the jobs submitted through Condor.

After a short length of time, the Globus resource can be seen in the local Condor pool, as with this example.

```
% condor_status | grep denal
7591386@denal IRIX65      SGI    Unclaimed  Idle       3.700  24064  0+00:06:35
```

Once the Globus resource has been added to the local Condor pool with *condor_glidein*, job(s) may be submitted. To force a job to run on the Globus resource, specify that Globus resource as a machine requirement in the submit description file. Here is an example from within the submit description file that forces submission to the Globus resource denali.mcs.anl.gov:

```
      requirements = ( machine == "denali.mcs.anl.gov" ) \
         && FileSystemDomain != "" \
         && Arch != "" && OpSys != ""
```

This example requires that the job run only on denali.mcs.anl.gov, and it prevents Condor from inserting the filesystem domain, architecture, and operating system attributes as requirements in the matchmaking process. Condor must be told not to use the submission machine's attributes in those cases where the Globus resource's attributes do not match the submission machine's attributes.

2.11 Inter-job Dependencies: DAGMan Meta-Scheduler

A directed acyclic graph (DAG) can be used to represent a set of programs where the input, output, or execution of one or more programs is dependent on one or more other programs. The programs are nodes (vertices) in the graph, and the edges (arcs) identify the dependencies. Condor alone finds machines for the execution of programs, but it does not schedule programs (jobs) based on dependencies. The Directed Acyclic Graph Manager (DAGMan) is a meta-scheduler for Condor jobs. DAGMan submits jobs to Condor in an order represented by a DAG and processes the results. An input file defined prior to submission describes the DAG, and a Condor submit description file for each program in the DAG is used by Condor.

Each node (program) in the DAG needs its own Condor submit description file. As DAGMan submits jobs to Condor, it uses a single Condor log file to enforce the ordering required for the DAG. The DAG itself is defined by the contents of a DAGMan input file. DAGMan is responsible for scheduling, recovery, and reporting for the set of programs submitted to Condor.

The following sections specify the use of DAGMan.

2.11.1 Input File describing the DAG

The input file used by DAGMan specifies three items:

1. A list of the programs in the DAG. This serves to name each program and specify each program's Condor submit description file.
2. Processing that takes place before submission of any programs in the DAG to Condor or after Condor has completed execution of any program in the DAG.
3. Description of the dependencies in the DAG.

These three items are placed in the input file for DAGMan in the order listed.

Comments may be placed in the input file that describes the DAG. The pound character (#) as the first character on a line identifies the line as a comment. Comments do not span lines.

An example input file for DAGMan is

```
# Filename: diamond.dag
#
Job  A  A.condor
Job  B  B.condor
Job  C  C.condor
Job  D  D.condor
Script PRE  A top_pre.csh
Script PRE  B mid_pre.perl  $JOB
Script POST B mid_post.perl $JOB $RETURN
Script PRE  C mid_pre.perl  $JOB
Script POST C mid_post.perl $JOB $RETURN
Script PRE  D bot_pre.csh
PARENT A CHILD B C
PARENT B C CHILD D
```

This input file describes the DAG shown in Figure 2.2.

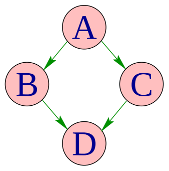


Figure 2.2: Diamond DAG

The first section of the input file lists all the programs that appear in the DAG. Each program is described by a single line called a Job Entry. The syntax used for each Job Entry is

JOB JobName CondorSubmitDescriptionFile [*DONE*]

A Job Entry maps a *JobName* to a Condor submit description file. The *JobName* uniquely identifies programs within the DAGMan input file and within output messages.

The keyword *JOB* and the *JobName* are not case sensitive. A *JobName* of *joba* is equivalent to *JobA*. The *CondorSubmitDescriptionFile* is case sensitive, since the UNIX file system is case sensitive. The *JobName* can be any string that contains no white space.

The optional *DONE* identifies a job as being already completed. This is useful in situations where the user wishes to verify results, but does not need all programs within the dependency graph to be executed. The *DONE* feature is also utilized when an error occurs causing the DAG to not be completed. DAGMan generates a Rescue DAG, a DAGMan input file that can be used to restart and complete a DAG without re-executing completed programs.

The second type of item in a DAGMan input file enumerates processing that is done either before a program within the DAG is submitted to Condor for execution or after a program within the DAG completes its execution. Processing done before a program is submitted to Condor is called a *PRE* script. Processing done after a program successfully completes its execution under Condor is called a *POST* script. A node in the DAG is comprised of the program together with *PRE* and/or *POST* scripts. The dependencies in the DAG are enforced based on nodes.

Syntax for *PRE* and *POST* script lines within the input file

SCRIPT PRE JobName ExecutableName [*arguments*]

SCRIPT POST JobNameExecutableName [*arguments*]

The *SCRIPT* keyword identifies the type of line within the DAG input file. The *PRE* or *POST* keyword specifies the relative timing of when the script is to be run. The *JobName* specifies the job to which the script is attached. The *ExecutableName* specifies the script to be executed, and it may be followed by any command line arguments to that script. The *ExecutableName* and optional *arguments* have their case preserved.

Scripts are optional for each job, and any scripts are executed on the machine to which the DAGMan is submitted.

The PRE and POST scripts are commonly used when files must be placed into a staging area for the job to use, and files are cleaned up or removed once the job is finished running. An example using PRE/POST scripts involves staging files that are stored on tape. The PRE script reads compressed input files from the tape drive, and it uncompresses them, placing the input files in the current directory. The program within the DAG node is submitted to Condor, and it reads these input files. The program produces output files. The POST script compresses the output files, writes them out to the tape, and then deletes the staged input and output files.

DAGMan takes note of the exit value of the program as well as the exit value of its scripts. If the PRE script fails (exit value != 0), then neither the job nor the POST script runs, and the node is marked as failed.

If the PRE script succeeds, the program is submitted to Condor. If the program fails, the DAG node is marked as failed. An exit value not equal to 0 indicates program failure. It is therefore important that the program returns the exit value 0 to indicate the program did not fail.

The POST script is run regardless of the job's return value. If the POST script fails (exit value != 0), then the node is marked as failed.

A node not mark as failed at any point is successful.

Two variables are available to ease script writing. The `$JOB` variable evaluates to *JobName*. The `$RETURN` variable evaluates to the return value of the program. The variables may be placed anywhere within the arguments.

As an example, suppose the *PRE* script expands a compressed file named `JobName.gz`. The *SCRIPT* entry for jobs A, B, and C are

```
SCRIPT PRE  A  pre.csh $JOB .gz
SCRIPT PRE  B  pre.csh $JOB .gz
SCRIPT PRE  C  pre.csh $JOB .gz
```

The script `pre.csh` may use these arguments

```
#!/bin/csh
gunzip $argv[1]$argv[2]
```

The third type of item in the DAG input file describes the dependencies within the DAG. Nodes are parents and/or children within the DAG. A parent node must be completed successfully before any child node may be started. A child node is started once all its parents have successfully completed.

The syntax of a dependency line within the DAG input file:

PARENT ParentJobName. . . *CHILD ChildJobName*. . .

The *PARENT* keyword is followed by one or more *ParentJobName*s. The *CHILD* keyword is followed by one or more *ChildJobName*s. Each child job depends on every parent job on the line. A single line in the input file can specify the dependencies from one or more parents to one or more children. As an example, the line

```
PARENT p1 p2 CHILD c1 c2
```

produces four dependencies:

1. `p1` to `c1`
2. `p1` to `c2`

3. `p2` to `c1`
4. `p2` to `c2`

2.11.2 Condor Submit Description File

Each node in a DAG may be a unique executable, each with a unique Condor submit description file. Each program may be submitted to a different universe within Condor, for example standard, vanilla, or DAGMan.

Two limitations exist. First, each Condor submit description file must submit only one job. There may not be multiple `queue` lines, or DAGMan will fail. The second limitation is that the submit description file for all jobs within the DAG must use the same log. DAGMan enforces the dependencies within a DAG using the events recorded in the log file produced by job submission to Condor.

Here is an example Condor submit description file to go with the diamond-shaped DAG example.

```
# Filename: diamond_job.condor
#
executable   = /path/diamond.exe
output       = diamond.out.$(cluster)
error        = diamond.err.$(cluster)
log          = diamond_condor.log
universe     = vanilla
notification = NEVER
queue
```

This example uses the same Condor submit description file for all the jobs in the DAG. This implies that each node within the DAG runs the same program. The `$(cluster)` macro is used to produce unique file names for each program's output. Each job is submitted separately, into its own cluster, so this provides unique names for the output files.

The notification is set to `NEVER` in this example. This tells Condor not to send e-mail about the completion of a program submitted to Condor. For DAGs with many nodes, this becomes the method used to reduce or eliminate excessive numbers of e-mails.

2.11.3 Job Submission

A DAG is submitted using the program *condor_submit_dag*. See the manual page 305 for complete details. A simple submission has the syntax

condor_submit_dag DAGInputFileName

The example may be submitted with

```
condor_submit_dag diamond.dag
```

In order to guarantee recoverability, the DAGMan program itself is run as a Condor job. As such, it needs a submit description file. DAGMan produces the needed file, naming it by appending the *DAGInputFileName* with `.condor.sub`. This submit description file may be editted if the DAG is submitted with

```
condor_submit_dag -no_submit diamond.dag
```

causing DAGMan to generate the submit description file, but not submit DAGMan to Condor. To submit the DAG, once the submit description file is editted, use

```
condor_submit diamond.dag.condor.sub
```

An optional argument to *condor_submit_dag*, *maxjobs*, is used to specify the maximum number of jobs that DAGMan may submit to Condor at one time. It is commonly used when there is a limited amount of input file staging capacity. As a specific example, consider a case where each job will require 4 Mbytes of input files, and the jobs will run in a directory with a volume of 100 MB of free space. Using the argument *-maxjobs 25* guarantees that a maximum of 25 jobs can be submitted to Condor at one time.

2.11.4 Job Monitoring

After submission, the progress of the DAG can be monitored by looking at the common log file, observing the e-mail that program submission to Condor causes, or by using *condor_q*.

2.11.5 Job Failure and Job Removal

A DAG can fail in one of two ways. Either DAGMan itself fails, or a node within the DAG fails. If DAGMan fails, no Condor jobs will remain. Currently, if a node within the DAG fails, DAGMan continues running as a Condor job.

condor_submit_dag attempts to check the DAG input file to verify that all the nodes in the DAG specify the same log file. If a problem is detected, *condor_submit_dag* prints out an error message and aborts.

To omit the check that all nodes use the same log file, as may be desired in the case where there are thousands of nodes, submit the job with the *-log* option. An example of this submission:

```
condor_submit_dag -log diamond_condor.log
```

This option tells *condor_submit_dag* to omit the verification step and use the given file as the log file.

To remove an entire DAG, consisting of DAGMan plus any jobs submitted to Condor, remove the DAGMan job running under Condor. *condor_q* will list the job number. Use the job number to remove the job, for example

```
% condor_q
-- Submitter: turunmaa.cs.wisc.edu : <128.105.175.125:36165> : turunmaa.cs.wisc.edu
 ID      OWNER            SUBMITTED     RUN_TIME ST PRI SIZE CMD
    9.0   smoler         10/12 11:47   0+00:01:32 R  0   8.7  con-
dor_dagman -f -
    11.0   smoler         10/12 11:48   0+00:00:00 I  0   3.6  B.out
    12.0   smoler         10/12 11:48   0+00:00:00 I  0   3.6  C.out

         3 jobs; 2 idle, 1 running, 0 held

% condor_rm 9.0
```

Before the DAGMan job stops running, it uses *condor_rm* to remove any Condor jobs within the DAG that are running.

In the case where a machine is scheduled to go down, DAGMan will clean up memory and exit. However, in will leave any submitted jobs in Condor's queue.

2.11.6 Job Recovery: The Rescue DAG

NOTE: The Rescue DAG feature is not implemented.

DAGMan does not support job resubmission on failure. If any node in the DAG fails, the entire DAG is aborted. As a substitute for resubmission, DAGMan offers an approach called the Rescue DAG.

The Rescue DAG is a DAG input file, functionally the same as the original DAG file. It additionally contains indication of successfully completed nodes using the *DONE* option in the input description file. If the DAG is resubmitted, the jobs marked as completed will not be resubmitted.

The Rescue DAG is automatically generated by DAGMan when a node within the DAG fails. The file is named using the *DAGInputFileName*, and appending the suffix `.rescue` to it. Statistics about the failed DAG execution are presented as comments at the beginning of the Rescue DAG input file.

2.12 About How Condor Jobs Vacate Machines

When Condor needs a job to vacate a machine for whatever reason, it sends the job an asynchronous signal specified in the `KillSig` attribute of the job's ClassAd. The value of this attribute can be specified by the user at submit time by placing the **kill_sig** option in the Condor submit description file.

If a program wanted to do some special work when required to vacate a machine, the program may set up a signal handler to use a trappable signal as an indication to clean up. When submitting this job, this clean up signal is specified to be used with **kill_sig**. Note that the clean up work needs to be quick. If the job takes too long to go away, Condor follows up with a SIGKILL signal which immediately terminates the process.

A job that is linked using *condor_compile* and is subsequently submitted into the standard universe, will checkpoint and exit upon receipt of a SIGTSTP signal. Thus, SIGTSTP is the default value for `KillSig` when submitting to the standard universe. The user's code may still checkpoint itself at any time by calling one of the following functions exported by the Condor libraries:

`ckpt()` Performs a checkpoint and then returns.

`ckpt_and_exit()` Checkpoints and exits; Condor will then restart the process again later, potentially on a different machine.

For jobs submitted into the vanilla universe, the default value for `KillSig` is SIGTERM, the usual method to nicely terminate a Unix program.

2.13 Special Environment Considerations

2.13.1 AFS

The Condor daemons do not run authenticated to AFS; they do not possess AFS tokens. Therefore, no child process of Condor will be AFS authenticated. The implication of this is that you must set file permissions so that your job can access any necessary files residing on an AFS volume without relying on having your AFS permissions.

If a job you submit to Condor needs to access files residing in AFS, you have the following choices:

1. Copy the needed files from AFS to either a local hard disk where Condor can access them using remote system calls (if this is a standard universe job), or copy them to an NFS volume.
2. If you must keep the files on AFS, then set a host ACL (using the AFS *fs setacl* command) on the subdirectory to serve as the current working directory for the job. If a standard universe job, then the host ACL needs to give read/write permission to any process on the submit

machine. If vanilla universe job, then you need to set the ACL such that any host in the pool can access the files without being authenticated. If you do not know how to use an AFS host ACL, ask the person at your site responsible for the AFS configuration.

The Condor Team hopes to improve upon how Condor deals with AFS authentication in a subsequent release.

Please see section 3.11.1 on page 157 in the Administrators Manual for further discussion of this problem.

2.13.2 NFS Automounter

If your current working directory when you run *condor_submit* is accessed via an NFS automounter, Condor may have problems if the automounter later decides to unmount the volume before your job has completed. This is because *condor_submit* likely has stored the dynamic mount point as the job's initial current working directory, and this mount point could become automatically unmounted by the automounter.

There is a simple work around: When submitting your job, use the *initialdir* command in your submit description file to point to the stable access point. For example, suppose the NFS automounter is configured to mount a volume at mount point `/a/myserver.company.com/vol1/johndoe` whenever the directory `/home/johndoe` is accessed. Adding the following line to the submit description file solves the problem.

```
    initialdir = /home/johndoe
```

2.13.3 Using Globus software with Condor

Use of the Globus project software http://www.globus.org with Condor affects these issues:

GSS Authentication Is an option only in special versions of Condor, available by request only, due to cryptographic software export controls and Condor distribution policy. Sites running the Condor software distributed with GSS-Authentication can set up their own Certification Authority (CA) by running the *create_ca* script. Once the CA is set up, the *condor_ca* script is used to generate certificates for the Condor daemons (e.g., *condor_schedd*) and to sign user and daemon certificates. Users can generate certificate requests and other needed files with the *condor_cert* program. An X.509 certificate directory pointed to by the submit description file variable *x509CertDir* indicates a client program which can use GSS authentication as a possible authentication method. Alternately, the environment variables `X509_CERT_DIR`, `X509_USER_CERT`, `X509_USER_KEY` can be used to override the default filenames and locations. NOTE: the AUTHENTICATION_METHOD configuration value list must contain the value 'GSS' for GSS authentication to be attempted.

bmitting to the Globus Universe requires Globus version 1.1, as well as a valid Globus X.509 certificate. The default location for the necessary files is $HOME/.globus, but they can be overridden by setting the X509_* variables in your environment or the submit description file. NOTE: AFS issues apply here, so you may have to copy your certificate, trusted certificates directory, private key, and proxy to a local file system disk.

condor_glidein Globus!*condor_glidein* requires a valid Globus X.509 certificate, and the PATH to the *globus-run* program must be in your environment. NOTE: to allow a globus resource to join your Condor pool, your administrator must add the hostname(s) to the HOSTALLOW_WRITE and HOSTALLOW_READ configuration values.

2.13.4 Condor Daemons That Do Not Run as root

Condor is normally installed such that the Condor daemons have root permission. This allows Condor to run the condor_shadow process and your job with your UID and file access rights. When Condor is started as root, your Condor jobs can access whatever files you can.

However, it is possible that whomever installed Condor did not have root access, or decided not to run the daemons as root. That is unfortunate, since Condor is designed to be run as the Unix user root. To see if Condor is running as root on a specific machine, enter the command

```
        condor\_status -master -l <machine-name>
```

where `machine-name` is the name of the specified machine. This command displays a condor_master ClassAd; if the attribute `RealUid` equals zero, then the Condor daemons are indeed running with root access. If the `RealUid` attribute is not zero, then the Condor daemons do not have root access.

NOTE: The UNIX program *ps* is *not* an effective method of determining if Condor is running with root access. When using *ps*, it may often appear that the daemons are running as the condor user instead of root. However, note that the *ps*, command shows the current *effective* owner of the process, not the *real* owner. (See the *getuid*(2) and *geteuid*(2) Unix man pages for details.) In Unix, a process running under the real UID of root may switch its effective UID. (See the *seteuid*(2) man page.) For security reasons, the daemons only set the effective uid to root when absolutely necessary (to perform a privileged operation).

If they are not running with root access, you need to make any/all files and/or directories that your job will touch readable and/or writable by the UID (user id) specified by the RealUid attribute. Often this may mean using the Unix command `chmod 777` on the directory where you submit your Condor job.

2.14 Potential Problems

2.14.1 Renaming of argv[0]

When Condor starts up your job, it renames argv[0] (which usually contains the name of the program) to condor_exec. This is convenient when examining a machine's processes with the UNIX command *ps*; the process is easily identified as a Condor job.

Unfortunately, some programs read argv[0] expecting their own program name and get confused if they find something unexpected like condor_exec.

CHAPTER

THREE

Administrators' Manual

3.1 Introduction

This is the Condor Administrator's Manual for UNIX. Its purpose is to aid in the installation and administration of a Condor pool. For help on using Condor, see the Condor User's Manual.

A Condor pool is comprised of a single machine which serves as the *central manager*, and an arbitrary number of other machines that have joined the pool. Conceptually, the pool is a collection of resources (machines) and resource requests (jobs). The role of Condor is to match waiting requests with available resources. Every part of Condor sends periodic updates to the central manager, the centralized repository of information about the state of the pool. Periodically, the central manager assesses the current state of the pool and tries to match pending requests with the appropriate resources.

Each resource has an owner, the user who works at the machine. This person has absolute power over their own resource and Condor goes out of its way to minimize the impact on this owner caused by Condor. It is up to the resource owner to define a policy for when Condor requests will serviced and when they will be denied.

Each resource request has an owner as well: the user who submitted the job. These people want Condor to provide as many CPU cycles as possible for their work. Often the interests of the resource owners are in conflict with the interests of the resource requesters.

The job of the Condor administrator is to configure the Condor pool to find the happy medium that keeps both resource owners and users of resources satisfied. The purpose of this manual is to help you understand the mechanisms that Condor provides to enable you to find this happy medium for your particular set of users and resource owners.

3.1.1 The Different Roles a Machine Can Play

Every machine in a Condor pool can serve a variety of roles. Most machines serve more than one role simultaneously. Certain roles can only be performed by single machines in your pool. The following list describes what these roles are and what resources are required on the machine that is providing that service:

Central Manager There can be only one central manager for your pool. The machine is the collector of information, and the negotiator between resources and resource requests. These two halves of the central manager's responsibility are performed by separate daemons, so it would be possible to have different machines providing those two services. However, normally they both live on the same machine. This machine plays a very important part in the Condor pool and should be reliable. If this machine crashes, no further matchmaking can be performed within the Condor system (although all current matches remain in effect until they are broken by either party involved in the match). Therefore, choose for central manager a machine that is likely to be online all the time, or at least one that will be rebooted quickly if something goes wrong. The central manager will ideally have a good network connection to all the machines in your pool, since they all send updates over the network to the central manager. All queries go to the central manager.

Execute Any machine in your pool (including your Central Manager) can be configured for whether or not it should execute Condor jobs. Obviously, some of your machines will have to serve this function or your pool won't be very useful. Being an execute machine doesn't require many resources at all. About the only resource that might matter is disk space, since if the remote job dumps core, that file is first dumped to the local disk of the execute machine before being sent back to the submit machine for the owner of the job. However, if there isn't much disk space, Condor will simply limit the size of the core file that a remote job will drop. In general the more resources a machine has (swap space, real memory, CPU speed, etc.) the larger the resource requests it can serve. However, if there are requests that don't require many resources, any machine in your pool could serve them.

Submit Any machine in your pool (including your Central Manager) can be configured for whether or not it should allow Condor jobs to be submitted. The resource requirements for a submit machine are actually much greater than the resource requirements for an execute machine. First of all, every job that you submit that is currently running on a remote machine generates another process on your submit machine. So, if you have lots of jobs running, you will need a fair amount of swap space and/or real memory. In addition all the checkpoint files from your jobs are stored on the local disk of the machine you submit from. Therefore, if your jobs have a large memory image and you submit a lot of them, you will need a lot of disk space to hold these files. This disk space requirement can be somewhat alleviated with a checkpoint server (described below), however the binaries of the jobs you submit are still stored on the submit machine.

Checkpoint Server One machine in your pool can be configured as a checkpoint server. This is optional, and is not part of the standard Condor binary distribution. The checkpoint server is a centralized machine that stores all the checkpoint files for the jobs submitted in your pool.

This machine should have lots of disk space and a good network connection to the rest of your pool, as the traffic can be quite heavy.

Now that you know the various roles a machine can play in a Condor pool, we will describe the actual daemons within Condor that implement these functions.

3.1.2 The Condor Daemons

The following list describes all the daemons and programs that could be started under Condor and what they do:

condor_master This daemon is responsible for keeping all the rest of the Condor daemons running on each machine in your pool. It spawns the other daemons, and periodically checks to see if there are new binaries installed for any of them. If there are, the master will restart the affected daemons. In addition, if any daemon crashes, the master will send e-mail to the Condor Administrator of your pool and restart the daemon. The *condor_master* also supports various administrative commands that let you start, stop or reconfigure daemons remotely. The *condor_master* will run on every machine in your Condor pool, regardless of what functions each machine are performing.

condor_startd This daemon represents a given resource (namely, a machine capable of running jobs) to the Condor pool. It advertises certain attributes about that resource that are used to match it with pending resource requests. The startd will run on any machine in your pool that you wish to be able to execute jobs. It is responsible for enforcing the policy that resource owners configure which determines under what conditions remote jobs will be started, suspended, resumed, vacated, or killed. When the startd is ready to execute a Condor job, it spawns the *condor_starter*, described below.

condor_starter This program is the entity that actually spawns the remote Condor job on a given machine. It sets up the execution environment and monitors the job once it is running. When a job completes, the starter notices this, sends back any status information to the submitting machine, and exits.

condor_schedd This daemon represents resources requests to the Condor pool. Any machine that you wish to allow users to submit jobs from needs to have a *condor_schedd* running. When users submit jobs, they go to the schedd, where they are stored in the *job queue*, which the schedd manages. Various tools to view and manipulate the job queue (such as *condor_submit*, *condor_q*, or *condor_rm*) all must connect to the schedd to do their work. If the schedd is down on a given machine, none of these commands will work.

The schedd advertises the number of waiting jobs in its job queue and is responsible for claiming available resources to serve those requests. Once a schedd has been matched with a given resource, the schedd spawns a *condor_shadow* (described below) to serve that particular request.

condor_shadow This program runs on the machine where a given request was submitted and acts as the resource manager for the request. Jobs that are linked for Condor's standard universe, which perform remote system calls, do so via the *condor_shadow*. Any system call performed on the remote execute machine is sent over the network, back to the *condor_shadow* which actually performs the system call (such as file I/O) on the submit machine, and the result is sent back over the network to the remote job. In addition, the shadow is responsible for making decisions about the request (such as where checkpoint files should be stored, how certain files should be accessed, etc).

condor_collector This daemon is responsible for collecting all the information about the status of a Condor pool. All other daemons (except the negotiator) periodically send ClassAd updates to the collector. These ClassAds contain all the information about the state of the daemons, the resources they represent or resource requests in the pool (such as jobs that have been submitted to a given schedd). The *condor_status* command can be used to query the collector for specific information about various parts of Condor. In addition, the Condor daemons themselves query the collector for important information, such as what address to use for sending commands to a remote machine.

condor_negotiator This daemon is responsible for all the match-making within the Condor system. Periodically, the negotiator begins a *negotiation cycle*, where it queries the collector for the current state of all the resources in the pool. It contacts each schedd that has waiting resource requests in priority order, and tries to match available resources with those requests. The negotiator is responsible for enforcing user priorities in the system, where the more resources a given user has claimed, the less priority they have to acquire more resources. If a user with a better priority has jobs that are waiting to run, and resources are claimed by a user with a worse priority, the negotiator can preempt that resource and match it with the user with better priority.

NOTE: A higher numerical value of the user priority in Condor translate into worse priority for that user. The best priority you can have is 0.5, the lowest numerical value, and your priority gets worse as this number grows.

condor_kbdd This daemon is only needed on Digital Unix and IRIX. On these platforms, the *condor_startd* cannot determine console (keyboard or mouse) activity directly from the system. The *condor_kbdd* connects to the X Server and periodically checks to see if there has been any activity. If there has, the kbdd sends a command to the startd. That way, the startd knows the machine owner is using the machine again and can perform whatever actions are necessary, given the policy it has been configured to enforce.

condor_ckpt_server This is the checkpoint server. It services requests to store and retrieve checkpoint files. If your pool is configured to use a checkpoint server but that machine (or the server itself is down) Condor will revert to sending the checkpoint files for a given job back to the submit machine.

See figure 3.1 for a graphical representation of the pool architecture.

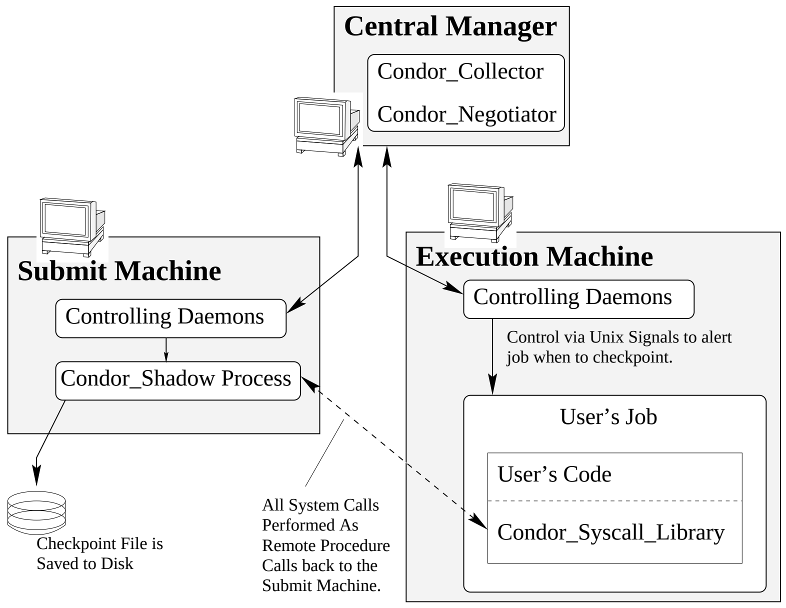


Figure 3.1: Pool Architecture

3.2 Installation of Condor

This section contains the instructions for installing Condor at your Unix site. Read this entire section before starting installation. The installation will have a default configuration that can be customized. Sections of the manual that follow this one explain customization.

Please read the copyright and disclaimer information in section on page xi of the manual, or in the file `LICENSE.TXT`, before proceeding. Installation and use of Condor is acknowledgement that you have read and agree to the terms.

3.2.1 Obtaining Condor

The first step to installing Condor is to download it from the Condor web site, http://www.cs.wisc.edu/condor. The downloads are available from the downlaods page, at http://www.cs.wisc.edu/condor/downloads/.

The platform-dependent Condor files are currently available from two sites. The main site is at the University of Wisconsin–Madison, Madison, Wisconsin, USA. A second site is the Istituto Nazionale di Fisica Nucleare Sezione di Bologna, Bologna, Italy. Please choose the site nearest you.

Make note of the location of where you download the binary into.

3.2.2 Condor Distribution Contents

The Condor binary distribution is packaged in the following 5 files and 2 directories:

`DOC` directions on where to find Condor documentation

`INSTALL` these installation directions

`LICENSE.TXT` the licensing agreement. By installing Condor, you agree to the contents of this file

`README` general information

`condor_install` the Perl script used to install and configure Condor

`examples` directory containing C, Fortran and C++ example programs to run with Condor

`release.tar` tar file of the release directory, which contains the Condor binaries and libraries

Before you install, please consider joining the condor-world mailing list. Traffic on this list is kept to an absolute minimum. It is only used to announce new releases of Condor. To subscribe, send a message to majordomo@cs.wisc.edu with the body:

```
subscribe condor-world
```

3.2.3 Preparation

Before installation, make a few important decisions about the basic layout of your pool. The decisions answer the questions:

1. What machine will be the central manager?
2. Will Condor run as root or not?
3. Who will be administering Condor on the machines in your pool?
4. Will you have a Unix user named condor and will its home directory be shared?
5. Where should the machine-specific directories for Condor go?
6. Where should the parts of the Condor system be installed?
   - Config files
   - Release directory
     - user binaries
     - system binaries

    - `lib` directory
    - `etc` directory
  - Documentation

7. Am I using AFS?

8. Do I have enough disk space for Condor?

If you feel you already know the answers to these questions, you can skip to the Installation Procedure section below, section 3.2.4 on page 68. If you are unsure about any of them, read on.

What machine will be the central manager?

One machine in your pool must be the central manager. Install Condor on this machine first. This is the centralized information repository for the Condor pool, and it is also the machine that does match-making between available machines and submitted jobs. If the central manager machine crashes, any currently active matches in the system will keep running, but no new matches will be made. Moreover, most Condor tools will stop working. Because of the importance of this machine for the proper functioning of Condor, install the central manager on a machine that is likely to stay up all the time, or on one that will be rebooted quickly if it does crash. Also consider network traffic and your network layout when choosing your central manager. All the daemons send updates (by default, every 5 minutes) to this machine.

Will Condor run as root or not?

Start up the Condor daemons as the Unix user root. Without this, Condor can do very little to enforce security and policy decisions. You can install Condor as any user, however there are both serious security and performance consequences. Please see section 3.12.1 on page 175 in the manual for the details and ramifications of on running Condor as a Unix user other than root.

Who will administer Condor?

Either root will be administering Condor directly, or someone else would be acting as the Condor administrator. If root has delegated the responsibility to another person but doesn't want to grant that person root access, root can specify a `condor_config.root` file that will override settings in the other condor configuration files. This way, the global `condor_config` file can be owned and controlled by whoever is condor-admin, and the condor_config.root can be owned and controlled only by root. Settings that would compromise root security (such as which binaries are started as root) can be specified in the `condor_config.root` file while other settings that only control policy or condor-specific settings can still be controlled without root access.

Will you have a Unix user named condor, and will its home directory be shared?

To simplify installation of Condor, create a Unix user named condor on all machines in the pool. The Condor daemons will create files (such as the log files) owned by this user, and the home directory can be used to specify the location of files and directories needed by Condor. The home directory of this user can either be shared among all machines in your pool, or could be a separate home directory on the local partition of each machine. Both approaches have advantages and disadvantages. Having the directories centralized can make administration easier, but also concentrates the resource usage such that you potentially need a lot of space for a single shared home directory. See the section below on machine-specific directories for more details.

If you choose not to create a user named condor, then you must specify via the CONDOR_IDS environment variable which uid.gid pair should be used for the ownership of various Condor files. See section 3.12.2 on UIDs in Condor on page 176 in the Administrator's Manual for details.

Where should the machine-specific directories for Condor go?

Condor needs a few directories that are unique on every machine in your pool. These are `spool`, `log`, and `execute`. Generally, all three are subdirectories of a single machine specific directory called the local directory (specified by the `LOCAL_DIR` macro in the configuration file).

If you have a Unix user named condor with a local home directory on each machine, the `LOCAL_DIR` could just be user condor's home directory (`LOCAL_DIR = $(TILDE)` in the configuration file). If this user's home directory is shared among all machines in your pool, you would want to create a directory for each host (named by hostname) for the local directory (for example, `LOCAL_DIR = $(TILDE)`/hosts/`$(HOSTNAME)`). If you do not have a condor account on your machines, you can put these directories wherever you'd like. However, where to place them will require some thought, as each one has its own resource needs:

`execute` This is the directory that acts as the current working directory for any Condor jobs that run on a given execute machine. The binary for the remote job is copied into this directory, so there must be enough space for it. (Condor will not send a job to a machine that does not have enough disk space to hold the initial binary). In addition, if the remote job dumps core for some reason, it is first dumped to the execute directory before it is sent back to the submit machine. So, put the execute directory on a partition with enough space to hold a possible core file from the jobs submitted to your pool.

`spool` The `spool` directory holds the job queue and history files, and the checkpoint files for all jobs submitted from a given machine. As a result, disk space requirements for the `spool` directory can be quite large, particularly if users are submitting jobs with very large executables or image sizes. By using a checkpoint server (see section 3.11.5 on Installing a Checkpoint Server on page 163 for details), you can ease the disk space requirements, since all checkpoint files are stored on the server instead of the spool directories for each machine. However, the initial checkpoint files (the executables for all the clusters you submit) are still stored in the spool directory, so you will need some space, even with a checkpoint server.

`log` Each Condor daemon writes its own log file, and each log file is placed in the `log` directory. You can specify what size you want these files to grow to before they are rotated, so the disk space requirements of the directory are configurable. The larger the log files, the more historical information they will hold if there is a problem, but the more disk space they use up. If you have a network file system installed at your pool, you might want to place the log directories in a shared location (such as `/usr/local/condor/logs/$(HOSTNAME)`), so that you can view the log files from all your machines in a single location. However, if you take this approach, you will have to specify a local partition for the `lock` directory (see below).

lock Condor uses a small number of lock files to synchronize access to certain files that are shared between multiple daemons. Because of problems encountered with file locking and network file systems (particularly NFS), these lock files should be placed on a local partition on each machine. By default, they are placed in the `log` directory. If you place your `log` directory on a network file system partition, specify a local partition for the lock files with the `LOCK` parameter in the configuration file (such as `/var/lock/condor`).

Generally speaking, it is recommended that you do not put these directories (except `lock`) on the same partition as `/var`, since if the partition fills up, you will fill up `/var` as well. This will cause lots of problems for your machines. Ideally, you will have a separate partition for the Condor directories. Then, the only consequence of filling up the directories will be Condor's malfunction, not your whole machine.

Where should the parts of the Condor system be installed?

- Configuration Files
- Release directory
  - User Binaries
  - System Binaries
  - `lib` Directory
  - `etc` Directory
- Documentation

Configuration Files There are a number of configuration files that allow you different levels of control over how Condor is configured at each machine in your pool. The global configuration file is shared by all machines in the pool. For ease of administration, this file should be located on a shared file system, if possible. In addition, there is a local configuration file for each machine, where you can override settings in the global file. This allows you to have different daemons running, different policies for when to start and stop Condor jobs, and so on. You can also have configuration files specific to each platform in your pool. See section 3.11.2 on page 158 about Configuring Condor for Multiple Platforms for details.

In addition, because we recommend that you start the Condor daemons as root, we allow you to create configuration files that are owned and controlled by root that will override any other Condor settings. This way, if the Condor administrator is not root, the regular Condor configuration files can be owned and writable by condor-admin, but root does not have to grant root access to this person. See section 3.12.3 on page 176 in the manual for a detailed discussion of the root configuration files, if you should use them, and what settings should be in them.

In general, there are a number of places that Condor will look to find its configuration files. The first file it looks for is the global configuration file. These locations are searched in order until a configuration file is found. If none contain a valid configuration file, Condor will print an error message and exit:

1. File specified in `CONDOR_CONFIG` environment variable
2. `/etc/condor/condor_config`
3. `~condor/condor_config`

Next, Condor tries to load the local configuration file(s). The only way to specify the local configuration file(s) is in the global configuration file, with the `LOCAL_CONFIG_FILE` macro. If that macro is not set, no local configuration file is used. This macro can be a list of files or a single file.

The root configuration files come in last. The global file is searched for in the following places:

1. `/etc/condor/condor_config.root`
2. `~condor/condor_config.root`

The local root configuration file(s) are found with the `LOCAL_ROOT_CONFIG_FILE` macro. If that is not set, no local root configuration file is used. This macro can be a list of files or a single file.

Release Directory Every binary distribution contains a `release.tar` file that contains four subdirectories: `bin`, `etc`, `lib` and `sbin`. Wherever you choose to install these 4 directories we call the release directory (specified by the `RELEASE_DIR` macro in the configuration file). Each release directory contains platform-dependent binaries and libraries, so you will need to install a separate one for each kind of machine in your pool. For ease of administration, these directories should be located on a shared file system, if possible.

- User Binaries:

  All of the files in the `bin` directory are programs the end Condor users should expect to have in their path. You could either put them in a well known location (such as `/usr/local/condor/bin`) which you have Condor users add to their `PATH` environment variable, or copy those files directly into a well known place already in user's PATHs (such as `/usr/local/bin`). With the above examples, you could also leave the binaries in `/usr/local/condor/bin` and put in soft links from `/usr/local/bin` to point to each program.

- System Binaries:

  All of the files in the `sbin` directory are Condor daemons and agents, or programs that only the Condor administrator would need to run. Therefore, add these programs only to the `PATH` of the Condor administrator.

- `lib` Directory:

  The files in the `lib` directory are the Condor libraries that must be linked in with user jobs for all of Condor's checkpointing and migration features to be used. `lib` also contains scripts used by the *condor_compile* program to help re-link jobs with the Condor libraries. These files should be placed in a location that is world-readable, but they do not need to be placed in anyone's `PATH`. The *condor_compile* script checks the configuration file for the location of the `lib` directory.

- `etc` Directory:

  `etc` contains an `examples` subdirectory which holds various example configuration files and other files used for installing Condor. `etc` is the recommended location to keep the master copy of your configuration files. You can put in soft links from one of the places mentioned above that Condor checks automatically to find its global configuration file.

Documentation The documentation provided with Condor is currently available in HTML, Postscript and PDF (Adobe Acrobat). It can be locally installed wherever is customary at your site. You can also find the Condor documentation on the web at: http://www.cs.wisc.edu/condor/manual.

Am I using AFS?

If you are using AFS at your site, be sure to read the section 3.11.1 on page 156 in the manual. Condor does not currently have a way to authenticate itself to AFS. A solution is not ready for Version 6.1.17. This implies that you are probably not going to want to have the `LOCAL_DIR` for Condor on AFS. However, you can (and probably should) have the Condor `RELEASE_DIR` on AFS, so that you can share one copy of those files and upgrade them in a centralized location. You will also have to do something special if you submit jobs to Condor from a directory on AFS. Again, read manual section 3.11.1 for all the details.

Do I have enough disk space for Condor?

The Condor release directory takes up a fair amount of space. This is another reason why it's a good idea to have it on a shared file system. The rough size requirements for the release directory on various platforms are listed in table 3.1.

In addition, you will need a lot of disk space in the local directory of any machines that are submitting jobs to Condor. See question 5 above for details on this.

Platform	*Size*
Intel/Linux	11 Mbytes (statically linked)
Intel/Linux	6.5 Mbytes (dynamically linked)
Intel/Solaris	8 Mbytes
Sparc/Solaris	10 Mbytes
SGI/IRIX	17.5 Mbytes
Alpha/Digital Unix	15.5 Mbytes

Table 3.1: Release Directory Size Requirements

3.2.4 Installation Procedure

IF YOU HAVE DECIDED TO CREATE A condor USER AND GROUP, DO THAT ON ALL YOUR MACHINES BEFORE YOU DO ANYTHING ELSE.

The easiest way to install Condor is to use one or both of the scripts provided to help you: *condor_install* and *condor_init*. Run these scripts as the user that you are going to run the Condor daemons as. First, run *condor_install* on the machine that will be a file server for shared files used by Condor, such as the release directory, and possibly the condor user's home directory. When you do, choose the "full-install" option in step #1 described below.

Once you have run *condor_install* on a file server to set up your release directory and configure Condor for your site, you should run *condor_init* on any other machines in your pool to create any locally used files that are not created by *condor_install*. In the most simple case, where nearly all of Condor is installed on a shared file system, even though *condor_install* will create nearly all the files and directories you need, you will still need to use *condor_init* to create the `LOCK` directory on the local disk of each machine. If you have a shared release directory, but the `LOCAL_DIR` is local on each machine, *condor_init* will create all the directories and files needed in `LOCAL_DIR` . In addition, *condor_init* will create any soft links on each machine that are needed so that Condor can find its global configuration file.

If you do not have a shared file system, you need to run *condor_install* on each machine in your pool to set up Condor. In this case, there is no need to run *condor_init* at all.

In addition, you will want to run *condor_install* on your central manager machine if that machine is different from your file server, using the "central-manager" option in step #1 described below. Run *condor_install* on your file server first, then on your central manager. If this step fails for some reason (NFS permissions, etc), you can do it manually quite easily. All this does is copy the `condor_config.local.central.manager` file from `<release_dir>/etc/examples` to the proper location for the local configuration file of your central manager machine. If your central manager is an Alpha or an SGI, you might want to add `KBDD` to the `$(DAEMON_LIST)` macro. See section 3.3 Configuring Condor on page 75 of the manual for details.

condor_install assumes you have perl installed in `/usr/bin/perl`. If this is not the case, you can either edit the script to put in the right path, or you will have to invoke perl directly from your shell (assuming perl is in your PATH):

```
% perl condor_install
```

condor_install breaks down the installation procedure into various steps. Each step is clearly numbered. The following section explains what each step is for, and suggests how to answer the questions *condor_install* will ask you for each one.

condor_install, step-by-step

STEP 1: What type of Condor installation do you want? There are three types of Condor installation you might choose: 'submit-only', 'full-install', and 'central-manager'. A submit-only machine can submit jobs to a Condor pool, but Condor jobs will not run on it. A full-install machine can both submit and run Condor jobs.

If you are planning to run Condor jobs on your machines, you should either install and run Condor as root, or as the Unix user condor.

If you are planning to set up a submit-only machine, you can either install Condor machine-wide as root or user condor, or, you can install Condor as yourself into your home directory.

The other possible installation type is setting up a machine as a central manager. If you do a full-install and you say that you want the local host to be your central manager, this step will be done automatically. You should only choose the central-manager option at step 1 if you have already run *condor_install* on your file server and you now want to run *condor_install* on a different machine that will be your central manager.

STEP 2: How many machines are you setting up this way? If you are installing Condor for multiple machines and you have a shared file system, then *condor_install* will prompt you for the hostnames of each machine you want to add to your Condor pool. If you do not have a shared file system, you will have to run *condor_install* locally on each machine, so *condor_install* does not ask for the names. If you provide a list, it will use the names to automatically create directories and files later. At the end, *condor_install* will dump out this list to a `roster` file which can be used by scripts to help maintain your Condor pool.

If you are only installing Condor on 1 machine, you would answer no to the first question, and move on.

STEP 3: Install the Condor release directory The release directory contains four subdirectories: `bin`, `etc`, `lib` and `sbin`. `bin` contains user-level executable programs. `etc` is the recommended location for your Condor configuration files, and it also includes an `examples` directory with default configuration files and other default files used for installing Condor. `lib` contains libraries to link Condor user programs and scripts used by the Condor system. `sbin` contains all administrative executable programs and the Condor daemons.

If you have multiple machines with a shared file system that will be running Condor, put the release directory on that shared file system so you only have one copy of all the binaries, and so that when you update them, you can do so in one place. Note that the release directory is architecture dependent, so download separate binary distributions for every platform in your pool.

condor_install tries to find an already installed release directory. If it cannot find one, it asks if you have installed one already. If you have not installed one, it tries to do so for you by untarring the `release.tar` file from the binary distribution.

NOTE: If you are only setting up a central manager (you chose 'central manager' in STEP 1), STEP 3 is the last question you will need to answer.

STEP 4: How and where should Condor send e-mail if things go wrong? Various parts of Condor will send e-mail to a condor administrator if something goes wrong that needs human attention. You will need to specify the e-mail address of this administrator.

You also specify the full path to a mail program that Condor will use to send the e-mail. This program needs to understand the **-s** option, to specify a subject for the outgoing message. The default on most platforms will probably be correct. On Linux machines, since there is such variation in Linux distributions and installations, verify that the default works. If the script complains that it cannot find the mail program that was specified, try

```
% which mail
```

to see what mail program is currently in your PATH. If there is none, try

```
% which mailx
```

If you still cannot find anything, ask your system administrator. Verify that the program you use supports **-s**. The man page for that program will probably tell you.

STEP 5: File system and UID domains. While Condor does not depend on a shared file system or common UID space for running jobs in the standard universe, vanilla jobs (ones that are not relinked with the Condor libraries) do need a shared file system and a common UID space. Therefore, it is very important for you to correctly configure Condor with respect to a shared file system. For complete details on what these settings do and how you should answer the questions, read section 3.3.5, Shared File System Configuration File Entries", on page 85.

You will be asked if you have a shared file system. If so, condor_install will configure your `FILESYSTEM_DOMAIN` setting to be set to the domain name of the machine running condor_install. If not, `FILESYSTEM_DOMAIN` will be set to `$(FULL_HOSTNAME)`, indicating that each machine is in its own domain.

For the UID domain, Condor needs to know if all users across all the machines in your pool have a unique UID. If so, `UID_DOMAIN` will be set to the domainname of the machine running condor_install. If not, `UID_DOMAIN` will be set to `$(FULL_HOSTNAME)`, indicating that each machine is in its own domain.

If you have a common `UID_DOMAIN` , condor_install will ask you if have a *soft UID domain*, meaning that although you have unique UIDs, not every machine in your pool has all the users in their individual password files. Please see the description of `SOFT_UID_DOMAIN` in section 3.3.5 on page 86 for details.

STEP 6: Where should public programs be installed? It is recommended that you install the user-level Condor programs in the release directory, (where they go by default). This way, when you want to install a new version of the Condor binaries, you can just replace your release directory and everything will be updated at once. So, one option is to have Condor users add `<release_dir>/bin` to their PATH, so that they can access the programs. However, we recommend putting in soft links from some directory already in their PATH (such as `/usr/local/bin`) that point back to the Condor user programs. *condor_install* will do this for you. All you do is tell it what directory to put these links into. This way, users do not have to change their PATH to use Condor, and you can still have the binaries installed in their own location.

If you are installing Condor as neither root nor condor, there is a perl script wrapper to all the Condor tools that is created which sets some appropriate environment variables and automatically passes certain options to the tools. This is all created automatically by *condor_install*. So, you need to tell *condor_install* where to put this perl script. The script itself is linked to itself with many different names, since it is the name that determines the behavior of the script. This script should go somewhere that is in your PATH already, if possible (such as ˜bin).

At this point, the remaining steps differ based on the whether the installation is a full install or a submit-only. Skip to the appropriate section below, based on the kind of installation.

Full Install

STEP 7: What machine will be your central manager? Type in the full hostname of the machine you have chosen for your central manager. If *condor_install* cannot find information about the host you typed by querying your nameserver, it will print out an error message and ask you to confirm.

STEP 8: Where will the local directory go? This is the directory discussed in question 5 of the installation introduction. *condor_install* tries to make some educated guesses as to what directory you want to use for the purpose. Agree to the correct guess, or (when *condor_install* has run out of guesses) type in what you want. Since this directory needs to be unique, it is common to use the hostname of each machine in its name. When typing in your own path, you can use '`$(HOSTNAME)`' which *condor_install* (and the Condor configuration files) will expand to the hostname of the machine you are currently on. *condor_install* will try to create the corresponding directories for all the machines you told it about in STEP 2 above.

Once you have selected the local directory, *condor_install* creates all the needed subdirectories of each one with the proper permissions. They should have the following permissions and ownerships:

```
drwxr-xr-x   2 condor   root         1024 Mar  6 01:30 execute/
drwxr-xr-x   2 condor   root         1024 Mar  6 01:30 log/
drwxr-xr-x   2 condor   root         1024 Mar  6 01:30 spool/
```

If your local directory is on a shared file system, *condor_install* will prompt you for the location of your lock files, as discussed in question #5 above. In this case, when *condor_install* is finished, you will have to run *condor_init* on each machine in your pool to create the `lock` directory before you can start up Condor.

STEP 9: Where will the local (machine-specific) configuration files go? As discussed in question STEP 6 above, there are a few different levels of Condor configuration files. There is the global configuration file that will be installed in <`release_dir`>`/etc/condor_config`, and there are machine-specific, or local configuration files, that override the settings in the global file. If you are installing on multiple machines or are configuring your central manager machine, you must select a location for your local configuration files.

The two main options are to have a single directory that holds all the local configuration files, each one named `$(HOSTNAME).local`, or to have the local configuration files go into the individual local directories for each machine. Given a shared file system, we recommend the first option, since it makes it easier to configure your pool from a centralized location.

STEP 10: How shall Condor find its configuration file? Since there are a few known places Condor looks to find your configuration file, we recommend that you put a soft link from one of them to point to <`release_dir`>`/etc/condor_config`. This way, you can keep your Condor configuration in a centralized location, but all the Condor daemons and tools will be able to find their configuration files. Alternatively, you can set the CONDOR_CONFIG environment variable to contain <`release_dir`>`/etc/condor_config`.

condor_install will ask you if you want to create a soft link from either of the two fixed locations that Condor searches.

Once you have completed STEP 10, you are done. *condor_install* prints out a messages describing what to do next. Please skip to section 3.2.5.

Submit Only

A submit-only installation of Condor implies that the machine will be submitting jobs to one or more established Condor pools. Configuration for this installation needs to account for the other pools.

For the submit-only installation, STEP 6 continues and completes the installation.

STEP 6: continued. A submit-only machine has the option of submission to more than one Condor pool. The full hostname of the central manager is required for each pool. The first entered becomes the default for start up and job submission.

There is a separate configuration file for each pool. The location of each file is specified.

Identification of each pool requires a unique name. A final question sets a name for each pool. The name will be the argument for **-pool** command line options.

3.2.5 Condor is installed... now what?

Now that Condor has been installed on your machine(s), there are a few things you should check before you start up Condor.

1. Read through the `<release_dir>/etc/condor_config` file. There are a lot of possible settings and you should at least take a look at the first two main sections to make sure everything looks okay. In particular, you might want to set up host/ip based security for Condor. See the section 3.8 on page 145 in the manual to learn how to do this.

2. Condor can monitor the activity of your mouse and keyboard, provided that you tell it where to look. You do this with the `CONSOLE_DEVICES` entry in the condor_startd section of the configuration file. On most platforms, reasonable defaults are provided. For example, the default device for the mouse on Linux is 'mouse', since most Linux installations have a soft link from `/dev/mouse` that points to the right device (such as `tty00` if you have a serial mouse, `psaux` if you have a PS/2 bus mouse, etc). If you do not have a `/dev/mouse` link, you should either create one (you will be glad you did), or change the `CONSOLE_DEVICES` entry in Condor's configuration file. This entry is a comma separated list, so you can have any devices in `/dev` count as 'console devices' and activity will be reported in the condor_startd's ClassAd as `ConsoleIdleTime`.

3. (Linux only) Condor needs to be able to find the `utmp` file. According to the Linux File System Standard, this file should be `/var/run/utmp`. If Condor cannot find it there, it looks in `/var/adm/utmp`. If it still cannot find it, it gives up. So, if your Linux distribution places this file somewhere else, be sure to put a soft link from `/var/run/utmp` to point to the real location.

3.2.6 Starting up the Condor daemons

To start up the Condor daemons, execute `<release_dir>/sbin/condor_master`. This is the Condor master, whose only job in life is to make sure the other Condor daemons are running. The master keeps track of the daemons, restarts them if they crash, and periodically checks to see if you have installed new binaries (and if so, restarts the affected daemons).

If you are setting up your own pool, you should start Condor on your central manager machine first. If you have done a submit-only installation and are adding machines to an existing pool, the start order does not matter.

To ensure that Condor is running, you can run either:

```
ps -ef | egrep condor_
```

or

```
ps -aux | egrep condor_
```

depending on your flavor of Unix. On your central manager machine you should have processes for:

- condor_master

- condor_collector
- condor_negotiator
- condor_startd
- condor_schedd

On all other machines in your pool you should have processes for:

- condor_master
- condor_startd
- condor_schedd

(NOTE: On Alphas and IRIX machines, there will also be a condor_kbdd – see section 3.11.4 on page 162 of the manual for details.) If you have set up a submit-only machine, you will only see:

- condor_master
- condor_schedd

Once you are sure the Condor daemons are running, check to make sure that they are communicating with each other. You can run *condor_status* to get a one line summary of the status of each machine in your pool.

Once you are sure Condor is working properly, you should add *condor_master* into your startup/bootup scripts (i.e. `/etc/rc`) so that your machine runs *condor_master* upon bootup. *condor_master* will then fire up the necessary Condor daemons whenever your machine is rebooted.

If your system uses System-V style init scripts, you can look in <`release_dir`>`/etc/examples/condor.boot` for a script that can be used to start and stop Condor automatically by init. Normally, you would install this script as `/etc/init.d/condor` and put in soft link from various directories (for example, `/etc/rc2.d`) that point back to `/etc/init.d/condor`. The exact location of these scripts and links will vary on different platforms.

If your system uses BSD style boot scripts, you probably have an `/etc/rc.local` file. Add a line to start up <`release_dir`>`/sbin/condor_master`.

3.2.7 The Condor daemons are running... now what?

Now that the Condor daemons are running, there are a few things you can and should do:

1. (Optional) Do a full install for the *condor_compile* script. condor_compile assists in linking jobs with the Condor libraries to take advantage of all of Condor's features. As it is currently installed, it will work by placing it in front of any of the following commands that you would normally use to link your code: gcc, g++, g77, cc, acc, c89, CC, f77, fort77 and ld. If you complete the full install, you will be able to use condor_compile with any command whatsoever, in particular, make. See section 3.11.3 on page 160 in the manual for directions.
2. Try building and submitting some test jobs. See `examples/README` for details.
3. If your site uses the AFS network file system, see section 3.11.1 on page 156 in the manual.
4. We strongly recommend that you start up Condor (run the *condor_master* daemon) as user root. If you must start Condor as some user other than root, see section 3.12.1 on page 175.

3.3 Configuring Condor

This section describes how to configure all parts of the Condor system. General information about the configuration files and their syntax is follwed by a description of settings that affect all Condor daemons and tools. At the end is a section describing the settings for each part of Condor. The settings that control the policy under which Condor will start, suspend, resume, vacate or kill jobs are described in section 3.6 on Configuring Condor's Job Execution Policy.

3.3.1 Introduction to Configuration Files

The Condor configuration files are used to customize how Condor operates at a given site. The basic configuration as shipped with Condor works well for most sites, with few exceptions.

See section 3.2 on page 61 for details on where Condor's configuration files are found.

Each Condor program will, as part of its initialization process, configure itself by calling a library routine which parses the various configuration files that might be used including pool-wide, platform-specific, machine-specific, and root-owned configuration files. The result is a list of constants and expressions which are evaluated as needed at run time.

The order in which attributes are defined is important, since later definitions will override existing definitions. This is particularly important if configuration files are broken up using the `LOCAL_CONFIG_FILE` setting described in sections 3.3.2 and 3.11.2 below.

Config File Macros

Macro definitions are of the form:

```
<macro_name> = <macro_definition>
```

NOTE: You must have white space between the macro name, the "=" sign, and the macro definition.

Macro invocations are of the form:

```
        $(macro_name)
```

Macro definitions may contain references to other macros, even ones that aren't yet defined (so long as they are eventually defined in your config files somewhere). All macro expansion is done after all config files have been parsed (with the exception of macros that reference themselves, described below).

```
        A = xxx
        C = $(A)
```

is a legal set of macro definitions, and the resulting value of `C` is `xxx`. Note that `C` is actually bound to `$(A)`, not its value.

As a further example,

```
        A = xxx
        C = $(A)
        A = yyy
```

is also a legal set of macro definitions, and the resulting value of `C` is `yyy`.

A macro may be incrementally defined by invoking itself in its definition. For example,

```
A = xxx
B = $(A)
A = $(A)yyy
A = $(A)zzz
```

is a legal set of macro definitions, and the resulting value of `A` is `xxxyyyzzz`. Note that invocations of a macro in its own definition are immediately expanded. `$(A)` is immediately expanded in line 3 of the example. If it were not, then the definition would be impossible to evaluate.

NOTE: Macros should not be incrementally defined in the `LOCAL_ROOT_CONFIG_FILE` for security reasons.

NOTE: Condor used to distingish between "macros" and "expressions" in its config files. Begining with Condor version 6.1.13, this distinction has been removed. For backwards compatibility, you can still use ":" instead of "=" in your config files, and these attributes will just be treated as macros.

Comments and Line Continuations

Other than macros, a Condor configuration file can contain comments or line continuations. A comment is any line beginning with a "#" character. A continuation is any entry that continues across multiples lines. Line continuation is accomplished by placing the "\" character at the end of any line to be continued onto another. Valid examples of line continuation are

```
        START = (KeyboardIdle > 15 * $(MINUTE)) && \
                ((LoadAvg - CondorLoadAvg) <= 0.3)
```

and

```
        ADMIN_MACHINES = condor.cs.wisc.edu, raven.cs.wisc.edu, \
                         stork.cs.wisc.edu, ostrich.cs.wisc.edu, \
                         bigbird.cs.wisc.edu
        HOSTALLOW_ADMIN = $(ADMIN_MACHINES)
```

Pre-Defined Macros

Condor provides pre-defined macros that help configure Condor. Pre-defined macros are listed as `$(macro_name)`.

This first set are entries whose values are determined at run time and cannot be overwritten. These are inserted automatically by the library routine which parses the configuration files.

`$(FULL_HOSTNAME)` The fully qualified hostname of the local machine (hostname plus domain name).

`$(HOSTNAME)` The hostname of the local machine (no domain name).

`$(TILDE)` The full path to the home directory of the UNIX user condor, if such a user exists on the local machine.

`$(SUBSYSTEM)` The subsystem name of the daemon or tool that is evaluating the macro. This is a unique string which identifies a given daemon within the Condor system. The possible subsystem names are:

- STARTD
- SCHEDD
- MASTER
- COLLECTOR
- NEGOTIATOR
- KBDD

- SHADOW
- STARTER
- CKPT_SERVER
- SUBMIT

This second set of macros are entries whose default values are determined automatically at run-time but which can be overwritten.

`$(ARCH)` Defines the string used to identify the architecture of the local machine to Condor. The *condor_startd* will advertise itself with this attribute so that users can submit binaries compiled for a given platform and force them to run on the correct machines. *condor_submit* will append a requirement to the job ClassAd that it must run on the same `ARCH` and `OPSYS` of the machine where it was submitted, unless the user specifies `ARCH` and/or `OPSYS` explicitly in their submit file. See the the *condor_submit* manual page on page 305 for details.

`$(OPSYS)` Defines the string used to identify the operating system of the local machine to Condor. If it is not defined in the configuration file, Condor will automatically insert the operating system of this machine as determined by *uname*.

`$(FILESYSTEM_DOMAIN)` Defaults to the fully qualified hostname of the machine it is evaluated on. See section 3.3.5, Shared File System Configuration File Entries for the full description of its use and under what conditions you would want to change it.

`$(UID_DOMAIN)` Defaults to the fully qualified hostname of the machine it is evaluated on. See section 3.3.5 on “Shared File System Configuration File Entries” for the full description of its use and under what conditions you would want to change it.

Since `$(ARCH)` and `$(OPSYS)` will automatically be set to the correct values, we recommend that you do not overwrite them. Only do so if you know what you are doing.

3.3.2 Condor-wide Configuration File Entries

This section describes settings which affect all parts of the Condor system.

`CONDOR_HOST` This macro is used to define the `$(NEGOTIATOR_HOST)` and `$(COLLECTOR_HOST)` macros. Normally the *condor_collector* and *condor_negotiator* would run on the same machine. If for some reason they were not run on the same machine, `$(CONDOR_HOST)` would not be needed. Some of the host-based security macros use `$(CONDOR_HOST)` by default. See section 3.8, Setting up IP/host-based security in Condor for details.

`COLLECTOR_HOST` The hostname of the machine where the *condor_collector* is running for your pool. Normally it is defined with the `$(CONDOR_HOST)` macro described above.

`NEGOTIATOR_HOST` The hostname of the machine where the *condor_negotiator* is running for your pool. Normally it is defined with the `$(CONDOR_HOST)` macro described above.

`RELEASE_DIR` The full path to the Condor release directory, which holds the `bin`, `etc`, `lib`, and `sbin` directories. Other macros are defined relative to this one.

`BIN` This directory points to the Condor directory where user-level programs are installed. It is usually defined relative to the `$(RELEASE_DIR)` macro.

`LIB` This directory points to the Condor directory where libraries used to link jobs for Condor's standard universe are stored. The *condor_compile* program uses this macro to find these libraries, so it must be defined. `$(LIB)` is usually defined relative to the `$(RELEASE_DIR)` macro.

`SBIN` This directory points to the Condor directory where Condor's system binaries (such as the binaries for the Condor daemons) and administrative tools are installed. Whatever directory `$(SBIN)` points to ought to be in the `PATH` of users acting as Condor administrators.

`LOCAL_DIR` The location of the local Condor directory on each machine in your pool. One common option is to use the condor user's home directory which may be specified with `$(TILDE)`. For example:

```
LOCAL_DIR = $(tilde)
```

On machines with a shared file system, where either the `$(TILDE)` directory or another directory you want to use is shared among all machines in your pool, you might use the `$(HOSTNAME)` macro and have a directory with many subdirectories, one for each machine in your pool, each named by hostnames. For example:

```
LOCAL_DIR = $(tilde)/hosts/$(hostname)
```

or:

```
LOCAL_DIR = $(release_dir)/hosts/$(hostname)
```

`LOG` Used to specify the directory where each Condor daemon writes its log files. The names of the log files themselves are defined with other macros, which use the `$(LOG)` macro by default. The log directory also acts as the current working directory of the Condor daemons as the run, so if one of them should produce a core file for any reason, it would be placed in the directory defined by this macro. Normally, `$(LOG)` is defined in terms of `$(LOCAL_DIR)`.

`SPOOL` The spool directory is where certain files used by the *condor_schedd* are stored, such as the job queue file and the initial executables of any jobs that have been submitted. In addition, for systems not using a checkpoint server, all the checkpoint files from jobs that have been submitted from a given machine will be store in that machine's spool directory. Therefore, you will want to ensure that the spool directory is located on a partition with enough disk space. If a given machine is only set up to execute Condor jobs and not submit them, it would not need a spool directory (or this macro defined). Normally, `$(SPOOL)` is defined in terms of `$(LOCAL_DIR)`.

`EXECUTE` This directory acts as the current working directory of any Condor job that is executing on the local machine. If a given machine is only set up to only submit jobs and not execute them, it would not need an execute directory (or this macro defined). Normally, `$(EXECUTE)` is defined in terms of `$(LOCAL_DIR)`.

`LOCAL_CONFIG_FILE` The location of the local, machine-specific configuration file for each machine in your pool. The two most common options would be putting this file in the `$(LOCAL_DIR)`, or putting all local configuration files for your pool in a shared directory, each one named by hostname. For example,

```
LOCAL_CONFIG_FILE = $(LOCAL_DIR)/condor_config.local
```

or,

```
LOCAL_CONFIG_FILE = $(release_dir)/etc/$(hostname).local
```

or, not using your release directory

```
LOCAL_CONFIG_FILE = /full/path/to/configs/$(hostname).local
```

Beginning with Condor version 6.0.1, the `$(LOCAL_CONFIG_FILE)` is treated as a list of files, not a single file. You can use either a comma or space separated list of files as its value. This allows you to specify multiple files as the local configuration file and each one will be processed in the order given (with parameters set in later files overriding values from previous files). This allows you to use one global configuration file for multiple platforms in your pool, define a platform-specific configuration file for each platform, and use a local configuration file for each machine. For more information on this, see section 3.11.2 about Configuring Condor for Multiple Platforms on page 158.

`CONDOR_ADMIN` The email address that Condor will send mail to if something goes wrong in your pool. For example, if a daemon crashes, the *condor_master* can send an *obituary* to this address with the last few lines of that daemon's log file and a brief message that describes what signal or exit status that daemon exited with.

`MAIL` The full path to a mail sending program that uses **-s** to specify a subject for the message. On all platforms, the default shipped with Condor should work. Only if you installed things in a non-standard location on your system would you need to change this setting.

`RESERVED_SWAP` Determines how much swap space you want to reserve for your own machine. Condor will not start up more *condor_shadow* processes if the amount of free swap space on your machine falls below this level.

`RESERVED_DISK` Determines how much disk space you want to reserve for your own machine. When Condor is reporting the amount of free disk space in a given partition on your machine, it will always subtract this amount. An example is the *condor_startd*, which advertises the amount of free space in the `$(EXECUTE)` directory.

`LOCK` Condor needs to create lock files to synchronize access to various log files. Because of problems with network file systems and file locking over the years, we *highly* recommend that you put these lock files on a local partition on each machine. If you do not have your `$(LOCAL_DIR)` on a local partition, be sure to change this entry. Whatever user or group Condor is running as needs to have write access to this directory. If you are not running as root, this is whatever user you started up the *condor_master* as. If you are running as root, and there is a condor account, it is most likely condor. Otherwise, it is whatever you set in the `CONDOR_IDS` environment variable. See section 3.12.2 on UIDs in Condor for details.

`HISTORY` Defines the location of the Condor history file, which stores information about all Condor jobs that have completed on a given machine. This macro is used by both the *condor_schedd* which appends the information and *condor_history*, the user-level program used to view the history file.

`DEFAULT_DOMAIN_NAME` If you do not use a fully qualified name in file `/etc/hosts` (or NIS, etc.) for either your official hostname or as an alias, Condor would not normally be able to use fully qualified names in places that it wants to. You can set this macro to the domain to be appended to your hostname, if changing your host information is not a good option. This macro must be set in the global configuration file (not the `$(LOCAL_CONFIG_FILE)`. The reason for this is that the special `$(FULL_HOSTNAME)` macro is used by the configuration file code in Condor needs to know the full hostname. So, for `$(DEFAULT_DOMAIN_NAME)` to take effect, Condor must already have read in its value. However, Condor must set the `$(FULL_HOSTNAME)` special macro since you might use that to define where your local configuration file is. After reading the global configuration file, Condor figures out the right values for `$(HOSTNAME)` and `$(FULL_HOSTNAME)` and inserts them into its configuration table.

`CREATE_CORE_FILES` Defines whether or not Condor daemons are to create a core file if something really bad happens. It is used to set the resource limit for the size of a core file. If not defined, it leaves in place whatever limit was in effect when you started the Condor daemons (normally the *condor_master*). If this parameter is set and TRUE, the limit is increased to the maximum. If it is set to FALSE, the limit is set at 0 (which means that no core files are created). Core files greatly help the Condor developers debug any problems you might be having. By using the parameter, you do not have to worry about tracking down where in your boot scripts you need to set the core limit before starting Condor. You set the parameter to whatever behavior you want Condor to enforce. This parameter has no default value, and is commented out in the default configuration file.

3.3.3 Daemon Logging Config File Entries

These entries control how and where the Condor daemons write their log files. Each of the entries in this section represents multiple macros. There is one for each subsystem (listed in section 3.3.1). The macro name for each substitutes `SUBSYS` with the name of the subsystem corresponding to the daemon.

SUBSYS_LOG The name of the log file for a given subsystem. For example, `$(STARTD_LOG)` gives the location of the log file for *condor_startd*. The name is defined relative to the `$(LOG)` macro described above. The actual names of the files are also used in the `$(VALID_LOG_FILES)` entry used by *condor_preen*. A change to one of the file names with this setting requires a change to the `$(VALID_LOG_FILES)` entry as well, or *condor_preen* will delete your newly named log files.

MAX_SUBSYS_LOG Controls the maximum length in bytes to which a log will be allowed to grow. Each log file will grow to the specified length, then be saved to a file with the suffix `.old`. The `.old` files are overwritten each time the log is saved, thus the maximum space devoted to logging for any one program will be twice the maximum length of its log file. A value of 0 specifies that the file may grow without bounds. The default is 64 Kbytes.

TRUNC_SUBSYS_LOG_ON_OPEN If this macro is defined and set to TRUE, the affected log will be truncated and started from an empty file with each invocation of the program. Otherwise, new invocations of the program will append to the previous log file. By default this setting is FALSE for all daemons.

SUBSYS_LOCK This macro specifies the lock file used to synchronize append operations to the log file for this subsystem. It must be a separate file from the `$(SUBSYS_LOG)` file, since the `$(SUBSYS_LOG)` file may be rotated and you want to be able to synchronize access across log file rotations. A lock file is only required for log files which are accessed by more than one process. Currently, this includes only the `SHADOW` subsystem. This macro is defined relative to the `$(LOCK)` macro. If, for some strange reason, you decide to change this setting, be sure to change the `$(VALID_LOG_FILES)` entry that *condor_preen* uses as well.

SUBSYS_DEBUG All of the Condor daemons can produce different levels of output depending on how much information you want to see. The various levels of verbosity for a given daemon are determined by this macro. All daemons have the default level `D_ALWAYS`, and log messages for that level will be printed to the daemon's log, regardless of this macro's setting. The other possible debug levels are:

D_FULLDEBUG This level provides very verbose output in the log files. Only exceptionally frequent log messages for very specific debugging purposes would be excluded. In those cases, the messages would be viewed by having that another flag and `D_FULLDEBUG` both listed in the configuration file.

D_DAEMONCORE Provides log file entries specific to DaemonCore, such as timers the daemons have set and the commands that are registered. If both `D_FULLDEBUG` and `D_DAEMONCORE` are set, expect *very* verbose output.

D_PRIV This flag provides log messages about the *privilege state* switching that the daemons do. See section 3.12.2 on UIDs in Condor for details.

D_COMMAND With this flag set, any daemon that uses DaemonCore will print out a log message whenever a command comes in. The name and integer of the command, whether the command was sent via UDP or TCP, and where the command was sent from are all logged. Because the messages about the command used by *condor_kbdd* to communicate with the *condor_startd* whenever there is activity on the X server, and the command used for keep-alives are both only printed with `D_FULLDEBUG` enabled, it is best if this setting is used for all daemons.

`D_LOAD` The *condor_startd* keeps track of the load average on the machine where it is running. Both the general system load average, and the load average being generated by Condor's activity there are determined. With this flag set, the *condor_startd* will log a message with the current state of both of these load averages whenever it computes them. This flag only affects the *condor_startd*.

`D_KEYBOARD` With this flag set, the *condor_startd* will print out a log message with the current values for remote and local keyboard idle time. This flag affects only the *condor_startd*.

`D_JOB` When this flag is set, the *condor_startd* will send to its log file the contents of any job ClassAd that the *condor_schedd* sends to claim the *condor_startd* for its use. This flag affects only the *condor_startd*.

`D_MACHINE` When this flag is set, the *condor_startd* will send to its log file the contents of its resource ClassAd when the *condor_schedd* tries to claim the *condor_startd* for its use. This flag affects only the *condor_startd*.

`D_SYSCALLS` This flag is used to make the *condor_shadow* log remote syscall requests and return values. This can help track down problems a user is having with a particular job by providing the system calls the job is performing. If any are failing, the reason for the failure is given. The *condor_schedd* also uses this flag for the server portion of the queue management code. With `D_SYSCALLS` defined in `SCHEDD_DEBUG` there will be verbose logging of all queue management operations the *condor_schedd* performs.

`D_BANDWIDTH` When this flag is set, the negotiator logs a message for every match. It includes the amount of network bandwidth used for job placement and preemption.

`D_NETWORK` When this flag is set, all Condor daemons will log a message on every TCP accept, connect, and close, and on every UDP send and receive. This flag is not yet fully supported in the *condor_shadow*.

Log files may optionally be specified per debug level as follows:

`SUBSYS_LEVEL_LOG` This is the name of a log file for messages at a specific debug level for a specific subsystem. If the debug level is included in `$(SUBSYS_DEBUG)`, then all messages of this debug level will be written both to the `$(SUBSYS_LOG)` file and the `$(SUBSYS_LEVEL_LOG)` file. For example, `$(SHADOW_SYSCALLS_LOG)` specifies a log file for all remote system call debug messages.

`MAX_SUBSYS_LEVEL_LOG` Similar to `MAX_SUBSYS_LOG` .

`TRUNC_SUBSYS_LEVEL_LOG_ON_OPEN` Similar to `TRUNC_SUBSYS_LOG_ON_OPEN` .

3.3.4 DaemonCore Config File Entries

Please read section 3.7 for details on DaemonCore. There are certain configuration file settings that DaemonCore uses which affect all Condor daemons (except the checkpoint server, shadow, and starter, none of which use DaemonCore yet).

HOSTALLOW. . . All macros that begin with either HOSTALLOW or HOSTDENY are settings for Condor's host-based security. See section 3.8 on Setting up IP/host-based security in Condor for details on these macros and how to configure them.

SHUTDOWN_GRACEFUL_TIMEOUT Determines how long Condor will allow daemons try their graceful shutdown methods before they do a hard shutdown. It is defined in terms of seconds. The default is 1800 (30 minutes).

AUTHENTICATION_METHODS There are many instances when the Condor system needs to authenticate the identity of the user. For instance, when a job is submitted with *condor_submit*, Condor needs to authenticate the user so that the job goes into the queue and runs with the proper credentials. The AUTHENTICATION_METHODS parameter should be a list of permitted authentication methods. The list should be ordered by preference. The actual authentication method used is the first method in this list that both the server and client are able to perform. Possible values are:

- NTSSPI Use NT's standard LAN-MANAGER challenge-reponse protocol. NOTE: This is the default method used on Windows NT.
- FS Use the filesystem to authenticate the user. The server requests the client to create a specified temporary file, then the server verifies the ownership of that file. NOTE: This is the default method used on Unix systems.
- FS_REMOTE Use a shared filesystem to authenticate the user. This is useful for submitting jobs to a remote schedd. Similar to FS authentication, except the temporary file to be created by the user must be on a shared filesystem (AFS, NFS, etc.) If the client's submit description file does not define the command **rendezvousdir**, the **initialdir** value is used as the default directory in which to create the temporary file. NOTE: Normal AFS issues apply here: Condor must be able to write to the directory used.
- GSS Use Generic Security Services, which is implemented in Condor with X.509 certificates. See section 3.9. These X.509 certificates are compatible with the Globus system from Argonne National Labs.
- CLAIMTOBE The server should simply trust the client. NOTE: You had better trust all users who have access to your Condor pool if you enable CLAIMTOBE authentication.

SHUTDOWN_GRACEFUL_TIMEOUT This entry determines how long you are willing to let daemons try their graceful shutdown methods

SUBSYS_ADDRESS_FILE Every Condor daemon that uses DaemonCore has a command port where commands are sent. The IP/port of the daemon is put in that daemon's ClassAd so that other machines in the pool can query the *condor_collector* (which listens on a well-known port) to find the address of a given daemon on a given machine. However, tools and daemons executing on the same machine they wish to communicate with are not required to query the collector. They look in a file on the local disk to find the IP/port. Setting this macro will cause daemons to write the IP/port of their command socket to a specified file. In this way, local tools will continue to operate, even if the machine running the *condor_collector* crashes.

Using this file will also generate slightly less network traffic in your pool (since *condor_q*, *condor_rm*, and others do not have to send any messages over the network to locate the *condor_schedd*). This macro is not needed for the collector or negotiator, since their command sockets are at well-known ports.

`SUBSYS_EXPRS` Allows any DaemonCore daemon to advertise arbitrary expressions from the configuration file in its ClassAd. Give the comma-separated list of entries from the configuration file you want in the given daemon's ClassAd.

NOTE: The *condor_negotiator* and *condor_kbdd* do not send ClassAds now, so this entry does not affect them. The *condor_startd*, *condor_schedd*, *condor_master*, and *condor_collector* do send ClassAds, so those would be valid subsystems to set this entry for.

Setting `$(SUBMIT_EXPRS)` has the slightly different effect of having the named expressions inserted into all the job ClassAds that *condor_submit* creates. This is equivalent to the "+" syntax in submit files. See the the *condor_submit* manual page on page 305 for details.

Because of the different syntax of the configuration file and ClassAds, a little extra work is required to get a given entry into a ClassAd. In particular, ClassAds require quote marks (") around strings. Numeric values and boolean expressions can go in directly. For example, if the startd is to advertise a string macro, a numeric macro, and a boolean expression, do something similar to:

```
STRING = This is a string
NUMBER = 666
BOOL1 = True
BOOL2 = CurrentTime >= $(NUMBER_MACRO) || $(BOOL1)
MY_STRING = "$(STRING_MACRO)"
STARTD_EXPRS = MY_STRING, NUMBER, BOOL1, BOOL2
```

3.3.5 Shared File System Configuration File Macros

These macros control how Condor interacts with various shared and network filesystems. If you are using AFS as your shared filesystem, be sure to read section 3.11.1 on Using Condor with AFS.

`UID_DOMAIN` Often times, especially if all the machines in the pool are administered by the same organization, all the machines to be added into a Condor pool share the same login account information. User X has UID Y on all machines within a given Internet/DNS domain. This is usually the case if a central authority creates user logins and maintains a common `/etc/passwd` file on all machines. If this is the case, then set this macro to the name of the Internet/DNS domain where this is true. For instance, if all the machines in this Condor pool within the Internet/DNS zone "cs.wisc.edu" have a common password file, `$(UID_DOMAIN)` is set to "cs.wisc.edu". If this is not the case, comment out the entry and Condor will automatically use the fully qualified hostname of each machine. An asterisk character ("*") is a wildcard to match all domains and therefore to honor all UIDs - a dangerous idea.

Condor uses this information to determine if it should run a given Condor job on the remote execute machine with the UID of whomever submitted the job or with the UID of the Unix user nobody. If the macro is set to “none” or not set, then Condor jobs will always execute with the access permissions of user nobody. For security purposes, it is not a bad idea to have Condor jobs that migrate around on machines across an entire organization to run as user nobody, which by convention has very restricted access to the disk files of a machine. Standard universe Condor jobs are fine running as user nobody since all I/O is redirected back through the use of remote system calls to a shadow process running on the submit machine (which is authenticated as the user). If you only plan on running standard universe jobs, then it is a good idea to simply set this to “none” or omit it. Vanilla universe jobs, however, cannot take advantage of Condor’s remote system calls. Vanilla universe jobs are dependent upon NFS, RFS, AFS, or some shared file system set up to read/write files as they bounce around from machine to machine. If you want to run vanilla jobs and your shared file systems are via AFS, then you can safely leave this as “none” as well. But, if you wish to use vanilla jobs with Condor and you have shared file systems with NFS or RFS, then enter in a legitimate domain name where all your UIDs match (you should be doing this with NFS anyway!) on all machines in the pool, or else users in your pool who submit vanilla jobs will have to make their files world read/write (so that user nobody can access them).

Some gritty details for folks who want to know: If the submitting machine and the remote machine about to execute the job both have the same login name in the password file for a given UID, and the `$(UID_DOMAIN)` claimed by the submit machine is indeed found to be a subset of what an inverse lookup to a DNS (domain name server) or NIS reports as the fully qualified domain name for the submit machine’s IP address (this security measure safeguards against the submit machine from lying), *then* the job will run with the same UID as the user who submitted the job. Otherwise it will run as user nobody.

Note: the `$(UID_DOMAIN)` parameter is also used when Condor sends e-mail back to the user about a completed job; the address `Job-Owner@UID_DOMAIN` is used, unless `$(UID_DOMAIN)` is “none”, in which case `Job-Owner@submit-machine` is used.

`SOFT_UID_DOMAIN` Used in conjunction with the `$(UID_DOMAIN)` macro described above. If the `$(UID_DOMAIN)` settings match on both the execute and submit machines, but the UID of the user who submitted the job is not in the password file (or password information if NIS is being used) of the execute machine, the *condor_starter* will exit with an error. If you set `$(SOFT_UID_DOMAIN)` to be TRUE, Condor will start the job with the specified UID, even if it is not in the password file.

`FILESYSTEM_DOMAIN` Similar in concept to `$(UID_DOMAIN)`, but this is the Internet/DNS domain name where all the machines within that domain can access the same set of NFS file servers.

Often times, especially if all the machines in the pool are administered by the same organization, all the machines to be added into a Condor pool can mount the same set of NFS fileservers onto the same place in the directory tree. If all the machines in the pool within a specific Internet/DNS domain mount the same set of NFS file servers onto the same path mount-points, then set this macro to the name of the Internet/DNS domain where this is true. For instance, if all the machines in the Condor pool within the Internet/DNS zone “cs.wisc.edu” have a common password file and mount the same volumes from the same NFS servers, set `$(FILESYSTEM_DOMAIN)` to “cs.wisc.edu”. If this is not the case, comment out the entry, and Condor will automatically set it to the fully qualified hostname of the local machine.

HAS_AFS Set this macro to TRUE if all the machines you plan on adding in your pool can all access a common set of AFS fileservers. Otherwise, set it to FALSE.

RESERVE_AFS_CACHE If your machine is running AFS and the AFS cache lives on the same partition as the other Condor directories, and you want Condor to reserve the space that your AFS cache is configured to use, set this macro to TRUE. It defaults to FALSE.

USE_NFS This macro influences how Condor jobs running in the standard universe access their files. Condor will redirect the file I/O requests of standard universe jobs to be executed on the machine which submitted the job. Because of this, as a Condor job migrates around the network, the file system always appears to be identical to the file system where the job was submitted. However, consider the case where a user's data files are sitting on an NFS server. The machine running the user's program will send all I/O over the network to the machine which submitted the job, which in turn sends all the I/O over the network a second time back to the NFS file server. Thus, all of the program's I/O is being sent over the network twice.

If this macro to TRUE, then Condor will attempt to read/write files without redirecting I/O back to the submitting machine if both the submitting machine and the machine running the job are both accessing the same NFS servers (*if* they are both in the same `$(FILESYSTEM_DOMAIN)` and in the same `$(UID_DOMAIN)`, as described above). The result is I/O performed by Condor standard universe jobs is only sent over the network once. While sending all file operations over the network twice might sound really bad, unless you are operating over networks where bandwidth as at a very high premium, practical experience reveals that this scheme offers very little real performance gain. There are also some (fairly rare) situations where this scheme can break down.

Setting `$(USE_NFS)` to FALSE is always safe. It may result in slightly more network traffic, but Condor jobs are most often heavy on CPU and light on I/O. It also ensures that a remote standard universe Condor job will always use Condor's remote system calls mechanism to reroute I/O and therefore see the exact same file system that the user sees on the machine where she/he submitted the job.

Some gritty details for folks who want to know: If the you set `$(USE_NFS)` to TRUE, and the `$(FILESYSTEM_DOMAIN)` of both the submitting machine and the remote machine about to execute the job match, and the `$(FILESYSTEM_DOMAIN)` claimed by the submit machine is indeed found to be a subset of what an inverse lookup to a DNS (domain name server) reports as the fully qualified domain name for the submit machine's IP address (this security measure safeguards against the submit machine from lying), *then* the job will access files using a local system call, without redirecting them to the submitting machine (with NFS). Otherwise, the system call will get routed back to the submitting machine using Condor's remote system call mechanism. NOTE: When submitting a vanilla job, *condor_submit* will, by default, append requirements to the Job ClassAd that specify the machine to run the job must be in the same `$(FILESYSTEM_DOMAIN)` and the same `$(UID_DOMAIN)`.

USE_AFS If your machines have AFS, this macro determines whether Condor will use remote system calls for standard universe jobs to send I/O requests to the submit machine, or if it should use local file access on the execute machine (which will then use AFS to get to the submitter's files). Read the setting above on `$(USE_NFS)` for a discussion of why you might want to use AFS access instead of remote system calls.

One important difference between `$(USE_NFS)` and `$(USE_AFS)` is the AFS cache. With `$(USE_AFS)` set to TRUE, the remote Condor job executing on some machine will start modifying the AFS cache, possibly evicting the machine owner's files from the cache to make room for its own. Generally speaking, since we try to minimize the impact of having a Condor job run on a given machine, we do not recommend using this setting.

While sending all file operations over the network twice might sound really bad, unless you are operating over networks where bandwidth as at a very high premium, practical experience reveals that this scheme offers very little real performance gain. There are also some (fairly rare) situations where this scheme can break down.

Setting `$(USE_AFS)` to FALSE is always safe. It may result in slightly more network traffic, but Condor jobs are usually heavy on CPU and light on I/O. FALSE ensures that a remote standard universe Condor job will always see the exact same file system that the user on sees on the machine where he/she submitted the job. Plus, it will ensure that the machine where the job executes does not have its AFS cache modified as a result of the Condor job being there.

However, things may be different at your site, which is why the setting is there.

3.3.6 Checkpoint Server Configuration File Macros

These macros control whether or not Condor uses a checkpoint server. If you are using a checkpoint server, this section describes the settings that the checkpoint server itself needs defined. A checkpoint server is installed separately. It is not included in the main Condor binary distribution or installation procedure. See section 3.11.5 on Installing a Checkpoint Server for details on installing and running a checkpoint server for your pool.

NOTE: If you are setting up a machine to join the UW-Madison CS Department Condor pool, you *should* configure the machine to use a checkpoint server, and use "condor-ckpt.cs.wisc.edu" as the checkpoint server host (see below).

`CKPT_SERVER_HOST` The hostname of a checkpoint server.

`STARTER_CHOOSES_CKPT_SERVER` If this parameter is TRUE or undefined on the submit machine, the checkpoint server specified by `$(CKPT_SERVER_HOST)` on the execute machine is used. If it is FALSE on the submit machine, the checkpoint server specified by `$(CKPT_SERVER_HOST)` on the submit machine is used.

`CKPT_SERVER_DIR` The checkpoint server needs this macro defined to the full path of the directory the server should use to store checkpoint files. Depending on the size of your pool and the size of the jobs your users are submitting, this directory (and its subdirectories) might need to store many Mbytes of data.

`USE_CKPT_SERVER` A boolean which determines if you want a given submit machine to use a checkpoint server if one is available. If a checkpoint server isn't available or `USE_CKPT_SERVER` is set to False, checkpoints will be written to the local `$(SPOOL)` directory on the submission machine.

MAX_DISCARDED_RUN_TIME If the shadow is unable to read a checkpoint file from the checkpoint server, it keeps trying only if the job has accumulated more than this many seconds of CPU usage. Otherwise, the job is started from scratch. Defaults to 3600 (1 hour). This setting is only used if `$(USE_CKPT_SERVER)` is TRUE.

3.3.7 condor_master Configuration File Macros

These macros control the *condor_master*.

DAEMON_LIST This macro determines what daemons the *condor_master* will start and keep its watchful eyes on. The list is a comma or space separated list of subsystem names (listed in section 3.3.1). For example,

```
DAEMON_LIST = MASTER, STARTD, SCHEDD
```

NOTE: On your central manager, your `$(DAEMON_LIST)` will be different from your regular pool, since it will include entries for the *condor_collector* and *condor_negotiator*.

NOTE: On machines running Digital Unix or IRIX, your `$(DAEMON_LIST)` will also include KBDD, for the *condor_kbdd*, which is a special daemon that runs to monitor keyboard and mouse activity on the console. It is only with this special daemon that we can acquire this information on those platforms.

DC_DAEMON_LIST This macro lists the daemons in `DAEMON_LIST` which use the Condor DaemonCore library. The *condor_master* must differentiate between daemons that use DaemonCore and those that don't so it uses the appropriate inter-process communication mechanisms. This list currently includes all Condor daemons except the checkpoint server by default.

SUBSYS Once you have defined which subsystems you want the *condor_master* to start, you must provide it with the full path to each of these binaries. For example:

```
MASTER          = $(SBIN)/condor_master
STARTD          = $(SBIN)/condor_startd
SCHEDD          = $(SBIN)/condor_schedd
```

These are most often defined relative to the `$(SBIN)` macro.

SUBSYS_ARGS This macro allows the specification of additional command line arguments for any process spawned by the *condor_master*. List the desired arguments, as typing the command line into the configuration file. Set the arguments for a specific daemon with this macro, and the macro will affect only that daemon. Define one of these for each daemon the *condor_master* is controlling. For example, set `$(STARTD_ARGS)` to specify any extra command line arguments to the *condor_startd*.

PREEN In addition to the daemons defined in `$(DAEMON_LIST)`, the *condor_master* also starts up a special process, *condor_preen* to clean out junk files that have been left laying around by Condor. This macro determines where the *condor_master* finds the *condor_preen* binary. Comment out this macro, and *condor_preen* will not run.

`PREEN_ARGS` Controls how *condor_preen* behaves by allowing the specification of command-line arguments. This macro works as `$(SUBSYS_ARGS)` does. The difference is that you must specify this macro for *condor_preen* if you want it to do anything. *condor_preen* takes action only because of command line arguments. **-m** means you want e-mail about files *condor_preen* finds that it thinks it should remove. **-r** means you want *condor_preen* to actually remove these files.

`PREEN_INTERVAL` This macro determines how often *condor_preen* should be started. It is defined in terms of seconds and defaults to 86400 (once a day).

`PUBLISH_OBITUARIES` When a daemon crashes, the *condor_master* can send e-mail to the address specified by `$(CONDOR_ADMIN)` with an obituary letting the administrator know that the daemon died, the cause of death (which signal or exit status it exited with), and (optionally) the last few entries from that daemon's log file. If you want obituaries, set this macro to TRUE.

`OBITUARY_LOG_LENGTH` This macro controls how many lines of the log file are part of obituaries.

`START_MASTER` If this setting is defined and set to FALSE when the *condor_master* starts up, the first thing it will do is exit. This appears strange, but perhaps you do not want Condor to run on certain machines in your pool, yet the boot scripts for your entire pool are handled by a centralized system that starts up the *condor_master* automatically. This is an entry you would most likely find in a local configuration file, not a global configuration file.

`START_DAEMONS` This macro is similar to the `$(START_MASTER)` macro described above. However, the *condor_master* does not exit; it does not start any of the daemons listed in the `$(DAEMON_LIST)`. The daemons may be started at a later time with a *condor_on* command.

`MASTER_UPDATE_INTERVAL` This macro determines how often the *condor_master* sends a ClassAd update to the *condor_collector*. It is defined in seconds and defaults to 300 (every 5 minutes).

`MASTER_CHECK_NEW_EXEC_INTERVAL` This macro controls how often the *condor_master* checks the timestamps of the running daemons. If any daemons have been modified, the master restarts them. It is defined in seconds and defaults to 300 (every 5 minutes).

`MASTER_NEW_BINARY_DELAY` Once the *condor_master* has discovered a new binary, this macro controls how long it waits before attempting to execute the new binary. This delay exists because the *condor_master* might notice a new binary while it is in the process of being copied, in which case trying to execute it yields unpredictable results. The entry is defined in seconds and defaults to 120 (2 minutes).

`SHUTDOWN_FAST_TIMEOUT` This macro determines the maximum amount of time daemons are given to perform their fast shutdown procedure before the *condor_master* kills them outright. It is defined in seconds and defaults to 300 (5 minutes).

`MASTER_BACKOFF_FACTOR` If a daemon keeps crashing, an exponential backoff waits longer and longer before restarting it. At the end of this section, there is an example that shows how all these settings work. This setting is the base of the exponent used to determine how long to wait before starting the daemon again. It defaults to 2 seconds.

MASTER_BACKOFF_CEILING This entry determines the maximum amount of time you want the master to wait between attempts to start a given daemon. (With 2.0 as the `$(MASTER_BACKOFF_FACTOR)`, 1 hour is obtained in 12 restarts). It is defined in terms of seconds and defaults to 3600 (1 hour).

MASTER_RECOVER_FACTOR A macro to set How long a daemon needs to run without crashing before it is considered *recovered*. Once a daemon has recovered, the number of restarts is reset, so the exponential backoff stuff returns to its initial state. The macro is defined in terms of seconds and defaults to 300 (5 minutes).

For clarity, the following is an example of the workings of the exponential backoff settings. The example is worked out assuming the default settings.

When a daemon crashes, it is restarted in 10 seconds. If it keeps crashing, a longer amount of time is waited before restarting. The length of time is based on how many times it has been restarted. Take the `$(MASTER_BACKOFF_FACTOR)` (defaults to 2) to the power the number of times the daemon has restarted, and add 9. An example:

```
1st crash:  restarts == 0, so, 9 + 2^0 = 9 + 1 = 10 seconds
2nd crash:  restarts == 1, so, 9 + 2^1 = 9 + 2 = 11 seconds
3rd crash:  restarts == 2, so, 9 + 2^2 = 9 + 4 = 13 seconds
...
6th crash:  restarts == 5, so, 9 + 2^5 = 9 + 32 = 41 seconds
...
9th crash:  restarts == 8, so, 9 + 2^8 = 9 + 256 = 265 seconds
```

After the 13th crash, it would be:

```
13th crash:  restarts == 12, so, 9 + 2^12 = 9 + 4096 = 4105 seconds
```

This is bigger than the `$(MASTER_BACKOFF_CEILING)`, which defaults to 3600, so the daemon would really be restarted after only 3600 seconds, not 4105. The *condor_master* tries again every hour (since the numbers would get larger and would always be capped by the ceiling). Eventually, imagine that daemon finally started and did not crash. This might happen if, for example, an administrator reinstalled an accidentally deleted binary after receiving e-mail about the daemon crashing. If it stayed alive for `$(MASTER_RECOVER_FACTOR)` seconds (defaults to 5 minutes), the count of how many restarts this daemon has performed is reset to 10 seconds.

The moral of the example is that the defaults work quite well, and you probably will not want to change them for any reason.

MASTER_EXPRS This macro is described in section 3.3.4 as `SUBSYS_EXPRS` .

`MASTER_DEBUG` This macro is described in section 3.3.3 as `SUBSYS_DEBUG` .

`MASTER_ADDRESS_FILE` This macro is described in section 3.3.4 as `SUBSYS_ADDRESS_FILE`

3.3.8 condor_startd Configuration File Macros

NOTE: If you are running Condor on a multi-CPU machine, be sure to also read section 3.11.7 on page 169 which describes how to setup and configure Condor on SMP machines.

These settings control general operation of the *condor_startd*. Information on how to configure the *condor_startd* to start, suspend, resume, vacate and kill remote Condor jobs is found in section 3.6 on Configuring The Startd Policy. In that section is information on the startd's *states* and *activities*. Macros in the configuration file not described here are ones that control state or activity transitions within the *condor_startd*.

`STARTER` This macro holds the full path to the *condor_starter* binary that the startd should spawn. It is normally defined relative to `$(SBIN)`.

`ALTERNATE_STARTER_1` This macro holds the full path to the *condor_starter.pvm* binary that the startd spawns to service PVM jobs. It is normally defined relative to `$(SBIN)`, since by default, *condor_starter.pvm* is installed in the regular Condor release directory.

`POLLING_INTERVAL` When a startd enters the claimed state, this macro determines how often the state of the machine is polled to check the need to suspend, resume, vacate or kill the job. It is defined in terms of seconds and defaults to 5.

`UPDATE_INTERVAL` Determines how often the startd should send a ClassAd update to the *condor_collector*. The startd also sends update on any state or activity change, or if the value of its `START` expression changes. See section 3.6.5 on condor_startd States, section 3.6.6 on condor_startd Activities, and section 3.6.3 on condor_startd `START` expression for details on states, activities, and the `START` expression. This macro is defined in terms of seconds and defaults to 300 (5 minutes).

`STARTD_HAS_BAD_UTMP` When the startd is computing the idle time of all the users of the machine (both local and remote), it checks the `utmp` file to find all the currently active ttys, and only checks access time of the devices associated with active logins. Unfortunately, on some systems, `utmp` is unreliable, and the startd might miss keyboard activity by doing this. So, if your `utmp` is unreliable, set this macro to TRUE and the startd will check the access time on all tty and pty devices.

`CONSOLE_DEVICES` This macro allows the startd to monitor console (keyboard and mouse) activity by checking the access times on special files in `/dev`. Activity on these files shows up as `ConsoleIdle` time in the startd's ClassAd. Give a comma-separated list of the names of devices considered the console, without the `/dev/` portion of the pathname. The defaults vary from platform to platform, and are usually correct.

One possible exception to this is on Linux, where we use "mouse" as one of the entries. Most Linux installations put in a soft link from `/dev/mouse` that points to the appropriate device (for example, `/dev/psaux` for a PS/2 bus mouse, or `/dev/tty00` for a serial mouse connected to com1). However, if your installation does not have this soft link, you will either need to put it in (you will be glad you did), or change this macro to point to the right device.

Unfortunately, there are no such devices on Digital Unix or IRIX (don't be fooled by `/dev/keyboard0`; the kernel does not update the access times on these devices), so this macro is not useful in these cases, and we must use the *condor_kbdd* to get this information by connecting to the X server.

`STARTD_JOB_EXPRS` When the machine is claimed by a remote user, the startd can also advertise arbitrary attributes from the job ClassAd in the machine ClassAd. List the attribute names to be advertised. NOTE: Since these are already ClassAd expressions, do not do anything unusual with strings.

`STARTD_EXPRS` This macro is described in section 3.3.4 as `SUBSYS_EXPRS` .

`STARTD_DEBUG` This macro (and other settings related to debug logging in the startd) is described in section 3.3.3 as `SUBSYS_DEBUG` .

`STARTD_ADDRESS_FILE` This macro is described in section 3.3.4 as `SUBSYS_ADDRESS_FILE`

`NUM_CPUS` This macro can be used to "lie" to the startd about how many CPUs your machine has. If you set this, it will override Condor's automatic computation of the number of CPUs in your machine, and Condor will use whatever integer you specify here. In this way, you can allow multiple Condor jobs to run on a single-CPU machine by having that machine treated like an SMP machine with multiple CPUs, which could have different Condor jobs running on each one. Or, you can have an SMP machine advertise more virtual machines than it has CPUs. However, using this parameter will hurt the performance of the jobs, since you would now have multiple jobs running on the same CPU, competing with each other. The option is only meant for people who specifically want this behavior and know what they are doing. It is disabled by default.

NOTE: This setting cannot be changed with a simple reconfig (either by sending a SIGHUP or using *condor_reconfig*. If you change this, you must restart the *condor_startd* for the change to take effect (by using "condor_restart -startd").

NOTE: If you use this setting on a given machine, you should probably advertise that fact in the machine's ClassAd by using the `STARTD_EXPRS` setting (described above). This way, jobs submitted in your pool could specify that they did or did not want to be matched with machines that were only really offering "fractional CPUs".

These macros only apply to the startd when it is running on an SMP machine. See section 3.11.7 on page 169 on Configuring The Startd for SMP Machines for details.

`VIRTUAL_MACHINES_CONNECTED_TO_CONSOLE` An integer which indicates how many of the virtual machines the startd is representing should be "connected" to the console (in other words, notice when there's console activity). This defaults to all virtual machines (N in a machine with N CPUs).

VIRTUAL_MACHINES_CONNECTED_TO_KEYBOARD An integer which indicates how many of the virtual machines the startd is representing should be "connected" to the keyboard (for remote tty activity, as well as console activity). Defaults to 1.

DISCONNECTED_KEYBOARD_IDLE_BOOST If there are virtual machines not connected to either the keyboard or the console, the corresponding idle time reported will be the time since the startd was spawned, plus the value of this macro. It defaults to 1200 seconds (20 minutes). We do this because if the virtual machine is configured not to care about keyboard activity, we want it to be available to Condor jobs as soon as the startd starts up, instead of having to wait for 15 minutes or more (which is the default time a machine must be idle before Condor will start a job). If you do not want this boost, set the value to 0. If you change your START expression to require more than 15 minutes before a job starts, but you still want jobs to start right away on some of your SMP nodes, increase this macro's value.

The following settings control the number of virtual machines reported for a given SMP host, and what attributes each one has. They are only needed if you do not want to have an SMP machine report to Condor with a seperate virtual machine for each CPU, with all shared system resources evenly divided among them. Please read section 3.11.7 on page 169 for details on how to properly configure these settings to suit your needs.

NOTE: You can only change the number of each type of virtual machine the *condor_startd* is reporting with a simple reconfig (such as sending a SIGHUP signal, or using the *condor_reconfig* command). You cannot change the definition of the different virtual machine types with a reconfig. If you change them, you must restart the *condor_startd* for the change to take effect (for example, using "condor_restart -startd").

MAX_VIRTUAL_MACHINE_TYPES The maximum number of different virtual machine types. Note: this is the maximum number of different *types*, not of actual virtual machines. Defaults to 10. (You should only need to change this setting if you define more than 10 seperate virtual machine types, which would be pretty rare.)

VIRUAL_MACHINE_TYPE_<N> This setting defines a given virtual machine type, by specifying what part of each shared system resource (like RAM, swap space, etc) this kind of virtual machine gets. N can be any integer from 1 to the value of `$(MAX_VIRTUAL_MACHINE_TYPES)`, such as `VIRTUAL_MACHINE_TYPE_1`. The format of this entry can be somewhat complex, so please refer to section 3.11.7 on page 169 for details on the different possibilities.

NUM_VIRUAL_MACHINES_TYPE_<N> This macro controls how many of a given virtual machine type are actually reported to Condor. There is no default.

NUM_VIRUAL_MACHINES If your SMP machine is being evenly divided, and the virtual machine type settings described above are not being used, this macro controls how many virtual machines will be reported. The default is one virtual machine for each CPU. This setting can be used to reserve some CPUs on an SMP which would not be reported to the Condor pool.

3.3.9 condor_schedd Configuration File Entries

These macros control the *condor_schedd*.

`SHADOW` This macro determines the full path of the *condor_shadow* binary that the *condor_schedd* spawns. It is normally defined in terms of `$(SBIN)`.

`SHADOW_PVM` This macro determines the full path of the special *condor_shadow.pvm* binary used for supporting PVM jobs that the *condor_schedd* spawns. It is normally defined in terms of `$(SBIN)`.

`MAX_JOBS_RUNNING` This macro controls the maximum number of *condor_shadow* processes a given *condor_schedd* is allowed to spawn. The actual number of *condor_shadow*s may be less if you have reached your `$(RESERVED_SWAP)` limit.

`MAX_SHADOW_EXCEPTIONS` This macro controls the maximum number of times that *condor_shadow* processes can have a fatal error (exception) before the *condor_schedd* will relinquish the match associated with the dying shadow. Defaults to 5.

`SCHEDD_INTERVAL` This macro determines how often the *condor_schedd* sends a ClassAd update to the *condor_collector*. It is defined in terms of seconds and defaults to 300 (every 5 minutes).

`JOB_START_DELAY` When the *condor_schedd* has finished negotiating and has many new machines that it has claimed, the *condor_schedd* can wait for a delay period before starting up a *condor_shadow* for each job it is going to run. The delay prevents a sudden, large load on the submit machine as it spawns many shadows simultaneously. It prevents having to deal with their startup activity all at once. This macro determines how how long the *condor_schedd* should wait in between spawning each *condor_shadow*. Similarly, this macro is also used during the graceful shutdown of the *condor_schedd*. During graceful shutdown, this macro determines how long to wait in between asking each *condor_shadow* to gracefully shutdown. Defined in terms of seconds and defaults to 2.

`ALIVE_INTERVAL` This macro determines how often the *condor_schedd* should send a keep alive message to any startd it has claimed. When the schedd claims a startd, it tells the startd how often it is going to send these messages. If the startd does not get one of these messages after 3 of these intervals has passed, the startd releases the claim, and the schedd is no longer paying for the resource (in terms of priority in the system). The macro is defined in terms of seconds and defaults to 300 (every 5 minutes).

`SHADOW_SIZE_ESTIMATE` This macro sets the estimated virtual memory size of each *condor_shadow* process. Specified in kilobytes. The default varies from platform to platform.

`SHADOW_RENICE_INCREMENT` When the schedd spawns a new *condor_shadow*, it can do so with a *nice-level*. A nice-level is a UNIX mechanism that allows users to assign their own processes a lower priority so that the processes do not interfere with interactive use of the machine. This is very handy for keeping a submit machine with lots of shadows running still useful to the owner of the machine. The value can be any integer between 0 and 19, with a value of 19 being the lowest priority. It defaults to 10.

QUEUE_CLEAN_INTERVAL The schedd maintains the job queue on a given machine. It does so in a persistent way such that if the schedd crashes, it can recover a valid state of the job queue. The mechanism it uses is a transaction-based log file (the `job_queue.log` file, not the `SchedLog` file). This file contains an initial state of the job queue, and a series of transactions that were performed on the queue (such as new jobs submitted, jobs completing, and checkpointing). Periodically, the schedd will go through this log, truncate all the transactions and create a new file with containing only the new initial state of the log. This is a somewhat expensive operation, but it speeds up when the schedd restarts since there are fewer transactions it has to play to figure out what state the job queue is really in. This macro determines how often the schedd should rework this queue to cleaning it up. It is defined in terms of seconds and defaults to 86400 (once a day).

WALL_CLOCK_CKPT_INTERVAL The job queue contains a counter for each job's "wall clock" run time, i.e., how long each job has executed so far. This counter is displayed by *condor_q*. The counter is updated when the job is evicted or when the job completes. When the schedd crashes, the run time for jobs that are currently running will not be added to the counter (and so, the run time counter may become smaller than the cpu time counter). The schedd saves run time "checkpoints" periodically for running jobs so if the schedd crashes, only run time since the last checkpoint is lost. This macro controls how often the schedd saves run time checkpoints. It is defined in terms of seconds and defaults to 3600 (one hour). A value of 0 will disable wall clock checkpoints.

ALLOW_REMOTE_SUBMIT Starting with Condor Version 6.0, users can run *condor_submit* on one machine and actually submit jobs to another machine in the pool. This is called a *remote submit*. Jobs submitted in this way are entered into the job queue owned by the Unix user nobody. This macro determines whether this is allowed. It defaults to FALSE.

QUEUE_SUPER_USERS This macro determines what user names on a given machine have *super-user access* to the job queue, meaning that they can modify or delete the job ClassAds of other users. (Normally, you can only modify or delete ClassAds from the job queue that you own). Whatever user name corresponds with the UID that Condor is running as (usually the Unix user condor) will automatically be included in this list because that is needed for Condor's proper functioning. See section 3.12.2 on UIDs in Condor for more details on this. By default, we give root the ability to remove other user's jobs, in addition to user condor.

SCHEDD_LOCK This macro specifies what lock file should be used for access to the `SchedLog` file. It must be a separate file from the `SchedLog`, since the `SchedLog` may be rotated and synchronization across log file rotations is desired. This macro is defined relative to the `$(LOCK)` macro. If you decide to change this setting (not recommended), be sure to change the `$(VALID_LOG_FILES)` entry that *condor_preen* uses as well.

SCHEDD_EXPRS This macro is described in section 3.3.4 as `SUBSYS_EXPRS`.

SCHEDD_DEBUG This macro (and other settings related to debug logging in the schedd) is described in section 3.3.3 as `SUBSYS_DEBUG`.

SCHEDD_ADDRESS_FILE This macro is described in section 3.3.4 as `SUBSYS_ADDRESS_FILE`.

FLOCK_NEGOTIATOR_HOSTS This macro defines a list of negotiator hostnames (not including the local `$(NEGOTIATOR_HOST)` machine) for pools in which the schedd should attempt to run jobs. Hosts in the list should be in order of preference. The schedd will only send a request to a central manager in the list if the local pool and pools earlier in the list are not satisfying all the job requests. `$(HOSTALLOW_NEGOTIATOR_SCHEDD)` (see section 3.3.4) must also be configured to allow negotiators from all of the `$(FLOCK_NEGOTIATOR_HOSTS)` to contact the schedd. Please make sure the `$(NEGOTIATOR_HOST)` is first in the `$(HOSTALLOW_NEGOTIATOR_SCHEDD)` list. Similarly, the central managers of the remote pools must be configured to listen to requests from this schedd.

FLOCK_COLLECTOR_HOSTS This macro defines a list of collector hostnames for pools in which the schedd should attempt to run jobs. The collectors must be specified in order, corresponding to the `$(FLOCK_NEGOTIATOR_HOSTS)` list. In the typical case, where each pool has the collector and negotiator running on the same machine, `$(FLOCK_COLLECTOR_HOSTS)` should have the same definition as `$(FLOCK_NEGOTIATOR_HOSTS)`.

FLOCK_VIEW_SERVERS This macro defines a list of hostnames where the condor-view server is running in the pools to which you want your jobs to flock. The order of this list must correspond to the order of the `$(FLOCK_COLLECTOR_HOSTS)` and `$(FLOCK_NEGOTIATOR_HOSTS)` lists. List items may be empty for pools which don't use a separate condor-view server. `$(FLOCK_VIEW_SERVER)` may be left undefined if no remote pools use separate condor-view servers. Note: It is required that the same hostname does not appear twice in the `$(FLOCK_VIEW_SERVERS)` list and that the `$(CONDOR_VIEW_HOST)` does not appear in the `$(FLOCK_VIEW_SERVERS)` list.

NEGOTIATE_ALL_JOBS_IN_CLUSTER If this macro is set to False (the default), when the schedd fails to start an idle job, it will not try to start any other idle jobs in the same cluster during that negotiation cycle. This makes negotiation much more efficient for large job clusters. However, in some cases other jobs in the cluster can be started even though an earlier job can't. For example, the jobs' requirements may differ, because of different disk space, memory, or operating system requirements. Or, machines may be willing to run only some jobs in the cluster, because their requirements reference the jobs' virtual memory size or other attribute. Setting this macro to True will force the schedd to try to start all idle jobs in each negotiation cycle. This will make negotiation cycles last longer, but it will ensure that all jobs that can be started will be started.

3.3.10 condor_shadow Configuration File Entries

These settings affect the *condor_shadow*.

SHADOW_LOCK This macro specifies the lock file to be used for access to the `ShadowLog` file. It must be a separate file from the `ShadowLog`, since the `ShadowLog` may be rotated and you want to synchronize access across log file rotations. This macro is defined relative to the `$(LOCK)` macro. If you decide to change this setting (not recommended), be sure to change the `$(VALID_LOG_FILES)` entry that *condor_preen* uses as well.

`SHADOW_DEBUG` This macro (and other settings related to debug logging in the shadow) is described in section 3.3.3 as `SUBSYS_DEBUG` .

`COMPRESS_PERIODIC_CKPT` This boolean macro specifies whether the shadow should instruct applications to compress periodic checkpoints (when possible). The default is FALSE.

`COMPRESS_VACATE_CKPT` This boolean macro specifies whether the shadow should instruct applications to compress vacate checkpoints (when possible). The default is FALSE.

`PERIODIC_MEMORY_SYNC` This boolean macro specifies whether the shadow should instruct applications to commit dirty memory pages to swap space during a periodic checkpoint. The default is FALSE. This potentially reduces the number of dirty memory pages at vacate time, thereby reducing swapping activity on the remote machine.

`SLOW_CKPT_SPEED` This macro specifies the speed at which vacate checkpoints should be written, in kilobytes per second. If zero (the default), vacate checkpoints are written as fast as possible. Writing vacate checkpoints slowly can avoid overwhelming the remote machine with swapping activity.

3.3.11 condor_shadow.pvm Configuration File Entries

These macros control the *condor_shadow.pvm*, the special shadow that supports PVM jobs inside Condor. See section 3.4.5 on Installing PVM Support in Condor for details. *condor_shadow* macros also apply to this special shadow. See section 3.3.10.

`PVMD` This macro holds the full path to the special *condor_pvmd*, the Condor PVM daemon. This daemon is installed in the regular Condor release directory by default, so the macro is usually defined in terms of `$(SBIN)`.

`PVMGS` This macro holds the full path to the special *condor_pvmgs*, the Condor PVM Group Server daemon, which is needed to support PVM groups. This daemon is installed in the regular Condor release directory by default, so the macro is usually defined in terms of `$(SBIN)`.

3.3.12 condor_starter Configuration File Entries

These settings affect the *condor_starter*.

`EXEC_TRANSFER_ATTEMPTS` Sometimes due to a router misconfiguration, kernel bug, or other Act of God network problem, the transfer of the initial checkpoint from the submit machine to the execute machine will fail midway through. This parameter allows a retry of the transfer a certain number of times that must be equal to or greater than 1. If this parameter is not specified, or specified incorrectly, then it will default to three. If the transfer of the initial executable fails every attempt, then the job goes back into the idle state until the next renegotiation cycle.

NOTE: : This parameter does not exist in the NT starter.

JOB_RENICE_INCREMENT When the starter spawns a Condor job, it can do so with a *nice-level*. A nice-level is a UNIX mechanism that allows users to assign their own processes a lower priority so that the processes do not interfere with interactive use of the machine. If you have machines with lots of real memory and swap space so the only scarce resource is CPU time, you may use this macro in conjunction with a policy that always allowed Condor to start jobs on your machines so that Condor jobs would always run, but interactive response on your machines would never suffer. You most likely will not notice Condor is running jobs. See section 3.6 on Configuring The Startd Policy for more details on setting up a policy for starting and stopping jobs on a given machine. The entry can be any integer between 0 and 20, with a value of 19 being the lowest priority. It is commented out by default.

STARTER_LOCAL_LOGGING This macro determines whether the starter should do local logging to its own log file, or send debug information back to the *condor_shadow* where it will end up in the ShadowLog. It defaults to TRUE.

STARTER_DEBUG This setting (and other settings related to debug logging in the starter) is described above in section 3.3.3 as `$(SUBSYS_DEBUG)`.

USER_JOB_WRAPPER This macro allows the administrator to specify a "wrapper" script to handle the execution of all user jobs. If specified, Condor will never directly execute a job but instead will invoke the program specified by this macro. The command-line arguments passed to this program will include the full-path to the actual user job which should be executed, followed by all the command-line parameters to pass to the user job. This wrapper program must ultimately replace its image with the user job; in other words, it must *exec()* the user job, not *fork()* it. For instance, if the wrapper program is a Bourne/C/Korn shell script, the last line of execution should be:

```
exec $*
```

3.3.13 condor_submit Configuration File Entries

If you want *condor_submit* to automatically append an expression to the `Requirements` expression or `Rank` expression of jobs at your site use the following macros:

APPEND_REQ_VANILLA Expression to be appended to vanilla job requirements.

APPEND_REQ_STANDARD Expression to be appended to standard job requirements.

APPEND_RANK_STANDARD Expression to be appended to standard job rank.

APPEND_RANK_VANILLA Expression to append to vanilla job rank.

NOTE: The `APPEND_RANK_STANDARD` and `APPEND_RANK_VANILLA` macros were called `APPEND_PREF_STANDARD` and `APPEND_PREF_VANILLA` in previous versions of Condor.

In addition, you may provide default `Rank` expressions if your users do nt specify their own with:

DEFAULT_RANK_VANILLA Default Rank for vanilla jobs.

DEFAULT_RANK_STANDARD Default Rank for standard jobs.

Both of these macros default to the jobs preferring machines where there is more main memory than the image size of the job, expressed as:

```
        ((Memory*1024) > Imagesize)
```

GLOBUSRUN This macro holds the full path to the *globusrun* program which is needed for submitting to the GLOBUS universe.

SHADOW_GLOBUS This macro holds the full path to the *condor_shadow.globus* program which is needed for submitting to the GLOBUS universe.

DEFAULT_IO_BUFFER_SIZE Condor keeps a buffer of recently-used data for each file an application opens. This macro specifies the default maximum number of bytes to be buffered for each open file at the executing machine. The *condor_status* `buffer_size` command will override this default. If this macro is undefined, a default size of 512 KB will be used.

DEFAULT_IO_BUFFER_BLOCK_SIZE When buffering is enabled, Condor will attempt to consolidate small read and write operations into large blocks. This macro specifies the default block size Condor will use. The *condor_status* `buffer_block_size` command will override this default. If this macro is undefined, a default size of 32 KB will be used.

3.3.14 condor_preen Configutation File Entries

These macros affect *condor_preen*.

PREEN_ADMIN This macro sets the e-mail address where *condor_preen* will send e-mail (if it is configured to send email at all... see the entry for `PREEN`). Defaults to `$(CONDOR_ADMIN)`.

VALID_SPOOL_FILES This macro contains a (comma or space separated) list of files that *condor_preen* considers valid files to find in the `$(SPOOL)` directory. Defaults to all the files that are valid. A change to the `$(HISTORY)` macro requires a change to this macro as well.

VALID_LOG_FILES This macro contains a (comma or space separated) list of files that *condor_preen* considers valid files to find in the `$(LOG)` directory. Defaults to all the files that are valid. A change to the names of any of the log files above requires a change to this macro as well. In addition, the defaults for the `$(SUBSYS_ADDRESS_FILE)` are listed here, so a change to those requires a change this entry as well.

3.3.15 condor_collector Configuration File Entries

These macros affect the *condor_collector*.

`CLASSAD_LIFETIME` This macro determines how long a ClassAd can remain in the collector before it is discarded as stale information. The ClassAds sent to the collector might also have an attribute that says how long the lifetime should be for that specific ad. If that attribute is present, the collector will either use it or the `$(CLASSAD_LIFETIME)`, whichever is greater. The macro is defined in terms of seconds, and defaults to 900 (15 minutes).

`MASTER_CHECK_INTERVAL` This macro defines how often the collector should check for machines that have ClassAds from some daemons, but not from the *condor_master* (*orphaned daemons*) and send e-mail about it. It is defined in seconds and defaults to 10800 (3 hours).

`CLIENT_TIMEOUT` Network timeout when talking to daemons that are sending an update. It is defined in seconds and defaults to 30.

`QUERY_TIMEOUT` Network timeout when talking to anyone doing a query. It is defined in seconds and defaults to 60.

`CONDOR_DEVELOPERS` Condor will send e-mail once per week to this address with the output of the *condor_status* command, which lists how many machines are in the pool and how many are running jobs. Use the default value of condor-admin@cs.wisc.edu and the weekly status message will be sent to the Condor Team at University of Wisconsin-Madison, the developers of Condor. The Condor Team uses these weekly status messages in order to have some idea as to how many Condor pools exist in the world. We appreciate getting the reports, as this is one way we can convince funding agencies that Condor is being used in the real world. If you do not wish this information to be sent to the Condor Team, set the value to NONE which disables this feature, or put in some other address that you want the weekly status report sent to.

`COLLECTOR_NAME` This macro is used to specify a short description of your pool. It should be about 20 characters long. For example, the name of the UW-Madison Computer Science Condor Pool is "UW-Madison CS".

`CONDOR_DEVELOPERS_COLLECTOR` By default, every pool sends periodic updates to a central *condor_collector* at UW-Madison with basic information about the status of your pool. This includes only the number of total machines, the number of jobs submitted, the number of machines running jobs, the hostname of your central manager, and the `$(COLLECTOR_NAME)` specified above. These updates help the Condor Team see how Condor is being used around the world. By default, they will be sent to condor.cs.wisc.edu. If you don't want these updates to be sent from your pool, set this macro to NONE.

`COLLECTOR_SOCKET_BUFSIZE` This specifies the buffer size, in bytes, reserved for *condor_collector* network sockets. The default is 1024000, or a one megabyte buffer. This is a healthy size, even for a large pool. The larger this value, the less likely the *condor_collector* will have stale information about the pool due to dropping update packets. If your pool is small or your central manager has very little RAM, considering setting this parameter to a lower value (perhaps 256000 or 128000).

KEEP_POOL_HISTORY This boolean macro is used to decide if the collector will write out statistical information about the pool to history files. The default is FALSE. The location, size and frequency of history logging is controlled by the other macros.

POOL_HISTORY_DIR This macro sets the name of the directory where the history files reside (if history logging is enabled). The default is the `SPOOL` directory.

POOL_HISTORY_MAX_STORAGE This macro sets the maximum combined size of the history files. When the size of the history files is close to this limit, the oldest information will be discarded. Thus, the larger this parameter's value is, the larger the time range for which history will be available. The default value is 10000000 (10 Mbytes).

POOL_HISTORY_SAMPLING_INTERVAL This macro sets the interval, in seconds, between samples for history logging purposes. When a sample is taken, the collector goes through the information it holds, and summarizes it. The information is written to the history file once for each 4 samples. The default (and recommended) value is 60 seconds. Setting this macro's value too low will increase the load on the collector, while setting it to high will produce less precise statistical information.

COLLECTOR_DEBUG This macro (and other macros related to debug logging in the collector) is described in section 3.3.3 as `SUBSYS_DEBUG` .

3.3.16 condor_negotiator Configuration File Entries

These macros affect the *condor_negotiator*.

NEGOTIATOR_INTERVAL Sets how often the negotiator starts a negotiation cycle. It is defined in seconds and defaults to 300 (5 minutes).

NEGOTIATOR_TIMEOUT Sets the timeout that the negotiator uses on its network connections to the schedds and startds. It is defined in seconds and defaults to 30.

PRIORITY_HALFLIFE This macro defines the half-life of the user priorities. See section 2.7.2 on User Priorities for details. It is defined in seconds and defaults to 86400 (1 day).

NICE_USER_PRIO_FACTOR This macro sets the priority factor for nice users. See section 2.7.2 on User Priorities for details. Defaults to 10000000.

REMOTE_PRIO_FACTOR This macro defines the priority factor for remote users (users who who do not belong to the accountant's local domain - see below). See section 2.7.2 on User Priorities for details. Defaults to 10000.

ACCOUNTANT_LOCAL_DOMAIN This macro is used to decide if a user is local or remote. A user is considered to be in the local domain if the UID_DOMAIN matches the value of this macro. Usually, this macro is set to the local UID_DOMAIN. If it is not defined, all users are considered local.

NEGOTIATOR_SOCKET_CACHE_SIZE This macro defines the maximum number of sockets that the negotiator keeps in its open socket cache. Caching open sockets makes the negotiation protocol more efficient by eliminating the need for socket connection establishment for each negotiation cycle. The default is currently 16. To be effective, this parameter should be set to a value greater than the number of schedds submitting jobs to the negotiator at any time.

PREEMPTION_REQUIREMENTS The negotiator will not preempt a job running on a given machine unless the `PREEMPTION_REQUIREMENTS` expression evaluates to TRUE and the owner of the idle job has a better priority than the owner of the running job. This expression defaults to TRUE.

PREEMPTION_RANK This expression is used to rank machines that the job ranks the same. For example, if the job has no preference, it is usually preferable to preempt a job with a small `ImageSize` instead of a job with a large `ImageSize`. The default is to rank all preemptable matches the same. However, the negotiator will always prefer to match the job with an idle machine over a preemptable machine, if the job has no preference between them.

NEGOTIATOR_TRAFFIC_LIMIT This macro specifies the maximum amount of network traffic (in Kbytes) that the negotiator may initiate per `NEGOTIATOR_TRAFFIC_INTERVAL` for job placement and preemption. The negotiator uses the job `ImageSize` and `ExecutableSize` parameters to track network usage. The negotiator will try to use bandwidth up to the limit, so if starting a large `ImageSize` job would put the negotiator over the limit, it will try to start a small `ImageSize` job in its place. Thus, using traffic limits penalizes large `ImageSize` jobs for the load they place on the network. This parameter defaults to 0, which disables network usage management in the negotiator.

NEGOTIATOR_TRAFFIC_INTERVAL This macro specifies the interval (in seconds) to be used in maintaining the `NEGOTIATOR_TRAFFIC_LIMIT` . This macro defaults to 0, which disables network usage management in the negotiator. It is common to set this macro equal to `NEGOTIATOR_INTERVAL` .

NEGOTIATOR_DEBUG This macro (and other settings related to debug logging in the negotiator) is described in section 3.3.3 as `SUBSYS_DEBUG` .

3.3.17 condor_eventd Configuration File Entries

These macros affect the Condor Event daemon. See section 3.4.7 on page 115 for an introduction. The eventd is not included in the main Condor binary distribution or installation procedure. It can be installed as a contrib module.

EVENT_LIST List of macros which define events to be managed by the event daemon.

EVENTD_INTERVAL The number of seconds between collector queries to determine pool state. The default is 15 minutes (300 seconds).

EVENTD_MAX_PREPARATION The number of minutes before a scheduled event when the eventd should start periodically querying the collector. If 0 (default), the eventd always polls.

`EVENTD_SHUTDOWN_SLOW_START_INTERVAL` The number of seconds between each machine startup after a shutdown event. The default is 0.

`EVENTD_SHUTDOWN_CLEANUP_INTERVAL` The number of seconds between each check for old shutdown configurations in the pool. The default is one hour (3600 seconds).

3.4 Installing Contrib Modules

This section describes how to install various *contrib modules* in the Condor system. Some of these modules are separate, optional pieces, not included in the main distribution of Condor. Examples are the checkpoint server and DAGMan. Others are integral parts of Condor taken from the development series that have certain features users might want to install. Examples are the new SMP-aware *condor_startd* and the CondorView collector. Both of these things come automatically with Condor version 6.1 and later versions. However, if you do not want to switch over to using only the development binaries, you can install these seperate modules while maintaining most of the stable release at your site.

3.4.1 Installing CondorView Contrib Modules

To install CondorView for your pool, you really need two things:

1. The CondorView server, which collects historical information.
2. The CondorView client, a Java applet that views this data.

These are separate modules, and they are installed separately.

3.4.2 Installing the CondorView Server Module

The CondorView server is an enhanced version of the *condor_collector* that logs information on disk, providing a persistent, historical database of your pool state. This includes machine state, as well as the state of jobs submitted by users, and so on. This enhanced *condor_collector* is the version 6.1 development series, but it can be installed in a 6.0 pool. The historical information logging can be turned on or off, so you can install the CondorView collector without using up disk space for historical information if you don't want it.

To install the CondorView server, you download the appropriate binary module for the platform on which you will run CondorView. This does not have to be the same platform as your existing central manager (see below). After you uncompress and untar the module, you will have a directory with a `view_server.tar` file, a `README`, and so on. The `view_server.tar` acts much like the `release.tar` file for a main release of Condor. It contains all the binaries and supporting files you would install in your release directory:

```
sbin/condor_collector
etc/examples/condor_config.local.view_server
```

You have two options to choose from when deciding how to install this enhanced *condor_collector* in your pool:

1. Replace your existing *condor_collector* and use the new version for both historical information and the regular role the collector plays in your pool.
2. Install the new *condor_collector* and run it on a separate host from your main *condor_collector* and configure your machines to send updates to both collectors.

If you replace your existing collector with the enhanced version, there may be bugs or problems that cause problems for your pool. This is because it is development code. Installing the enhanced version on a separate host may cause problems, but only CondorView will be affected, not your entire pool. Unfortunately, installing the CondorView collector on a separate host generates more network traffic (from all the duplicate updates that are sent from each machine in your pool to both collectors). In addition, the installation procedure to have both collectors running is a more complicated process. Decide for yourself which solution you feel more comfortable with.

What follows are details common to both types of installation.

Setting up the CondorView Server Module

Before you install the CondorView collector (as described in the following sections), you have to add a few settings to the local configuration file of that machine to enable historical data collection. These settings are described in detail in the Condor Version 6.1 Administrator's Manual, in the section "condor_collector Config File Entries". A short explanation of the entries you must customize is provided below. These entries are also explained in the `etc/examples/condor_config.local.view_server` file, included in the contrib module. Insert that file into the local configuration file for your CondorView collector host and customize as appropriate at your site.

`POOL_HISTORY_DIR` This is the directory where historical data will be stored. This directory must be writable by whatever user the CondorView collector is running as (usually the user condor). There is a configurable limit to the maximum space required for all the files created by the CondorView server called (`POOL_HISTORY_MAX_STORAGE`).

NOTE: This directory should be separate and different from the `spool` or `log` directories already set up for Condor. There are a few problems putting these files into either of those directories.

`KEEP_POOL_HISTORY` This is a boolean value that determines if the CondorView collector should store the historical information. It is false by default, which is why you must specify it as true in your local configuration file to enable data collection.

Once these settings are in place in the local configuration file for your CondorView server host, you must to create the directory you specified in POOL_HISTORY_DIR and make it writable by the user your CondorView collector is running as. This is the same user that owns the CollectorLog file in your log directory. The user is usually condor.

Once these steps are completed, you are ready to install the new binaries and you will begin collecting historical information. After that, install the CondorView client contrib module which contains the tools used to query and display this information.

CondorView Collector as Your Only Collector

To install the new CondorView collector as your main collector, you replace your existing binary with the new one, found in the view_server.tar file. Move your existing condor_collector binary out of the way with the *mv* command. For example:

```
% cd /full/path/to/your/release/directory
% cd sbin
% mv condor_collector condor_collector.old
```

Then, from that same directory, untar the view_server.tar file into your release directory. This will install a new condor_collector binary and an example configuration file. Within 5 minutes, the *condor_master* will notice the new timestamp on your new condor_collector binary, shutdown your existing collector, and spawn the new version. You will see messages about this in the log file for your *condor_master* (usually MasterLog in your log directory). Once the new collector is running, it is safe to remove the old binary, although you may want to keep it around in case you have problems with the new version and want to revert back.

Once this is completed, add configuration file entries to the local configuration file on your central manager to enable historical data collection as described below in the "Configuring the CondorView Server Module" section.

CondorView Collector in Addition to Your Main Collector

Installing the CondorView collector in addition to your regular collector requires a little extra work. First, untar the view_server.tar file into a temporary location (not your main release directory). Copy the sbin/condor_collector file from the temporary location to your main release directory's sbin with a new name (such as condor_collector.view_server).

Next, configure whatever host is going to run your separate CondorView server to spawn this new collector in addition to other daemons it is running. You do this by adding COLLECTOR to the DAEMON_LIST on this machine and defining what COLLECTOR means. For example:

```
DAEMON_LIST = MASTER, STARTD, SCHEDD, COLLECTOR
COLLECTOR = $(SBIN)/condor_collector.view_server
```

For this change to take effect, you must re-start the *condor_master* on this host (which you can do with the *condor_restart* command, if you run the command from a machine with administrator access to your pool. (See section 3.8 on page 145 for full details of IP/host-based security in Condor).

As a last step, you tell all the machines in your pool to start sending updates to both collectors. You do this by specifying the following setting in your global configuration file:

```
CONDOR_VIEW_HOST = full.hostname
```

where `full.hostname` is the full hostname of the machine where you are running your CondorView collector.

Once this setting is in place, send a *condor_reconfig* to all machines in your pool so the changes take effect. This is described in section 3.10.2 on page 156.

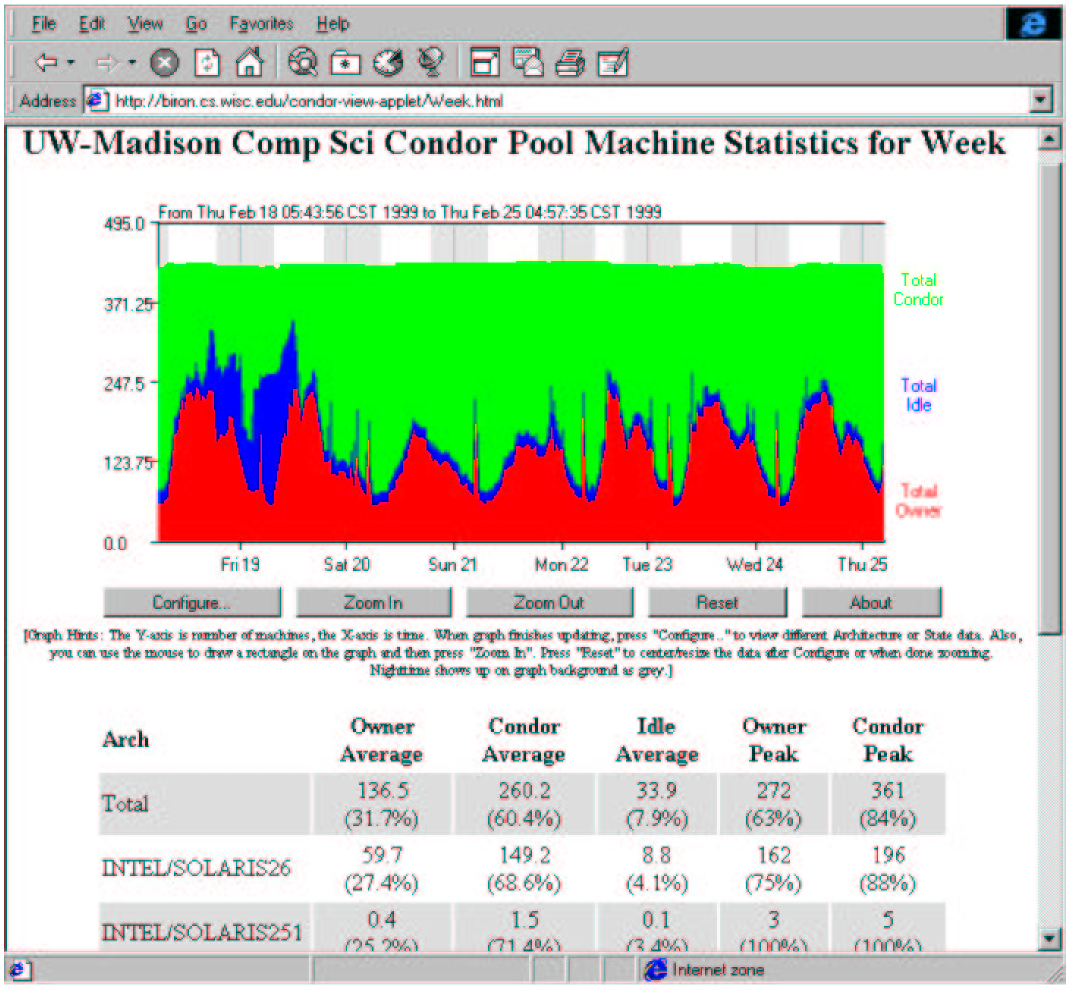
3.4.3 Installing the CondorView Client Contrib Module

The CondorView Client contrib module is used to automatically generate World Wide Web (WWW) pages displaying usage statistics of your Condor Pool. Included in the module is a shell script which invokes the *condor_stats* command to retrieve pool usage statistics from the CondorView server and generate HTML pages from the results. Also included is a Java applet which graphically visualizes Condor usage information. Users can interact with the applet to customize the visualization and to zoom in to a specific time frame. Figure 3.2 on page 108 is a screenshot of a web page created by CondorView. To get a further feel for what pages generated by CondorView look like, you can view the statistics for the University of Wisconsin-Madison pool by going to URL http://www.cs.wisc.edu/condor and clicking on Condor View.

After unpacking and installing the CondorView Client, a script named *make_stats* can be invoked to create HTML pages displaying Condor usage for the past hour, day, week, or month. By using the Unix *cron* facility to periodically execute *make_stats*, Condor pool usage statistics can be kept up to date automatically. This simple model allows the CondorView Client to be easily installed; no Web server CGI interface is needed.

Step-by-Step Installation of the CondorView Client

1. First, make certain that you have configured your pool's *condor_collector* (typically running on the central manager) to log information to disk in order to provide a persistent, historical database of pool statistics. The CondorView Client makes queries over the network against this database. The *condor_collector* included with version 6.0.x of Condor does not have this database support; you will need to download and install the CondorView Server contrib module. If you are running Condor version 6.1 or above, there is no need to install the CondorView Server contrib module because the *condor_collector* included in Condor v6.1+ already has the necessary database support. To activate the persistent database logging, add the following entries into the configuration file on your central manager:


File Edit View Go Favorites Help
Address http://biron.cs.wisc.edu/condor-view-applet/Week.html
From Thu Feb 18 05:43:56 CST 1999 to Thu Feb 25 04:57:35 CST 1999
495.0
371.25
247.5
123.75
0.0
Fri 19
Sat 20
Sun 21
Mon 22
Tue 23
Wed 24
Thu 25
Total Condor
Total Idle
Total Owner
Configure...
Zoom In
Zoom Out
Reset
About
Internet zone

UW-Madison Comp Sci Condor Pool Machine Statistics for Week

[Graph Hints: The Y-axis is number of machines, the X-axis is time. When graph finishes updating, press "Configure..." to view different Architecture or State data. Also, you can use the mouse to draw a rectangle on the graph and then press "Zoom In". Press "Reset" to center/resize the data after Configure or when done zooming. Nighttime shows up on graph background as grey.]

Arch	Owner Average	Condor Average	Idle Average	Owner Peak	Condor Peak
Total	136.5 (31.7%)	260.2 (60.4%)	33.9 (7.9%)	272 (63%)	361 (84%)
INTEL/SOLARIS26	59.7 (27.4%)	149.2 (68.6%)	8.8 (4.1%)	162 (75%)	196 (88%)
INTEL/SOLARIS251	0.4 (25.2%)	1.5 (71.4%)	0.1 (3.4%)	3 (100%)	5 (100%)

Figure 3.2: Screenshot of CondorView Client

```
POOL_HISTORY_DIR = /full/path/to/directory/to/store/historical/data
KEEP_POOL_HISTORY = True
```

For full details on these and other condor_collector configuration file entries, see section 3.3.15 on page 101.

2. Create a directory where CondorView places the HTML files. This directory should be one published by a web server, so HTML files which exist in this directory can be accessed via a web browser. This is referred to as the `VIEWDIR` directory.

3. Unpack/untar the CondorView Client contrib module into `VIEWDIR`. This creates several files and subdirectories within `VIEWDIR`.

4. Edit the *make_stats*script. At the top of this file are six parameters to customize. The parameters are:

   ORGNAME Set to a brief name identifying your organization, for example "Univ of Wisconsin". Do not use any slashes in the name or other special regular-expression characters. Avoid characters / \ ^ $.

   CONDORADMIN Set to the email address of the Condor administrator at your site. This email address will appear at the bottom of the web pages.

   VIEWDIR Set to the full pathname (*not* a relative path) to the `VIEWDIR` directory selected in installation step 2. It is the directory that contains the *make_stats* script.

   STATSDIR Set to the full pathname of the *directory* which contains the *condor_stats* binary. The *condor_stats* program is included in the `<release_dir>/bin` directory with Condor version 6.1 and above; for Condor version 6.0x, the *condor_stats* program can be found in the CondorView Server contrib module. The value for `STATSDIR` is added to the `PATH` parameter by default; see below.

   PATH Set to a list of subdirectories, separated by colons, where the *make_stats* script can find *awk*, *bc*, *sed*, *date*, and *condor_stats* programs. If you have *perl* installed, set the path to include the directory where *perl* is installed as well. Using the following default works on most systems:

   ```
   PATH=/bin:/usr/bin:$STATSDIR:/usr/local/bin
   ```

5. To create all of the initial HTML files, type

   ```
   ./make_stats setup
   ```

   Open the file `index.html` to verify things look good.

6. Add the *make_stats* program to *cron*. Running *make_stats* in step 5 created a `cronentries` file. This `cronentries` file is ready to be processed by the Unix *crontab* command. The *crontab* manual page can familiarize you with the *crontab* command and the *cron* daemon. Take a look at the `cronentries` file; by default, it will run *make_stats hour* every 15 minutes, *make_stats day* once an hour, *make_stats week* twice per day, and *make_stats month* once per day. These are reasonable defaults. You can add these commands to cron on any system that can access the `$(VIEWDIR)` and `$(STATSDIR)` directories, even on a system that does not have Condor installed. The commands do not have to run as user root; in fact, they should probably not run as root. These commands can run as any user that has read/write access to the `VIEWDIR`. To add these commands to cron, enter :

   ```
   crontab cronentries
   ```

7. Point your web browser at the `VIEWDIR` directory, and you are finished with the installation.

3.4.4 Installing a Checkpoint Server

The Checkpoint Server maintains a repository for checkpoint files. Using checkpoint servers reduces the disk requirements of submitting machines in the pool, since the submitting machines no longer need to store checkpoint files locally. Checkpoint server machines should have a large amount of disk space available, and they should have a fast connection to machines in the Condor pool.

If your spool directories are on a network file system, then checkpoint files will make two trips over the network: one between the submitting machine and the execution machine, and a second between the submitting machine and the network file server. If you install a checkpoint server and configure it to use the server's local disk, the checkpoint will travel only once over the network, between the execution machine and the checkpoint server. You may also obtain checkpointing network performance benefits by using multiple checkpoint servers, as discussed below.

NOTE: It is a good idea to pick very stable machines for your checkpoint servers. If individual checkpoint servers crash, the Condor system will continue to operate, although poorly. While the Condor system will recover from a checkpoint server crash as best it can, there are two problems that can (and will) occur:

1. A checkpoint cannot be sent to a checkpoint server that is not functioning. Jobs will keep trying to contact the checkpoint server, backing off exponentially in the time they wait between attempts. Normally, jobs only have a limited time to checkpoint before they are kicked off the machine. So, if the server is down for a long period of time, chances are that a lot of work will be lost by jobs being killed without writing a checkpoint.
2. If a checkpoint is not available from the checkpoint server, a job cannot be retrieved, and it will either have to be restarted from the beginning, or the job will wait for the server to come back online. This behavior is controlled with the `MAX_DISCARDED_RUN_TIME` parameter in the config file (see section 3.3.6 on page 88 for details). This parameter represents the maximum amount of CPU time you are willing to discard by starting a job over from scratch if the checkpoint server is not responding to requests.

Preparing to Install a Checkpoint Server

The location of checkpoints changes upon the installation of a checkpoint server. A configuration change would cause currently queued jobs with checkpoints to not be able to find their checkpoints. This results in the jobs with checkpoints remaining indefinitely queued (never running) due to the lack of finding their checkpoints. It is therefore best to either remove jobs from the queues or let them complete before installing a checkpoint server. It is advisable to shut your pool down before doing any maintenance on your checkpoint server. See section 3.10 on page 153 for details on shutting down your pool.

A graduated installation of the checkpoint server may be accomplished by configuring submit machines as their queues empty.

Installing the Checkpoint Server Module

To install a checkpoint server, download the appropriate binary contrib module for the platform(s) on which your server will run. Uncompress and untar the file to result in a directory that contains a `README`, `ckpt_server.tar`, and so on. The file `ckpt_server.tar` acts much like the `release.tar` file from a main release. This archive contains the files:

```
        sbin/condor_ckpt_server
        sbin/condor_cleanckpts
        etc/examples/condor_config.local.ckpt.server
```

These new files are not found in the main release, so you can safely untar the archive directly into your existing release directory. `condor_ckpt_server` is the checkpoint server binary. `condor_cleanckpts` is a script that can be periodically run to remove stale checkpoint files from your server. The checkpoint server normally cleans all old files itself. However, in certain error situations, stale files can be left that are no longer needed. You may set up a cron job that calls *condor_cleanckpts* every week or so to automate the cleaning up of any stale files. The example configuration file give with the module is described below.

After unpacking the module, there are three steps to complete. Each is discussed in its own section:

1. Configure the checkpoint server.
2. Start the checkpoint server.
3. Configure your pool to use the checkpoint server.

Configuring a Checkpoint Server

Place settings in the local configuration file of the checkpoint server. The file `etc/examples/condor_config.local.ckpt.server` contains the needed settings. Insert these into the local configuration file of your checkpoint server machine.

The `CKPT_SERVER_DIR` must be customized. The `CKPT_SERVER_DIR` attribute defines where your checkpoint files are to be located. It is better if this is on a very fast local file system (preferably a RAID). The speed of this file system will have a direct impact on the speed at which your checkpoint files can be retrieved from the remote machines.

The other optional settings are:

`DAEMON_LIST` (Described in section 3.3.7). To have the checkpoint server managed by the *condor_master*, the `DAEMON_LIST` entry must have `MASTER` and `CKPT_SERVER`. Add `STARTD` if you want to allow jobs to run on your checkpoint server. Similarly, add `SCHEDD` if you would like to submit jobs from your checkpoint server.

The rest of these settings are the checkpoint server-specific versions of the Condor logging entries, as described in section 3.3.3 on page 81.

CKPT_SERVER_LOG The CKPT_SERVER_LOG is where the checkpoint server log is placed.

MAX_CKPT_SERVER_LOG Sets the maximum size of the checkpoint server log before it is saved and the log file restarted.

CKPT_SERVER_DEBUG Regulates the amount of information printed in the log file. Currently, the only debug level supported is D_ALWAYS.

Start the Checkpoint Server

To start the newly configured checkpoint server, restart Condor on that host to enable the *condor_master* to notice the new configuration. Do this by sending a *condor_restart* command from any machine with administrator access to your pool. See section 3.8 on page 145 for full details about IP/host-based security in Condor.

Configuring your Pool to Use the Checkpoint Server

After the checkpoint server is running, you change a few settings in your configuration files to let your pool know about your new server:

USE_CKPT_SERVER This parameter should be set to TRUE (the default).

CKPT_SERVER_HOST This parameter should be set to the full hostname of the machine that is now running your checkpoint server.

It is most convenient to set these parameters in your global configuration file, so they affect all submission machines. However, you may configure each submission machine separately (using local configuration files) if you do not want all of your submission machines to start using the checkpoint server at one time. If USE_CKPT_SERVER is set to FALSE, the submission machine will not use a checkpoint server.

Once these settings are in place, send a *condor_reconfig* to all machines in your pool so the changes take effect. This is described in section 3.10.2 on page 156.

Configuring your Pool to Use Multiple Checkpoint Servers

It is possible to configure a Condor pool to use multiple checkpoint servers. The deployment of checkpoint servers across the network improves checkpointing performance. In this case, Condor machines are configured to checkpoint to the *nearest* checkpoint server. There are two main performance benefits to deploying multiple checkpoint servers:

- Checkpoint-related network traffic is localized by intelligent placement of checkpoint servers.
- Faster checkpointing implies that jobs spend less time checkpointing, more time doing useful work, jobs have a better chance of checkpointing successfully before returning a machine to its owner, and workstation owners see Condor jobs leave their machines quicker.

Once you have multiple checkpoint servers running in your pool, the following configuration changes are required to make them active.

First, `USE_CKPT_SERVER` should be set to TRUE (the default) on all submitting machines where Condor jobs should use a checkpoint server. Additionally, `STARTER_CHOOSES_CKPT_SERVER` should be set to TRUE (the default) on these submitting machines. When TRUE, this parameter specifies that the checkpoint server specified by the machine running the job should be used instead of the checkpoint server specified by the submitting machine. See section 3.3.6 on page 88 for more details. This allows the job to use the checkpoint server closest to the machine on which it is running, instead of the server closest to the submitting machine. For convenience, set these parameters in the global configuration file.

Second, set `CKPT_SERVER_HOST` on each machine. As described, this is set to the full hostname of the checkpoint server machine. In the case of multiple checkpoint servers, set this in the local configuraton file. It is the hostname of the nearest server to the machine.

Third, send a *condor_reconfig* to all machines in the pool so the changes take effect. This is described in section 3.10.2 on page 156.

After completing these three steps, the jobs in your pool will send checkpoints to the nearest checkpoint server. On restart, a job will remember where its checkpoint was stored and get it from the appropriate server. After a job successfully writes a checkpoint to a new server, it will remove any previous checkpoints left on other servers.

NOTE: If the configured checkpoint server is unavailable, the job will keep trying to contact that server as described above. It will not use alternate checkpoint servers. This may change in future versions of Condor.

Checkpoint Server Domains

The configuration described in the previous section ensures that jobs will always write checkpoints to their nearest checkpoint server. In some circumstances, it is also useful to configure Condor to localize checkpoint read transfers, which occur when the job restarts from its last checkpoint on a new machine. To localize these transfers, we want to schedule the job on a machine which is near the checkpoint server on which the job's checkpoint is stored.

We can say that all of the machines configured to use checkpoint server "A" are in "checkpoint server domain A." To localize checkpoint transfers, we want jobs which run on machines in a given checkpoint server domain to continue running on machines in that domain, transferring checkpoint files in a single local area of the network. There are two possible configurations which specify what a job should do when there are no available machines in its checkpoint server domain:

- The job can remain idle until a workstation in its checkpoint server domain becomes available.
- The job can try to immediately begin executing on a machine in another checkpoint server domain. In this case, the job transfers to a new checkpoint server domain.

These two configurations are described below.

The first step in implementing checkpoint server domains is to include the name of the nearest checkpoint server in the machine ClassAd, so this information can be used in job scheduling decisions. To do this, add the following configuration to each machine:

```
  CkptServer = "$(CKPT_SERVER_HOST)"
  STARTD_EXPRS = $(STARTD_EXPRS), CkptServer
```

For convenience, we suggest that you set these parameters in the global config file. Note that this example assumes that `STARTD_EXPRS` is defined previously in your configuration. If not, then you should use the following configuration instead:

```
  CkptServer = "$(CKPT_SERVER_HOST)"
  STARTD_EXPRS = CkptServer
```

Now, all machine ClassAds will include a `CkptServer` attribute, which is the name of the checkpoint server closest to this machine. So, the `CkptServer` attribute defines the checkpoint server domain of each machine.

To restrict jobs to one checkpoint server domain, we need to modify the jobs' `Requirements` expression as follows:

```
  Requirements = ((LastCkptServer == TARGET.CkptServer) || (LastCkpt-
Server =?= UNDEFINED))
```

This `Requirements` expression uses the `LastCkptServer` attribute in the job's ClassAd, which specifies where the job last wrote a checkpoint, and the `CkptServer` attribute in the machine ClassAd, which specifies the checkpoint server domain. If the job has not written a checkpoint yet, the `LastCkptServer` attribute will be UNDEFINED, and the job will be able to execute in any checkpoint server domain. However, once the job performs a checkpoint, `LastCkptServer` will be defined and the job will be restricted to the checkpoint server domain where it started running.

If instead we want to allow jobs to transfer to other checkpoint server domains when there are no available machines in the current checkpoint server domain, we need to modify the jobs' `Rank` expression as follows:

```
  Rank = ((LastCkptServer == TARGET.CkptServer) || (LastCkpt-
Server =?= UNDEFINED))
```

This Rank expression will evaluate to 1 for machines in the job's checkpoint server domain and 0 for other machines. So, the job will prefer to run on machines in its checkpoint server domain, but if no such machines are available, the job will run in a new checkpoint server domain.

You can automatically append the checkpoint server domain Requirements or Rank expressions to all STANDARD universe jobs submitted in your pool using APPEND_REQ_STANDARD or APPEND_RANK_STANDARD . See section 3.3.13 on page 99 for more details.

3.4.5 Installing PVM Support in Condor

To install support for PVM in Condor, download the file archive from http://www.cs.wisc.edu/condor/downloads and follow the directions found the INSTALL file contained in the archive. NOTE: The PVM contrib module version must agree with your installed Condor version.

3.4.6 Installing MPI Support in Condor

For complete documentation on using MPI in Condor, see the section entitled "Running MPICH jobs in Condor" in the version 6.1 manual. This manual can be found at http://www.cs.wisc.edu/condor/manual/v6.1. You must have Condor version 6.1.15 or better in order to use the MPI contrib module.

To install the MPI contrib module, all you have to do is download to appropriate binary module for whatever platform(s) you plan to use for MPI jobs in Condor. Once you have downloaded each module, uncompressed and untarred it, you will be left with a directory that contains a mpi.tar, README and so on. The mpi.tar acts much like the release.tar file for a main release. It contains all the binaries and supporting files you would install in your release directory:

```
sbin/condor_shadow.v61
sbin/condor_starter.v61
sbin/rsh
```

Since these files do not exist in a main release, you can safely untar the mpi.tar directly into your release directory, and you're done installing the MPI contrib module. Again, see the 6.1 manual for instructions on how to use MPI in Condor.

3.4.7 Condor Event Daemon

The event daemon is an administrative tool for scheduling events in a Condor pool. Every EVENTD_INTERVAL , for each defined event, the event daemon (eventd) computes an estimate of the time required to complete or prepare for the event. If the time required is less than the time between the next interval and the start of the event, the event daemon activates the event.

Currently, this daemon supports SHUTDOWN events, which place machines in the owner state during scheduled times. The eventd causes machines to vacate jobs one at a time in anticipation of SHUTDOWN events. Scheduling this improves performance, because the machines do not all attempt to checkpoint their jobs at the same time. To determine the estimate of the time required to complete a SHUTDOWN event, the ImageSize values for all running standard universe jobs are totalled and then divided by the maximum bandwidth specified for this event.

When a SHUTDOWN event is activated, the eventd contacts all startd daemons that match constraints given in the configuration file, and instructs them to shut down. In response to this instruction, the startd on any machine not running a job will immediately transition to the owner state. Any machine currently running a job will continue to run the job, but will not start any new job. The eventd then sends a vacate command to the each startd that is currently running a job. Once the job is vacated, the startd transitions to the owner state.

condor_eventd must run on a machine with administrator access to your pool. See section 3.8 on page 145 for full details about IP/host-based security in Condor.

Installing the Event Daemon

condor_eventd requires version 6.1.3 or later of *condor_startd*. So, you should first install either the latest version of the SMP *condor_startd* contrib module or the latest release of Condor version 6.1.

First, download the *condor_eventd* contrib module. Uncompress and untar the file, to have a directory that contains a eventd.tar. The eventd.tar acts much like the release.tar file from a main release. This archive contains the files:

```
sbin/condor_eventd
etc/examples/condor_config.local.eventd
```

These are all new files, not found in the main release, so you can safely untar the archive directly into your existing release directory. The file condor_eventd is the eventd binary. The example configuration file is described below.

Configuring the Event Daemon

The file etc/examples/condor_config.local.eventd contains an example configuration. To define events, first set the EVENT_LIST macro. This macro contains a list of macro names which define the individual events. The definition of individual events depends on the type of the event. Currently, there is only one event type: SHUTDOWN . The format for SHUTDOWN events is

```
SHUTDOWN DAY TIME DURATION BANDWIDTH CONSTRAINT RANK
```

TIME and DURATION are specified in an hours:minutes format. DAY is a string of days, where M = Monday, T = Tuesday, W = Wednesday, R = Thursday, F = Friday, S = Saturday, and U = Sunday.

For example, `MTWRFSU` would specify that the event occurs daily, `MTWRF` would specify that the event occurs only on weekdays, and `SU` would specificy that the event occurs only on weekends.

The following is an example event daemon configuration:

```
EVENT_LIST = TestEvent, TestEvent2
TestEvent = SHUTDOWN W 16:00 1:00 2.5 TestEventCon-
straint TestEventRank
TestEvent2 = SHUTDOWN F 14:00 0:30 6.0 TestEventCon-
straint2 TestEventRank
TestEventConstraint = (Arch == "INTEL")
TestEventConstraint2 = (True)
TestEventRank = (0 - ImageSize)
```

In this example, the `TestEvent` is a `SHUTDOWN` type event, which specifies that all machines whose startd ads match the constraint `Arch == "INTEL"` should be shutdown for one hour starting at 16:00 every Wednesday, and no more than 2.5 Mbytes/s of bandwidth should be used to vacate jobs in anticipation of the shutdown event. According to the `TestEventRank`, jobs will be vacated in reverse order of their `ImageSize` (larger jobs first, smaller jobs last). `TestEvent2` is a `SHUTDOWN` type event, which specifies that all machines should be shutdown for 30 minutes starting at 14:00 every Friday, and no more than 6.0 Mbytes/s of bandwidth should be used to vacate jobs in anticipation of the shutdown event.

Note that the `DAEMON_LIST` macro (described in section 3.3.7) is defined in the section of settings you may want to customize. If you want the event daemon managed by the *condor_master*, the `DAEMON_LIST` entry must contain both `MASTER` and `EVENTD`. Verify that this macro is set to run the correct daemons on this machine. By default, the list also includes `SCHEDD` and `STARTD`.

See section 3.3.17 on page 103 for a description of optional event daemon parameters.

Starting the Event Daemon

To start an event daemon once it is configured to run on a given machine, restart Condor on that given machine to enable the *condor_master* to notice the new configuration. Send a *condor_restart* command from any machine with administrator access to your pool. See section 3.8 on page 145 for full details about IP/host-based security in Condor.

3.5 User Priorities in the Condor System

Condor uses priorities to determine machine allocation for jobs. This section details the priorities.

For accounting purposes, each user is identified by username@uid_domain. Each user is assigned a priority value even if submitting jobs from different machines in the same domain, or even submit from multiple machines in the different domains.

The numerical priority value assigned to a user is inversely related to the *goodness* of the priority. A user with a numerical priority of 5 gets more resources than a user with a numerical priority of 50. There are two priority values assigned to Condor users:

- Real User Priority (RUP), which measures resource usage of the user.
- Effective User Priority (EUP), which determines the number of resources the user can get.

This section describes these two priorities and how they affect resource allocations in Condor. Documentation on configuring and controlling priorities may be found in section 3.3.16.

3.5.1 Real User Priority (RUP)

A user's RUP measures the resource usage of the user through time. Every user begins with a RUP of one half (0.5), and at steady state, the RUP of a user equilibrates to the number of resources used by that user. Therefore, if a specific user continuously uses exactly ten resources for a long period of time, the RUP of that user stabilizes at ten.

However, if the user decreases the number of resources used, the RUP gets better. The rate at which the priority value decays can be set by the macro `PRIORITY_HALFLIFE` , a time period defined in seconds. Intuitively, if the `PRIORITY_HALFLIFE` in a pool is set to 86400 (one day), and if a user whose RUP was 10 removes all his jobs, the user's RUP would be 5 one day later, 2.5 two days later, and so on.

3.5.2 Effective User Priority (EUP)

The effective user priority (EUP) of a user is used to determine how many resources that user may receive. The EUP is linearly related to the RUP by a *priority factor* which may be defined on a per-user basis. Unless otherwise configured, the priority factor for all users is 1.0, and so the EUP is the same as the the RUP. However, if desired, the priority factors of specific users (such as remote submitters) can be increased so that others are served preferentially.

The number of resources that a user may receive is inversely related to the ratio between the EUPs of submitting users. Therefore user A with EUP=5 will receive twice as many resources as user B with EUP=10 and four times as many resources as user C with EUP=20. However, if A does not use the full number of allocated resources, the available resources are repartitioned and distributed among remaining users according to the inverse ratio rule.

Condor supplies mechanisms to directly support two policies in which EUP may be useful:

Nice users A job may be submitted with the parameter `nice_user` set to TRUE in the submit command file. A nice user job gets its RUP boosted by the `NICE_USER_PRIO_FACTOR` priority factor specified in the configuration file, leading to a (usually very large) EUP. This corresponds to a low priority for resources. These jobs are therefore equivalent to Unix background jobs, which use resources not used by other Condor users.

Remote Users The flocking feature of Condor (see section 3.11.6) allows the *condor_schedd* to submit to more than one pool. In addition, the submit-only feature allows a user to run a *condor_schedd* that is submitting jobs into another pool. In such situations, submitters from other domains can submit to the local pool. It is often desirable to have Condor treat local users preferentially over these remote users. If configured, Condor will boost the RUPs of remote users by `REMOTE_PRIO_FACTOR` specified in the configuration file, thereby lowering their priority for resources.

The priority boost factors for individual users can be set with the **setfactor** option of *condor_userprio*. Details may be found in the *condor_submit* manual page on page 320.

3.5.3 Priorities and Preemption

Priorities are used to ensure that users get their fair share of resources. The priority values are used at allocation time. In addition, Condor preempts machines (by performing a checkpoint and vacate) and reallocates them to maintain priority standing.

To ensure that preemptions do not lead to *thrashing*, a `PREEMPTION_REQUIREMENTS` expression is defined to specify the conditions that must be met for a preemption to occur. It is usually defined to deny preemption if a current running job has been running for a relatively short period of time. This effectively limits the number of preemptions per resource per time interval.

3.5.4 Priority Calculation

This section may be skipped if the reader so feels, but for the curious, here is Condor's priority calculation algorithm.

The RUP of a user u at time t, $\pi_r(u,t)$, is calculated every time interval δt using the formula

$$\pi_r(u,t) = \beta \times \pi(u,t-\delta t) + (1-\beta) \times \rho(u,t)$$

where $\rho(u,t)$ is the number of resources used by user u at time t, and $\beta = 0.5^{\delta t/h}$. h is the half life period set by `PRIORITY_HALFLIFE` .

The EUP of user u at time t, $\pi_e(u,t)$ is calculated by

$$\pi_e(u,t) = \pi_r(u,t) \times f(u,t)$$

where $f(u,t)$ is the priority boost factor for user u at time t.

As mentioned previously, the RUP calculation is designed so that at steady state, each user's RUP stabilizes at the number of resources used by that user. The definition of β ensures that the calculation of $\pi_r(u,t)$ can be calculated over non-uniform time intervals δt without affecting the calculation. The time interval δt varies due to events internal to the system, but Condor guarantees that unless the central manager machine is down, no matches will be unaccounted for due to this variance.

3.6 Configuring The Startd Policy

This section describes the configuration of the *condor_startd* to implement the desired policy for when remote jobs should start, be suspended, (possibly) resumed, vacate (with a checkpoint) or be killed (no checkpoint). This policy is the heart of Condor's balancing act between the needs and wishes of resource owners (machine owners) and resource users (people submitting their jobs to Condor). Please read this section carefully if you plan to change any of the settings described here, as getting it wrong can have a severe impact on either the owners of machines in your pool (they may ask to be removed from the pool entirely) or the users of your pool (they may stop using Condor).

Before we get into the details, there are a few things to note:

- Much of this section refers to ClassAd expressions. You probably want to read through section 4.1 on ClassAd expressions before continuing with this.
- If you are familiar with the version 6.0 policy expressions and what they do, you read section 3.6.10 on page 142 which explains the differences between the version 6.0 policy expressions and later versions.
- If you are defining the policy for an SMP (multi-CPU) machine, also read section 3.11.7 on Configuring The Startd for SMP Machines. Each *virtual machine* represented by the condor_startd on an SMP machine will have its own *state* and *activity* (described below). In the future, each virtual machine will be able to have its own policy expressions defined. For the rest of this section, the word "machine" means an individual virtual machine, for an SMP machine that is showing up as multiple virtual machines in your pool.

To define your policy, you set expressions in the configuration file (see section 3.3 on Configuring Condor for an introduction to Condor's configuration files). The expressions are evaluated in the context of the machine's ClassAd and a job ClassAd. The expressions can therefore reference attributes from either ClassAd. Listed in this section are the attributes that are included in the machine's ClassAd and the attributes that are included in a job ClassAd. The `START` expression, which describes to Condor what conditions must be met for a machine to start a job are explained. The `RANK` expression is described. It allows the specification of the kinds of jobs a machine prefers to run. A final discussion details how the *condor_startd* works. Included are the machine *states* and *activities*, to give an idea of what is possible in policy decisions. Two example policy settings are presented.

3.6.1 Startd ClassAd Attributes

The *condor_startd* represents the machine on which it is running to the Condor pool. It publishes characteristics about the machine in its ClassAd to aid matchmaking with resource requests. The values of these attributes can be found by using *condor_status -l hostname*. On an SMP machine, the startd will break the machine up and advertise it as separate virtual machines, each with its own name and ClassAd. The attributes themselves and what they represent are described below:

`Activity` : String which describes Condor job activity on the machine. Can have one of the following values:

- **`"Idle"`** : There is no job activity
- **`"Busy"`** : A job is busy running
- **`"Suspended"`** : A job is currently suspended
- **`"Vacating"`** : A job is currently checkpointing
- **`"Killing"`** : A job is currently being killed
- **`"Benchmarking"`** : The startd is running benchmarks

`Arch` : String with the architecture of the machine. Typically one of the following:

- **`"INTEL"`** : Intel x86 CPU (Pentium, Xeon, etc).
- **`"ALPHA"`** : Digital Alpha CPU
- **`"SGI"`** : Silicon Graphics MIPS CPU
- **`"SUN4u"`** : Sun UltraSparc CPU
- **`"SUN4x"`** : A Sun Sparc CPU other than an UltraSparc, i.e. sun4m or sun4c CPU found in older Sparc workstations such as the Sparc 10, Sparc 20, IPC, IPX, etc.
- **`"HPPA1"`** : Hewlett Packard PA-RISC 1.x CPU (i.e. PA-RISC 7000 series CPU) based workstation
- **`"HPPA2"`** : Hewlett Packard PA-RISC 2.x CPU (i.e. PA-RISC 8000 series CPU) based workstation

`ClockDay` : The day of the week, where 0 = Sunday, 1 = Monday, . . ., 6 = Saturday.

`ClockMin` : The number of minutes passed since midnight.

`CondorLoadAvg` : The portion of the load average generated by Condor (either from remote jobs or running benchmarks).

`ConsoleIdle` : The number of seconds since activity on the system console keyboard or console mouse has last been detected.

`Cpus` : Number of CPUs in this machine, i.e. 1 = single CPU machine, 2 = dual CPUs, etc.

`CurrentRank` : A float which represents this machine owner's affinity for running the Condor job which it is currently hosting. If not currently hosting a Condor job, `CurrentRank` is -1.0.

`Disk` : The amount of disk space on this machine available for the job in kbytes (e.g. 23000 = 23 megabytes). Specifically, this is the amount of disk space available in the directory specified in the Condor configuration files by the `EXECUTE` macro, minus any space reserved with the `RESERVED_DISK` macro.

`EnteredCurrentActivity` : Time at which the machine entered the current Activity (see `Activity` entry above). On all platforms (including NT), this is measured in the number of seconds since the UNIX epoch (00:00:00 UTC, Jan 1, 1970).

FileSystemDomain : A "domain" name configured by the Condor administrator which describes a cluster of machines which all access the same, uniformly-mounted, networked file systems usually via NFS or AFS. This is useful for Vanilla universe jobs which require remote file access.

KeyboardIdle : The number of seconds since activity on any keyboard or mouse associated with this machine has last been detected. Unlike `ConsoleIdle`, `KeyboardIdle` also takes activity on pseudo-terminals into account (i.e. virtual "keyboard" activity from telnet and rlogin sessions as well). Note that `KeyboardIdle` will always be equal to or less than `ConsoleIdle`.

KFlops : Relative floating point performance as determined via a Linpack benchmark.

LastHeardFrom : Time when the Condor central manager last received a status update from this machine. Expressed as seconds since the epoch (integer value). Note: This attribute is only inserted by the central manager once it receives the ClassAd. It is not present in the *condor_startd* copy of the ClassAd. Therefore, you could not use this attribute in defining *condor_startd* expressions (and you would not want to).

LoadAvg : A floating point number with the machine's current load average.

Machine : A string with the machine's fully qualified hostname.

Memory : The amount of RAM in megabytes.

Mips : Relative integer performance as determined via a Dhrystone benchmark.

MyType : The ClassAd type; always set to the literal string `"Machine"`.

Name : The name of this resource; typically the same value as the `Machine` attribute, but could be customized by the site administrator. On SMP machines, the *condor_startd* will divide the CPUs up into separate virtual machines, each with with a unique name. These names will be of the form "vm#@full.hostname", for example, "vm1@vulture.cs.wisc.edu", which signifies virtual machine 1 from vulture.cs.wisc.edu.

OpSys : String describing the operating system running on this machine. For Condor Version 6.1.17 typically one of the following:

"HPUX10" : for HPUX 10.20

"IRIX6" : for IRIX 6.2, 6.3, or 6.4

"LINUX" : for LINUX 2.0.x or LINUX 2.2.x kernel systems

"OSF1" : for Digital Unix 4.x

"SOLARIS251"

"SOLARIS26"

Requirements : A boolean, which when evaluated within the context of the machine ClassAd and a job ClassAd, must evaluate to TRUE before Condor will allow the job to use this machine.

`StartdIpAddr` : String with the IP and port address of the *condor_startd* daemon which is publishing this machine ClassAd.

`State` : String which publishes the machine's Condor state. Can be:

- **`"Owner"`** : The machine owner is using the machine, and it is unavailable to Condor.
- **`"Unclaimed"`** : The machine is available to run Condor jobs, but a good match is either not available or not yet found.
- **`"Matched"`** : The Condor central manager has found a good match for this resource, but a Condor scheduler has not yet claimed it.
- **`"Claimed"`** : The machine is claimed by a remote *condor_schedd* and is probably running a job.
- **`"Preempting"`** : A Condor job is being preempted (possibly via checkpointing) in order to clear the machine for either a higher priority job or because the machine owner wants the machine back.

`TargetType` : Describes what type of ClassAd to match with. Always set to the string literal `"Job"`, because machine ClassAds always want to be matched with jobs, and vice-versa.

`UidDomain` : a domain name configured by the Condor administrator which describes a cluster of machines which all have the same `passwd` file entries, and therefore all have the same logins.

`VirtualMemory` : The amount of currently available virtual memory (swap space) expressed in kbytes.

3.6.2 Job ClassAd Attributes

`CkptArch` : String describing the architecture of the machine where this job last checkpointed. If the job has never checkpointed, this attribute is UNDEFINED.

`CkptOpSys` : String describing the operating system of the machine where this job last checkpointed. If the job has never checkpointed, this attribute is UNDEFINED.

`ClusterId` : Integer cluster identifier for this job. A "cluster" is a group of jobs that were submitted together. Each job has its own unique job identifier within the cluser, but shares a common cluster identifier.

`ExecutableSize` : Size of the executable in kbytes.

`ImageSize` : Estimate of the memory image size of the job in kbytes. The initial estimate may be specified in the job submit file. Otherwise, the initial value is equal to the size of the executable. When the job checkpoints, the `ImageSize` attribute is set to the size of the checkpoint file (since the checkpoint file contains the job's memory image).

`JobPrio` : Integer priority for this job, set by *condor_submit* or *condor_prio*. The default value is 0. The higher the number, the worse the priority.

JobStatus : Integer which indicates the current status of the job, where 1 = Idle, 2 = Running, 3 = Removed, 4 = Completed, and 5 = Held.

JobUniverse : Integer which indicates the job universe, where 1 = Standard, 4 = PVM, 5 = Vanilla, and 7 = Scheduler.

LastCkptServer : Hostname of the last checkpoint server used by this job. When a pool is using multiple checkpoint servers, this tells the job where to find its checkpoint file.

LastCkptTime : Time at which the job last performed a successful checkpoint. Measured in the number of seconds since the epoch (00:00:00 UTC, Jan 1, 1970).

LastVacateTime : Time at which the job was last evicted from a remote workstation. Measured in the number of seconds since the epoch (00:00:00 UTC, Jan 1, 1970).

NumCkpts : A count of the number of checkpoints written by this job during its lifetime.

NumRestarts : A count of the number of restarts from a checkpoint attempted by this job during its lifetime.

NiceUser : Boolean value which indicates whether this is a nice-user job.

Owner : String describing the user who submitted this job.

ProcId : Integer process identifier for this job. In a cluster of many jobs, each job will have the same ClusterId but will have a unique ProcId.

QDate : Time at which the job was submitted to the job queue. Measured in the number of seconds since the epoch (00:00:00 UTC, Jan 1, 1970).

JobStartDate : Time at which the job first began running. Measured in the number of seconds since the epoch (00:00:00 UTC, Jan 1, 1970).

3.6.3 The START expression

The most important expression in the startd (and possibly in all of Condor) is the START expression. This expression describes the conditions to must be met for a machine to service a resource request (in other words, to start a job). This expression (like other expressions) can reference attributes in the machine's ClassAd (such as KeyboardIdle and LoadAvg) or attributes in a job ClassAd (such as Owner, Imagesize, and even Cmd, the name of the executable the requester wants to run). What the START expression evaluates to plays a crucial role in determining the state and activity of a machine.

It is the Requirements expression that is used for matching with other jobs. The startd defines the Requirements expression as the START expression. However, in situations where a machine wants to make itself unavailable for further matches, it sets its Requirements expression to FALSE, not its START expression. When the START expression locally evaluates to TRUE, the machine advertises the Requirements expression as TRUE and does not publish the START expression.

Normally, the expressions in the machine ClassAd are evaluated against certain request ClassAds in the *condor_negotiator* to see if there is a match, or against whatever request ClassAd currently has claimed the machine. However, by locally evaluating an expression, the machine only evaluates the expression against its own ClassAd. If an expression cannot be locally evaluated (because it references other expressions that are only found in a request ad, such as `Owner` or `Imagesize`), the expression is (usually) undefined. See section 4.1 for specifics on how undefined terms are handled in ClassAd expression evaluation.

NOTE: If you have machines with lots of real memory and swap space so the only scarce resource is CPU time, you could use `JOB_RENICE_INCREMENT` (see section 3.3.12 on condor_starter Configuration File Macros for details) so that Condor starts jobs on your machine with low priority. Then, set up your machines with:

```
START : True
SUSPEND : False
PREEMPT : False
KILL : False
```

In this way, Condor jobs always run and never be kicked off. However, because they would run with "nice priority", interactive response on your machines will not suffer. You probably would not notice Condor was running the jobs, assuming you had enough free memory for the Condor jobs that there was little swapping.

3.6.4 The RANK expression

A machine may be configured to prefer certain jobs over others using the `RANK` expression. It is an expression, like any other in a machine ClassAd. It can reference any attribute found in either the machine ClassAd or a request ad (normally, in fact, it references things in the request ad). The most common use of this expression is likely to configure a machine to prefer to run jobs from the owner of that machine, or by extension, a group of machines to prefer jobs from the owners of those machines.

For example, imagine there is a small research group with 4 machines called tenorsax, piano, bass, and drums. These machines are owned by the 4 users coltrane, tyner, garrison, and jones, respectively.

Assume that there is a large Condor pool in your department, but you spent a lot of money on really fast machines for your group. You want to implement a policy that gives priority on your machines to anyone in your group. To achieve this, set the `RANK` expression on your machines to reference the `Owner` attribute and prefer requests where that attribute matches one of the people in your group as in

```
RANK : Owner == "coltrane" || Owner == "tyner" \
       || Owner == "garrison" || Owner == "jones"
```

The RANK expression is evaluated as a floating point number. However, like in C, boolean expressions evaluate to either 1 or 0 depending on if they are TRUE or FALSE. So, if this expression evaluated to 1 (because the remote job was owned by one of the preferred users), it would be a larger value than any other user (for whom the expression would evaluate to 0).

A more complex RANK expression has the same basic set up, where anyone from your group has priority on your machines. Its difference is that the machine owner has better priority on their own machine. To set this up for Jimmy Garrison, place the following entry in Jimmy Garrison's local configuration file bass.local:

```
RANK : (Owner == "coltrane") + (Owner == "tyner") \
       + ((Owner == "garrison") * 10) + (Owner == "jones")
```

NOTE: The parentheses in this expression are important, because "+" operator has higher default precedence than "==".

The use of "+" instead of "| | " allows us to distinguish which terms matched and which ones didn't. If anyone not in the John Coltrane quartet was running a job on the machine called bass, the RANK would evaluate numerically to 0, since none of the boolean terms evaluates to 1, and 0+0+0+0 still equals 0.

Suppose Elvin Jones submits a job. His job would match this machine (assuming the START was True for him at that time) and the RANK would numerically evaluate to 1. Therefore, Elvin would preempt the Condor job currently running. Assume that later Jimmy submits a job. The RANK evaluates to 10, since the boolean that matches Jimmy gets multiplied by 10. Jimmy would preempt Elvin, and Jimmy's job would run on Jimmy's machine.

The RANK expression is not required to reference the Owner of the jobs. Perhaps there is one machine with an enormous amount of memory, and others with not much at all. You can configure your large-memory machine to prefer to run jobs with larger memory requirements:

```
RANK : ImageSize
```

That's all there is to it. The bigger the job, the more this machine wants to run it. It is an altruistic preference, always servicing the largest of jobs, no matter who submitted them. A little less altruistic is John's RANK that prefers his jobs over those with the largest Imagesize:

```
RANK : (Owner == "coltrane" * 1000000000000) + Imagesize
```

This RANK breaks if a job is submitted with an image size of more 10^{12} Kbytes. However, with that size, this RANK expression preferring that job would not be Condors only problem!

3.6.5 Machine States

A machine is assigned a *state* by Condor. The state depends on whether or not the machine is available to run Condor jobs, and if so, what point in the negotiations has been reached. The possible states are

Owner The machine is being used by the machine owner, and/or is not available to run Condor jobs. When the machine first starts up, it begins in this state.

Unclaimed The machine is available to run Condor jobs, but it is not currently doing so.

Matched The machine is available to run jobs, and it has been matched by the negotiator with a specific schedd. That schedd just has not yet claimed this machine. In this state, the machine is unavailable for further matches.

Claimed The machine has been claimed by a schedd.

Preempting The machine was claimed by a schedd, but is now preempting that claim for one of the following reasons.

1. the owner of the machine came back
2. another user with higher priority has jobs waiting to run
3. another request that this resource would rather serve was found

Figure 3.3 shows the states and the possible transitions between the states.

3.6.6 Machine Activities

Within some machine states, *activities* of the machine are defined. The state has meaning regardless of activity. Differences between activities are significant. Therefore, a “state/activity” pair describes a machine. The following list describes all the possible state/activity pairs.

- Owner

  Idle This is the only activity for Owner state. As far as Condor is concerned the machine is Idle, since it is not doing anything for Condor.

- Unclaimed

  Idle This is the normal activity of Unclaimed machines. The machine is still Idle in that the machine owner is willing to let Condor jobs run, but Condor is not using the machine for anything.

  Benchmarking The machine is running benchmarks to determine the speed on this machine. This activity only occurs in the Unclaimed state. How often the activity occurs is determined by the `RunBenchmarks` expression.

- Matched

  Idle When Matched, the machine is still Idle to Condor.

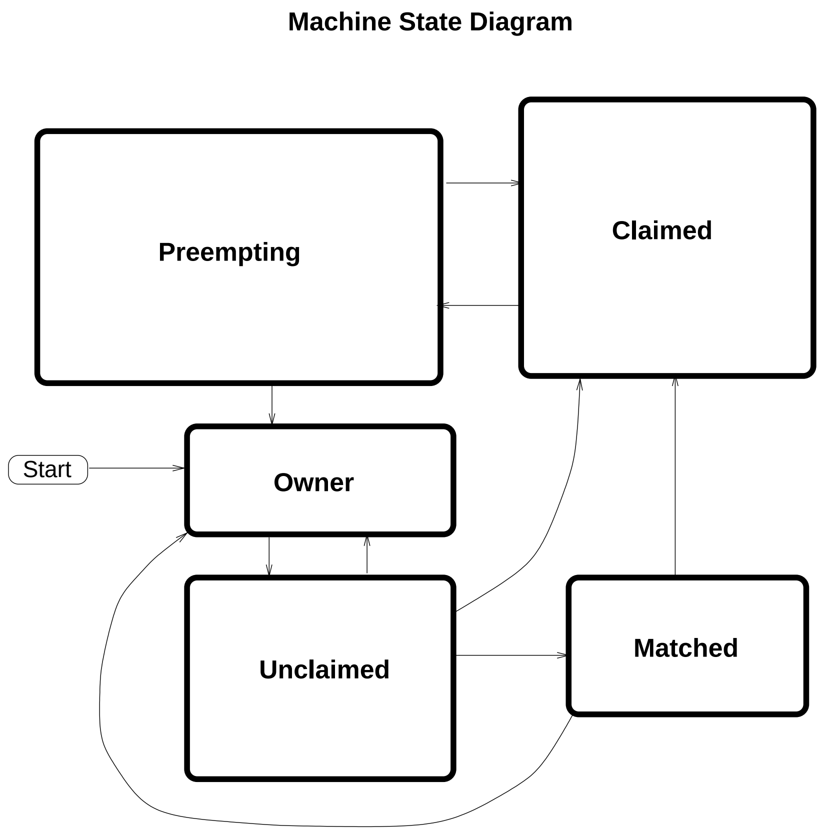


Figure 3.3: Machine States

- Claimed

  Idle In this activity, the machine has been claimed, but the schedd that claimed it has yet to *activate* the claim by requesting a *condor_starter* to be spawned to service a job.

  Busy Once a *condor_starter* has been started and the claim is active, the machine moves to the Busy activity to signify that it is doing something as far as Condor is concerned.

  Suspended If the job is suspended by Condor, the machine goes into the Suspended activity. The match between the schedd and machine has not been broken (the claim is still valid), but the job is not making any progress and Condor is no longer generating a load on the machine.

- Preempting The preempting state is used for evicting a Condor job from a given machine. When the machine enters the Preempting state, it checks the `WANT_VACATE` expression to determine its activity.

  Vacating In the Vacating activity, the job that was running is in the process of checkpointing. As soon as the checkpoint process completes, the machine moves into either the Owner state or the Claimed state, depending on the reason for its preemption.

Killing Killing means that the machine has requested the running job to exit the machine immediately, without checkpointing.

Figure 3.4 on page 129 gives the overall view of all machine states and activities and shows the possible transitions from one to another within the Condor system. Each transition is labeled with a number on the diagram, and transition numbers referred to in this manual will be **bold**.

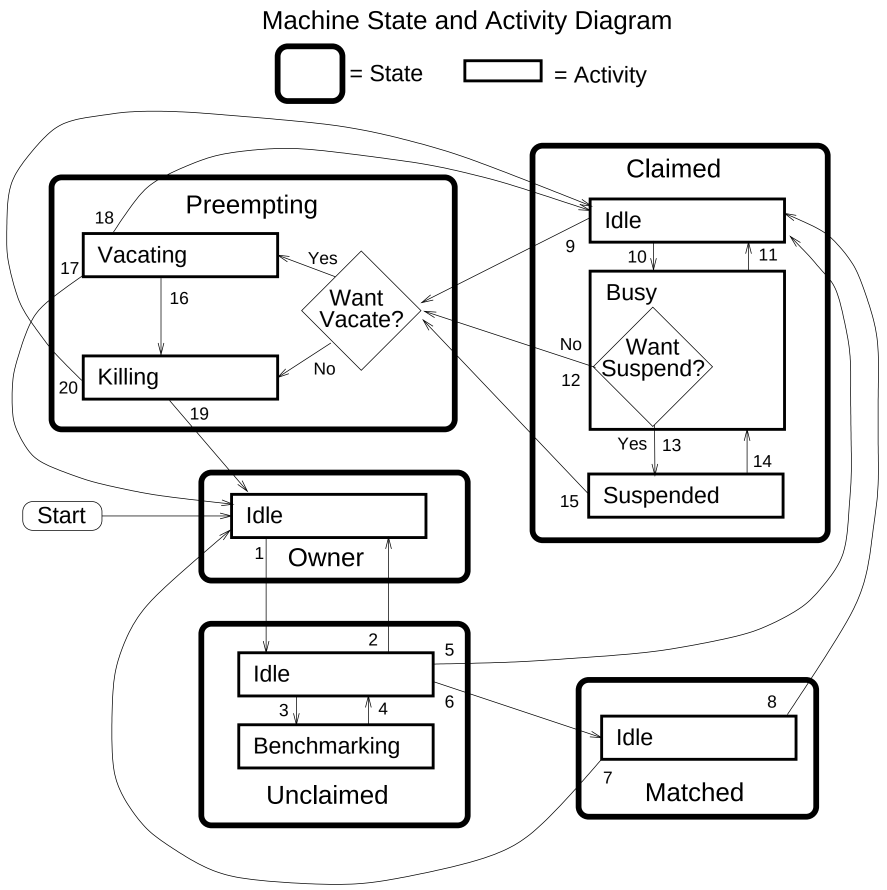


Figure 3.4: Machine States and Activities

Various expressions are used to determine when and if many of these state and activity transitions occur. Other transitions are initiated by parts of the Condor protocol (such as when the *condor_negotiator* matches a machine with a schedd). The following section describes the conditions that lead to the various state and activity transitions.

3.6.7 State and Activity Transitions

This section traces through all possible state and activity transitions within a machine and describes the conditions under which each one occurs. Whenever a transition occurs, Condor records when the machine entered its new activity and/or new state. These times are often used to write expressions that determine when further transitions occurred. For example, enter the Killing activity if a machine has been in the Vacating activity longer than a specified amount of time.

Owner State

When the startd is first spawned, the machine it represents enters the Owner state. The machine will remain in this state as long as the `START` expression locally evaluates to FALSE. If the `START` locally evaluates to TRUE or cannot be locally evaluated (it evaluates to UNDEFINED, transition **1** occurs and the machine enters the Unclaimed state.

As long as the `START` expression evaluates locally to FALSE, there is no possible request in the Condor system that could match it. The machine is unavailable to Condor and stays in the Owner state. For example, if the `START` expression is

```
START : KeyboardIdle > 15 * $(MINUTE) && Owner == "coltrane"
```

and if `KeyboardIdle` is 34 seconds, then the machine would remain in the Owner state. Owner is undefined, and `anything && FALSE` is FALSE.

If, however, the `START` expression is

```
        START : KeyboardIdle > 15 * $(MINUTE) || Owner == "coltrane"
```

and `KeyboardIdle` is 34 seconds, then the machine leaves the Owner state and becomes Unclaimed. This is because `FALSE || UNDEFINED` is UNDEFINED. So, while this machine is not available to just anybody, if user coltrane has jobs submitted, the machine is willing to run them. Any other user's jobs have to wait until `KeyboardIdle` exceeds 15 minutes. However, since coltrane might claim this resource, but has not yet, the machine goes to the Unclaimed state.

While in the Owner state, the startd polls the status of the machine every `UPDATE_INTERVAL` to see if anything has changed that would lead it to a different state. This minimizes the impact on the Owner while the Owner is using the machine. Frequently waking up, computing load averages, checking the access times on files, computing free swap space take time, and there is nothing time critical that the startd needs to be sure to notice as soon as it happens. If the `START` expression evaluates to TRUE and five minutes pass before the startd notices, that's a drop in the bucket of high-throughput computing.

The machine can only transition to the Unclaimed state from the Owner state. It only does so when the `START` expression no longer locally evaluates to FALSE. In general, if the `START` expression locally evaluates to FALSE at any time, the machine will either transition directly to the

Owner state or to the Preempting state on its way to the Owner state, if there is a job running that needs preempting.

Unclaimed State

While in the Unclaimed state, if the `START` expression locally evaluates to FALSE, the machine returns to the Owner state by transition **2**.

When in the Unclaimed state, the `RunBenchmarks` expression is relevant. If `RunBenchmarks` evaluates to TRUE while the machine is in the Unclaimed state, then the machine will transition from the Idle activity to the Benchmarking activity (transition **3**) and perform benchmarks to determine `MIPS` and `KFLOPS`. When the benchmarks complete, the machine returns to the Idle activity (transition **4**).

The startd automatically inserts an attribute, `LastBenchmark`, whenever it runs benchmarks, so commonly `RunBenchmarks` is defined in terms of this attribute, for example:

```
BenchmarkTimer = (CurrentTime - LastBenchmark)
RunBenchmarks : $(BenchmarkTimer) >= (4 * $(HOUR))
```

Here, a macro, `BenchmarkTimer` is defined to help write the expression. This macro holds the time since the last benchmark, so when this time exceeds 4 hours, we run the benchmarks again. The startd keeps a weighted average of these benchmarking results to try to get the most accurate numbers possible. This is why it is desirable for the startd to run them more than once in its lifetime.

NOTE: `LastBenchmark` is initialized to 0 before benchmarks have ever been run. So, if you want the startd to run benchmarks as soon as the machine is Unclaimed (if it hasn't done so already), include a term for `LastBenchmark` as in the example above.

NOTE: If `RunBenchmarks` is defined and set to something other than FALSE, the startd will automatically run one set of benchmarks when it first starts up. To disable benchmarks, both at startup and at any time thereafter, set `RunBenchmarks` to FALSE or comment it out of the configuration file.

From the Unclaimed state, the machine can go to two other possible states: Matched or Claimed/Idle. Once the *condor_negotiator* matches an Unclaimed machine with a requester at a given schedd, the negotiator sends a command to both parties, notifying them of the match. If the schedd receives that notification and initiates the claiming procedure with the machine before the negotiator's message gets to the machine, the Match state is skipped, and the machine goes directly to the Claimed/Idle state (transition **5**). However, normally the machine will enter the Matched state (transition **6**), even if it is only for a brief period of time.

Matched State

The Matched state is not very interesting to Condor. Noteworthy in this state is that the machine lies about its `START` expression while in this state and says that `Requirements` are false to prevent being matched again before it has been claimed. Also interesting is that the startd starts a timer to make sure it does not stay in the Matched state too long. The timer is set with the `MATCH_TIMEOUT` configuration file macro. It is specified in seconds and defaults to 300 (5 minutes). If the schedd that was matched with this machine does not claim it within this period of time, the machine gives up, and goes back into the Owner state via transition **7**. It will probably leave the Owner state right away for the Unclaimed state again and wait for another match.

At any time while the machine is in the Matched state, if the `START` expression locally evaluates to FALSE, the machine enters the Owner state directly (transition **7**).

If the schedd that was matched with the machine claims it before the `MATCH_TIMEOUT` expires, the machine goes into the Claimed/Idle state (transition **8**).

Claimed State

The Claimed state is certainly the most complex state. It has the most possible activities and the most expressions that determine its next activities. In addition, the *condor_checkpoint* and *condor_vacate* commands affect the machine when it is in the Claimed state. In general, there are two sets of expressions that might take effect. They depend on the universe of the request: standard or vanilla. The standard universe expressions are the normal expressions. For example:

```
        WANT_SUSPEND            : True
        WANT_VACATE             : $(Activation-
Timer) > 10 * $(MINUTE)
        SUSPEND                 : $(KeyboardBusy) || $(CPUBusy)
        ...
```

The vanilla expressions have the string"_VANILLA" appended to their names. For example:

```
        WANT_SUSPEND_VANILLA    : True
        WANT_VACATE_VANILLA     : True
        SUSPEND_VANILLA         : $(KeyboardBusy) || $(CPUBusy)
        ...
```

Without specific vanilla versions, the normal versions will be used for all jobs, including vanilla jobs. In this manual, the normal expressions are referenced. The difference exists for the the resource owner that might want the machine to behave differently for vanilla jobs, since they cannot checkpoint. For example, owners may want vanilla jobs to remain suspended for longer than standard jobs.

While Claimed, the POLLING_INTERVAL takes effect, and the startd polls the machine much more frequently to evaluate its state.

If the machine owner starts typing on the console again, it is best to notice this as soon as possible to be able to start doing whatever the machine owner wants at that point. For SMP machines, if any virtual machine is in the Claimed state, the startd polls the machine frequently. If already polling one virtual machine, it does not cost much to evaluate the state of all the virtual machines at the same time.

In general, when the startd is going to take a job off a machine (usually because of activity on the machine that signifies that the owner is using the machine again), the startd will go through successive levels of getting the job out of the way. The first and least costly to the job is suspending it. This works for both standard and vanilla jobs. If suspending the job for a short while does not satisfy the machine owner (the owner is still using the machine after a specific period of time), the startd moves on to vacating the job. Vacating a job involves performing a checkpoint so that the work already completed is not lost. If even that does not satisfy the machine owner (usually because it is taking too long and the owner wants their machine back *now*), the final, most drastic stage is reached: killing. Killing is a quick death to the job, without a checkpoint. For vanilla jobs, vacating and killing are equivalent, although a vanilla job can request to have a specific *softkill signal* sent to it at vacate time so that the job itself can perform application-specific checkpointing.

The WANT_SUSPEND expression determines if the machine will evaluate the SUSPEND expression to consider entering the Suspended activity. The WANT_VACATE expression determines what happens when the machine enters the Preempting state. It will go to the Vacating activity or directly to Killing. If one or both of these expressions evaluates to FALSE, the machine will skip that stage of getting rid of the job and proceed directly to the more drastic stages.

When the machine first enters the Claimed state, it goes to the Idle activity. From there, it has two options. It can enter the Preempting state via transition **9** (if a *condor_vacate* arrives, or if the START expression locally evaluates to FALSE), or it can enter the Busy activity (transition **10**) if the schedd that has claimed the machine decides to activate the claim and start a job.

From Claimed/Busy, the machine can transition to three other state/activity pairs. The startd evaluates the WANT_SUSPEND expression to decide which other expressions to evaluate. If WANT_SUSPEND is TRUE, then the startd evaluates the SUSPEND expression. If SUSPEND is FALSE, then the startd will evaluate the PREEMPT expression and skip the Suspended activity entirely. By transition, the possible state/activity destinations from Claimed/Busy:

Claimed/Idle If the starter that is serving a given job exits (for example because the jobs completes), the machine will go to Claimed/Idle (transition **11**).

Preempting If WANT_SUSPEND is FALSE and the PREEMPT expression is TRUE, the machine enters the Preempting state (transition **12**). The other reason the machine would go from Claimed/Busy to Preempting is if the *condor_negotiator* matched the machine with a “better” match. This better match could either be from the machine’s perspective using the RANK Expression above, or it could be from the negotiator’s perspective due to a job with a higher user priority. In this case, WANT_VACATE is assumed to be TRUE, and the machine transitions to Preempting/Vacating.

Claimed/Suspended If both the `WANT_SUSPEND` and `SUSPEND` expressions evaluate to TRUE, the machine suspends the job (transition **13**).

If a *condor_checkpoint* command arrives, or the `PeriodicCheckpoint` expression evaluates to TRUE, there is no state change. The startd has no way of knowing when this process completes, so periodic checkpointing can not be another state. Periodic checkpointing remains in the Claimed/Busy state and appears as a running job.

From the Claimed/Suspended state, the following transitions may occur:

Claimed/Busy If the `CONTINUE` expression evaluates to TRUE, the machine resumes the job and enters the Claimed/Busy state (transition **14**).

Preempting If the `PREEMPT` expression is TRUE, the machine will enter the Preempting state (transition **15**).

Preempting State

The Preempting state is less complex than the Claimed state. There are two activities. Depending on the value of `WANT_VACATE`, a machine will be in the Vacating activity (if TRUE) or the Killing activity (if FALSE).

While in the Preempting state (regardless of activity) the machine advertises its `Requirements` expression as FALSE to signify that it is not available for further matches, either because it is about to transition to the Owner state, or because it has already been matched with one preempting match, and further preempting matches are disallowed until the machine has been claimed by the new match.

The main function of the Preempting state is to get rid of the starter associated with the resource. If the *condor_starter* associated with a given claim exits while the machine is still in the Vacating activity, then the job successfully completed its checkpoint.

If the machine is in the Vacating activity, it keeps evaluating the `KILL` expression. As soon as this expression evaluates to TRUE, the machine enters the Killing activity (transition **16**).

When the starter exits, or if there was no starter running when the machine enters the Preempting state (transition **9**), the other purpose of the Preempting state is completed: notifying the schedd that had claimed this machine that the claim is broken.

At this point, the machine enters either the Owner state by transition **17** (if the job was preempted because the machine owner came back) or the Claimed/Idle state by transition **18** (if the job was preempted because a better match was found). The machine enters the Killing activity, and it starts a timer, the length of which is defined by the `KILLING_TIMEOUT` macro. This macro is defined in seconds and defaults to 30. If this timer expires and the machine is still in the Killing activity, something has gone seriously wrong with the *condor_starter* and the startd tries to vacate the job immediately by sending SIGKILL to all of the *condor_starter*'s children, and then to the *condor_starter* itself.

Once the starter is gone and the schedd that had claimed the machine is notified that the claim is broken, the machine will either enter the Owner state by transition **19** (if the job was preempted because the machine owner came back) or the Claimed/Idle state by transition **20** (if the job was preempted because a better match was found).

3.6.8 State/Activity Transition Expression Summary

This section is a summary of the information from the previous sections. It serves as a quick reference.

`START` When TRUE, the machine is willing to spawn a remote Condor job.

`RunBenchmarks` While in the Unclaimed state, the machine will run benchmarks whenever TRUE.

`MATCH_TIMEOUT` If the machine has been in the Matched state longer than this value, it will transition to the Owner state.

`WANT_SUSPEND` If TRUE, the machine evaluates the `SUSPEND` expression to see if it should transition to the Suspended activity. If FALSE, the machine look at the `PREEMPT` expression.

`SUSPEND` If `WANT_SUSPEND` is TRUE, and the machine is in the Claimed/Busy state, it enters the Suspended activity if `SUSPEND` is TRUE.

`CONTINUE` If the machine is in the Claimed/Suspended state, it enter the Busy activity if `CONTINUE` is TRUE.

`PREEMPT` If the machine is either in the Claimed/Suspended activity, or is in the Claimed/Busy activity and `WANT_SUSPEND` is FALSE, the machine enters the Preempting state whenever `PREEMPT` is TRUE.

`WANT_VACATE` This is checked only when the `PREEMPT` expression is TRUE and the machine enters the Preempting state. If `WANT_VACATE` is TRUE, the machine enters the Vacating activity. If it is FALSE, the machine will proceed directly to the Killing activity.

`KILL` If the machine is the Preempting/Vacating state, it enters Preempting/Killing whenever `KILL` is TRUE.

`KILLING_TIMEOUT` If the machine is in the Preempting/Killing state for longer than `KILLING_TIMEOUT` seconds, the startd sends a SIGKILL to the *condor_starter* and all its children to try to kill the job as quickly as possible.

`PERIODIC_CHECKPOINT` If the machine is in the Claimed/Busy state and `PERIODIC_CHECKPOINT` is TRUE, the user's job begins a periodic checkpoint.

`RANK` If this expression evaluates to a higher number for a pending resource request than it does for the current request, the machine preempts the current request (enters the Preempting/Vacating state). When the preemption is complete, the machine enters the Claimed/Idle state with the new resource request claiming it.

3.6.9 Example Policy Settings

The following section provides two examples of how you might configure the policy at your pool. Each one is described in English, then the actual macros and expressions used are listed and explained with comments. Finally the entire set of macros and expressions are listed in one block so you can see them in one place for easy reference.

Default Policy Settings

These settings are the default as shipped with Condor. They have been used for many years with no problems. The vanilla expressions are identical to the regular ones. (They are not listed here. If not defined, the standard expressions are used for vanilla jobs as well).

The following are macros to help write the expressions clearly.

`StateTimer` Amount of time in the current state.

`ActivityTimer` Amount of time in the current activity.

`ActivationTimer` Amount of time the job has been running on this machine.

`LastCkpt` Amount of time since the last periodic checkpoint.

`NonCondorLoadAvg` The difference between the system load and the Condor load (the load generated by everything but Condor).

`BackgroundLoad` Amount of background load permitted on the machine and still start a Condor job.

`HighLoad` If the `$(NonCondorLoadAvg)` goes over this, the CPU is considered too busy, and eviction of the Condor job should start.

`StartIdleTime` Amount of time the keyboard must to be idle before Condor will start a job.

`ContinueIdleTime` Amount of time the keyboard must to be idle before resumption of a suspended job.

`MaxSuspendTime` Amount of time a job may be suspended before more drastic measures are taken.

`MaxVacateTime` Amount of time a job may be checkpointing before we give up kill it outright.

`KeyboardBusy` A boolean string that evaluates to TRUE when the keyboard is being used.

`CPU_Idle` A boolean string that evaluates to TRUE when the CPU is idle.

`CPU_Busy` A boolean string that evaluates to TRUE when the CPU is busy.

`MachineBusy` The CPU or the Keyboard is busy.

```
##  These macros are here to help write legible expressions:
MINUTE          = 60
HOUR            = (60 * $(MINUTE))
StateTimer      = (CurrentTime - EnteredCurrentState)
ActivityTimer   = (CurrentTime - EnteredCurrentActivity)
ActivationTimer = (CurrentTime - JobStart)

NonCondorLoadAvg        = (LoadAvg - CondorLoadAvg)
BackgroundLoad          = 0.3
HighLoad                = 0.5
StartIdleTime           = 15 * $(MINUTE)
ContinueIdleTime        = 5 * $(MINUTE)
MaxSuspendTime          = 10 * $(MINUTE)
MaxVacateTime           = 5 * $(MINUTE)

KeyboardBusy            = KeyboardIdle < $(MINUTE)
CPU_Idle                = $(NonCondorLoadAvg) <= $(BackgroundLoad)
CPU_Busy                = $(NonCondorLoadAvg) >= $(HighLoad)
MachineBusy             = ($(CPU_Busy) || $(KeyboardBusy))
```

Macros are defined to always want to suspend jobs. If that is not enough, always try to gracefully vacate them, unless they have only been running for less than 10 minutes anyway, in which case just kill them, instead of trying to checkpoint those 10 minutes of work.

```
WANT_SUSPEND            : True
WANT_VACATE             : $(ActivationTimer) > 10 * $(MINUTE)
```

Finally, definitions of the actual expressions. Start any job if the CPU is idle (as defined by the macro) and the keyboard has been idle long enough.

```
START           : $(CPU_Idle) && KeyboardIdle > $(StartIdleTime)
```

Suspend a job if the machine is busy.

```
SUSPEND         : $(MachineBusy)
```

Continue a suspended job if the CPU is idle and the Keyboard has been idle for long enough.

```
CONTINUE        : $(CPU_Idle) && KeyboardIdle > $(ContinueIdleTime)
```

There are two conditions that signal preemption. The first condition is if the job is suspended, but it has been suspended too long. The second condition is if suspension is not desired and the machine is busy.

```
PREEMPT         : ( ($(ActivityTimer) > $(MaxSuspendTime)) && \
                   (Activity == "Suspended") ) || \
                  ( SUSPEND && (WANT_SUSPEND == False) )
```

Kill a job if it has been vacating for too long.

```
KILL            : $(ActivityTimer) > $(MaxVacateTime)
```

Finally, specify periodic checkpointing. For jobs smaller than 60 Mbytes, do a periodic checkpoint every 6 hours. For larger jobs, only checkpoint every 12 hours.

```
PERIODIC_CHECKPOINT     : ( (ImageSize < 60000) && \
                            ($(LastCkpt) > (6 * $(HOUR))) ) || \
                          ( $(LastCkpt) > (12 * $(HOUR)) )
```

For reference, the entire set of policy settings are included once more without comments:

```
##  These macros are here to help write legible expressions:
MINUTE          = 60
HOUR            = (60 * $(MINUTE))
StateTimer      = (CurrentTime - EnteredCurrentState)
ActivityTimer   = (CurrentTime - EnteredCurrentActivity)
ActivationTimer = (CurrentTime - JobStart)
LastCkpt = (CurrentTime - LastPeriodicCheckpoint)

NonCondorLoadAvg        = (LoadAvg - CondorLoadAvg)
BackgroundLoad          = 0.3
HighLoad                = 0.5
StartIdleTime           = 15 * $(MINUTE)
ContinueIdleTime        = 5 * $(MINUTE)
MaxSuspendTime          = 10 * $(MINUTE)
MaxVacateTime           = 5 * $(MINUTE)

KeyboardBusy            = KeyboardIdle < $(MINUTE)
CPU_Idle                = $(NonCondorLoadAvg) <= $(BackgroundLoad)
CPU_Busy                = $(NonCondorLoadAvg) >= $(HighLoad)
MachineBusy             = ($(CPU_Busy) || $(KeyboardBusy))

WANT_SUSPEND            : True
WANT_VACATE             : $(ActivationTimer) > 10 * $(MINUTE)

START           : $(CPU_Idle) && KeyboardIdle > $(StartIdleTime)
SUSPEND         : $(MachineBusy)
CONTINUE        : $(CPU_Idle) && KeyboardIdle > $(ContinueIdleTime)
```

```
PREEMPT          : ( ($(ActivityTimer) > $(MaxSuspendTime)) && \
                    (Activity == "Suspended") ) || \
                   ( $(MachineBusy) && (WANT_SUSPEND == False) )
KILL             : $(ActivityTimer) > $(MaxVacateTime)

PERIODIC_CHECKPOINT      : ( (ImageSize < 60000) && \
                             ($(LastCkpt) > (6 * $(HOUR))) ) || \
                           ( $(LastCkpt) > (12 * $(HOUR)) )
```

UW-Madison CS Condor Pool Policy Settings

Due to a recent increase in the number of Condor users and the size of their jobs (many users here are submitting jobs with an `Imagesize` of more than 100 Mbytes!), we have had to customize our policy to try to better handle this range of `Imagesize`.

Whether or not we suspend or vacate jobs is now a function of the `Imagesize` of the job currently running. We divide the `Imagesize` into three possible categories, which are defined with macros. `Imagesize` is defined in terms of kilobytes.

```
BigJob           = (ImageSize > (30 * 1024))
MediumJob        = (ImageSize <= (30 * 1024) && Image-
Size >= (10 * 1024))
SmallJob         = (ImageSize < (10 * 1024))
```

The policy may be summarized by: If the job is Small, it goes through the normal progression of suspend to vacate to kill based on the tried and true times. If the job is Medium, then when a user returns, the job starts vacating the machine right away. The idea is that with an immediate checkpoint, the job will find all its pages still in memory, and checkpointing will be fast. The memory pages will be freed up as soon as the checkpoint completes. If the job was suspended instead, its pages start getting swapped out and when it is time to checkpoint (10 minutes later), the user's pages will be swapped out again, and the user will see reduced performance. In addition, checkpointing will take much longer. If the job is Big, we do not bother checkpointing, since the checkpointing will not finish before the owner gets too upset. It is a waste to put the load on the network and checkpoint server.

The logic for our special policy is tuned with the `WANT_` expressions. All other expressions and macros use defaults. We want to suspend jobs if they are Small, and we only want to vacate jobs that are Small or Medium. Vanilla jobs are always suspended, regardless of their size.

```
WANT_SUSPEND             : $(SmallJob)
WANT_VACATE              : $(MediumJob) || $(SmallJob)
WANT_SUSPEND_VANILLA     : True
WANT_VACATE_VANILLA      : True
```

The following are the expressions. It is done with macros and the expressions are defined using the macros. As strange as it seems, we do this because it makes for easier customized settings (for example, for testing purposes) and still references the defaults. There is a brief example of this at the end of this section.

```
CS_START        = $(CPU_Idle) && KeyboardIdle > $(StartIdleTime)
CS_SUSPEND      = $(MachineBusy)
CS_CONTINUE     = (KeyboardIdle > $(ContinueIdle-
Time)) && $(CPU_Idle)
CS_PREEMPT      = ( ($(ActivityTimer) > $(MaxSuspendTime)) && \
                   (Activity == "Suspended") ) || \
                  ( CS_SUSPEND && (WANT_SUSPEND == False) )
CS_KILL         = ($(ActivityTimer) > $(MaxVacateTime))
```

We define the expressions in terms of our special macros.

```
START       : $(CS_START)
SUSPEND     : $(CS_SUSPEND)
CONTINUE    : $(CS_CONTINUE)
PREEMPT     : $(CS_PREEMPT)
KILL        : $(CS_KILL)
```

There are no separate vanilla versions of any of these, since we already have a different `WANT_SUSPEND` for vanilla jobs, and all of the policy expressions are written in terms of that.

Periodic checkpoints also take image size into account. We periodically checkpoint Big jobs more frequently (every 3 hours), since the Big jobs are killed right away at eviction time. Utilization of checkpoints is the only way Big jobs make forward progress. However, with all the Big jobs' periodic checkpoints occurring frequently, we do not want to bog down our network or our checkpoint servers. Small or Medium jobs receive a periodic checkpoint every 12 hours, since they get the privilege of checkpointing at eviction time.

```
PERIODIC_CHECKPOINT  : (($(LastCkpt) > (3 * $(HOUR))) \
      && $(BigJob)) || (($(LastCkpt) > (12 * $(HOUR))) && \
      ($(SmallJob) || $(MediumJob)))
```

For reference, the entire set of policy settings are given here, without comments:

```
ActivationTimer = (CurrentTime - JobStart)
StateTimer      = (CurrentTime - EnteredCurrentState)
ActivityTimer   = (CurrentTime - EnteredCurrentActivity)
LastCkpt        = (CurrentTime - LastPeriodicCheckpoint)

NonCondorLoadAvg   = (LoadAvg - CondorLoadAvg)
BackgroundLoad     = 0.3
```

```
HighLoad           = 0.5
StartIdleTime      = 15 * $(MINUTE)
ContinueIdleTime   = 5 * $(MINUTE)
MaxSuspendTime     = 10 * $(MINUTE)
MaxVacateTime      = 5 * $(MINUTE)

KeyboardBusy       = KeyboardIdle < $(MINUTE)
CPU_Idle           = $(NonCondorLoadAvg) <= $(BackgroundLoad)
CPU_Busy           = $(NonCondorLoadAvg) >= $(HighLoad)
MachineBusy        = ($(CPU_Busy) || $(KeyboardBusy))

BigJob       = (ImageSize > (30 * 1024))
MediumJob    = (ImageSize <= (30 * 1024) && Image-
Size >= (10 * 1024))
SmallJob     = (ImageSize < (10 * 1024))

WANT_SUSPEND            : $(SmallJob)
WANT_VACATE             : $(MediumJob) || $(SmallJob)
WANT_SUSPEND_VANILLA    : True
WANT_VACATE_VANILLA     : True

CS_START    = $(CPU_Idle) && KeyboardIdle > $(StartIdleTime)
CS_SUSPEND  = $(CPU_Busy) || $(KeyboardBusy)
CS_CONTINUE = (KeyboardIdle > $(ContinueIdleTime)) && $(CPU_Idle)
CS_PREEMPT  = ( ($(ActivityTimer) > $(MaxSuspendTime)) && \
               (Activity == "Suspended") ) || \
              ( CS_SUSPEND && (WANT_SUSPEND == False) )
CS_KILL     = ($(ActivityTimer) > $(MaxVacateTime))

START       : $(CS_START)
SUSPEND     : $(CS_SUSPEND)
CONTINUE    : $(CS_CONTINUE)
PREEMPT     : $(CS_PREEMPT)
KILL        : $(CS_KILL)

PERIODIC_CHECKPOINT  : (($(LastCkpt) > (3 * $(HOUR))) \
      && $(BigJob)) || (($(LastCkpt) > (12 * $(HOUR))) && \
      ($(SmallJob) || $(MediumJob)))
```

This last example shows how the default macros can be used to set up a machine for testing. Suppose we want the machine to behave normally, except if user coltrane submits a job. In that case, we want that job to start regardless of what is happening on the machine. We do not want the job suspended, vacated or killed. This is reasonable if we know coltrane is submitting very short running programs testing purposes. The jobs should be executed right away. The following configuration works with any machine (or the whole pool, for that matter) with the following 5 expressions:

```
        START      : ($(CS_START)) || Owner == "coltrane"
        SUSPEND    : ($(CS_SUSPEND)) && Owner != "coltrane"
        CONTINUE   : $(CS_CONTINUE)
        PREEMPT    : ($(CS_PREEMPT)) && Owner != "coltrane"
        KILL       : $(CS_KILL)
```

Notice that there is nothing special in either the `CONTINUE` or `KILL` expressions. If Coltrane's jobs never suspend, they never look at `CONTINE`. Similarly, if they never preempt, they never look at `KILL`.

3.6.10 Differences from the Version 6.0 Policy Settings

This section describes how the current policy expressions differ from the policy expressions in previous versions of Condor. If you have never used Condor version 6.0 or earlier, or you never looked closely at the policy settings, skip this section.

In summary, there is no longer a `VACATE` expression, and the `KILL` expression is not evaluated while a machine is claimed. There is a `PREEMPT` expression which describes the conditions when a machine will move from the Claimed state to the Preempting state. Once a machine is transitioning into the Preempting state, the `WANT_VACATE` expression controls whether the job should be vacated with a checkpoint or directly killed. The `KILL` expression determines the transition from Preempting/Vacating to Preempting/Killing.

In previous versions of Condor, the `KILL` expression handled three distinct cases (the transitions from Claimed/Busy, Claimed/Suspended and Preempting/Vacating), and the `VACATE` expression handled two cases (the transitions from Claimed/Busy and Claimed/Suspended). In the current version of Condor, `PREEMPT` handles the same two cases as the previous `VACATE` expression, but the `KILL` expression handles one case. Very complex policies can now be specified using all of the default expressions, only tuning the `WANT_VACATE` and `WANT_SUSPEND` expressions. In previous versions, heavy use of the `WANT_*` expressions caused a complex `KILL` expression.

3.7 DaemonCore

This section is a brief description of *DaemonCore*. DaemonCore is a library that is shared among most of the Condor daemons which provides common functionality. Currently, the following daemons use DaemonCore:

- *condor_master*
- *condor_startd*
- *condor_schedd*
- *condor_collector*

- *condor_negotiator*
- *condor_kbdd*

Most of DaemonCore's details are not interesting for administrators. However, DaemonCore does provide a uniform interface for the daemons to various UNIX signals, and provides a common set of command-line options that can be used to start up each daemon.

3.7.1 DaemonCore and UNIX signals

One of the most visible features DaemonCore provides for administrators is that all daemons which use it behave the same way on certain UNIX signals. The signals and the behavior DaemonCore provides are listed below:

SIGHUP Causes the daemon to reconfigure itself.

SIGTERM Causes the daemon to gracefully shutdown.

SIGQUIT Causes the daemon to quickly shutdown.

Exactly what "gracefully" and "quickly" means varies from daemon to daemon. For daemons with little or no state (the kbdd, collector and negotiator) there's no difference and both signals result in the daemon shutting itself down basically right away. For the master, graceful shutdown just means it asks all of its children to perform their own graceful shutdown methods, while fast shutdown means it asks its children to perform their own fast shutdown methods. In both cases, the master only exits once all its children have exited. In the startd, if the machine is not claimed and running a job, both result in an immediate exit. However, if the startd is running a job, graceful shutdown results in that job being checkpointed, while fast shutdown does not. In the schedd, if there are no jobs currently running (i.e. no *condor_shadow* processes), both signals result in an immediate exit. With jobs running, however, graceful shutdown means that the schedd asks each shadow to gracefully vacate whatever job it is serving, while fast shutdown results in a hard kill of every shadow with no chance of checkpointing.

For all daemons, "reconfigure" just means that the daemon re-reads its config file(s) and any settings that have changed take effect. For example, changing the level of debugging output, the value of timers that determine how often daemons perform certain actions, the paths to the binaries you want the *condor_master* to spawn, etc. See section 3.3 on page 75, "Configuring Condor" for full details on what settings are in the config files and what they do.

3.7.2 DaemonCore and Command-line Arguments

The other visible feature that DaemonCore provides to administrators is a common set of command-line arguments that all daemons understand. The arguments and what they do are described below:

-b Causes the daemon to start up in the background. When a DaemonCore process starts up with this option, disassociates itself from the terminal and forks itself so that it runs in the background. This is the default behavior for Condor daemons, and what you get if you specify no options at all.

-f Causes the daemon to start up in the foreground. Instead of forking, the daemon just runs in the foreground.

NOTE: when the *condor_master* starts up daemons, it does so with the -f option since it has already forked a process for the new daemon. That is why you will see -f in the argument list of all Condor daemons that the master spawns.

-c filename Causes the daemon to use the specified filename (you must use a full path) as its global config file. This overrides the `CONDOR_CONFIG` environment variable, and the regular locations that Condor checks for its config file: the condor user's home directory and `/etc/condor/condor_config`.

-p port Causes the daemon to bind to the specified port for its *command socket*. The master uses this option to make sure the *condor_collector* and *condor_negotiator* start up on the well-known ports that the rest of Condor depends on them using.

-t Causes the daemon to print out its error message to `stderr` instead of its specified log file. This option forces the -f option described above.

-v Causes the daemon to print out version information and exit.

-l directory Overrides the value of `LOG` as specified in your config files. Primarily, this option would be used with the *condor_kbdd* when it needs to run as the individual user logged into the machine, instead of running as root. Regular users would not normally have permission to write files into Condor's log directory. Using this option, they can override the value of `LOG` and have the *condor_kbdd* write its log file into a directory that the user has permission to write to.

-a string Whatever string you specify is automatically appended (with a ".") to the filename of the log for this daemon, as specified in your config file.

-pidfile filename Causes the daemon to write out its PID, or process id number, to the specified file. This file can be used to help shutdown the daemon without searching through the output of the "ps" command.

Since daemons run with their current working directory set to the value of `LOG` , if you don't specify a full path (with a "/" to begin), the file will be left in the log directory. If you leave your pidfile in your log directory, you will want to add whatever filename you use to the `VALID_LOG_FILES` parameter, described in section 3.3.14 on page 100, so that *condor_preen* does not remove it.

-k filename Causes the daemon to read out a pid from the specified filename and send a SIGTERM to that process. The daemon that you start up with "-k" will wait until the daemon it is trying to kill has exited.

-r minutes Causes the daemon to set a timer, upon expiration of which, sends itself a SIGTERM for graceful shutdown.

3.8 Setting Up IP/Host-Based Security in Condor

This section describes the mechanisms for setting up Condor's host-based security. This allows you to control what machines can join your Condor pool, what machines can find out information about your pool, and what machines within your pool can perform administrative commands. By default, Condor is configured to allow anyone to view or join your pool. You probably want to change that.

First, we discuss how the host-based security works inside Condor. Then, we list the different levels of access you can grant and what parts of Condor use which levels. Next, we describe how to configure your pool to grant (or deny) certain levels of access to various machines. Finally, we provide some examples of how you might configure your pool.

3.8.1 How does it work?

Inside the Condor daemons or tools that use DaemonCore (see section 3.7 on "DaemonCore" for details), most things are accomplished by sending commands to another Condor daemon. These commands are just an integer to specify which command, followed by any optional information that the protocol requires at that point (such as a ClassAd, capability string, etc). When the daemons start up, they register which commands they are willing to accept, what to do with them when they arrive, and what access level is required for that command. When a command comes in, Condor sees what access level is required, and then checks the IP address of the machine that sent the command and makes sure it passes the various allow/deny settings in your config file for that access level. If permission is granted, the command continues. If not, the command is aborted.

As you would expect, settings for the access levels in your global config file will affect all the machines in your pool. Settings in a local config file will only affect that specific machine. The settings for a given machine determine what other hosts can send commands to that machine. So, if you want machine "foo" to have administrator access on to machine "bar", you need to put "foo" in bar's config file access list, not the other way around.

3.8.2 Security Access Levels

The following are the various access levels that commands within Condor can be registered with:

`READ` Machines with `READ` access can read information from Condor. For example, they can view the status of the pool, see the job queue(s) or view user permissions. `READ` access does not allow for anything to be changed or jobs to be submitted. Basically, a machine listed with `READ` permission cannot join a condor pool - it can only view information about the pool.

`WRITE` Machines with `WRITE` access can write information to condor. Most notably, it means that it can join your pool by sending ClassAd updates to your central manager and can talk to the other machines in your pool to submit or run jobs. In addition, any machine with `WRITE` access can request the *condor_startd* to perform a periodic checkpoint on any job it is currently executing (after a periodic checkpoint, the job will continue to execute and the machine will still be claimed by whatever schedd had claimed it). This allows users on the machines where they submitted their jobs to use the *condor_checkpoint* command to get their jobs to periodically checkpoint, even if they don't have an account on the remote execute machine.

IMPORTANT: For a machine to join a condor pool, it must have `WRITE` permission **AND** `READ` permission! (Just `WRITE` permission is not enough).

`ADMINISTRATOR` Machines with `ADMINISTRATOR` access have special Condor administrator rights to the pool. This includes things like changing user priorities (with "*condor_userprio -set*"), turning Condor on and off ("*condor_off <machine>*), asking Condor to reconfigure or restart itself, etc. Typically you would want only a couple machines in this list - perhaps the workstations where the Condor administrators or sysadmins typically work, or perhaps just your Condor central manager.

IMPORTANT: This is host-wide access we're talking about. So, if you grant `ADMINISTRATOR` access to a given machine, **ANY USER** on that machine now has `ADMINISTRATOR` rights (including users who can run Condor jobs on that machine). Therefore, you should grant `ADMINISTRATOR` access carefully.

`OWNER` This level of access is required for commands that the owner of a machine (any local user) should be able to use, in addition to the Condor administrators. For example the *condor_vacate* command that causes the *condor_startd* to vacate any running condor job is registered with `OWNER` permission, so that anyone can issue *condor_vacate* to the local machine they are logged into.

`NEGOTIATOR` This access level means that the specified command must come from the Central Manager of your pool. The commands that have this access level are the ones that tell the *condor_schedd* to begin negotiating and that tell an available *condor_startd* that it has been matched to a *condor_schedd* with jobs to run.

`CONFIG` This access level is required to modify a daemon's configuration using *condor_config_val*. Hosts with this level of access will be able to change any configuration parameters, except those specified in the `condor_config.root` configuration file. Therefore, this level of host-wide access should only be granted with extreme caution. By default, `CONFIG` access is denied from all hosts.

3.8.3 Configuring your Pool

The permissions are specified in the config files. See the section on Configuring Condor for details on where these files might be located, general information about how to set parameters, and how to reconfigure the Condor daemons.

`ADMINISTRATOR` and `NEGOTIATOR` access default to your central manager machine. `OWNER` access defaults to the local machine, and any machines listed with `ADMINISTRATOR` access. You can probably leave that how it is. If you want other machines to have `OWNER` access, you probably want them to have `ADMINISTRATOR` access as well. By granting machines `ADMINISTRATOR` access, they would automatically have `OWNER` access, given how `OWNER` access is configured.

For these permissions, you can optionally list an ALLOW or a DENY.

- If you have an ALLOW, it means ”only allow these machines”. No ALLOW means allow anyone.
- If you have a DENY, it means ”deny these machines”. No DENY means to deny nobody.
- If you have both an ALLOW and a DENY, it means allow the machines listed in ALLOW except for the machines listed in DENY.

Therefore, the settings you might set are:

```
HOSTALLOW_READ = <machines>
HOSTDENY_READ = ...
HOSTALLOW_WRITE = ...
HOSTDENY_WRITE = ...
HOSTALLOW_ADMINISTRATOR = ...
HOSTDENY_ADMINISTRATOR = ...
HOSTALLOW_OWNER = ...
HOSTDENY_OWNER = ...
```

Machines can be listed by:

- Individual hostnames - example: condor.cs.wisc.edu
- Individual IP address - example: 128.105.67.29
- IP subnets (use a trailing “*”) - examples: 144.105.*, 128.105.67.*
- Hostnames with a wildcard “*” character (only one “*” is allowed per name) - examples: *.cs.wisc.edu, sol*.cs.wisc.edu

Multiple machine entries can be separated by either a space or a comma.

For resolving something that falls into both allow and deny: Individual machines have a higher order of precedence than wildcard entries, and hostnames with a wildcard have a higher order of precedence than IP subnets. Otherwise, DENY has a higher order of precedence than ALLOW. (this is intuitively how most people would expect it to work).

In addition, you can specify any of the above access levels on a per-daemon basis, instead of machine-wide for all daemons. You do this with the subsystem string (described in section 3.3.1 on “Subsystem Names”), which is one of: “STARTD”, “SCHEDD”, “MASTER”, “NEGOTIATOR”, or “COLLECTOR”. For example, if you wanted to grant different read access for the *condor_schedd*:

```
HOSTALLOW_READ_SCHEDD = <machines>
```

3.8.4 Access Levels each Daemons Uses

Here are all the commands registered in Condor, what daemon registers them, and what permission they are registered with. With this information, you should be able to grant exactly the permission you wish for your pool:

STARTD:

`WRITE` : All commands that relate to a schedd claiming the startd, starting jobs there, and stopping those jobs.

The command that *condor_checkpoint* sends to periodically checkpoint all running jobs.

`READ` : The command that *condor_preen* sends to find the current state of the startd.

`OWNER` : The command that *condor_vacate* sends to vacate any running jobs.

`NEGOTIATOR` : The command that the negotiator sends to match this startd with a given schedd.

NEGOTIATOR:

`WRITE` : The command that initiates a new negotiation cycle (sent by the schedd when new jobs are submitted, or someone issues a *condor_reschedule*).

`READ` : The command that can retrieve the current state of user priorities in the pool (what *condor_userprio* sends).

`ADMINISTRATOR` : The command that can set the current values of user priorities (what *condor_userprio -set* sends).

COLLECTOR:

`WRITE` : All commands that update the collector with new ClassAds.

`READ` : All commands that query the collector for ClassAds.

SCHEDD:

`NEGOTIATOR` : The command that the negotiator sends to begin negotiating with this schedd to match its jobs with available startds.

`WRITE` : The command which *condor_reschedule* sends to the schedd to get it to update the collector with a current ClassAd and begin a negotiation cycle.

The commands that a startd sends to the schedd when it must vacate its jobs and release the schedd's claim.

The commands which write information into the job queue (such as *condor_submit*, *condor_hold*, etc). Note that for most commands which try to write to the job queue, Condor will perform an additional user-level authentication step. This additional user-level authentication prevents, for example, an ordinary user from removing a different user's jobs.

`OWNER` : The command that *condor_reconfig_schedd* sends to get the schedd to re-read it's config files.

`READ` : The command which all tools which view the status of the job queue send (such as *condor_q*).

MASTER: All commands are registered with `ADMINISTRATOR` access:

reconfig : Master and all its children reconfigure themselves

restart : Master restarts itself (and all its children)

off : Master shuts down all its children

on : Master spawns all the daemons it's configured to spawn

master_off : Master shuts down all its children and exits

3.8.5 Access Level Examples

Notice in all these examples that `ADMINISTRATOR` access is only granted through a HOSTALLOW setting to explicitly grant access to a small number of machines. We recommend this.

- Let anyone join your pool. Only your central manager has administrative access (this is the default that ships with Condor)

  ```
  HOSTALLOW_ADMINISTRATOR = $(CONDOR_HOST)
  HOSTALLOW_OWNER = $(FULL_HOSTNAME), $(HOSTALLOW_ADMINISTRATOR)
  ```

- Only allow machines at NCSA to join or view the pool, Central Manager is the only machine with `ADMINISTRATOR` access.

  ```
  HOSTALLOW_READ = *.ncsa.uiuc.edu
  HOSTALLOW_WRITE = *.ncsa.uiuc.edu
  HOSTALLOW_ADMINISTRATOR = $(CONDOR_HOST)
  HOSTALLOW_OWNER = $(FULL_HOSTNAME), $(HOSTALLOW_ADMINISTRATOR)
  ```

- Only allow machines at NCSA and U of I Math department join the pool, EXCEPT do **not** allow lab machines to do so. Also do not allow the 177.55 subnet (perhaps this is the dial-in subnet). Allow anyone to view pool statistics. Only let ”bigcheese” administer the pool (not the central manager).

```
HOSTALLOW_WRITE = *.ncsa.uiuc.edu, *.math.uiuc.edu
HOSTDENY_WRITE = lab-*.edu, *.lab.uiuc.edu, 177.55.*
HOSTALLOW_ADMINISTRATOR = bigcheese.ncsa.uiuc.edu
HOSTALLOW_OWNER = $(FULL_HOSTNAME), $(HOSTALLOW_ADMINISTRATOR)
```

- Only allow machines at NCSA and UW-Madison's CS department to view the pool. Only NCSA machines and "raven.cs.wisc.edu" can join the pool: (Note: raven has the read access it needs through the wildcard setting in HOSTALLOW_READ). This example also shows how you could use "\" to continue a long list of machines onto multiple lines, making it more readable (this works for all config file entries, not just host access entries, see section 3.3 on "Configuring Condor" for details).

```
HOSTALLOW_READ = *.ncsa.uiuc.edu, *.cs.wisc.edu
HOSTALLOW_WRITE = *.ncsa.uiuc.edu, raven.cs.wisc.edu
HOSTALLOW_ADMINISTRATOR = $(CONDOR_HOST), bigcheese.ncsa.uiuc.edu, \
                          biggercheese.uiuc.edu
HOSTALLOW_OWNER = $(FULL_HOSTNAME), $(HOSTALLOW_ADMINISTRATOR)
```

- Allow anyone except the military to view the status of your pool, but only let machines at NCSA view the job queues. Only NCSA machines can join the pool. The central manager, bigcheese, and biggercheese can perform most administrative functions. However, only "biggercheese" can update user priorities.

```
HOSTDENY_READ = *.mil
HOSTALLOW_READ_SCHEDD = *.ncsa.uiuc.edu
HOSTALLOW_WRITE = *.ncsa.uiuc.edu
HOSTALLOW_ADMINISTRATOR = $(CONDOR_HOST), bigcheese.ncsa.uiuc.edu, \
                          biggercheese.uiuc.edu
HOSTALLOW_ADMINISTRATOR_NEGOTIATOR = biggercheese.uiuc.edu
HOSTALLOW_OWNER = $(FULL_HOSTNAME), $(HOSTALLOW_ADMINISTRATOR)
```

3.9 Using X.509 Certificates for Authentication

3.9.1 Introduction to X.509 Authentication

Condor can use the same authentication technology as that used for secure connections in web browsers, i.e., SSL authentication with X.509 certificates.

SSL, an abbreviation for "secure sockets layer", was developed in the Netscape web browser and has since become a de-facto industry standard. Versions of Condor which include this technology supports the authentication method GSS, an abbreviation of "Generic Security Services". The primary difference between SSL and GSS is that GSS is a security API which uses the underlying mechanisms of SSL to accomplish such tasks as user authentication, key exchange, and secure communication. The implementation of SSL used is SSLeay, which is written in Australia, and therefore not subject to the U.S. encryption technology export guidelines. The maintenance of SSLeay was adopted by the OpenSSL group, which oversees its continuing development and documentation. However, the implementation of GSS used in Condor is part of the Globus software http://www.globus.org, which uses the older SSLeay technology. The export restrictions in effect at the time of this writing precludes the Condor team from making this capability available to the general public, and can only be distributed on a case-by-case basis. Email condor-admin@cs.wisc.edu for information.

These technologies use an X.509 certificate hierarchy with public-key cryptography to accomplish two tasks- Key Distribution and User Authentication.

Here is a simplified version of how this works: A public/private keypair (usually RSA) is generated by a CA. All private keys must be safeguarded by their owner against compromise. Public keys are incorporated into a certificate, which is a binding between an X.500 hierarchical name identity and a public key. Public keys (and likewise, certificates) do not need to be protected from disclosure to unauthorized parties (a.k.a. compromise), and can be distributed with software or by insecure electronic means, such as web sites, information servers, etc.

A user wishing to acquire an X.509 certificate also creates a keypair, safeguarding his private key. The public key is incorporated into a ”certificate request”, which is usually an email message to the CA requesting identity verification and the issuance of a certificate.

If approved, the CA returns to the user a certificate, signed by the CA. A signed certificate is simply the user’s public key and X.509 identity encrypted with the CA’s private key. Anyone who has access to a copy of the CA’s certificate can verify the authenticity of the user’s certificate by decrypting the user’s certificate with the public key contained in the CA’s certficate. Again, the actual implementation is more complicated, but here is a simplified version of how two entities perform mutual authentication: Both the client and server have valid copies of the issuing CA’s certificate. A client informs the server that it wishes to mutually authenticate, so the parties exchange certificates Each party verifies the authenticity of the certificate by decrypting the infomation in the certificate with the public key of the CA. The server can then send some value to the client, encrypted with the public key of the client. Only the client can decrypt the ciphertext and read the value. The client performs a transformation of the value, and encrypts the result with the public key of the server and returns this information. Once the parties are satisfied as to the identity of the other party, it is possible to establish a secure connection between the client and server by negotiating a session key and security. Globus (and therefore, Condor) do not perform this final step of establishing a secure connection because of cryptographic export controls.

3.9.2 Using X.509 Authentication in Condor

To use GSS authentication in Condor, the pool administrator(s) must also act as a Certification Authority (CA), as well as maintaining an authorization list. Although these are actually two separate but related activities, for the purposes of simplification, consider both these tasks to be the responsibility of a CA. The CA may perform several tasks, including:

1. Create a local CA with the tool *create_ca*

2. Use the tool *condor_ca* to issue host certificates, as well as to sign host and user certificate requests. The *condor_ca* utility is a script which automates, configures and simplifies several of the complex tasks in the setup and maintenance of a CA.

Instructions for installing SSLeay and creating a Condor CA

1. Download and install SSLeay. See http://www2.psy.uq.edu.au/ ftp/Crypto/#Where to get SSLeay - FTP site list for download sites. See http://www2.psy.uq.edu.au/ ftp/Crypto/ for general information. <u>NOTE</u>: There is an error in the SSLeay Makefile. For compilation on Solaris, you have to add -lsocket -nsl to the EX_LIB line in Makefile.ssl
2. The SSL executables *ssleay* and *c_hash* must be in the path of the administrator and any users who want to create certificate requests. If not already normally installed at your site, just symlink these files to the condor bin directory.
3. Use *perl* to run the *create_ca.pl* script, providing the fully-qualified pathname of the install directory (e.g., perl create_ca.pl /usr/local/condor/ca). This will create the install directory and install several needed files there. <u>NOTE</u>: During installation, you will be asked to create a pass-phrase, verify it, and then enter it when your key is used to generate the CA certificate. If you mistype your passphrase, the SSL programs die in a messy manner. This script tries to at least do some graceful cleanup.
4. Create a symbolic link from ¡CA install directory¿/condor_cert to a directory in the user's path, preferably the condor bin directory
5. Create certificate directories for daemons using authentication by running: ¡CA install directory¿/*condor_ca* -daemon ¡daemon certificate directory¿ <u>NOTE</u>: Daemon names in the certificate must be of the form: schedd@<fully qualfied host name>
6. Sign certificate requests ONLY when you are VERY sure of the identity of the requestor. For example, have the user email you their certificate request, and verify their existance with out of band means. to sign certificates:

   ```
   condor_ca <in cert request> <out signed cert file>
   ```

7. Add a line to the local condor configuation file defining

   ```
   CONDOR_CERT_DIR = <full path of this daemon's certificate di-
   rectory>.
   ```

8. The local condor configuration file must also have the `AUTHENTICATION_METHODS` value defined, and it must include the value GSS.
9. Restart the daemon.

Instructions for Acquiring User Certificates for X.509 Authentication

1. The SSL executables *ssleay* and *c_hash* must be in the path of the administrator and any users who want to create certificate requests. If not already normally installed at your site, just symlink these files to the condor bin directory.
2. `run: condor_cert <certificate directory to create>`
   `[suggested directory: $HOME/.condorcerts]`
3. Upon success, mail the certificate request (¡cert dir¿/usercert_request.pem) to your CA account or condor admin account (at cs.wisc.edu, it's "condorca")
4. If approved, the admin will send you a signed certificate, which you must save as ¡cert dir¿/usercert.pem
5. Authenticated submissions require a variable "x509Directory" to be specified in the submit file, which is set to the full path of their certificate directory. Under the current configuration, the new schedd will allow remote submission if its AUTHENTICATION_METHODS includes GSS. Here is a sample submission file:

```
x509Directory = /home/yourname/.condorcerts
notify_user = mikeu@cs.wisc.edu
executable = testit
input = in.$(Process)
output = out.$(Process)
queue 2
```

3.10 Managing your Condor Pool

There are a number of administrative tools Condor provides to help you manage your pool. The following sections describe various tasks you might wish to perform on your pool and explains how to most efficiently do them.

All of the commands described in this section must be run from a machine listed in the `HOST_ALLOW_ADMINISTRATOR` setting in your config files, so that the IP/host-based security allows the administrator commands to be serviced. See section 3.8 on page 145 for full details about IP/host-based security in Condor.

3.10.1 Shutting Down and Restarting your Condor Pool

There are a couple of situations where you might want to shutdown and restart your entire Condor pool. In particular, when you want to install new binaries, it is generally best to make sure no jobs are running, shutdown Condor, and then install the new daemons.

Shutting Down your Condor Pool

The best way to shutdown your pool is to take advantage of the remote administration capabilities of the *condor_master*. The first step is to save the IP address and port of the *condor_master* daemon on all of your machines to a file, so that even if you shutdown your *condor_collector*, you can still send administrator commands to your different machines. You do this with the following command:

```
        % condor_status -master -format "%s\n" MasterI-
pAddr > addresses
```

The first step to shutting down your pool is to shutdown any currently running jobs and give them a chance to checkpoint. Depending on the size of your pool, your network infrastructure, and the image-size of the standard jobs running in your pool, you may want to make this a slow process, only vacating one host at a time. You can either shutdown hosts that have jobs submitted (in which case all the jobs from that host will try to checkpoint simultaneously), or you can shutdown individual hosts that are running jobs. To shutdown a host, simply send:

```
        % condor_off hostname
```

where “hostname” is the name of the host you want to shutdown. This will only work so long as your *condor_collector* is still running. Once you have shutdown Condor on your central manager, you will have to rely on the `addresses` file you just created.

If all the running jobs are checkpointed and stopped, or if you’re not worried about the network load put in effect by shutting down everything at once, it is safe to turn off all daemons on all machines in your pool. You can do this with one command, so long as you run it from a blessed administrator machine:

```
        % condor_off ‘cat addresses‘
```

where `addresses` is the file where you saved your master addresses. *condor_off* will shutdown all the daemons, but leave the *condor_master* running, so that you can send a *condor_on* in the future.

Once all of the Condor daemons (except the *condor_master*) on each host is turned off, you’re done. You are now safe to install new binaries, move your checkpoint server to another host, or any other task that requires the pool to be shutdown to successfully complete.

NOTE: If you are planning to install a new *condor_master* binary, be sure to read the following section for special considerations with this somewhat delicate task.

Installing a New condor_master

If you are going to be installing a new *condor_master* binary, there are a few other steps you should take. If the *condor_master* restarts, it will have a new port it is listening on, so your `addresses` file will be stale information. Moreover, when the master restarts, it doesn't know that you sent it a *condor_off* in its past life, and will just start up all the daemons it's configured to spawn unless you explicitly tell it otherwise.

If you just want your pool to completely restart itself whenever the master notices its new binary, neither of these issues are of any concern and you can skip this (and the next) section. Just be sure installing the new master binary is the last thing you install, and once you put the new binary in place, the pool will restart itself over the next 5 minutes (whenever all the masters notice the new binary, which they each check for once every 5 minutes by default).

However, if you want to have absolute control over when the rest of the daemons restart, you must take a few steps.

1. Put the following setting in your global config file:

   ```
           START_DAEMONS = False
   ```

   This will make sure that when the master restarts itself that it doesn't also start up the rest of its daemons.

2. Install your new *condor_master* binary.

3. Start up Condor on your central manager machine. You will have to do this manually by logging into the machine and sending commands locally. First, send a *condor_restart* to make sure you've got the new master, then send a *condor_on* to start up the other daemons (including, most importantly, the *condor_collector*).

4. Wait 5 minutes, such that all the masters have a chance to notice the new binary, restart themselves, and send an update with their new address. Make sure that:

   ```
           % condor_status -master
   ```

   lists all the machines in your pool.

5. Remove the special setting from your global config file.

6. Recreate your `addresses` file as described above:

   ```
           % condor_status -master -format "%s\n" MasterI-
   pAddr > addresses
   ```

Once the new master is in place, and you're ready to start up your pool again, you can restart your whole pool by simply following the steps in the next section.

Restarting your Condor Pool

Once you are done performing whatever tasks you need to perform and you're ready to restart your pool, you simply have to send a *condor_on* to all the *condor_master* daemons on each host. You can do this with one command, so long as you run it from a blessed administrator machine:

```
        % condor_on ‘cat addresses‘
```

That's it. All your daemons should now be restarted, and your pool will be back on its way.

3.10.2 Reconfiguring Your Condor Pool

If you change a global config file setting and want to have all your machines start to use the new setting, you must send a *condor_reconfig* command to each host. You can do this with one command, so long as you run it from a blessed administrator machine:

```
        % condor_reconfig ‘condor_status -master‘
```

NOTE: If your global config file is not shared among all your machines (using a shared filesystem), you will need to make the change to each copy of your global config file before sending the *condor_reconfig*.

3.11 Setting up Condor for Special Environments

The following sections describe how to setup Condor for use in a number of special environments or configurations. See section 3.4 on page 104 for installation instructions for the various "contrib modules" that you can optionally download and install in your pool.

3.11.1 Using Condor with AFS

If you are using AFS at your site, be sure to read section 3.3.5 on "Shared Filesystem Config Files Entries" for details on configuring your machines to interact with and use shared filesystems, AFS in particular.

Condor does not currently have a way to authenticate itself to AFS. This is true of the Condor daemons that would like to authenticate as AFS user Condor, and the *condor_shadow*, which would like to authenticate as the user who submitted the job it is serving. Since neither of these things can happen yet, there are a number of special things people who use AFS with Condor must do. Some of this must be done by the administrator(s) installing Condor. Some of this must be done by Condor users who submit jobs.

AFS and Condor for Administrators

The most important thing is that since the Condor daemons can't authenticate to AFS, the `LOCAL_DIR` (and it's subdirectories like "log" and "spool") for each machine must be either writable to unauthenticated users, or must not be on AFS. The first option is a **VERY** bad security hole so you should **NOT** have your local directory on AFS. If you've got NFS installed as well and want to have your `LOCAL_DIR` for each machine on a shared file system, use NFS. Otherwise, you should put the `LOCAL_DIR` on a local partition on each machine in your pool. This means that you should run *condor_install* to install your release directory and configure your pool, setting the `LOCAL_DIR` parameter to some local partition. When that's complete, log into each machine in your pool and run *condor_init* to set up the local Condor directory.

The `RELEASE_DIR`, which holds all the Condor binaries, libraries and scripts can and probably should be on AFS. None of the Condor daemons need to write to these files, they just need to read them. So, you just have to make your `RELEASE_DIR` world readable and Condor will work just fine. This makes it easier to upgrade your binaries at a later date, means that your users can find the Condor tools in a consistent location on all the machines in your pool, and that you can have the Condor config files in a centralized location. This is what we do at UW-Madison's CS department Condor pool and it works quite well.

Finally, you might want to setup some special AFS groups to help your users deal with Condor and AFS better (you'll want to read the section below anyway, since you're probably going to have to explain this stuff to your users). Basically, if you can, create an AFS group that contains all unauthenticated users but that is restricted to a given host or subnet. You're supposed to be able to make these host-based ACLs with AFS, but we've had some trouble getting that working here at UW-Madison. What we have instead is a special group for all machines in our department. So, the users here just have to make their output directories on AFS writable to any process running on any of our machines, instead of any process on any machine with AFS on the Internet.

AFS and Condor for Users

The *condor_shadow* process runs on the machine where you submitted your Condor jobs and performs all file system access for your jobs. Because this process isn't authenticated to AFS as the user who submitted the job, it will not normally be able to write any output. So, when you submit jobs, any directories where your job will be creating output files will need to be world writable (to non-authenticated AFS users). In addition, if your program writes to `stdout` or `stderr`, or you're using a user log for your jobs, those files will need to be in a directory that's world-writable.

Any input for your job, either the file you specify as input in your submit file, or any files your program opens explicitly, needs to be world-readable.

Some sites may have special AFS groups set up that can make this unauthenticated access to your files less scary. For example, there's supposed to be a way with AFS to grant access to any unauthenticated process on a given host. That way, you only have to grant write access to unauthenticated processes on your submit machine, instead of any unauthenticated process on the Internet. Similarly, unauthenticated read access could be granted only to processes running your submit machine. Ask your AFS administrators about the existence of such AFS groups and details of how to use them.

The other solution to this problem is to just not use AFS at all. If you have disk space on your submit machine in a partition that is not on AFS, you can submit your jobs from there. While the *condor_shadow* is not authenticated to AFS, it does run with the effective UID of the user who submitted the jobs. So, on a local (or NFS) file system, the *condor_shadow* will be able to access your files normally, and you won't have to grant any special permissions to anyone other than yourself. If the Condor daemons are not started as root however, the shadow will not be able to run with your effective UID, and you'll have a similar problem as you would with files on AFS. See the section on "Running Condor as Non-Root" for details.

3.11.2 Configuring Condor for Multiple Platforms

Beginning with Condor version 6.0.1, you can use a single, global config file for all platforms in your Condor pool, with only platform-specific settings placed in separate files. This greatly simplifies administration of a heterogeneous pool by allowing you to change platform-independent, global settings in one place, instead of separately for each platform. This is made possible by the `LOCAL_CONFIG_FILE` parameter being treated by Condor as a list of files, instead of a single file. Of course, this will only help you if you are using a shared filesystem for the machines in your pool, so that multiple machines can actually share a single set of configuration files.

If you have multiple platforms, you should put all platform-independent settings (the vast majority) into your regular condor_config file, which would be shared by all platforms. This global file would be the one that is found with the `CONDOR_CONFIG` environment variable, user condor's home directory, or `/etc/condor/condor_config`.

You would then set the `LOCAL_CONFIG_FILE` parameter from that global config file to specify both a platform-specific config file and optionally, a local, machine-specific config file (this parameter is described in section 3.3.2 on "Condor-wide Config File Entries").

The order in which you specify files in the `LOCAL_CONFIG_FILE` parameter is important, because settings in files at the beginning of the list are overridden if the same settings occur in files later in the list. So, if you specify the platform-specific file and then the machine-specific file, settings in the machine-specific file would override those in the platform-specific file (which is probably what you want).

Specifying a Platform-Specific Config File

To specify the platform-specific file, you could simply use the `ARCH` and `OPSYS` parameters which are defined automatically by Condor. For example, if you had Intel Linux machines, Sparc Solaris 2.6 machines, and SGIs running IRIX 6.x, you might have files named:

```
condor_config.INTEL.LINUX
condor_config.SUN4x.SOLARIS26
```

```
        condor_config.SGI.IRIX6
```

Then, assuming these three files were in the directory held in the `ETC` macro, and you were using machine-specific config files in the same directory, named by each machine's hostname, your `LOCAL_CONFIG_FILE` parameter would be set to:

```
  LOCAL_CONFIG_FILE = $(ETC)/condor_config.$(ARCH).$(OPSYS), \
                      $(ETC)/$(HOSTNAME).local
```

Alternatively, if you are using AFS, you can use an "@sys link" to specify the platform-specific config file and let AFS resolve this link differently on different systems. For example, perhaps you have a soft linked named "condor_config.platform" that points to "condor_config.@sys". In this case, your files might be named:

```
        condor_config.i386_linux2
        condor_config.sun4x_56
        condor_config.sgi_64
        condor_config.platform -> condor_config.@sys
```

and your `LOCAL_CONFIG_FILE` parameter would be set to:

```
  LOCAL_CONFIG_FILE = $(ETC)/condor_config.platform, \
                      $(ETC)/$(HOSTNAME).local
```

Platform-Specific Config File Settings

The only settings that are truly platform-specific are:

`RELEASE_DIR` Full path to where you have installed your Condor binaries. While the config files may be shared among different platforms, the binaries certainly cannot. Therefore, you must still maintain separate release directories for each platform in your pool. See section 3.3.2 on "Condor-wide Config File Entries" for details.

`MAIL` The full path to your mail program. See section 3.3.2 on "Condor-wide Config File Entries" for details.

`CONSOLE_DEVICES` Which devices in /dev should be treated as "console devices". See section 3.3.8 on "condor_startd Config File Entries" for details.

`DAEMON_LIST` Which daemons the *condor_master* should start up. The only reason this setting is platform-specific is because on Alphas running Digital Unix and SGIs running IRIX, you must use the *condor_kbdd*, which is not needed on other platforms. See section 3.3.7 on "condor_master Config File Entries" for details.

Reasonable defaults for all of these settings will be found in the default config files inside a given platform's binary distribution (except the `RELEASE_DIR` , since it is up to you where you want to install your Condor binaries and libraries). If you have multiple platforms, simply take one of the condor_config files you get from either running *condor_install* or from the `<release_dir>/etc/examples/condor_config.generic` file, take these settings out and save them into a platform-specific file, and install the resulting platform-independent file as your global config file. Then, find the same settings from the config files for any other platforms you are setting up and put them in their own platform specific files. Finally, set your `LOCAL_CONFIG_FILE` parameter to point to the appropriate platform-specific file, as described above.

Not even all of these settings are necessarily going to be different. For example, if you have installed a mail program that understands the "-s" option in `/usr/local/bin/mail` on all your platforms, you could just set `MAIL` to that in your global file and not define it anywhere else. If you've only got Digital Unix and IRIX machines, the `DAEMON_LIST` will be the same for each, so there's no reason not to put that in the global config file (or, if you have no IRIX or Digital Unix machines, `DAEMON_LIST` won't have to be platform-specific either).

Other Uses for Platform-Specific Config Files

It is certainly possible that you might want other settings to be platform-specific as well. Perhaps you want a different startd policy for one of your platforms. Maybe different people should get the email about problems with different platforms. There's nothing hard-coded about any of this. What you decide should be shared and what should not is entirely up to you and how you lay out your config files.

Since the `LOCAL_CONFIG_FILE` parameter can be an arbitrary list of files, you can even break up your global, platform-independent settings into separate files. In fact, your global config file might only contain a definition for `LOCAL_CONFIG_FILE` , and all other settings would be handled in separate files.

You might want to give different people permission to change different Condor settings. For example, if you wanted some user to be able to change certain settings, but nothing else, you could specify those settings in a file which was early in the `LOCAL_CONFIG_FILE` list, give that user write permission on that file, then include all the other files after that one. That way, if the user was trying to change settings she/he shouldn't, they would simply be overridden.

As you can see, this mechanism is quite flexible and powerful. If you have very specific configuration needs, they can probably be met by using file permissions, the `LOCAL_CONFIG_FILE` setting, and your imagination.

3.11.3 Full Installation of condor_compile

In order to take advantage of two major Condor features: checkpointing and remote system calls, users of the Condor system need to relink their binaries. Programs that are not relinked for Condor can run in Condor's "vanilla" universe just fine, however, they cannot checkpoint and migrate, or run on machines without a shared filesystem.

To relink your programs with Condor, we provide a special tool, *condor_compile*. As installed by default, *condor_compile* works with the following commands: *gcc*, *g++*, *g77*, *cc*, *acc*, *c89*, *CC*, *f77*, *fort77*, *ld*. On Solaris and Digital Unix, *f90* is also supported. See the *condor_compile*(1) man page for details on using *condor_compile*.

However, you can make *condor_compile* work transparently with all commands on your system whatsoever, including *make*.

The basic idea here is to replace the system linker (*ld*) with the Condor linker. Then, when a program is to be linked, the condor linker figures out whether this binary will be for Condor, or for a normal binary. If it is to be a normal compile, the old *ld* is called. If this binary is to be linked for condor, the script performs the necessary operations in order to prepare a binary that can be used with condor. In order to differentiate between normal builds and condor builds, the user simply places *condor_compile* before their build command, which sets the appropriate environment variable that lets the condor linker script know it needs to do its magic.

In order to perform this full installation of *condor_compile*, the following steps need to be taken:

1. Rename the system linker from ld to ld.real.
2. Copy the condor linker to the location of the previous ld.
3. Set the owner of the linker to root.
4. Set the permissions on the new linker to 755.

The actual commands that you must execute depend upon the system that you are on. The location of the system linker (*ld*), is as follows:

```
Operating System              Location of ld (ld-path)
Linux                         /usr/bin
Solaris 2.X                   /usr/ccs/bin
OSF/1 (Digital Unix)          /usr/lib/cmplrs/cc
```

On these platforms, issue the following commands (as root), where *ld-path* is replaced by the path to your system's *ld*.

```
        mv /[ld-path]/ld /[ld-path]/ld.real
        cp /usr/local/condor/lib/ld /[ld-path]/ld
        chown root /[ld-path]/ld
        chmod 755 /[ld-path]/ld
```

On IRIX, things are more complicated in that there are multiple *ld* binaries that need to be moved, and symbolic links need to be made in order to convince the linker to work, since it looks at the name of it's own binary in order to figure out what to do.

```
        mv /usr/lib/ld /usr/lib/ld.real
        mv /usr/lib/uld /usr/lib/uld.real
        cp /usr/local/condor/lib/ld /usr/lib/ld
        ln /usr/lib/ld /usr/lib/uld
        chown root /usr/lib/ld /usr/lib/uld
        chmod 755 /usr/lib/ld /usr/lib/uld
        mkdir /usr/lib/condor
        chown root /usr/lib/condor
        chmod 755 /usr/lib/condor
        ln -s /usr/lib/uld.real /usr/lib/condor/uld
        ln -s /usr/lib/uld.real /usr/lib/condor/old_ld
```

If you remove Condor from your system latter on, linking will continue to work, since the condor linker will always default to compiling normal binaries and simply call the real ld. In the interest of simplicity, it is recommended that you reverse the above changes by moving your ld.real linker back to it's former position as ld, overwriting the condor linker. On IRIX, you need to do this for both linkers, and you will probably want to remove the symbolic links as well.

NOTE: If you ever upgrade your operating system after performing a full installation of *condor_compile*, you will probably have to re-do all the steps outlined above. Generally speaking, new versions or patches of an operating system might replace the system ld binary, which would undo the full installation of *condor_compile*.

3.11.4 Installing the *condor_kbdd*

The condor keyboard daemon (*condor_kbdd*) monitors X events on machines where the operating system does not provide a way of monitoring the idle time of the keyboard or mouse. In particular, this is necessary on Digital Unix machines and IRIX machines.

NOTE: If you are running on Solaris, Linux, or HP/UX, you do not need to use the keyboard daemon.

Although great measures have been taken to make this daemon as robust as possible, the X window system was not designed to facilitate such a need, and thus is less then optimal on machines where many users log in and out on the console frequently.

In order to work with X authority, the system by which X authorizes processes to connect to X servers, the condor keyboard daemon needs to run with super user privileges. Currently, the daemon assumes that X uses the `HOME` environment variable in order to locate a file named `.Xauthority`, which contains keys necessary to connect to an X server. The keyboard daemon attempts to set this environment variable to various users home directories in order to gain a connection to the X server and monitor events. This may fail to work on your system, if you are using a non-standard approach. If the keyboard daemon is not allowed to attach to the X server, the state of a machine may be incorrectly set to idle when a user is, in fact, using the machine.

In some environments, the keyboard daemon will not be able to connect to the X server because the user currently logged into the system keeps their authentication token for using the X server in a place that no local user on the current machine can get to. This may be the case if you are running AFS and have the user's X authority file in an AFS home directory. There may also be cases where you cannot run the daemon with super user privileges because of political reasons, but you would still like to be able to monitor X activity. In these cases, you will need to change your XDM configuration in order to start up the keyboard daemon with the permissions of the currently logging in user. Although your situation may differ, if you are running X11R6.3, you will probably want to edit the files in /usr/X11R6/lib/X11/xdm. The Xsession file should have the keyboard daemon startup at the end, and the Xreset file should have the keyboard daemon shutdown. As of patch level 4 of Condor version 6.0, the keyboard daemon has some additional command line options to facilitate this. The -l option can be used to write the daemons log file to a place where the user running the daemon has permission to write a file. We recommend something akin to $HOME/.kbdd.log since this is a place where every user can write and won't get in the way. The -pidfile and -k options allow for easy shutdown of the daemon by storing the process id in a file. You will need to add lines to your XDM config that look something like this:

```
condor_kbdd -l $HOME/.kbdd.log -pidfile $HOME/.kbdd.pid
```

This will start the keyboard daemon as the user who is currently logging in and write the log to a file in the directory $HOME/.kbdd.log/. Also, this will save the process id of the daemon to /.kbdd.pid, so that when the user logs out, XDM can simply do a:

```
condor_kbdd -k $HOME/.kbdd.pid
```

This will shutdown the process recorded in /.kbdd.pid and exit.

To see how well the keyboard daemon is working on your system, review the log for the daemon and look for successful connections to the X server. If you see none, you may have a situation where the keyboard daemon is unable to connect to your machines X server. If this happens, please send mail to condor-admin@cs.wisc.edu and let us know about your situation.

3.11.5 Installing a Checkpoint Server

The Checkpoint Server maintains a repository for checkpoint files. Using checkpoint servers reduces the disk requirements of submitting machines in the pool, since the submitting machines no longer need to store checkpoint files locally. Checkpoint server machines should have a large amount of disk space available, and they should have a fast connection to machines in the Condor pool.

If your spool directories are on a network file system, then checkpoint files will make two trips over the network: one between the submitting machine and the execution machine, and a second between the submitting machine and the network file server. If you install a checkpoint server and configure it to use the server's local disk, the checkpoint will travel only once over the network, between the execution machine and the checkpoint server. You may also obtain checkpointing network performance benefits by using multiple checkpoint servers, as discussed below.

NOTE: It is a good idea to pick very stable machines for your checkpoint servers. If individual checkpoint servers crash, the Condor system will continue to operate, although poorly. While the Condor system will recover from a checkpoint server crash as best it can, there are two problems that can (and will) occur:

1. A checkpoint cannot be sent to a checkpoint server that is not functioning. Jobs will keep trying to contact the checkpoint server, backing off exponentially in the time they wait between attempts. Normally, jobs only have a limited time to checkpoint before they are kicked off the machine. So, if the server is down for a long period of time, chances are that a lot of work will be lost by jobs being killed without writing a checkpoint.
2. If a checkpoint is not available from the checkpoint server, a job cannot be retrieved, and it will either have to be restarted from the beginning, or the job will wait for the server to come back online. This behavior is controlled with the `MAX_DISCARDED_RUN_TIME` parameter in the config file (see section 3.3.6 on page 88 for details). This parameter represents the maximum amount of CPU time you are willing to discard by starting a job over from scratch if the checkpoint server is not responding to requests.

Preparing to Install a Checkpoint Server

The location of checkpoints changes upon the installation of a checkpoint server. A configuration change would cause currently queued jobs with checkpoints to not be able to find their checkpoints. This results in the jobs with checkpoints remaining indefinitely queued (never running) due to the lack of finding their checkpoints. It is therefore best to either remove jobs from the queues or let them complete before installing a checkpoint server. It is advisable to shut your pool down before doing any maintenance on your checkpoint server. See section 3.10 on page 153 for details on shutting down your pool.

A graduated installation of the checkpoint server may be accomplished by configuring submit machines as their queues empty.

Installing the Checkpoint Server Module

To install a checkpoint server, download the appropriate binary contrib module for the platform(s) on which your server will run. Uncompress and untar the file to result in a directory that contains a `README`, `ckpt_server.tar`, and so on. The file `ckpt_server.tar` acts much like the `release.tar` file from a main release. This archive contains the files:

```
        sbin/condor_ckpt_server
        sbin/condor_cleanckpts
        etc/examples/condor_config.local.ckpt.server
```

These new files are not found in the main release, so you can safely untar the archive directly into your existing release directory. `condor_ckpt_server` is the checkpoint server binary. `condor_cleanckpts` is a script that can be periodically run to remove stale checkpoint files from your server. The checkpoint server normally cleans all old files itself. However, in certain error situations, stale files can be left that are no longer needed. You may set up a cron job that calls *condor_cleanckpts* every week or so to automate the cleaning up of any stale files. The example configuration file give with the module is described below.

After unpacking the module, there are three steps to complete. Each is discussed in its own section:

1. Configure the checkpoint server.
2. Start the checkpoint server.
3. Configure your pool to use the checkpoint server.

Configuring a Checkpoint Server

Place settings in the local configuration file of the checkpoint server. The file `etc/examples/condor_config.local.ckpt.server` contains the needed settings. Insert these into the local configuration file of your checkpoint server machine.

The `CKPT_SERVER_DIR` must be customized. The `CKPT_SERVER_DIR` attribute defines where your checkpoint files are to be located. It is better if this is on a very fast local file system (preferably a RAID). The speed of this file system will have a direct impact on the speed at which your checkpoint files can be retrieved from the remote machines.

The other optional settings are:

`DAEMON_LIST` (Described in section 3.3.7). To have the checkpoint server managed by the *condor_master*, the `DAEMON_LIST` entry must have `MASTER` and `CKPT_SERVER`. Add `STARTD` if you want to allow jobs to run on your checkpoint server. Similarly, add `SCHEDD` if you would like to submit jobs from your checkpoint server.

The rest of these settings are the checkpoint server-specific versions of the Condor logging entries, as described in section 3.3.3 on page 81.

`CKPT_SERVER_LOG` The `CKPT_SERVER_LOG` is where the checkpoint server log is placed.

`MAX_CKPT_SERVER_LOG` Sets the maximum size of the checkpoint server log before it is saved and the log file restarted.

`CKPT_SERVER_DEBUG` Regulates the amount of information printed in the log file. Currently, the only debug level supported is `D_ALWAYS`.

Start the Checkpoint Server

To start the newly configured checkpoint server, restart Condor on that host to enable the *condor_master* to notice the new configuration. Do this by sending a *condor_restart* command from any machine with administrator access to your pool. See section 3.8 on page 145 for full details about IP/host-based security in Condor.

Configuring your Pool to Use the Checkpoint Server

After the checkpoint server is running, you change a few settings in your configuration files to let your pool know about your new server:

`USE_CKPT_SERVER` This parameter should be set to TRUE (the default).

`CKPT_SERVER_HOST` This parameter should be set to the full hostname of the machine that is now running your checkpoint server.

It is most convenient to set these parameters in your global configuration file, so they affect all submission machines. However, you may configure each submission machine separately (using local configuration files) if you do not want all of your submission machines to start using the checkpoint server at one time. If `USE_CKPT_SERVER` is set to FALSE, the submission machine will not use a checkpoint server.

Once these settings are in place, send a *condor_reconfig* to all machines in your pool so the changes take effect. This is described in section 3.10.2 on page 156.

Configuring your Pool to Use Multiple Checkpoint Servers

It is possible to configure a Condor pool to use multiple checkpoint servers. The deployment of checkpoint servers across the network improves checkpointing performance. In this case, Condor machines are configured to checkpoint to the *nearest* checkpoint server. There are two main performance benefits to deploying multiple checkpoint servers:

- Checkpoint-related network traffic is localized by intelligent placement of checkpoint servers.
- Faster checkpointing implies that jobs spend less time checkpointing, more time doing useful work, jobs have a better chance of checkpointing successfully before returning a machine to its owner, and workstation owners see Condor jobs leave their machines quicker.

Once you have multiple checkpoint servers running in your pool, the following configuration changes are required to make them active.

First, `USE_CKPT_SERVER` should be set to TRUE (the default) on all submitting machines where Condor jobs should use a checkpoint server. Additionally, `STARTER_CHOOSES_CKPT_SERVER` should be set to TRUE (the default) on these submitting machines. When TRUE, this parameter specifies that the checkpoint server specified by the machine running the job should be used instead of the checkpoint server specified by the submitting machine. See section 3.3.6 on page 88 for more details. This allows the job to use the checkpoint server closest to the machine on which it is running, instead of the server closest to the submitting machine. For convenience, set these parameters in the global configuration file.

Second, set `CKPT_SERVER_HOST` on each machine. As described, this is set to the full hostname of the checkpoint server machine. In the case of multiple checkpoint servers, set this in the local configuraton file. It is the hostname of the nearest server to the machine.

Third, send a *condor_reconfig* to all machines in the pool so the changes take effect. This is described in section 3.10.2 on page 156.

After completing these three steps, the jobs in your pool will send checkpoints to the nearest checkpoint server. On restart, a job will remember where its checkpoint was stored and get it from the appropriate server. After a job successfully writes a checkpoint to a new server, it will remove any previous checkpoints left on other servers.

NOTE: If the configured checkpoint server is unavailable, the job will keep trying to contact that server as described above. It will not use alternate checkpoint servers. This may change in future versions of Condor.

Checkpoint Server Domains

The configuration described in the previous section ensures that jobs will always write checkpoints to their nearest checkpoint server. In some circumstances, it is also useful to configure Condor to localize checkpoint read transfers, which occur when the job restarts from its last checkpoint on a new machine. To localize these transfers, we want to schedule the job on a machine which is near the checkpoint server on which the job's checkpoint is stored.

We can say that all of the machines configured to use checkpoint server "A" are in "checkpoint server domain A." To localize checkpoint transfers, we want jobs which run on machines in a given checkpoint server domain to continue running on machines in that domain, transferring checkpoint files in a single local area of the network. There are two possible configurations which specify what a job should do when there are no available machines in its checkpoint server domain:

- The job can remain idle until a workstation in its checkpoint server domain becomes available.
- The job can try to immediately begin executing on a machine in another checkpoint server domain. In this case, the job transfers to a new checkpoint server domain.

These two configurations are described below.

The first step in implementing checkpoint server domains is to include the name of the nearest checkpoint server in the machine ClassAd, so this information can be used in job scheduling decisions. To do this, add the following configuration to each machine:

```
CkptServer = "$(CKPT_SERVER_HOST)"
STARTD_EXPRS = $(STARTD_EXPRS), CkptServer
```

For convenience, we suggest that you set these parameters in the global config file. Note that this example assumes that `STARTD_EXPRS` is defined previously in your configuration. If not, then you should use the following configuration instead:

```
  CkptServer = "$(CKPT_SERVER_HOST)"
  STARTD_EXPRS = CkptServer
```

Now, all machine ClassAds will include a `CkptServer` attribute, which is the name of the checkpoint server closest to this machine. So, the `CkptServer` attribute defines the checkpoint server domain of each machine.

To restrict jobs to one checkpoint server domain, we need to modify the jobs' `Requirements` expression as follows:

```
  Requirements = ((LastCkptServer == TARGET.CkptServer) || (LastCkpt-
Server =?= UNDEFINED))
```

This `Requirements` expression uses the `LastCkptServer` attribute in the job's ClassAd, which specifies where the job last wrote a checkpoint, and the `CkptServer` attribute in the machine ClassAd, which specifies the checkpoint server domain. If the job has not written a checkpoint yet, the `LastCkptServer` attribute will be UNDEFINED, and the job will be able to execute in any checkpoint server domain. However, once the job performs a checkpoint, `LastCkptServer` will be defined and the job will be restricted to the checkpoint server domain where it started running.

If instead we want to allow jobs to transfer to other checkpoint server domains when there are no available machines in the current checkpoint server domain, we need to modify the jobs' `Rank` expression as follows:

```
  Rank = ((LastCkptServer == TARGET.CkptServer) || (LastCkpt-
Server =?= UNDEFINED))
```

This `Rank` expression will evaluate to 1 for machines in the job's checkpoint server domain and 0 for other machines. So, the job will prefer to run on machines in its checkpoint server domain, but if no such machines are available, the job will run in a new checkpoint server domain.

You can automatically append the checkpoint server domain `Requirements` or `Rank` expressions to all STANDARD universe jobs submitted in your pool using `APPEND_REQ_STANDARD` or `APPEND_RANK_STANDARD` . See section 3.3.13 on page 99 for more details.

3.11.6 Flocking: Configuring a Schedd to Submit to Multiple Pools

The *condor_schedd* may be configured to submit jobs to more than one pool. In the default configuration, the *condor_schedd* contacts the Central Manager specified by the `CONDOR_HOST` macro (described in section 3.3.2 on page 78) to locate execute machines available to run jobs in its queue. However, the `FLOCK_NEGOTIATOR_HOSTS` and `FLOCK_COLLECTOR_HOSTS` macros (described in section 3.3.9 on page 95) may be used to specify additional Central Managers for the *condor_schedd* to contact. When the local pool does not satisfy all job requests, the *condor_schedd* will try the pools specified by these macros in turn until all jobs are satisfied.

`$(HOSTALLOW_NEGOTIATOR_SCHEDD)` (see section 3.3.4) must also be configured to allow negotiators from all of the `$(FLOCK_NEGOTIATOR_HOSTS)` to contact the schedd. Please make sure the `$(NEGOTIATOR_HOST)` is first in the `$(HOSTALLOW_NEGOTIATOR_SCHEDD)` list. Similarly, the central managers of the remote pools must be configured to listen to requests from this schedd.

3.11.7 Configuring The Startd for SMP Machines

This section describes how to configure the *condor_startd* for SMP (Symmetric Multi-Processor) machines. Beginning with Condor version 6.1, machines with more than one CPU can be configured to run more than one job at a time. As always, owners of the resources have great flexibility in defining the policy under which multiple jobs may run, suspend, vacate, etc.

How Shared Resources are Represented to Condor

The way SMP machines are represented to the Condor system is that the shared resources are broken up into individual *virtual machines* ("VM") that can be matched with and claimed by users. Each virtual machine is represented by an individual "ClassAd" (see the ClassAd reference, section 4.1, for details). In this way, a single SMP machine will appear to the Condor system as a collection of separate virtual machines. So for example, if you had an SMP machine named "vulture.cs.wisc.edu", it would appear to Condor as multiple machines, named "vm1@vulture.cs.wisc.edu", "vm2@vulture.cs.wisc.edu", and so on.

You can configure how you want the *condor_startd* to break up the shared system resources into the different virtual machines. All shared system resources (like RAM, disk space, swap space, etc) can either be divided evenly among all the virtual machines, with each CPU getting its own virtual machine, or you can define your own *virtual machine types*, so that resources can be unevenly partitioned. The following section gives details on how to configure Condor to divide the resources on an SMP machine into seperate virtual machines.

Dividing System Resources in SMP Machines

This section describes the settings that allow you to define your own virtual machine types and to control how many virtual machines of each type are reported to Condor.

There are two main ways to go about dividing an SMP machine:

Define your own virtual machine types. By defining your own types, you can specify what fraction of shared system resources (CPU, RAM, swap space and disk space) go to each virtual machine. Once you define your own types, you can control how many of each type are being reported at any given time.

Evenly divide all resources. If you do not define your own types, the *condor_startd* will automatically partition your machine into virtual machines for you. It will do so by giving each VM a single CPU, and evenly dividing all shared resources among each CPU. With this default partitioning, you only have to specify how many VMs are reported at a time. By default, all VMs are reported to Condor.

Begining with Condor version 6.1.6, the number of each type being reported can be changed at run-time, by issuing a simple reconfig to the *condor_startd* (sending a SIGHUP or using *condor_reconfig*). However, the definitions for the types themselves cannot be changed with a reconfig. If you change any VM type definitions, you must use "condor_restart -startd" for that change to take effect.

Defining Virtual Machine Types

To define your own virtual machine types, you simply add config file parameters that list how much of each system resource you want in the given VM type. You do this with settings of the form `VIRTUAL_MACHINE_TYPE_<N>` . The <N> is to be replaced with an integer, for example, `VIRTUAL_MACHINE_TYPE_1`, which specifies the virtual machine type you're defining. You will use this number later to configure how many VMs of this type you want to advertise.

A type describes what share of the total system resources a given virtual machine has available to it.

The type can be defined in a number of ways:

- A simple fraction, such as "1/4"
- A simple percentage, such as "25%"
- A comma-separated list of attributes, and a percentage, fraction, or value for each one.

If you just specify a fraction or percentage, that share of the total system resources, including the number of cpus, will be used for each virtual machine of this type. However, if you specify the comma-seperated list, you can fine-tune the amounts for specific attributes.

Some attributes, such as the number of CPUs and total amount of RAM in the machine, do not change (unless the machine is turned off and more chips are added to it). For these two attributes, you can specify either absolute values, or percentages of the total available amount. For example, in a machine with 128 megs of RAM, you could specify any of the following to get the same effect: "mem=64", "mem=1/2", or "mem=50%". Other resources are dynamic, such as disk space and swap space. For these, you must specify the percentage or fraction of the total value that is alloted to each VM, instead of specifying absolute values. As the total values of these resources change on your machine, each VM will take its fraction of the total and report that as its available amount.

All attribute names are case insensitive when defining VM types. You can use as much or as little of each word as you'd like. The attributes you can tune are:

- cpus
- ram
- disk (must specify with a fraction or percentage)
- swap (must specify with a fraction or percentage)

In addition, the following names are equivalent: "ram" = "memory" and "swap" = "virtualmemory".

Assume the host as 4 CPUs and 256 megs of RAM. Here are some example VM type definitions, all of which are valid. Types 1-3 are all equivalent with each other, as are types 4-6

```
VIRTUAL_MACHINE_TYPE_1 = cpus=2, ram=128, swap=25%, disk=1/2

VIRTUAL_MACHINE_TYPE_2 = cpus=1/2, memory=128, virt=25%, disk=50%

VIRTUAL_MACHINE_TYPE_3 = c=1/2, m=50%, v=1/4, disk=1/2

VIRTUAL_MACHINE_TYPE_4 = c=25%, m=64, v=1/4, d=25%

VIRTUAL_MACHINE_TYPE_5 = 25%

VIRTUAL_MACHINE_TYPE_6 = 1/4
```

Configuring the Number of Virtual Machines Reported

If you are not defining your own VM types, all you have to configure is how many of the evenly divided VMs you want reported to Condor. You do this by setting the `NUM_VIRTUAL_MACHINES` parameter. You just supply the number of machines you want reported. If you do not define this yourself, Condor will advertise all the CPUs in your machines by default.

If you define your own types, things are slightly more complicated. Now, you must specify how many virtual machines of each type should be reported. You do this with settings of the form `NUM_VIRTUAL_MACHINES_TYPE_<N>` . The <N> is to be replaced with an actual number, for example, `NUM_VIRTUAL_MACHINES_TYPE_1`.

Configuring Startd Policy for SMP Machines

NOTE: Be sure you have read and understand section 3.6 on "Configuring The Startd Policy" before you proceed with this section.

Each virtual machine from an SMP is treated as an independent machine, with its own view of its machine state. For now, a single set of policy expressions is in place for all virtual machines simultaneously. Eventually, you will be able to explicitly specify separate policies for each one. However, since you do have control over each virtual machine's view of its own state, you can effectively have separate policies for each resource.

For example, you can configure how many of the virtual machines "notice" console or tty activity on the SMP as a whole. Ones that aren't configured to notice any activity will report ConsoleIdle and KeyboardIdle times from when the startd was started, (plus a configurable number of seconds). So, you can setup a 4 CPU machine with all the default startd policy settings and with the keyboard and console "connected" to only one virtual machine. Assuming there isn't too much load average (see section 3.11.7 below on "Load Average for SMP Machines"), only one virtual machine will suspend or vacate its job when the owner starts typing at their machine again. The rest of the virtual machines could be matched with jobs and leave them running, even while the user was interactively using the machine.

Or, if you wish, you can configure all virtual machines to notice all tty and console activity. In this case, if a machine owner came back to her machine, all the currently running jobs would suspend or preempt (depending on your policy expressions), all at the same time.

All of this is controlled with the config file parameters listed below. These settings are fully described in section 3.3.8 on page 92 which lists all the configuration file settings for the *condor_startd*.

- `VIRTUAL_MACHINES_CONNECTED_TO_CONSOLE`
- `VIRTUAL_MACHINES_CONNECTED_TO_KEYBOARD`
- `DISCONNECTED_KEYBOARD_IDLE_BOOST`

Load Average for SMP Machines

Most operating systems define the load average for an SMP machine as the total load on all CPUs. For example, if you have a 4 CPU machine with 3 CPU-bound processes running at the same time, the load would be 3.0 In Condor, we maintain this view of the total load average and publish it in all resource ClassAds as `TotalLoadAvg`.

However, we also define the "per-CPU" load average for SMP machines. In this way, the model that each node on an SMP is a virtual machine, totally separate from the other nodes, can be maintained. All of the default, single-CPU policy expressions can be used directly on SMP machines, without modification, since the `LoadAvg` and `CondorLoadAvg` attributes are the per-virtual machine versions, not the total, SMP-wide versions.

The per-CPU load average on SMP machines is a number we basically invented. There is no system call you can use to ask your operating system for this value. Here's how it works:

We already compute the load average generated by Condor on each virtual machine. We do this by close monitoring of all processes spawned by any of the Condor daemons, even ones that are orphaned and then inherited by init. This *Condor load average* per virtual machine is reported as `CondorLoadAvg` in all resource ClassAds, and the total Condor load average for the entire machine is reported as `TotalCondorLoadAvg`. We also have the total, system-wide load average for the entire machine (reported as `TotalLoadAvg`). Basically, we walk through all the virtual machines and assign out portions of the total load average to each one. First, we assign out the known Condor load average to each node that is generating any. If there's any load average left in the total system load, that's considered *owner load*. Any virtual machines we already think are in the Owner state (like ones that have keyboard activity, etc), are the first to get assigned this owner load. We hand out owner load in increments of at most 1.0, so generally speaking, no virtual machine has a load average above 1.0. If we run out of total load average before we run out of virtual machines, all the remaining machines think they have no load average at all. If, instead, we run out of virtual machines and we still have owner load left, we start assigning that load to Condor nodes, too, creating individual nodes with a load average higher than 1.0.

Debug logging in the SMP Startd

This section describes how the startd handles its debug messages for SMP machines. In general, a given log message will either be something that is machine-wide (like reporting the total system load average), or it will be specific to a given virtual machine. Any log entrees specific to a virtual machine will have an extra header printed out in the entry: `vm#:`. So, for example, here's the output about system resources that are being gathered (with `D_FULLDEBUG` and `D_LOAD` turned on) on a 2 CPU machine with no Condor activity, and the keyboard connected to both virtual machines:

```
11/25 18:15 Swap space: 131064
11/25 18:15 number of kbytes available for (/home/condor/execute): 1345063
11/25 18:15 Looking up RESERVED_DISK parameter
11/25 18:15 Reserving 5120 kbytes for file system
11/25 18:15 Disk space: 1339943
11/25 18:15 Load avg: 0.340000 0.800000 1.170000
11/25 18:15 Idle Time: user= 0 , console= 4 seconds
11/25 18:15 SystemLoad: 0.340   TotalCondorLoad: 0.000  TotalOwn-
erLoad: 0.340
11/25 18:15 vm1: Idle time: Keyboard: 0        Console: 4
11/25 18:15 vm1: SystemLoad: 0.340  CondorLoad: 0.000  Owner-
Load: 0.340
11/25 18:15 vm2: Idle time: Keyboard: 0        Console: 4
11/25 18:15 vm2: SystemLoad: 0.000  CondorLoad: 0.000  Owner-
Load: 0.000
11/25 18:15 vm1: State: Owner           Activity: Idle
11/25 18:15 vm2: State: Owner           Activity: Idle
```

If, on the other hand, this machine only had one virtual machine connected to the keyboard and console, and the other vm was running a job, it might look something like this:

```
11/25 18:19 Load avg: 1.250000 0.910000 1.090000
```

```
11/25 18:19 Idle Time: user= 0 , console= 0 seconds
11/25 18:19 SystemLoad: 1.250   TotalCondorLoad: 0.996  TotalOwn-
erLoad: 0.254
11/25 18:19 vm1: Idle time: Keyboard: 0        Console: 0
11/25 18:19 vm1: SystemLoad: 0.254  CondorLoad: 0.000  Owner-
Load: 0.254
11/25 18:19 vm2: Idle time: Keyboard: 1496     Console: 1496
11/25 18:19 vm2: SystemLoad: 0.996  CondorLoad: 0.996  Owner-
Load: 0.000
11/25 18:19 vm1: State: Owner           Activity: Idle
11/25 18:19 vm2: State: Claimed         Activity: Busy
```

As you can see, shared system resources are printed without the header (like total swap space), which VM-specific messages (like the load average or state of each VM,) get the special header appended.

3.11.8 Configuring Condor for Machines With Multiple Network Interfaces

Beginning with Condor version 6.1.5, Condor can run on machines with multiple network interfaces. Basically, you tell each host with multiple interfaces which IP address you want the host to use for ingoing and outgoing Condor network communication. You do this by setting the `NETWORK_INTERFACE` parameter in the local config file for each host you need to. There are a few other special cases you might have to deal with, described below.

If your Central Manager is on a machine with multiple interfaces, instead of defining the `COLLECTOR_HOST` or `NEGOTIATOR_HOST` parameters (which are usually both defined in terms of `CONDOR_HOST`), you should set the `CM_IP_ADDR` .

WARNING: The default `HOSTALLOW_ADMINISTRATOR` setting in the config file references `$(CONDOR_HOST)`, and the default `HOSTALLOW_NEGOTIATOR` setting references `$(NEGOTIATOR_HOST)`. So you'll need to change both of these settings to reference `$(CM_IP_ADDR)` instead.

If your Checkpoint Server is on a machine with multiple interfaces, the only way to get things to work is if your different interfaces have different hostnames associated with them, and you set `CKPT_SERVER_HOST` to the hostname that corresponds with the IP address you want to use. You will still need to specify `NETWORK_INTERFACE` in the local config file for your Checkpoint Server.

3.12 Security In Condor

This section describes various aspects of security within Condor.

3.12.1 Running Condor as Non-Root

While we strongly recommend starting up the Condor daemons as root, we understand that that's not always possible. The main problems this causes are if you've got one Condor installation shared by many users on a single machine, or if you're setting up your machines to execute Condor jobs. If you're just setting up a submit-only installation for a single user, there's no need for (or benefit from) running as root.

What follows are the details of what effect running without root access has on the various parts of Condor:

condor_startd If you're setting up a machine to run Condor jobs and don't start the *condor_startd* as root, you're basically relying on the goodwill of your Condor users to agree to the policy you configure the startd to enforce as far as starting, suspending, vacating and killing Condor jobs under certain conditions. If you run as root, however, you can enforce these policies regardless of malicious users. By running as root, the Condor daemons run with a different UID than the Condor job that gets started (since the user's job is started as either the UID of the user who submitted it, or as user "nobody", depending on the `UID_DOMAIN` settings). Therefore, the Condor job cannot do anything to the Condor daemons. If you don't start the daemons as root, all processes started by Condor, including the end user's job, run with the same UID (since you can't switch UIDs unless you're root). Therefore, a user's job could just kill the *condor_startd* and *condor_starter* as soon as it starts up and by doing so, avoid getting suspended or vacated when a user comes back to the machine. This is nice for the user, since they get unlimited access to the machine, but awful for the machine owner or administrator. If you trust the users submitting jobs to Condor, this might not be a concern. However, to ensure that the policy you choose is effectively enforced by Condor, the *condor_startd* should be started as root.

In addition, some system information cannot be obtained without root access on some platforms (such as load average on IRIX). As a result, when we're running without root access, the startd has to call other programs (for example, "uptime") to get this information. This is much less efficient than getting the information directly from the kernel (which is what we do if we're running as root). On Linux and Solaris, we can get this information directly without root access, so this is not a concern on those platforms.

If you can't have all of Condor running as root, at least consider whether you can install the Condorstartd as setuid root. That would solve both of these problems. If you can't do that, you could also install it as a setgid sys or kmem program (depending on whatever group has read access to `/dev/kmem` on your system) and that would at least solve the system information problem.

condor_schedd The biggest problem running the schedd without root access is that the *condor_shadow* processes which it spawns are stuck with the same UID the *condor_schedd* has. This means that users submitting their jobs have to go out of their way to grant write access to user or group condor (or whoever the schedd is running as) for any files or directories their jobs write or create. Similarly, read access must be granted to their input files.

You might consider installing *condor_submit* as a setgid condor program so that at least the `stdout`, `stderr` and `UserLog` files get created with the right permissions. If *condor_submit* is a setgid program, it will automatically set it's umask to 002, so that creates group-writable files. This way, the simple case of a job that just writes to `stdout` and `stderr` will work. If users have programs that open their own files, they'll have to know to set the right permissions on the directories they submit from.

condor_master The *condor_master* is what spawns the *condor_startd* and *condor_schedd*, so if want them both running as root, you should have the master run as root. This happens automatically if you start the master from your boot scripts.

condor_negotiator

condor_collector There is no need to have either of these daemons running as root.

condor_kbdd On platforms that need the *condor_kbdd* (Digital Unix and IRIX) the *condor_kbdd* has to run as root. If it is started as any other user, it will not work. You might consider installing this program as a setuid root binary if you can't run the *condor_master* as root. Without the *condor_kbdd*, the startd has no way to monitor mouse activity at all, and the only keyboard activity it will notice is activity on ttys (such as xterms, remote logins, etc).

3.12.2 UIDs in Condor

This section has not yet been written

3.12.3 Root Config Files

This section has not yet been written

CHAPTER

FOUR

Miscellaneous Concepts

4.1 An Introduction to Condor's ClassAd Mechanism

ClassAds are a flexible mechanism for representing the characteristics and constraints of machines and jobs in the Condor system. ClassAds are used extensively in the Condor system to represent jobs, resources, submitters and other Condor daemons. An understanding of this mechanism is required to harness the full flexibility of the Condor system.

A ClassAd is is a set of uniquely named expressions. Each named expression is called an *attribute*. Figure 4.1 shows an example of a ClassAd with ten attributes.

```
MyType       = "Machine"
TargetType   = "Job"
Machine      = "froth.cs.wisc.edu"
Arch         = "INTEL"
OpSys        = "SOLARIS251"
Disk         = 35882
Memory       = 128
KeyboardIdle = 173
LoadAvg      = 0.1000
Requirements = TARGET.Owner=="smith" || LoadAvg<=0.3 && KeyboardI-
dle>15*60
```

Figure 4.1: An example ClassAd

ClassAd expressions look very much like expressions in C, and are composed of literals and attribute references composed with operators. The difference between ClassAd expressions and C expressions arise from the fact that ClassAd expressions operate in a much more dynamic environment. For example, an expression from a machine's ClassAd may refer to an attribute in a job's ClassAd, such as `TARGET.Owner` in the above example. The value and type of the attribute is not known until the expression is evaluated in an environment which pairs a specific job ClassAd with the machine ClassAd.

ClassAd expressions handle these uncertainties by defining all operators to be *total* operators, which means that they have well defined behavior regardless of supplied operands. This functionality is provided through two distinguished values, `UNDEFINED` and `ERROR`, and defining all operators so that they can operate on all possible values in the ClassAd system. For example, the multiplication operator which usually only operates on numbers, has a well defined behavior if supplied with values which are not meaningful to multiply. Thus, the expression `10 * "A string"` evaluates to the value `ERROR`. Most operators are *strict* with respect to `ERROR`, which means that they evaluate to `ERROR` if any of their operands are `ERROR`. Similarly, most operators are strict with respect to `UNDEFINED`.

4.1.1 Syntax

ClassAd expressions are formed by composing literals, attribute references and other subexpressions with operators.

Literals

Literals in the ClassAd language may be of integer, real, string, undefined or error types. The syntax of these literals is as follows:

Integer A sequence of continuous digits (i.e., `[0-9]`). Additionally, the keywords `TRUE` and `FALSE` (case insensitive) are syntactic representations of the integers 1 and 0 respectively.

Real Two sequences of continuous digits separated by a period (i.e., `[0-9]+.[0-9]+`).

String A double quote character, followed by an list of characters terminated by a double quote character. A backslash character inside the string causes the following character to be considered as part of the string, irrespective of what that character is.

Undefined The keyword `UNDEFINED` (case insensitive) represents the `UNDEFINED` value.

Error The keyword `ERROR` (case insensitive) represents the `ERROR` value.

Attributes

Every expression in a ClassAd is named by an *attribute name*. Together, the (name,expression) pair is called an *attribute*. An attributes may be referred to in other expressions through its attribute name.

Attribute names are sequences of alphabetic characters, digits and underscores, and may not begin with a digit. All characters in the name are significant, but case is *not* significant. Thus, `Memory`, `memory` and `MeMoRy` all refer to the same attribute.

An *attribute reference* consists of the name of the attribute being referenced, and an optional *scope resolution prefix*. The three prefixes that may be used are `MY.`, `TARGET.` and `ENV.`. The semantics of supplying a prefix are discussed in Section 4.1.2.

Operators

The operators that may be used in ClassAd expressions are similar to those available in C. The available operators and their relative precedence is shown in figure 4.2. The operator with the highest

```
-                   (high precedence)
*   /
+   -
<   <=   >=   >
==  !=  =?=  =!=
&&
||                  (low precedence)
```

Figure 4.2: Relative precedence of ClassAd expression operators

precedence is the unary minus operator. The only operators which are unfamiliar are the `=?=` and `=!=` operators, which are discussed in Section 4.1.2.

4.1.2 Evaluation Semantics

The ClassAd mechanism's primary purpose is for matching entities who supply constraints on candidate matches. The mechanism is therefore defined to carry out expression evaluations in the context of two ClassAds which are testing each other for a potential match. For example, the *condor_negotiator* evaluates the `Requirements` expressions of machine and job ClassAds to test if they can be matched. The semantics of evaluating such constraints is defined below.

Literals

Literals are self-evaluating, Thus, integer, string, real, undefined and error values evaluate to themselves.

Attribute References

Since the expression evaluation is being carried out in the context of two ClassAds, there is a potential for namespace ambiguities. The following rules define the semantics of attribute references made by ad A that is being evaluated in a context with another ad B:

1. If the reference is prefixed by a scope resolution prefix,
   - If the prefix is `MY.`, the attribute is looked up in ClassAd A. If the named attribute does not exist in A, the value of the reference is `UNDEFINED`. Otherwise, the value of the reference is the value of the expression bound to the attribute name.
   - Similarly, if the prefix is `TARGET.`, the attribute is looked up in ClassAd B. If the named attribute does not exist in B, the value of the reference is `UNDEFINED`. Otherwise, the value of the reference is the value of the expression bound to the attribute name.
   - Finally, if the prefix is `ENV.`, the attribute is evaluated in the "environment." Currently, the only attribute of the environment is `CurrentTime`, which evaluates to the integer value returned by the system call `time(2)`.
2. If the reference is not prefixed by a scope resolution prefix,
   - If the attribute is defined in A, the value of the reference is the value of the expression bound to the attribute name in A.
   - Otherwise, if the attribute is defined in B, the value of the reference is the value of the expression bound to the attribute name in B.
   - Otherwise, if the attribute is defined in the environment, the value of the reference is the evaluated value in the environment.
   - Otherwise, the value of the reference is `UNDEFINED`.
3. Finally, if the reference refers to an expression that is itself in the process of being evaluated, there is a circular dependency in the evaluation. The value of the reference is `ERROR`.

Operators

All operators in the ClassAd language are *total*, and thus have well defined behavior regardless of the supplied operands. Furthermore, most operators are *strict* with respect to `ERROR` and `UNDEFINED`, and thus evaluate to `ERROR` (or `UNDEFINED`) if either of their operands have these exceptional values.

- **Arithmetic operators:**
  1. The operators `*`, `/`, `+` and `-` operate arithmetically only on integers and reals.
  2. Arithmetic is carried out in the same type as both operands, and type promotions from integers to reals are performed if one operand is an integer and the other real.
  3. The operators are strict with respect to both `UNDEFINED` and `ERROR`.

4. If either operand is not a numerical type, the value of the operation is `ERROR`.

- **Comparison operators:**
  1. The comparison operators ==, !=, <=, <, >= and > operate on integers, reals and strings.
  2. Comparisons are carried out in the same type as both operands, and type promotions from integers to reals are performed if one operand is a real, and the other an integer. Strings may not be converted to any other type, so comparing a string and an integer results in `ERROR`.
  3. The operators ==, !=, <=, < and >= > are strict with respect to both `UNDEFINED` and `ERROR`.
  4. In addition, the operators `=?=` and `=!=` behave similar to `==` and `!=`, but are not strict. Semantically, the `=?=` tests if its operands are "identical," i.e., have the same type and the same value. For example, `10 == UNDEFINED` and `UNDEFINED == UNDEFINED` both evaluate to `UNDEFINED`, but `10 =?= UNDEFINED` and `UNDEFINED =?= UNDEFINED` evaluate to `FALSE` and `TRUE` respectively. The =!= operator test for the "is not identical to" condition.

- **Logical operators:**
  1. The logical operators && and `||` operate on integers and reals. The zero value of these types are considered `FALSE` and non-zero values `TRUE`.
  2. The operators are *not* strict, and exploit the "don't care" properties of the operators to squash `UNDEFINED` and `ERROR` values when possible. For example, `UNDEFINED && FALSE` evaluates to `FALSE`, but `UNDEFINED || FALSE` evaluates to `UNDEFINED`.
  3. Any string operand is equivalent to an `ERROR` operand.

4.1.3 ClassAds in the Condor System

The simplicity and flexibility of ClassAds is heavily exploited in the Condor system. ClassAds are not only used to represent machines and jobs in the Condor pool, but also other entities that exist in the pool such as checkpoint servers, submitters of jobs and master daemons. Since arbitrary expressions may be supplied and evaluated over these ads, users have a uniform and powerful mechanism to specify constraints over these ads. These constraints may take the form of `Requirements` expressions in resource and job ads, or queries over other ads.

Requirements and Ranks

This is the mechanism by which users specify the constraints over machines and jobs respectively. Requirements for machines are specified through configuration files, while requirements for jobs are specified through the submit command file.

In both cases, the `Requirements` expression specifies the correctness criterion that the match must meet, and the `Rank` expression specifies the desirability of the match (where higher numbers mean better matches). For example, a job ad may contain the following expressions:

```
Requirements = Arch=="SUN4u" && OpSys == "SOLARIS251"
Rank         = TARGET.Memory + TARGET.Mips
```

In this case, the customer requires an UltraSparc computer running the Solaris 2.5.1 operating system. Among all such computers, the customer prefers those with large physical memories and high MIPS ratings. Since the `Rank` is a user specified metric, *any* expression may be used to specify the perceived desirability of the match. The *condor_negotiator* runs algorithms to deliver the "best" resource (as defined by the `Rank` expression) while satisfying other criteria.

Similarly, owners of resources may place constraints and preferences on their machines. For example,

```
    Friend        = Owner == "tannenba" || Owner == "wright"
    ResearchGroup = Owner == "jbasney" || Owner == "raman"
    Trusted       = Owner != "rival" && Owner != "riffraff"
    Requirements  = Trusted && ( ResearchGroup || LoadAvg < 0.3 &&
                         KeyboardIdle > 15*60 )
    Rank          = Friend + ResearchGroup*10
```

The above policy states that the computer will never run jobs owned by users "rival" and "riffraff," while the computer will always run a job submitted by members of the research group. Furthermore, jobs submitted by friends are preferred to other foreign jobs, and jobs submitted by the research group are preferred to jobs submitted by friends.

Note: Because of the dynamic nature of ClassAd expressions, there is no *a priori* notion of an integer valued expression, a real valued expression, etc. However, it is intuitive to think of the `Requirements` and `Rank` expressions as integer valued and real valued expressions respectively. If the actual type of the expression is not of the expected type, the value is assumed to be zero.

Querying with ClassAd Expressions

The flexibility of this system may also be used when querying ClassAds through the *condor_status* and *condor_q* tools which allow users to supply ClassAd constraint expressions from the command line.

For example, to find all computers which have had their keyboards idle for more than 20 minutes and have more than 100 MB of memory:

```
% condor_status -const 'KeyboardIdle > 20*60 && Memory > 100'
```

```
Name       Arch     OpSys        State      Activity   Loa-
dAv Mem  ActvtyTime

amul.cs.wi SUN4u    SOLARIS251   Claimed    Busy       1.000  128   0+03:45:01
aura.cs.wi SUN4u    SOLARIS251   Claimed    Busy       1.000  128   0+00:15:01
balder.cs. INTEL    SOLARIS251   Claimed    Busy       1.000  1024  0+01:05:00
beatrice.c INTEL    SOLARIS251   Claimed    Busy       1.000  128   0+01:30:02
...
...
                     Machines Owner Claimed Un-
claimed Matched Preempting

    SUN4u/SOLARIS251        3     0       3         0       0           0
    INTEL/SOLARIS251       21     0      21         0       0           0
    SUN4x/SOLARIS251        3     0       3         0       0           0
           SGI/IRIX6        1     0       0         1       0           0
         INTEL/LINUX        1     0       1         0       0           0

               Total       29     0      28         1       0           0
```

The similar flexibility exists in querying job queues in the Condor system.

4.2 An Introduction to Condor's Checkpointing Mechanism

Checkpointing is taking a snapshot of the current state of a program in such a way that the program can be restarted from that state at a later time. Checkpointing gives the Condor scheduler the freedom to reconsider scheduling decisions through preemptive-resume scheduling. If the scheduler decides to no longer allocate a machine to a job (for example, when the owner of that machine returns), it can checkpoint the job and preempt it without losing the work the job has already accomplished. The job can be resumed later when the scheduler allocates it a new machine. Additionally, periodic checkpointing provides fault tolerance in Condor. Snapshots are taken periodically, and after an interruption in service the program can continue from the most recent snapshot.

Condor provides checkpointing services to single process jobs on a number of Unix platforms. To enable checkpointing, the user must link the program with the Condor system call library (`libcondorsyscall.a`), using the *condor_compile* command. This means that the user must have the object files or source code of the program to use Condor checkpointing. However, the checkpointing services provided by Condor are strictly optional. So, while there are some classes of jobs for which Condor does not provide checkpointing services, these jobs may still be submitted to Condor to take advantage of Condor's resource management functionality. (See section 2.4.1 on page 13 for a description of the classes of jobs for which Condor does not provide checkpointing services.)

Process checkpointing is implemented in the Condor system call library as a signal handler. When Condor sends a checkpoint signal to a process linked with this library, the provided signal handler writes the state of the process out to a file or a network socket. This state includes the contents of the process stack and data segments, all shared library code and data mapped into the process's address space, the state of all open files, and any signal handlers and pending signals. On restart, the process reads this state from the file, restoring the stack, shared library and data segments, file state, signal handlers, and pending signals. The checkpoint signal handler then returns to user code, which continues from where it left off when the checkpoint signal arrived.

Condor processes for which checkpointing is enabled perform a checkpoint when preempted from a machine. When a suitable replacement execution machine is found (of the same architecture and operating system), the process is restored on this new machine from the checkpoint, and computation is resumed from where it left off. Jobs that can not be checkpointed are preempted and restarted from the beginning.

Condor's periodic checkpointing provides fault tolerance. Condor pools are each configured with the `PERIODIC_CHECKPOINT` expression which controls when and how often jobs which can be checkpointed do periodic checkpoints (examples: never, every three hours, etc.). When the time for a periodic checkpoint occurs, the job suspends processing, performs the checkpoint, and immediately continues from where it left off. There is also a *condor_ckpt* command which allows the user to request that a Condor job immediately perform a periodic checkpoint.

In all cases, Condor jobs continue execution from the most recent complete checkpoint. If service is interrupted while a checkpoint is being performed, causing that checkpoint to fail, the process will restart from the previous checkpoint. Condor uses a commit style algorithm for writing checkpoints: a previous checkpoint is deleted only after a new complete checkpoint has been written successfully.

In certain cases, checkpointing may be delayed until a more appropriate time. For example, a Condor job will defer a checkpoint request if it is communicating with another process over the network. When the network connection is closed, the checkpoint will occur.

The Condor checkpointing facility can also be used for any Unix process outside of the Condor batch environment. Standalone checkpointing is described in section 4.2.1.

Condor can now read and write compressed checkpoints. This new functionality is provided in the `libcondorzsyscall.a` library. If `/usr/lib/libz.a` exists on your workstation, *condor_compile* will automatically link your job with the compression-enabled version of the checkpointing library.

By default, a checkpoint is written to a file on the local disk of the machine where the job was submitted. A checkpoint server is available to serve as a repository for checkpoints. (See section 3.11.5 on page 163.) When a host is configured to use a checkpoint server, jobs submitted on that machine write and read checkpoints to and from the server rather than the local disk of the submitting machine, taking the burden of storing checkpoint files off of the submitting machines and placing it instead on server machines (with disk space dedicated to the purpose of storing checkpoints).

4.2.1 Standalone Checkpointing

Using the Condor checkpoint library without the remote system call functionality and outside of the Condor system is known as standalone mode checkpointing.

To prepare a program for standalone checkpointing, simply use the *condor_compile* utility as for a standard Condor job, but do not use *condor_submit* – just run your program normally from the command line. The checkpointing library will print a message to let you know that checkpointing is enabled and to inform you where the checkpoint image is stored:

```
Condor: Will checkpoint to program_name.ckpt
Condor: Remote system calls disabled.
```

To force the program to write a checkpoint image and stop, send it the SIGTSP signal or press control-Z. To force the program to write a checkpoint image and continue executing, send it the SIGUSR2 signal.

To restart the program from a checkpoint, run it again with the option "-_condor_restart" and the name of the checkpoint image file.

To use a different filename for the checkpoint image, use the option "-_condor_ckpt" and the name of the file you want checkpoints written to.

4.2.2 Checkpoint Library Interface

A program need not be rewritten to take advantage of checkpointing. However, the checkpointing library provides several C entry points that allow for a program to control its own checkpointing behavior if needed.

- `void ckpt()`
  This function causes a checkpoint image to be written to disk. The program will continue to execute. This is identical to sending the program a SIGUSR2 signal.
- `void ckpt_and_exit()`
  This function causes a checkpoint image to be writtent to disk. The program will then exit. This is identical to sending the program a SIGTSTP signal.
- `void init_image_with_file_name( char *ckpt_file_name )`
  This function prepares the library to restart from the given file name. `restart()` must be called to perform the actual restart.
- `void init_image_with_file_descriptor( int fd )`
  This function prepares the library to restart from the given file descriptor. `restart()` must be called to perform the actual restart.

- `void restart()`
  This function causes the program to read the checkpoint image specified by one of the above functions, and to resume the program where the checkpoint left off. This function does not return.
- `void _condor_ckpt_disable()`
  This function temporarily disables checkpointing. This can be handy if your program does something with is not checkpoint-safe. For example, if a program must not be interrupted while accessing a special file, call `_condor_ckpt_disable()`, access the file, and then call `_condor_ckpt_enable()`. Some program actions, such as opening a socket or a pipe, implicitly cause checkpointing to be disabled.
- `void _condor_ckpt_enable()`
  This function re-enables checkpointing after a call to `_condor_ckpt_disable()`. If a checkpointing signal arrived while checkpointing was disabled, the checkpoint will occur when this function is called. Disabling and enabling of checkpointing must occur in matched pairs. `_condor_ckpt_enable()` must be called once for every time that `_condor_ckpt_disable()` is called.
- `extern int condor_compress_ckpt`
  Setting this variable to one causes checkpoint images to be compressed. Setting it to zero disables compression.
- `extern int condor_debug_output`
  Setting this variable to one causes additional debugging information to be shown during the checkpoint process. Setting it to zero disables debug messages.

4.3 The Condor Perl Module

The Condor perl module facilitates automatic submitting and monitoring of condor jobs, along with automated administration of condor. The most common use of the perl module is the monitoring of condor jobs. The condor perl module uses the user log of a condor job for monitoring.

The Condor perl module is made up of several subroutines. Many subroutines take other subroutines as arguments. These subroutines are used as callbacks which are called when interesting events happen.

4.3.1 Subroutines

1. Submit(command_file)
   The submit subroutine takes a command file name as an argument and submits it to condor. The *condor_submit* program should be in the path of the user. If the user wishes to monitor the job with condor they must specify a log file in the command file. The cluster submitted is returned. For more information see the *condor_submit* man page.

2. Vacate(machine)
   Vacate the machine specified. The machine may be specified either by hostname, or by *sinful string*. For more information see the *condor_vacate* man page.

3. Reschedule(machine)
   Reschedule the machine specified. The machine may be specified either by hostname, or by *sinful string*. For more information see the *condor_reschedule* man page.

4. RegisterEvicted(sub)
   Register an eviction handler that will be called anytime a job from the specified cluster is evicted. The eviction handler will be called with two arguments: cluster and job. The cluster and job are the cluster number and process number of the job that was evicted.

5. RegisterEvictedWithCheckpoint(sub)
   Same as RegisterEvicted except that the handler is called when the evicted job was checkpointed.

6. RegisterEvictedWithoutCheckpoint(sub)
   Same as RegisterEvicted except that the handler is called when the evicted job was not checkpointed.

7. RegisterExit(sub)
   Register a termination handler that is called when a job exits. The termination handler will be called with two arguments: cluster and job. The cluster and job are the cluster and process numbers of the existing job.

8. RegisterExitSuccess(sub)
   Register a termination handler that is called when a job exits without errors. The termination handler will be called with two arguments: cluster and job The cluster and job are the cluster and process numbers of the existing job.

9. RegisterExitFailure(sub)
   Register a termination handler that is called when a job exits with errors. The termination handler will be called with three arguments: cluster, job and retval. The cluster and job are the cluster and process numbers of the existing job and the retval is the exit code of the job.

10. RegisterExitAbnormal(sub)
    Register an termination handler that is called when a job abnormally exits (segmentation fault, bus error, ...). The termination handler will be called with four arguments: cluster, job signal and core. The cluster and job are the cluster and process numbers of the existing job. The signal indicates the signal that the job died with and core indicates whether a core file was created and if so, what the full path to the core file is.

11. RegisterAbort(sub)
    Register a handler that is called when a job is aborted by a user.

12. RegisterJobErr(sub)
    Register a handler that is called when a job is not executable.

13. RegisterExecute(sub)
    Register an execution handler that is called whenever a job starts running on a given host. The handler is called with four arguments: cluster, job host, and sinful. Cluster and job are the cluster and process numbers for the job, host is the Internet address of the machine running the job, and sinful is the Internet address and command port of the *condor_starter* supervising the job.

14. RegisterSubmit(sub)
    Register a submit handler that is called whenever a job is submitted with the given cluster. The handler is called with cluster, job host, and sinful. Cluster and job are the cluster and process numbers for the job, host is the Internet address of the machine running the job, and sinful is the Internet address and command port of the *condor_schedd* responsible for the job.

15. Monitor(cluster)
    Begin monitoring this cluster. This process starts a sub process in order to monitor the child, so other actions may proceed in the main loop of the perl script. However, handlers cannot rely on being able to communicate back to the main script by simply changing variables latter on.

16. Wait()
    Wait until all monitors finish and exit.

17. DebugOn()
    Turn debug messages on. This may be useful if you don't understand what your script is doing.

18. DebugOff()
    Turn debug messages off.

4.3.2 An Example

The following is a simple example of using the condor perl module.

```
#!/usr/bin/perl
use Condor;

$CMD_FILE = 'mycmdfile.cmd';
$evicts = 0;
$vacates = 0;

# A subroutine that will be used as the normal execution callback
$normal = sub
{
    %parameters = @_;
    $cluster = $parameters{'cluster'};
    $job = $parameters{'job'};
    print "Job $cluster.$job exited normally without errors.\n";
    print "Job was vacated $vacates times and evicted $evicts times\n";
    exit(0);
};

$evicted = sub
{
    %parameters = @_;
    $cluster = $parameters{'cluster'};
    $job = $parameters{'job'};

    print "Job $cluster, $job was evicted.\n";
    $evicts++;
    &Condor::Reschedule();
};

$execute = sub
{
    %parameters = @_;
    $cluster = $parameters{'cluster'};
    $job = $parameters{'job'};
    $host = $parameters{'host'};
    $sinful = $parameters{'sinful'};

    print "Job running on $sinful, vacating...\n";
    &Condor::Vacate($sinful);
    $vacates++;
};

$cluster = Condor::Submit($CMD_FILE);
&Condor::RegisterExitSuccess($normal);
&Condor::RegisterEvicted($evicted);
&Condor::RegisterExecute($execute);
&Condor::Monitor($cluster);
&Condor::Wait();
```

This example program will submit the command file 'mycmdfile.cmd' and attempt to vacate any machine that the job runs on. The termination handler then prints out a summary of what has happened.

CHAPTER

FIVE

Condor for Microsoft Windows NT 4.0

5.1 Introduction to Condor NT Preview

Welcome to Condor for Windows NT! We view Windows NT as a strategic platform for Condor, and therefore we are doing a full-blown "deep port" to Windows NT. Our goal is to make Condor every bit as capable on Windows NT as it is on Unix – or even more capable.

Porting Condor from Unix to Windows NT is a formidable task because many components of Condor must interact closely with the underlying operating system. Instead of waiting until all components of Condor are running and stabilized on Windows NT before making an initial public release, we have decided to make frequent "*preview releases*" of Condor for Windows NT. These preview releases are not feature complete and should be considered beta quality. However, many sites do not require all the components included in a full-blown release of Condor. Still other sites may desire to get their feet wet with a preview release of Condor NT in anticipation of setting up a production environment once a full-blown release on Windows NT is completed.

This chapter contains additional information specific to running Condor on Windows NT. Eventually this information will be integrated into the Condor Manual as a whole, and this section will disappear. In order to effectively use Condor NT, you must first read chapters 1 ("Overview") and 2 ("Users' Manual") in this manual. If you will also be administrating or customizing the policy/setup of Condor NT, you should also read chapter 3 ("Administrators' Manual"). After reading these chapters, then review the information in this chapter for important information and differences when using and administrating Condor on Windows NT. For information on installing Condor NT, see section 5.3.

5.2 Release Notes for Condor NT Preview 6.1.8

Released mid-October 1999, this is the first public release of Condor NT.

What is missing from Condor NT Preview 6.1.8?

In general, this preview release on NT works the same as the full-blown release of Condor for Unix.

However, following items are still being worked on and are not supported in this preview:

- The STANDARD, PVM, GLOBUS, and SCHEDULER job universes are not yet present. All jobs must be submitted to the VANILLA universe. This means transparent process checkpoint/migration, remote system calls, and DagMan are not available in this release (they will debut in upcoming releases). All job submit files must contain the statement:

  ```
  universe = vanilla
  ```

- Support for accessing files via a network share (i.e. files stored on a network volume managed by NT Server, Novell Netware, AFS) is not yet supported. All files required by the job must exist on a local disk on machine where the job was submitted. Condor NT will then automatically transfer the files to/from the submit machine to the machine selected to execute the job(s). See section 5.2.1 for important information on Condor NT's file transfer mechanism.
- The ability to run the job with the same credentials as the submitting user is not yet supported. Instead, Condor dynamically creates and runs the job in a special user account with minimal access rights.

What is included in Condor NT Preview 6.1.8?

Except for the functionality listed above, practically everything else works the same way in Condor NT Preview as it does in the full-blown release. This Preview release is based on the Condor 6.1.8 source tree, and thus the feature set is the same as 6.1.8. For instance, all of the following works in Condor NT:

- The ability to submit, run, and manage queues of jobs running on a cluster of NT machines.
- All tools (such as *condor_q*, *condor_status*, *condor_userprio*, etc), with the exception of *condor_compile* and *condor_submit_dag*, are included.
- The ability to customize job policy using Classified Ads. The machine ClassAds contain all the information included in the full-blown version, including current load average, RAM and virtual memory sizes, integer and floating-point performance, keyboard/mouse idle time, etc. Likewise, job ClassAds contain a full complement of information, including system dependent entries such as dynamic updates of the job's image size and CPU usage.

- Everything necessary to run a Condor Central Manager on Windows NT.
- Several security mechanisms (more details below).
- Support for SMP machines.
- Condor NT can run jobs at a lower operating system priority level. Jobs can be suspended (prevented from using any CPU at all), soft-killed via a WM_CLOSE message, or hard-killed automatically based upon policy expressions. For example, Condor NT can automatically suspend a job whenever keyboard/mouse or non-Condor created CPU activity is detected, and continue the job after the the machine has been idle for a specified amount of time.
- Condor NT correctly manages jobs which create multiple processes. For instance, if the job spawns multiple processes and Condor needs to kill the job, all processes created by the job will be terminated.
- In addition to interactive tools, users and administrators can receive information from Condor via email (standard SMTP) and/or via log files.
- Condor NT includes a friendly GUI installation/setup program which can perform a full install or deinstall of Condor. Information specified by the user in the setup program is stored in the system registry. The setup program can update a current installation with a new release with a minimal amount of effort.

5.2.1 Condor File Transfer Mechanism

Condor remote system calls and the ability to access network shares is not yet supported on NT — they will be in the near future. For now, Condor NT users must utilize the Condor File Transfer mechanism.

When Condor finds a machine willing to execute your job, it will create a temporary subdirectory for your job on the execute machine. The Condor File Transfer mechanism will then send via TCP the job executable(s) and input files from the submitting machine into this temporary directory on the execute machine. After the input files have been transferred, the execute machine will start running the job with the temporary directory as the job's current working directory. When the job completes or is kicked off, Condor File Transfer will automatically send back to the submit machine any output files created by the job. After the files have been sent back successfully, the temporary working directory on the execute machine is deleted.

Condor's File Transfer mechanism has several features to ensure data integrity in a non-dedicated environment. For instance, transfers of multiple files are performed atomically.

File Transfer Submit-Description Parameters

Condor File Transfer behavior is specified at job submit time via the submit-description file and *condor_submit*. Along with all the other job submit-description parameters (see section 8 on page 305), use the following new commands in the submit-description file:

transfer_input_files = < file1, file2, file... > Use this parameter to list all the files which should be transferred into the working directory for the job before the job is started. Separate multiple filenames with a comma. By default, the file specified via the **Executable** parameter and any file specified via the **Input** parameter (i.e. stdin) are transferred.

transfer_output_files = < file1, file2, file... > Use this parameter to explicitly list which output files to transfer back from the temporary working directory on the execute machine to the submit machine. Most of the time, however, there is no need to use this parameter. If **transfer_output_files** is not specified, Condor will automatically transfer back all files in the job's temporary working directory which have been modified or created by the job. This is usually the desired behavior. Explicitly listing output files is typically only done when the job creates many files, and the user really only cares to keep a subset of the files created. WARNING: Do not specify **transfer_output_file** in your submit-description file unless you really have a good reason — it is almost always best to let Condor figure things out by itself based upon what the job actually wrote.

transfer_files = <ONEXIT | ALWAYS> Setting **transfer_files** equal to *ONEXIT* will cause Condor to transfer the job's output files back to the submitting machine only when the job completes (exits). If not specified, *ONEXIT* is used as the default. Specifying *ALWAYS* tells Condor to transfer back the output files when the job completes *or* whenever Condor kicks off the job (preempts) from a machine prior to job completion (if, for example, activity is detected on the keyboard). The *ALWAYS* option is specifically intended for fault-tolerant jobs which periodocially write out their state to disk and can restart where the left off. Any output files transferred back to the submit machine when Condor kicks off a job will automatically be sent back out again as input files when the job restarts.

Ensuring File Transfer has enough disk space

It is **highly recommended** that you specify a **Requirements** expression in your submit-description file that checks the size of the `Disk` attribute when using File Transfer! Doing so can ensure that Condor picks a machine with enough local disk space for your job. Here is a sample submit-description file:

```
        # Condor submit file for program "foo.exe".
        #
        # foo reads from files "my-input-data" and "my-other-
input-data".
        # foo then writes out results into several files.
        # The total disk space foo uses for all input and out-
put files
        # is never more than 10 megabytes.
        #
        executable = foo.exe
        # Now set Requirements saying that the ma-
chine which runs our job
```

```
        # must have more than 10megs of free disk space.  Note that "Disk"
        # is expressed in kilobytes; 10meg is 10000 kbytes.
        requirements = Disk > 10000
        #
        queue
```

If you do not specify a requirement on `Disk` (a bad idea!), *condor_submit* will append to the job ad **Requirements** that `Disk >= DiskUsage`. The `DiskUsage` attribute is in the job ad and represents the maximum amount total disk space required by the job in kilobytes. Condor will automatically update `DiskUsage` approx every 20 minutes while your job runs with the amount of space being used by the job on the execute machine.

Current Limitations of File Transfer

Itemized below are some current limitations of the File Transfer mechanism. We anticipate improvement on these areas in upcoming releases.

- Transfer of subdirectories is not performed. When starting your job, Condor will create a temporary working directory on the execute machine and place your executable and all input files into this directory. Condor will then start your job with this directory as the current working directory. When your job completes, any files created in this temporary working directory are transferred back to the submit machine. However, if the job creates any subdirectories, files in those subdirectories are not transferred back. Similarly, only filenames, not directory names, can be specified with the **transfer_input_files** submit-description file parameter.
- Running out of disk space on the submit machine is not handled as gracefully as it should be.
- By default, any files created or modified by the job are automatically sent back to the submit machine. However, if the job deleted any files in its temporary working directory, they currently are not deleted back on the submit machine. This could cause problems if **transfer_files** is set to *ALWAYS* and the job uses the presence of a file as a lock file. Note there is no problem if **transfer_files** is set to the default, which is *ONEXIT*.

5.2.2 Some details on how Condor NT starts/stops a job

This section provides some details on how Condor NT starts and stops jobs. This discussion is geared for the Condor administrator or advanced user who is already familiar with the material in Chapter 2 (the Administrators' Manual) and wishes to know detailed information on what Condor NT does when starting/stopping jobs.

When Condor NT is about to start a job, the *condor_startd* on the execute machine spawns a *condor_starter* process. The *condor_starter* then creates:

1. a new temporary run account on the machine with a login name of “condor-run-dir_XXX”, where XXX is the process ID of the *condor_starter*. This account is added to group Users and group Everyone.
2. a new temporary working subdirectory for the job on the execute machine. This subdirectory is named “dir_XXX”, where XXX is the process ID of the *condor_starter*. The subdirectory is created in the `$(EXECUTE)` subdirectory as specified in Condor’s configuration file. Then Condor grants write permission to this subdirectory for user account it just created for the job.
3. a new, non-visible Window Station and Desktop for the job. Permissions are set so that only the user account just created has access rights to this Desktop. Any windows created by this job are not seen by anyone; the job is run “in the background”.

Next, the *condor_starter* (henceforth called the starter) contacts the *condor_shadow* (henceforth called the shadow) process which is running on the submitting machine and pulls over the job’s executable and input files. These files are placed into the temporary working subdirectory for the job. After all files have been received, the starter spawns the user’s executable as user “condor-run-dir_XXX” with its current working directory set to the temporary working subdirectory (i.e. `$(EXECUTE)`/dir_XXX).

While the job is running, the starter is closely monitoring the CPU usage and image size of all processes started by the job. Every 20 minutes it sends this information, along with the total size of all files contained in the job’s working subdirectory, to the shadow. The shadow then inserts this information into the job’s ClassAd so policy/scheduling expressions can make use of this dynamic information.

If the job exits of its own accord (i.e. the job completes), the starter first terminates any processes started by the job which could still be laying around if the job did not clean up after itself. examines the job’s temporary working subdirectory for any files which have been created or modified and sends these files back to the shadow running on the submit machine. The shadow places these files into the **initialdir** specified in the submit-description file; if no **initialdir** was specified, the files go into the directory where the user ran *condor_submit*. Once all the output files are safely transferred back, the job is removed from the queue. If, however, the *condor_startd* forcibly kills the job before all output files could be transferred, the job is not removed from the queue but instead switches back to Idle.

If the *condor_startd* decides to vacate a job prematurely (perhaps because the startd policy says to kick off jobs whenever activity on the keyboard is detected, or whatever), the starter sends a WM_CLOSE message to the job. If the job spawned multiple child processes, the WM_CLOSE message is only sent to the parent process (i.e. the one started by the starter). The WM_CLOSE message is the preferred way to terminate a process on Windows NT, since this method allows the job to cleanup and free any resources it may have allocated. Then when the job exits, the starter cleans up any processes left behind. At this point if **transfer_files** was set to *ONEXIT* (the default) in this job’s submit file, the job simply switches from state Running to state Idle and no files are transferred back. But if **transfer_files** is set to *ALWAYS*, then any files in the job’s temporary working directory which were changed or modified are first sent back to the shadow. But this time, the shadow places these so-called intermediate files into a subdirectory created in the `$(SPOOL)` directory on the submitting machine (`$(SPOOL)` is specified in Condor’s configuration file). Then the job is switched back to the Idle state until Condor finds a different machine for it to run on. When the job is started again, Condor will place into the job's temporary working directory the executable and input files as before, *plus* any files stored in the submit machine's `$(SPOOL)` directory for that job.

NOTE: A Windows console process can intercept a WM_CLOSE message via the Win32 SetConsoleCtrlHandler() function if it needs to do special cleanup work at vacate time; a WM_CLOSE message generates a CTRL_CLOSE_EVENT. See SetConsoleCtrlHandler() in the Win32 documentation for more info.

NOTE: The default handler in Windows NT for a WM_CLOSE message is for the process to exit. Of course, the job could be coded to ignore it an not exit, but eventually the *condor_startd* will get impatient and hard-kill the job (if that is the policy desired by the administrator).

Finally, after the job has left and any files transferred back, the *condor_starter* will delete the temporary working directory, the temporary run account, the WindowStation and the desktop before exiting itself. If the starter should terminate abnormally for some reason, the *condor_startd* will take upon itself to cleanup the directory, the account, etc. If for some reason the *condor_startd* should disappear as well (i.e. if the entire machine was power-cycled hard), the *condor_startd* will cleanup the temporary directory(s) and/or account(s) left behind when Condor is restarted at reboot time.

5.2.3 Security considerations in Condor NT Preview

On the execute machine, the user job is run using the access token of an account dynamically created by Condor which has bare-bones access rights and privileges. For instance, if your machines are configured so that only Administrators have write access `C:\WINNT`, then certainly no Condor job run on that machine would be able to write anything there. The only files the job should be able to access on the execute machine are files accessible by group Everybody and files in the job's temporary working directory.

On the submit machine, Condor permits the File Transfer mechanism to only read files which the submitting user has access to read, and only write files to which the submitting user has access to write. For example, say only Administrators can write to `C:\WINNT` on the submit machine, and a user gives the following to *condor_submit* :

```
executable = mytrojan.exe
initialdir = c:\winnt
output = explorer.exe
queue
```

Unless that user is in group Administrators, Condor will not permit `explorer.exe` to be overwritten.

If for some reason the submitting user's account disappears between the time *condor_submit* was run and when the job runs, Condor is not able to check and see if the now-defunct submitting user has read/write access to a given file. In this case, Condor will ensure that group "Everyone" has read or write access to any file the job subsequently tries to read or write. This is in consideration for some network setups, where the user account only exists for as long as the user is logged in.

Condor also provides protection to the job queue. It would be bad if the integrity of the job queue is compromised, because a malicious user could remove other user's jobs or even change what executable a user's job will run. To guard against this, in Condor's default configuration all connections to the *condor_schedd* (the process which manages the job queue on a given machine) are authenticated using Windows NT's SSPI security layer. The user is then authenticated using the same challenge-response protocol that NT uses to authenticate users to Windows NT file servers. Once authenticated, the only users allowed to edit job entry in the queue are:

1. the user who originally submitted that job (i.e. Condor allows users to remove or edit their own jobs)
2. users listed in the `condor_config` file parameter `QUEUE_SUPER_USERS`. In the default configuration, only the "SYSTEM" (LocalSystem) account is listed here.

WARNING: Do not remove "SYSTEM" from `QUEUE_SUPER_USERS`, or Condor itself will not be able to access the job queue when needed. If the LocalSystem account on your machine is compromised, you have all sorts of problems!

To protect the actual job queue files themselves, the Condor NT installation program will automatically set permissions on the entire Condor release directory so that only Administrators have write access.

Finally, Condor NT Preview has all the IP/Host-based security mechanisms present in the full-blown version of Condor. See section 3.8 starting on page 145 for complete information on how to allow/deny access to Condor based upon machine hostname or IP address.

5.2.4 Interoperability between Condor for Unix and Condor NT

Unix machines and Windows NT machines running Condor can happily co-exist in the same Condor pool without any problems. For now, the only restriction is jobs submitted on Windows NT must run on Windows NT, and job submitted on Unix must run on Unix. You will get this behavior by default, since *condor_submit* will automatically set a `Requirements` expression in the job ClassAd stating that the execute machine must have the same architecture and operating system as the submit machine.

There is absolutely no need to run more than one Condor central manager, even if you have both Unix and NT machines. The Condor central manager itself can run on either Unix or NT; there is no advantage to choosing one over the other. Here at University of Wisconsin-Madison, for instance, we have hundreds of Unix (Solaris, Linux, Irix, etc) and Windows NT machines in our Computer Science Department Condor pool. Our central manager is running on Windows NT. All is happy.

5.2.5 Some differences between Condor for Unix -vs- Condor NT

- As of Condor NT Preview 6.1.8, only VANILLA universe is supported on NT. Additionally, on Unix VANILLA universe requires a shared filesystem. On NT, a shared filesystem is not required (in fact, use of a shared filesystem is not yet supported), and the Condor File Transfer mechanism must be used. NOTE: The Condor File Transfer mechanism is currently only on Condor NT.
- On Unix, we recommend the creation of a "*condor*" account when installing Condor. On NT, this is not necesary, as Condor NT is designed to run as a system service as user LocalSystem.
- On Unix, the job ClassAd attributes relating to image size and CPU usage are not updated while the job is running. On NT, they are updated every 20 minutes while the job is running and again at job exit. Furthermore, on Unix image size and CPU usage only reflect the parent process of a job that spawns child processes. So if you submit a shell script on Unix which ultimately spawns your job, Condor's image size and CPU usage only report the size and usage of the shell script. On NT, image size and CPU usage is totaled across all processes spawned by the job.
- The job ClassAd attribute `DiskUsage` exists only on NT. Similarly, several job attributes relating to transparent process checkpointing only exist on Unix.
- On Unix, Condor finds the `condor_config` main configuration file by looking in condor, in /etc, or via an environment variable. On NT, the location of `condor_config` file is determined via the registry key `HKEY_LOCAL_MACHINE/Software/Condor`. You can override this value by setting an environment variable named `CONDOR_CONFIG`.
- On Unix, in the VANILLA universe at job vacate time Condor sends the job a softkill signal defined in the submit-description file (defaults to SIGTERM). On NT, Condor sends a WM_CLOSE message to the job at vacate time.
- On Unix, if one of the Condor daemons has a fault, a core file will be created in the `$(Log)` directory. On Condor NT, a "core" file will also be created, but instead of a memory dump of the process it will be a very short ASCII text file which describes what fault occurred and where it happened. This information can be used by the Condor developers to fix the problem.

5.3 Installation of Condor on Windows NT

This section contains the instructions for installing the Microsoft Windows NT version of Condor (Condor NT) at your site. The install program will set you up with a slightly customized configuration file that you can further customize after the installation has completed.

Please read the copyright and disclaimer information in section on page xi of the manual, or in the file `LICENSE.TXT`, before proceeding. Installation and use of Condor is acknowledgement that you have read and agreed to these terms.

The Condor NT executable for distribution is packaged in a single file such as:

```
condor-6.1.8_preview-WINNT40-x86.exe
```

This file is approximately 5 Mbytes in size, and may be removed once Condor is fully installed.

Before installing Condor, please consider joining the condor-world mailing list. Traffic on this list is kept to an absolute minimum. It is only used to announce new releases of Condor. To subscribe, send an email to majordomo@cs.wisc.edu with the body:

```
subscribe condor-world
```

5.3.1 Installation Requirements

- Condor NT requires Microsoft Windows NT 4.0 with Service Pack 3 or above. Service Pack 5 is recommended. NOTE: Condor NT has not yet been tested with Windows 2000.
- 30 megabytes of free disk space is recommended. Significantly more disk space could be desired to be able to run jobs with large data files.
- Condor NT will operate on either an NTFS or FAT filesystem. However, for security purposes, NTFS is preferred.

5.3.2 Preparing to Install Condor under Windows NT

Before you install the Windows NT version of Condor at your site, there are two major decisions to make about the basic layout of your pool.

1. What machine will be the central manager?
2. Do I have enough disk space for Condor?

If you feel that you already know the answers to these questions, skip to the Windows NT Installation Procedure section below, section 5.3.3 on page 200. If you are unsure, read on.

What machine will be the central manager?

One machine in your pool must be the central manager. This is the centralized information repository for the Condor pool and is also the machine that matches available machines with waiting jobs. If the central manager machine crashes, any currently active matches in the system will keep running, but no new matches will be made. Moreover, most Condor tools will stop working. Because of the importance of this machine for the proper functioning of Condor, we recommend you install it on a machine that is likely to stay up all the time, or at the very least, one that will be rebooted quickly if it does crash. Also, because all the services will send updates (by default every 5 minutes) to this machine, it is advisable to consider network traffic and your network layout when choosing the central manager.

For Personal Condor, your machine will act as your central manager.

Install Condor on the central manager before installing on the other machines within the pool.

Do I have enough disk space for Condor?

The Condor release directory takes up a fair amount of space. The size requirement for the release directory is approximately 20 Mbytes.

Condor itself, however, needs space to store all of your jobs, and their input files. If you will be submitting large amounts of jobs, you should consider installing Condor on a volume with a large amount of free space.

5.3.3 Installation Procedure using the included Setup Program

Installation of Condor must be done by a user with administrator privileges. After installation, the Condor services will be run under the local system account. When Condor is running a user job, however, it will run that User job with normal user permissions. Condor will dynamically create an account, and then delete that account when the job is finished or is removed from the machine.

Download Condor, and start the installation process by running the file (or by double clicking on the file). The Condor installation is completed by answering questions and choosing options within the following steps.

If Condor is already installed. For upgrade purposes, you may be running the installation of Condor after it has been previously installed. In this case, a dialog box will appear before the installation of Condor proceeds. The question asks if you wish to preserve your current Condor configuration files. Answer yes or no, as appropriate.

If you answer yes, your configuration files will not be changed, and you will proceed to the point where the new binaries will be installed.

If you answer no, then there will be a second question that asks if you want to use answers given during the previous installation as default answers.

STEP 1: License Agreement. The first step in installing Condor is a welcome screen and license agreement. You are reminded that it is best to run the installation when no other Windows programs are running. If you need to close other Windows NT programs, it is safe to cancel the installation and close them. You are asked to agree to the license. Answer yes or no. If you should disagree with the License, the installation will not continue.

After agreeing to the license terms, the next Window is where fill in your name and company information, or use the defaults as given.

STEP 2: Condor Pool Configuration. The Condor NT installation will require different information depending on whether the installer will be creating a new pool, or joining an existing one.

If you are creating a new pool, the installation program requires that this machine is the central manager. For the creation of a new Condor pool, you will be asked some basic information about your new pool:

Name of the pool

hostname of this machine.

Size of pool Condor needs to know if this a Personal Condor installation, or if there will be more than one machine in the pool. A Personal Condor pool implies that there is only one machine in the pool. For Personal Condor, several of the following steps are omitted as noted.

If you are joining an existing pool, all the installation program requires is the hostname of the central manager for your pool.

STEP 3: This Machine's Roles. This step is omitted for the installation of Personal Condor.

Each machine within a Condor pool may either submit jobs or execute submitted jobs, or both submit and execute jobs. This step allows the installation on this machine to choose if the machine will only submit jobs, only execute submitted jobs, or both. The common case is both, so the default is both.

STEP 4: Where will Condor be installed? The next step is where the destination of the Condor files will be decided. It is recommended that Condor be installed in the location shown as the default in the dialog box: `C:\Condor`.

Installation on the local disk is chosen for several reasons.

The Condor services run as local system, and within Microsoft Windows NT, local system has no network privileges. Therefore, for Condor to operate, Condor should be installed on a local hard drive as opposed to a network drive (file server).

The second reason for installation on the local disk is that the Windows NT usage of drive letters has implications for where Condor is placed. The drive letter used must be not change, even when different users are logged in. Local drive letters do not change under normal operation of Windows NT.

While it is strongly discouraged, it may be possible to place Condor on a hard drive that is not local, if a dependency is added to the service control manager such that Condor starts after the required file services are available.

STEP 5: Where should Condor send e-mail if things go wrong? Various parts of Condor will send e-mail to a Condor administrator if something goes wrong and requires human attention. You specify the e-mail address and the SMTP relay host of this administrator. Please pay close attention to this email since it will indicate problems in your Condor pool.

STEP 6: The domain. This step is omitted for the installation of Personal Condor.

Enter the machine's accounting (or UID) domain. On this version of Condor for Windows NT, this setting only used for User priorities (see section 3.5 on page 117) and to form a default email address for the user.

STEP 7: Access permissions. This step is omitted for the installation of Personal Condor.

Machines within the Condor pool will need various types of access permission. The three categories of permission are read, write, and administrator. Enter the machines to be given access permissions.

Read Read access allows a machine to obtain information about Condor such as the status of machines in the pool and the job queues. All machines in the pool should be given read access. In addition, giving read access to *.cs.wisc.edu will allow the Condor team to obtain information about your Condor pool in the event that debugging is needed.

Write All machines in the pool should be given write access. It allows the machines you specify to send information to your local Condor daemons, for example, to start a Condor Job. Note that for a machine to join the Condor pool, it must have both read and write access to all of the machines in the pool.

Administrator A machine with administrator access will be allowed more extended permission to to things such as change other user's priorities, modify the job queue, turn Condor services on and off, and restart Condor. The central manager should be given administrator access and is the default listed. This setting is granted to the entire machine, so care should be taken not to make this too open.

For more details on these access permissions, and others that can be manually changed in your `condor_config` file, please see the section titled Security Access Levels at section section **??** on page 148.

STEP 8: Job Start Policy. Condor will execute submitted jobs on machines based on a preference given at installation. Three options are given, and the first is most commonly used by Condor pools. This specification may be changed or refined in the machine ClassAd requirements attribute.

The three choices:

After 15 minutes of no console activity and low CPU activity.

Always run Condor jobs.

After 15 minutes of no console activity.

Console activity is the use of the mouse or keyboard. For instance, if you are reading this document online, and are using either the mouse or the keyboard to change your position, you are generating Console activity.

Low CPU activity is defined as a load of less than 30%(and is configurable in your `condor_config` file). If you have a multiple processor machine, this is the average percentage of CPU activity for both processors.

For testing purposes, it is often helpful to use use the Always run Condor jobs option. For production mode, however, most people chose the After 15 minutes of no console activity and low CPU activity.

STEP 9: Job Vacate Policy. This step is omitted if Condor jobs are always run as the option chosen in STEP 8.

If Condor is executing a job and the user returns, Condor will immediately suspend the job, and after five minutes Condor will decide what to do with the partially completed job. There are currently two options for the job.

The job is killed 5 minutes after your return. The job is suspended immediately once there is console activity. If the console activity continues, then the job is vacated (killed) after 5 minutes. Since this version does not include check-pointing, the job will be restarted from the beginning at a later time. The job will be placed back into the queue.

Suspend job, leaving it in memory. The job is suspended immediately. At a later time, when the console activity has stopped for ten minutes, the execution of Condor job will be resumed (the job will be unsuspended). The drawback to this option is that since the job will remain in memory, it will occupy swap space. In many instances, however, the amount of swap space that the job will occupy is small.

So which one do you choose? Killing a job is less intrusive on the workstation owner than leaving it in memory for a later time. A suspended job left in memory will require swap space, which could possibly be a scarce resource. Leaving a job in memory, however, has the benefit that accumulated run time is not lost for a partially completed job.

STEP 10: Review entered information. Check that the entered information is correctly entered. You have the option to return to previous dialog boxes to fix entries.

5.3.4 Manual Installation Condor on Windows NT

If you are to install Condor on many different machines, you may wish to use some other mechanism to install Condor NT on additional machines rather than running the Setup program described above on each machine.

WARNING: This is for advanced users only! All others should use the Setup program described above.

Here is a brief overview of how to install Condor NT manually without using the provided GUI-based setup program:

The Service The service that Condor NT will install is called "Condor". The Startup Type is Automatic. The service should log on as System Account, but **do not enable** "Allow Service to Interact with Desktop". The program that is run is *condor_master.exe*.

For your convenience, we have included a file called `install.exe` in the bin directory that will install a service. It is typically called in the following way:

```
install Condor Condor c:\condor\bin\condor_master.exe
```

If you wish to remove the service, we have provided a file called `remove.exe`. To use it, call it in the following way:

```
remove Condor
```

The Registry Condor NT uses a few registry entries in its operation. The key that Condor uses is HKEY_LOCAL_MACHINE/Software/Condor. The values that Condor puts in this registry key serve two purposes.

1. The values of CONDOR_CONFIG and RELEASE_DIR are used for Condor to start its service.

   CONDOR_CONFIG should point to the `condor_config` file. In this version of Condor NT, it **must** reside on the local disk.

   RELEASE_DIR should point to the directory where Condor is installed. This is typically `C:\Condor`, and again, this **must** reside on the local disk.

2. The other purpose is storing the entries from the last installation so that they can be used for the next one.

The Filesystem The files that are needed for Condor to operate are identical to the Unix version of Condor, except that executable files end in `.exe`. For example the on Unix one of the files is `condor_master` and on Condor NT the corresponding file is `condor_master.exe`.

These files currently must reside on the local disk for a variety of reasons. Advanced Windows NT users might be able to put the files on remote resources. The main concern is twofold. First, the files must be there when the service is started. Second, the files must always be in the same spot (including drive letter), no matter who is logged into the machine. Specifying a UNC path is not supported at this time.

5.3.5 Condor is installed... now what?

After the installation of Condor is completed, the Condor service must be started. If you used the GUI-based setup program to install Condor, the Condor service should already be started. If you installed manually, Condor must be started by hand, or you can simply reboot. NOTE: The Condor service will start automatically whenever you reboot your machine.

To start condor by hand:

1. From the Start menu, choose Settings.
2. From the Settings menu, choose Control Panel.
3. From the Control Panel, choose Services.
4. From Services, choose Condor, and Start.

Or, alternatively you can enter the following command from a command prompt:

```
net start condor
```

Run the Task Manager (Control-Shift-Escape) to check that Condor services are running. The following tasks should be running:

- *condor_master.exe*
- *condor_negotiator.exe*, if this machine is a central manager.
- *condor_collector.exe*, if this machine is a central manager.
- *condor_startd.exe*, if you indicated that this Condor node should start jobs
- *condor_schedd.exe*, if you indicated that this Condor node should submit jobs to the Condor pool.

Also, you should now be able to open up a new cmd (DOS prompt) window, and the Condor bin directory should be in your path, so you can issue the normal Condor commands, such as condor_q and condor_status.

5.3.6 Condor is running... now what?

Once Condor services are running, try building and submitting some test jobs. See the `README.TXT` file in the examples directory for details.

CHAPTER

SIX

Frequently Asked Questions (FAQ)

This is where you can find quick answers to some commonly asked questions about Condor.

6.1 Obtaining & Installing Condor

6.1.1 Where can I download Condor?

Condor can be downloaded from http://www.cs.wisc.edu/condor/downloads (Madison, Wisconsin, USA) or http://www.bo.infn.it/condor-mirror/downloads (a mirror site at the Istituto Nazionale di Fisica Nucleare in Bologna, Italy).

6.1.2 When I click to download Condor, it sends me back to the downloads page!

If you are trying to download Condor through a web proxy, try disabling it. Our web site uses the "referring page" as you navigate through our download menus in order to give you the right version of Condor, but sometimes proxies block this information from reaching our web site.

6.1.3 What platforms do you support?

See Section 1.6, on page 5.

6.1.4 Do you distribute source code?

At this time we do **not** distribute source code publicly, but instead consider requests on a case-by-case basis. If you need the source code, please email us at condor-admin@cs.wisc.edu explaining why, and we'll get back to you.

6.1.5 What is "Personal Condor"?

Personal Condor is a term used to describe a specific style of Condor installation suited for individual users who do not have their own pool of machines, but want to submit Condor jobs to run elsewhere.

A Personal Condor is essentially a one-machine, self-contained Condor pool which can use "flocking" to access resources in other Condor pools. See Section 3.11.6, on page 168 for more information on flocking.

6.2 Setting up Condor

6.2.1 How do I get more than one job to run on my SMP machine?

Condor will automatically recognize a SMP machine and advertise each CPU of the machine separately. For more details, see section 3.11.7 on page 169.

6.2.2 How do I set up my machines so that only certain users's jobs will run on them?

Restrictions on what jobs will run on a given resource can be easily specified in the resource's Requirements statement.

To specify that a given machine should only run certain users's jobs, for example, you could add the following Requirements entry to the machine's Condor configuration file:

```
Requirements = (RemoteUser == "userfoo@baz.edu" || Remo-
teUser == "userbar@baz.edu" )
```

To configure multiple machines to do so, simply create a common configuration file containing this requirement for them to share.

6.2.3 How do I configure Condor to run my jobs only on machines that have the right packages installed?

This is a two-step process. First, you need to tell the machines to report that they have special software instaled, and second, you need to tell the jobs to require machines that have that software.

To tell the machines to report the presence of special software, first add a parameter to their configuration files like so:

```
HAS_MY_SOFTWARE = True
```

And then, if there are already STARTD_EXPRS defined in that file, add HAS_MY_SOFTWARE to them, or, if not, add the line:

```
STARTD_EXPRS = HAS_MY_SOFTWARE
```

NOTE: For these changes to take effect, each *condor_startd* you update needs to be reconfigured with *condor_reconfig* -startd.

Next, to tell your jobs to only run on machines that have this software, add a requirements statement to their submit files like so:

```
Requirements = (HAS_MY_SOFTWARE =?= True)
```

NOTE: Be sure to use =?= instead of == so that if a machine doesn't have the HAS_MY_SOFTWARE parameter defined, the job's Requirements expression will not evaluate to "undefined", preventing it from running anywhere!

6.3 Running Condor Jobs

6.3.1 I'm at the University of Wisconsin-Madison Computer Science Dept., and I am having problems!

Please see the web page http://www.cs.wisc.edu/condor/uwcs. As it explains, your home directory is in AFS, which by default has access control restrictions which can prevent Condor jobs from running properly. The above URL will explain how to solve the problem.

6.3.2 I'm getting a lot of email from Condor. Can I just delete it all?

Generally you shouldn't ignore **all** of the mail Condor sends, but you can reduce the amount you get by telling Condor that you don't want to be notified every time a job successfully completes, only when a job experiences an error. To do this, include a line in your submit file like the following:

```
Notification = Error
```

See the Notification parameter in the *condor_q* man page on page 307 of this manual for more information.

6.3.3 Why will my vanilla jobs only run on the machine where I submitted them from?

Check the following:

1. Did you submit the job from a local filesystem that other computers can't access?

   See Section 3.3.5, on page 85.

2. Did you set a special requirements expression for vanilla jobs that's preventing them from running but not other jobs?

   See Section 3.3.5, on page 85.

3. Is Condor running as a non-root user?

   See Section 3.12.1, on page 175.

6.3.4 My job starts but exits right away with signal 9.

This can occur when the machine your job is running on is missing a shared library required by your program. One solution is to install the shared library on all machines the job may execute on. Another, easier, solution is to try to re-link your program statically so it contains all the routines it needs.

6.3.5 Why aren't any or all of my jobs running?

Problems like the following are often reported to us:

```
> I have submitted 100 jobs to my pool, and only 18 appear to be
> running, but there are plenty of machines available.
What should I
> do to investigate the reason why this happens?
```

Start by following these steps to understand the problem:

1. Run *condor_q* -analyze and see what it says.

2. Look at the User Log file (whatever you specified as ”log = XXX” in the submit file).

   See if the jobs are starting to run but then exiting right away, or if they never even start.

3. Look at the SchedLog on the submit machine after it negotiates for this user. If a user doesn’t have enough priority to get more machines the SchedLog will contain a message like ”lost priority, no more jobs”.

4. If jobs are successfully being matched with machines, they still might be dying when they try to execute due to file permission problems or the like. Check the ShadowLog on the submit machine for warnings or errors.

5. Look at the NegotiatorLog during the negotiation for the user. Look for messages about priority, ”no more machines”, or similar.

6.3.6 Can I submit my standard universe SPARC Solaris 2.6 jobs and have them run on a SPARC Solaris 2.7 machine?

No. You may only use binary compatibility between SPARC Solaris 2.5.1 and SPARC Solaris 2.6 and between SPARC Solaris 2.7 and SPARC Solaris 2.8, but not between SPARC Solaris 2.6 and SPARC Solaris 2.7. We may implement support for this feature in a future release of Condor.

6.4 Condor on Windows NT / Windows 2000

6.4.1 Will Condor work on a network of mixed Unix and NT machines?

You can have a Condor pool that consists of both Unix and NT machines.

Your central manager can be either Windows NT or Unix. For example, even if you had a pool consisting strictly of Unix machines, you could use an NT box for your central manager, and vice versa.

You can submit jobs destined to run on Windows NT from either an NT machine **or** a Unix machine. However, at this point in time you cannot submit jobs destined to run on Unix from NT. We do plan on adding this functionality, however.

So, in summary:

1. A single Condor pool can consist of both Windows NT and Unix machines.
2. It does not matter at all if your Central Manager is Unix or NT.
3. Unix machines can submit jobs to run on other Unix or Windows NT machines.
4. Windows NT machines can only submit jobs which will run on Windows NT machines.

6.4.2 When I run *condor_status* I get a communication error, or the Condor daemon log files report a failure to bind.

Condor uses the first network interface it sees on your machine. This problem usually means you have an extra, inactive network interface (such as a RAS dialup interface) defined before to your regular network interface.

To solve this problem, either change the order of your network interfaces in the Control Panel, or explicity set which network interface Condor should use by adding the following parameter to your Condor config file:

```
NETWORK_INTERFACE = ip-address
```

Where “ip-address” is the IP address of the interface you wish Condor to use.

6.4.3 My job starts but exits right away with status 128.

This can occur when the machine your job is running on is missing a DLL (Dynamically Linked Library) required by your program. The solution is to find the DLL file the program needs and put it in the TRANSFER_INPUT_FILES list in the job’s submit file.

To find out what DLLs your program depends on, right-click the program in Explorer, choose Quickview, and look under “Import List”.

6.5 Troubleshooting

6.5.1 What happens if the central manager crashes?

If the central manager crashes, jobs that are already running will continue to run unaffected. Queued jobs will remain in the queue unharmed, but can not begin running until the central manager is restarted and begins matchmaking again. Nothing special needs to be done after the central manager is brought back online.

6.6 Other questions

6.6.1 Is Condor Y2K-compliant?

Yes. Internally, Condor uses the standard UNIX time representation (the number of seconds since 1/1/1970) and is not affected by the Y2K bug. In addition, the Condor tools now correctly display the four-digit year in their output.

The output of Condor tools from some older versions (pre-6.2) may display years incorrectly, but their internal representation is still correct and their display bugs do not affect the operation of Condor.

6.6.2 Is there a Condor mailing-list?

Yes. We run an extremely low traffic mailing list solely to announce new versions of Condor. To subscribe, email majordomo@cs.wisc.edu with a message body of:

```
subscribe condor-world
```

6.6.3 Do you support Globus?

Yes, we support a variety of interactions with Globus software, including running Condor jobs on Globus-managed resources. At this time, however, we have not released this software publicly. If you are interested in using Condor with Globus, please send email to condor-admin@cs.wisc.edu and we can provide you with more information.

6.6.4 My question isn't in the FAQ!

If you have any questions that are not listed in this FAQ, try looking through the rest of the manual. If you still can't find an answer, feel free to contact us at condor-admin@cs.wisc.edu.

Note that Condor's free email support is provided on a best-effort basis, and at times we may not be able to provide a timely response. If guaranteed support is important to you, please inquire about our paid support services.

CHAPTER

SEVEN

Condor Version History

7.1 Introduction to Condor Versions

This chapter provides descriptions of what features have been added or bugs fixed for each version of Condor. The first section describes the Condor version numbering scheme, what the numbers mean, and what the different *release series* are. The rest of the sections each describe a specific release series, and all the Condor versions found in that series.

7.1.1 Condor Version Number Scheme

Starting with version 6.0.1, Condor adopted a new, hopefully easy to understand version numbering scheme. It reflects the fact that Condor is both a production system and a research project. The numbering scheme was primarily taken from the Linux kernel's version numbering, so if you are familiar with that, it should seem quite natural.

There will usually be two Condor versions available at any given time, the *stable* version, and the *development* version. Gone are the days of "patch level 3", "beta2", or any other random words in the version string. All versions of Condor now have exactly three numbers, seperated by "."

- The first number represents the major version number, and will change very infrequently.
- *The thing that determines whether a version of Condor is "stable" or "development" is the second digit. Even numbers represent stable versions, while odd numbers represent development versions.*
- The final digit represents the minor version number, which defines a particular version in a given release series.

7.1.2 The Stable Release Series

People expecting the stable, production Condor system should download the stable version, denoted with an even number in the second digit of the version string. Most people are encouraged to use this version. We will only offer our paid support for versions of Condor from the stable release series.

On the stable series, new minor version releases will only be made for bug fixes and to support new platforms. No new features will be added to the stable series. People are encouraged to install new stable versions of Condor when they appear, since they probably fix bugs you care about. Hopefully, there won't be many minor version releases for any given stable series.

7.1.3 The Development Release Series

Only people who are interested in the latest research, new features that haven't been fully tested, etc, should download the development version, denoted with an odd number in the second digit of the version string. We will make a best effort to ensure that the development series will work, but we make no guarantees.

On the development series, new minor version releases will probably happen frequently. People should not feel compelled to install new minor versions unless they know they want features or bug fixes from the newer development version.

Most sites will probably never want to install a development version of Condor for any reason. Only if you know what you are doing (and like pain), or were explicitly instructed to do so by someone on the Condor Team, should you install a development version at your site.

NOTE: Different releases within a development series cannot be installed side-by-side within the same pool. For example, the protocols used by version 6.1.6 are not compatible with the protocols used in version 6.1.5. When you upgrade to a new development release, make certain you upgrade all machines in your pool to the same version.

After the feature set of the development series is satisfactory to the Condor Team, we will put a code freeze in place, and from that point forward, only bug fixes will be made to that development series. When we have fully tested this version, we will release a new stable series, resetting the minor version number, and start work on a new development release from there.

7.2 Stable Release Series 6.2

This is the second stable release series of Condor. All of the new features developed in the 6.1 series are now considered stable, supported features of Condor. New releases of 6.2.0 should happen infrequently and will only include bug fixes and support for new platforms. New features will be added and tested in the 6.3 development series. The details of each version are described below.

Version 6.2.0

New Features Over the 6.0 Release Series

- Support for running multiple jobs on SMP (Symmetric Mutli-Processor) machines.

This section has not yet been written

Known Bugs:

- None.

This section has not yet been written

7.3 Development Release Series 6.1

This was the first development release series. It contains numerous enhancements over the 6.0 stable series. For example:

- Support for running multiple jobs on SMP machines
- Enhanced functionality for pool administrators
- Support for PVM, MPI and Globus jobs
- Support for *Flocking* jobs across different Condor pools

The 6.1 series has many other improvements over the 6.0 series, and is available on more platforms. The new features, bugs fixed, and known bugs of each version are described below in detail.

7.3.1 Version 6.1.17

This version is the 6.2.0 “release candidate”. It was publically released in Feburary of 2001, and it will be released as 6.2.0 once it is considered “stable” by heavy testing at the UW-Madison Computer Science Department Condor pool.

New Features:

- Hostnames in the HOSTALLOW and HOSTDENY entries are now case-insensitive.
- It is now possible to submit NT jobs from a UNIX machine.

- The NT release of Condor now supports a USE_VISIBLE_DESKTOP parameter. If true, Condor will allow the job to create windows on the desktop of the execute machine and interact with the job. This is particularly useful for debugging why an application will not run under Condor.
- The *condor_startd* contains support for the new MPI dedicated scheduler that will appear in the 6.3 development series. This will allow you to use your 6.2 Condor pool with the new scheduler.
- Added a **mixedcase** option to *condor_config_val* to allow for overriding the default of lower-casing all the config names
- Added a pid_snapshot_interval option to the config file to control how often the *condor_startd* should examine the running process family. It defaults to 50 seconds.

Bugs Fixed:

- Fixed a bug with the *condor_schedd* reaching the MAX_JOBS_RUNNING mark and properly calculating Scheduler Universe jobs for preemption.
- Fixed a bug in the *condor_schedd* loosing track of *condor_startd*s in the initial claiming phase. This bug affected all platforms, but was most likely to manifest on Solaris 2.6
- CPU Time can be greater than wall clock time in Multi-threaded apps, so do not consider it an error in the UserLog.
- *condor_restart* **-master** now works correctly.
- Fixed a rare condition in the *condor_startd* that could corrupt memory and result in a signal 11 (SIGSEGV, or segmentation violation).
- Fixed a bug that would cause the “execute event” to not be logged to the UserLog if the binary for the job resided on AFS.
- Fixed a race-condition in Condor’s PVM support on SMP machines (introduced in version 6.1.16) that caused PVM tasks to be associated with the wrong daemon.
- Better handling of checkpointing on large-memory Linux machines.
- Fixed random occasions of job completion email not being sent.
- It is no longer possible to use *condor_user_prio* to set a priority of less than 1.
- Fixed a bug in the job completion email statistics. Run Time was being underreported when the job completed after doing a periodic checkpoint.
- Fixed a bug that caused CondorLoadAvg to get stuck at 0.0 on Linux when the system clock was adjusted.
- Fixed a *condor_submit* bug that caused all machine_count commands after the first queue statement to be ignored for PVM jobs.

- PVM tasks now run as the user when appropriate instead of always running under the UNIX "nobody" account.
- Fixed support for the PVM group server.
- PVM uses an environment variable to communicate with it's children instead of a file in /tmp. This file previously could become overwritten by mulitple PVM jobs.
- *condor_stats* now lives in the "bin" directory instead of "sbin".

Known Bugs:

- The *condor_negotiator* can crash if the Accountantnew.log file becomes corrupted. This most often occurs if the Central Manager runs out of diskspace.

7.3.2 Version 6.1.16

New Features:

- Condor now supports multiple pvmds per user on a machine. Users can now submit more than one PVM job at a time, PVM tasks can now run on the submission machine, and multiple PVM tasks can run on SMP machines. *condor_submit* no longer inserts default job requirements to restrict PVM jobs to one pvmd per user on a machine. This new functionality requires the *condor_pvmd* included in this (and future) Condor releases. If you set "PVM_OLD_PVMD = True" in the Condor configuration file, *condor_submit* will insert the default PVM job requirements as it did in previous releases. You must set this if you don't upgrade your *condor_pvmd* binary or if your jobs flock with pools that user an older *condor_pvmd*.
- The NT release of Condor no longer contains debugging information. This drastically reduces the size of the binaries you must install.

Bugs Fixed:

- The configuration files shipped with version 6.1.15 contained a number of errors relating to host-based security, the configuration of the central manager, and a few other things. These errors have all been corrected.
- Fixed a memory management bug in the *condor_schedd* that could cause it to crash under certain circumstances when machines were taken away from the schedd's control.
- Fixed a potential memory leak in a library used by the *condor_startd* and *condor_master* that could leak memory while Condor jobs were executing.
- Fixed a bug in the NT version of Condor that would result in faulty reporting of the load average.

- The *condor_shadow.pvm* should now correctly return core files when a task or *condor_pvmd* crashes.
- This release fixes a memory error introduced in version 6.1.15 that could crash the *condor_shadow.pvm*.
- Some *condor_pvmd* binaries in previous releases included debugging code we added that could cause the *condor_pvmd* to crash. This release includes new *condor_pvmd* binaries for all platforms with the problematic debugging code removed.
- Fixed a bug in the **-unset** options to *condor_config_val* that was introduced in version 6.1.15. Both **-unset** and **-runset** work correctly, now.

Known Bugs:

- None.

7.3.3 Version 6.1.15

New Features:

- In the job submit description file passed to *condor_submit*, a new style of macro (with two dollar-signs) can reference attributes from the machine ClassAd. This new style macro can be used in the job's `Executable`, `Arguments`, or `Environment` settings in the submit description file. For example, if you have both Linux and Solaris machines in your pool, the following submit description file will run either foo.INTEL.LINUX or foo.SUN4u.SOLARIS27 as appropiate, and will pass in the amount of memory available on that machine on the command line:

  ```
  executable = foo.$$(Arch).$$(Opsys)
  arguments = $$(Memory)
  queue
  ```

- The `CONFIG` security access level now controls the modification of daemon configurations using *condor_config_val*. For more information about security access levels, see section 3.8.2 on page 145.
- The `DC_DAEMON_LIST` macro now indicates to the *condor_master* which processes in the `DAEMON_LIST` use Condor's DaemonCore inter-process communication mechanisms. This allows the *condor_master* to monitor both processes developed with or without the Condor DaemonCore library.
- The new `NEGOTIATE_ALL_JOBS_IN_CLUSTER` macro can be use to configure the *condor_schedd* to not assume (for efficiency) that if one job in a cluster can't be scheduled, then no other jobs in the cluster can be scheduled. If `NEGOTIATE_ALL_JOBS_IN_CLUSTER` is set to True, the *condor_schedd* will now always try to schedule each individual job in a cluster.

- The *condor_schedd* now automatically adds any machine it is matched with to its HOSTALLOW_WRITE list. This simplifies setting up a machine for flocking, since the submitting user doesn't have to know all the machines where the job might execute, they only have to know what central manager they wish to flock to. Submitting users must trust a central manager they report to, so this doesn't impact security in any way.
- Some static limits relating to the number of jobs which can be simultaneously started by the *condor_schedd* has been removed.
- The default Condor config file(s) which are installed by the installation program have been re-organized for greater clarity and simplicity.

Bugs Fixed:

- In the STANDARD Universe, jobs submitted to Condor could segfault if they opened multiple files with the same name. Usually this bug was exposed when users would submit jobs without specifying a file for either stdout or stderr; in this case, both would default to `/dev/null`, and this could trigger the problem.
- The Linux 2.2.14 kernel, which is used by default with RedHat 6.2, has a serious bug can cause the machine to lock up when the same socket is used for repeated connection attempts. Thus, previous versions of Condor could cause the 2.2.14 kernel to hang (lots of other applications could do this as well). The Condor Team recommends that you upgrade your kernel to 2.2.16 or later. However, in v6.1.15 of Condor, a patch was added to the Condor networking layer so that Condor would not trigger this Linux kernel bug.
- If no email address was specified when the job was submitted with *condor_submit*, completion email was being sent to user@submit-machine-hostname. This is not the correct behavior. Now email goes by default to user@uid-domain, where uid-domain is defined by the `UID_DOMAIN` setting in the config file.
- The *condor_master* can now correctly shutdown and restart the *condor_checkpoint_server*.
- Email sent when a SCHEDULER Universe job compeltes now has the correct From: header.
- In the STANDARD universe, jobs which call sigsuspend() will now receive the correct return value.
- Abnormal error conditions, such as the hard disk on the submit machine filling up, are much less likely to result in a job disappearing from the queue.
- The *condor_checkpoint_server* now correctly reconfigures when a *condor_reconfig* command is received by the *condor_master*.
- Fixed a bug with how the *condor_schedd* associates jobs with machines (claimed resources) which would, under certain circumstances, cause some jobs to remain idle until other jobs in the queue complete or are preempted.

- A number of PVM universe bugs are fixed in this release. Bugs in how the *condor_shadow.pvm* exited, which caused jobs to hang at exit or to run multiple times, have been fixed. The *condor_shadow.pvm* no longer exits if there is a problem starting up PVM on one remote host. The *condor_starter.pvm* now ignores the periodic checkpoint command from the startd. Previously, it would vacate the job when it received the periodic checkpoint command. A number of bugs with how the *condor_starter.pvm* handled asynchronous events, which caused it to take a long time to clean up an exited PVM task, have been fixed. The *condor_schedd* now sets the status correctly on multi-class PVM jobs and removes them from the job queue correctly on exit. *condor_submit* no longer ignores the machine_count command for PVM jobs. And, a problem which caused pvm_exit() to hang was diagnosed: PVM tasks which call pvm_catchout() to catch the output of child tasks should be sure to call it again with a NULL argument to disable output collection before calling pvm_exit().
- The change introduced in 6.1.13 to the *condor_shadow* regarding when it logged the execute event to the user log produced situations where the shadow could log other events (like the shadow exception event) before the execute event was logged. Now, the *condor_shadow* will always log an execute event before it logs any other events. The timing is still improved over 6.1.12 and older versions, with the execute event getting logged after the bulk of the job initialization has finished, right before the job will actually start executing. However, you will no longer see user logs that contain a “shadow exception” or “job evicted” message without a “job executing” event, first.
- `stat()` and varient calls now go through the file table to get the correct logical size and access times of buffered files. Before, `stat()` used to return zero size on a buffered file that had not yet been synced to disk.

Known Bugs:

- On IRIX 6.2, C++ programs compiled with GNU C++ (g++) 2.7.2 and linked with the Condor libraries (using *condor_compile*) will not execute the constructors for any global objects. There is a work-around for this bug, so if this is a problem for you, please send email to condor-admin@cs.wisc.edu.
- In HP-UX 10.20, *condor_compile* will not work correctly with HP’s C++ compiler. The jobs might link, but they will produce incorrect output, or die with a signal such as SIGSEGV during restart after a checkpoint/vacate cycle. However, the GNU C/C++ and the HP C compilers work just fine.
- The `getrusage()` call does not work always as expected in STANDARD Universe jobs. If your program uses `getrusage()`, it could decrease incorrectly by a second across a checkpoint and restart. In addition, the time it takes Condor to restart from a checkpoint is included in the usage times reported by `getrusage()`, and it probably should not be.

7.3.4 Version 6.1.14

New Features:

- Initial supported added for RedHat Linux 6.2 (i.e. glibc 2.1.3).

Bugs Fixed:

- In version 6.1.13, periodic checkpoints would not occur (see the Known Bugs section for v6.1.13 listed below). This bug, which only impacts v6.1.13, has been fixed.

Known Bugs:

- The `getrusage()` call does not work properly inside “standard” jobs. If your program uses `getrusage()`, it will not report correct values across a checkpoint and restart. If your program relies on proper reporting from `getrusage()`, you should either use version 6.0.3 or 6.1.10.
- While Condor now supports many networking calls such as `socket()` and `connect()`, (see the description below of this new feature added in 6.1.11), on Linux, we cannot at this time support `gethostbyname()` and a number of other database lookup calls. The reason is that on Linux, these calls are implemented by bringing in a shared library that defines them, based on whether the machine is using DNS, NIS, or some other database method. Condor does not support the way in which the C library tries to explicitly bring in these shared libraries and use them. There are a number of possible solutions to this problem, but the Condor developers are not yet agreed on the best one, so this limitation might not be resolved by 6.1.14.
- In HP-UX 10.20, *condor_compile* will not work correctly with HP's C++ compiler. The jobs might link, but they will produce incorrect output, or die with a signal such as SIGSEGV during restart after a checkpoint/vacate cycle. However, the GNU C/C++ and the HP C compilers work just fine.
- When a program linked with the Condor libraries (using *condor_compile*) is writing output to a file, `stat()`–and variant calls, will return zero for the size of the file if the program has not yet read from the file or flushed the file descriptors. This is a side effect of the file buffering code in Condor and will be corrected to the expected semantic.
- On IRIX 6.2, C++ programs compiled with GNU C++ (g++) 2.7.2 and linked with the Condor libraries (using *condor_compile*) will not execute the constructors for any global objects. There is a work-around for this bug, so if this is a problem for you, please send email to condor-admin@cs.wisc.edu.

7.3.5 Version 6.1.13

New Features:

- Added `DEFAULT_IO_BUFFER_SIZE` and `DEFAULT_IO_BUFFER_BLOCK_SIZE` to config parameters to allow the administrator to set the default file buffer sizes for user jobs in *condor_submit*.

- There is no longer any difference in the configuration file syntax between “macros” (which were specified with an “=” sign) and “expressions” (which were specified with a “:” sign). Now, all config file entries are treated and referenced as macros. You can use either “=” or “:” and they will work the same way. There is no longer any problem with forward-referencing macros (referencing macros you haven’t yet defined), so long as they are eventually defined in your config files (even if the forward reference is to a macro defined in another config file, like the local config file, for example).
- *condor_vacate* now supports a **-fast** option that forces Condor to hard-kill the job(s) immediately, instead of waiting for them to checkpoint and gracefully shutdown.
- *condor_userlog* now displays times in days+hours:minutes format instead of total hours or total minutes.
- The *condor_run* command provides a simple front-end to *condor_submit* for submitting a shell command-line as a vanilla universe job.
- Solaris 2.7 SPARC, 2.7 INTEL have been added to the list of ports that now support remote system calls and checkpointing.
- Any mail being sent from Condor now shows up as having been sent from the designated Condor Account, instead of root or “Super User”.
- The *condor_submit* “hold” command may be used to submit jobs to the queue in the hold state. Held jobs will not run until released with *condor_release*.
- It is now possible to use checkpoint servers in remote pools when flocking even if the local pool doesn’t use a checkpoint server. This is now the default behavior (see the next item).
- `USE_CKPT_SERVER` now defaults to True if a checkpoint server is available. It is usually more efficient to use a checkpoint server near the execution site instead of storing the checkpoint back to the submission machine, especially when flocking.
- All Condor tools that used to expect just a hostname or address (*condor_checkpoint*, *condor_off*, *condor_on*, *condor_restart*, *condor_reconfig*, *condor_reschedule*, *condor_vacate*) to specify what machine to effect, can now take an optional **-name** or **-addr** in front of each target. This provides consistancy with other Condor tools that require the **-name** or **-addr** options. For all of the above mentioned tools, you can still just provide hostnames or addresses, the new flags are not required.
- Added **-pool** and **-addr** options to *condor_rm*, *condor_hold* and *condor_release*.
- When you start up the *condor_master* or *condor_schedd* as any user other than “root” or “condor” on Unix, or “SYSTEM” on NT, the daemon will have a default `Name` attribute that includes both the username of the user who the daemon is running as and the full hostname of the machine where it is running.
- Clarified our Linux platform support. We now officially support the RedHat 5.2 and 6.x distributions, and although other Linux distributions (especially those with similar libc versions) may work, they are not tested or supported.

- The schedd now periodically updates the run-time counters in the job queue for running jobs, so if the schedd crashes, the counters will remain relatively up-to-date. This is controlled by the `WALL_CLOCK_CKPT_INTERVAL` parameter.
- The *condor_shadow* now logs the "job executing" event in the user log after the binary has been successfully transfered, so that the events appear closer to the actual time the job starts running. This can create some somewhat unexpected log files. If something goes wrong with the job's initialization, you might see an "evicted" event before you see an "executing" event.

Bugs Fixed:

- Fixed how we internally handle file names for user jobs. This fixes a nasty bug due to changing directories between checkpoints.
- Fixed a bug in our handling of the `Arguments` macro in the command file for a job. If the arguments were extremely long, or there were an extreme number of them, they would get corrupted when the job was spawned.
- Fixed DAGMan. It had not worked at all in the previous release.
- Fixed a nasty bug under Linux where file seeks did not work correctly when buffering was enabled.
- Fixed a bug where *condor_shadow* would crash while sending job completion e-mail forcing a job to restart multiple times and the user to get multiple completion messages.
- Fixed a long standing bug where Fortran 90 would occasionally truncate its output files to random sizes and fill them with zeros.
- Fixed a bug where `close()` did not propogate its return value back to the user job correctly.
- If a SIGTERM was delivered to a *condor_shadow*, it used to remove the job it was running from the job queue, as if *condor_rm* had been used. This could have caused jobs to leave the queue unexpectedly. Now, the *condor_shadow* ignores SIGTERM (since the *condor_schedd* knows how to gracefully shutdown all the shadows when it gets a SIGTERM), so jobs should no longer leave the queue prematurely. In addition, on a SIGQUIT, the shadow now does a fast shutdown, just like the rest of the Condor daemons.
- Fixed a number of bugs which caused checkpoint restarts to fail on some releases of Irix 6.5 (for example, when migrating from a mips4 to a mips3 CPU or when migrating between machines with different pagesizes).
- Fixed a bug in the implementation of the `stat()` family of remote system calls on Irix 6.5 which caused file opens in Fortran programs to sometimes fail.
- Fixed a number of problems with the statistics reported in the job completion email and by *condor_q* **-goodput**, including the number of checkpoints and total network usage. Correct values will now be computed for all new jobs.

- Changes in `USE_CKPT_SERVER` and `CKPT_SERVER_HOST` no longer cause problems for jobs in the queue which have already checkpointed.
- Many of the Condor administration tools had a bug where they would suffer a segmentation violation if you specified a **-pool** option and did not specify a hostname. This case now results in an error message instead.
- Fixed a bug where the *condor_schedd* could die with a segmentation violation if there was an error mapping an IP address into a hostname.
- Fixed a bug where resetting the time in a large negative direction caused the *condor_negotiator* to have a floating point error on some platforms.
- Fixed *condor_q*'s output so that certain arguments are not ignored.
- Fixed a bug in *condor_q* where issuing a **-global** with a fairly restrictive **-constraint** argument would cause garbage to be printed to the terminal sometimes.
- Fixed a bug which caused jobs to exit without completing a checkpoint when preempted in the middle of a periodic checkpoint. Now, the jobs will complete their periodic checkpoint in this case before exiting.

Known Bugs:

- Periodic checkpoints do not occur. Normally, when the config file attribute `PERIODIC_CHECKPOINT` evaluates to True, Condor performs a periodic checkpoint of the running job. This bug has been fixed in v6.1.14. NOTE: there is a work-around to permit periodic checkpoints to occur in v6.1.13: include the attribute name "PERIODIC_CHECKPOINT" to the attributes listed in the `STARTD_EXPRS` entry in the config file.
- The `getrusage()` call does not work properly inside "standard" jobs. If your program uses `getrusage()`, it will not report correct values across a checkpoint and restart. If your program relies on proper reporting from `getrusage()`, you should either use version 6.0.3 or 6.1.10.
- While Condor now supports many networking calls such as `socket()` and `connect()`, (see the description below of this new feature added in 6.1.11), on Linux, we cannot at this time support `gethostbyname()` and a number of other database lookup calls. The reason is that on Linux, these calls are implemented by bringing in a shared library that defines them, based on whether the machine is using DNS, NIS, or some other database method. Condor does not support the way in which the C library tries to explicitly bring in these shared libraries and use them. There are a number of possible solutions to this problem, but the Condor developers are not yet agreed on the best one, so this limitation might not be resolved by 6.1.14.
- In HP-UX 10.20, *condor_compile* will not work correctly with HP's C++ compiler. The jobs might link, but they will produce incorrect output, or die with a signal such as SIGSEGV during restart after a checkpoint/vacate cycle. However, the GNU C/C++ and the HP C compilers work just fine.

- When writing output to a file, `stat()`–and variant calls, will return zero for the size of the file if the program has not yet read from the file or flushed the file descriptors, This is a side effect of the file buffering code in Condor and will be corrected to the expected semantic.
- On IRIX 6.2, C++ programs compiled with GNU C++ (g++) 2.7.2 and linked with the Condor libraries (using *condor_compile*) will not execute the constructors for any global objects. There is a work-around for this bug, so if this is a problem for you, please send email to condor-admin@cs.wisc.edu.

7.3.6 Version 6.1.12

Version 6.1.12 fixes a number of bugs from version 6.1.11. If you linked your "standard" jobs with version 6.1.11, you should upgrade to 6.1.12 and re-link your jobs (using *condor_compile*) as soon as possible.

New Features:

- None.

Bugs Fixed:

- A number of system calls that were not being trapped by the Condor libraries in version 6.1.11 are now being caught and sent back to the submit machine. Not having these functions being executed as remote system calls prevented a number of programs from working, in particular Fortran programs, and many programs on IRIX and Solaris platforms.
- Sometimes submitted jobs report back as having no owner and have **-????-** in the status line for the job. This has been fixed.
- *condor_q* **-io** has been fixed in this release.

Known Bugs:

- The `getrusage()` call does not work properly inside "standard" jobs. If your program uses `getrusage()`, it will not report correct values across a checkpoint and restart. If your program relies on proper reporting from `getrusage()`, you should either use version 6.0.3 or 6.1.10.
- While Condor now supports many networking calls such as `socket()` and `connect()`, (see the description below of this new feature added in 6.1.11), on Linux, we cannot at this time support `gethostbyname()` and a number of other database lookup calls. The reason is that on Linux, these calls are implemented by bringing in a shared library that defines them, based on whether the machine is using DNS, NIS, or some other database method. Condor does not support the way in which the C library tries to explicitly bring in these shared libraries

and use them. There are a number of possible solutions to this problem, but the Condor developers are not yet agreed on the best one, so this limitation might not be resolved by 6.1.13.

- In HP-UX 10.20, *condor_compile* will not work correctly with HP's C++ compiler. The jobs might link, but they will produce incorrect output, or die with a signal such as SIGSEGV during restart after a checkpoint/vacate cycle. However, the GNU C/C++ and the HP C compilers work just fine.
- When writing output to a file, `stat()`–and variant calls, will return zero for the size of the file if the program has not yet read from the file or flushed the file descriptors, This is a side effect of the file buffering code in Condor and will be corrected to the expected semantic.
- On IRIX 6.2, C++ programs compiled with GNU C++ (g++) 2.7.2 and linked with the Condor libraries (using *condor_compile*) will not execute the constructors for any global objects. There is a work-around for this bug, so if this is a problem for you, please send email to condor-admin@cs.wisc.edu.
- The **-format** option in *condor_q* has no effect when querying remote machines with the **-n** option.
- *condor_dagman* does not work at all in this release. The behaviour of its failure is to exit immediately with a success and to not perform any work. It will be fixed in the next release of Condor.

7.3.7 Version 6.1.11

New Features:

- *condor_status* outputs information for held jobs instead of MaxRunningJobs when supplied with **-schedd** or **-submitter**.
- *condor_userprio* now prints 4 digit years (for Y2K compiance). If you give a two digit date, it also will assume that 1/1/00 is 1/1/2000 and not 1/1/1900.
- IRIX 6.5 has been added to the list of ports that now support remote system calls and checkpointing.
- *condor_q* has been fixed to be faster and much more memory efficient. This is much more obvious when getting the queue from *condor_schedd*'s that have more than 1000 jobs.
- Added support for support for socket() and pipe() in standard jobs. Both sockets and pipes are created on the executing machine. Checkpointing is deferred anytime a socket or pipe is open.
- Added limited support for select() and poll() in standard jobs. Both calls will work only on files opened locally.

- Added limited support for fcntl() and ioctl() in standard jobs. Both calls will be performed remotely if the control-number is understood and the third argument is an integer.
- Replaced buffer implementation in standard jobs. The new buffer code reads and writes variable sized chunks. It will never issue a read to satisfy a write. Buffering is enabled by default.
- Added extensive feedback on I/O performance in the user's email.
- Added **-io** option to *condor_q* to show I/O statistics.
- Removed libckpt.a and libzckpt.a. To build for standalone checkpointing, just do a regular *condor_compile*. No -standalone option is necessary.
- The checkpointing library now only re-opens files when they are actually used. If files or other needed resources cannot be found at restart time, the checkpointer will fail with a verbose error.
- The `RemoteHost` and `LastRemoteHost` attributes in the job classad now contain hostnames instead IP address and port numbers. The **-run** option of older versions of *condor_q* is not compatible with this change.
- Condor will now automatically check for compatibility between the version of the Condor libraries you have linked into a standard job (using *condor_compile*) and the version of the *condor_shadow* installed on your submit machine. If they are incompatible, the *condor_shadow* will now put your job on hold. Unless you set "Notification = Never" in your submit file, Condor will also send you email explaining what went wrong and what you can do about it.
- All Condor daemons and tools now have a `CondorPlatform` string, which shows which platform a given set of Condor binaries was built for. In all places that you used to see `CondorVersion`, you will now see both `CondorVersion` and `CondorPlatform`, such as in each daemon's ClassAd, in the output to a **-version** option (if supported), and when running *ident* on a given Condor binary. This string can help identify situations where you are running the wrong version of the Condor binaries for a given platform (for example, running binaries built for Solaris 2.5.1 on a Solaris 2.6 machine).
- Added commented-out settings in the default `condor_config` file we ship for various SMP-specific settings in the *condor_startd*. Be sure to read section 3.11.7 on "Configuring the Startd for SMP Machine" on page 169 for details about using these settings.
- *condor_rm*, *condor_hold*, and *condor_release* all support **-help** and **-version** options now.

Bugs Fixed:

- A race condition which could cause the *condor_shadow* to not exit when its job was removed has been fixed. This bug would cause jobs that had been removed with *condor_rm* to remain in the queue marked as status "X" for a long time. In addition, Condor would not shutdown quickly on hosts that had hit this race condition, since the *condor_schedd* wouldn't exit until all of its *condor_shadow* children had exited.

- A signal race condition during restart of a Condor job has been fixed.
- In a Condor linked job, `getdomainname()` is now supported.
- IRIX 6.5 can give negative time reports for how long a process has been running. We account for that now in our statistics about usage times.
- The *condor_status* memory error introduced in version 6.1.10 has been fixed.
- The `DAEMON_LIST` configuration setting is now case insensitive.
- Fixed a bug where the *condor_schedd*, under rare circumstances, cause another schedd's jobs not to be matched.
- The free disk space is now properly computed on Digital Unix. This fixed problems where the `Disk` attribute in the condor_startd classad reported incorrect values.
- The config file parser now detects incremental macro definitions correctly (see section 3.3.1 on page 75). Previously, when a macro (or expression) being defined was a substring of a macro (or expression) being referenced in its definition, the reference would be erroneously marked as an incremental definition and expanded immediately. The parser now verifies that the entire strings match.

Known Bugs:

- The output for condor_q **-io** is incorrect and will likely show zeroes for all values. A fixed version will appear in the next release.

7.3.8 Version 6.1.10

New Features:

- *condor_q* now accepts `-format` parameters like *condor_status*
- *condor_rm*, *condor_hold* and *condor_release* accept `-constraint` parameters like *condor_status*
- *condor_status* now sorts displayed totals by the first column. (This feature introduced a bug in *condor_status*. See "Known Bugs" below.)
- Condor version 6.1.10 introduces "clipped" support for Sparc Solaris version 2.7. This version does not support checkpointing or remote system calls. Full support for Solaris 2.7 will be released soon.
- Introduced code to enable Linux to use the standard C library's I/O buffering again, instead of relying on the Condor I/O buffering code (which is still in beta testing).

Bugs Fixed:

- The bug in checkpointing introduced in version 6.1.9 has been fixed. Checkpointing will now work on all platforms, as it always used to. Any jobs linked with the 6.1.9 Condor libraries will need to be relinked with *condor_compile* once version 6.1.10 has been installed at your site.

Known Bugs:

- The `CondorLoadAvg` attribute in the *condor_startd* has some problems in the way it is computed. The CondorLoadAvg is somewhat inaccurate for the first minute a job starts running, and for the first minute after it completes. Also, the computation of CondorLoadAvg is very wrong on NT. All of this will be fixed in a future version.
- A memory error may cause *condor_status* to die with SIGSEGV (segmentation violation) when displaying totals or cause incorrect totals to be displayed. This will be fixed in version 6.1.11.

7.3.9 Version 6.1.9

New Features:

- Added full support for Linux 2.0.x and 2.2.x kernels using libc5, glibc20 and glibc21. This includes support for RedHat 6.x, Debian 2.x and other popular Linux distributions. Whereas the Linux machines had once been fragmented across libc5 and GNU libc, they have now been reunified. This means there is no longer any need for the “LINUX-GLIBC” OpSys setting in your pool: all machines will now show up as “LINUX”. Part of this reunification process was the removal of dynamically linked user jobs on Linux. *condor_compile* now forces static linking of your Standard Universe Condor jobs. Also, please use *condor_compile* on the same machine on which you compiled your object files.
- Added *condor_qedit* utility to allow users to modify job attributes after submission. See the new manual page on page 279.
- Added **-runforminutes** *o*ption to daemonCore to have the daemon gracefully shut down after the given number of minutes.
- Added support for statfs(2) and fstatfs(2) in user jobs. We support only the fields *f_bsize, f_blocks, f_bfree, f_bavail, f_files, f_ffree* from the structure statfs. This is still in the experimental stage.
- Added the **-direct** option to *condor_status*. After you give **-direct**, you supply a hostname, and *condor_status* will query the *condor_startd* on the specified host and display information directly from there, instead of querying the *condor_collector*. See the manual page on page 305 for details.

- Users can now define `NUM_CPUS` to override the automatic computation of the number of CPUs in your machine. Using this config setting can cause unexpected results, and is not recommended. This feature is only provided for sites that specifically want this behavior and know what they are doing.
- The **-set** and **-rset** options to *condor_config_val* have been changed to allow administrators to set both macros and expressions. Previously, *condor_config_val* assumed you wanted to set expressions. Now, these two options each take a single argument, the string containing exactly what you would put into the config file, so you can specify you want to create a macro by including an "=" sign, or an expression by including a ":". See section 3.3.1 on page 75 for details on macros vs. expressions. See the *condor_config_val* man page on page **??** for details on *condor_config_val*.
- If the directory you specified for LOCK (which holds lock files used by Condor) doesn't exist, Condor will now try to create that directory for you instead of giving up right away.
- If you change the `COLLECTOR_HOST` setting and reconfig the *condor_startd*, the startd will "invalidate" its ClassAds at the old collector before it starts reporting to the new one.

Bugs Fixed:

- Fixed a major bug dealing with the group access a Condor job is started with. Now, Condor jobs are started with all the groups the job's owner is in, not just their default group. This also fixes a security hole where user jobs could be started up in access groups they didn't belong to.
- Fixed a bug where there was a needless limitation on the number of open file descriptors a user job could have.
- Fixed a standalone checkpointing bug where we weren't blocking signals in critical sections and causing file table corruption at checkpoint time.
- Fixed a linker bug on Digital Unix 4.0 concerning fortran where the linker would fail on __uname and __sigsuspend.
- Fixed a bug in *condor_shadow* that would send incorrect job completion email under Linux.
- Fixed a bug in the remote system call of `fchdir()` that caused a garbage file descriptor to be used in Standard Universe jobs.
- Fixed a bug in the *condor_shadow* which was causing *condor_q* **-goodput** to display incorrect values for some jobs.
- Fixed some minor bugs and made some minor enhancements in the *condor_install* script. The bugs included a typo in one of the questions asked, and incorrect handling for the answers of a few different questions. Also, if DNS is misconfigured on your system, *condor_install* will try a few ways to find your fully qualified hostname, and if it still can't determine the correct hostname, it will prompt the user for it. In addition, we now avoid one installation step in cases were it is not needed.

- Fixed a rare race condition that could delay the completion of large clusters of short running jobs.
- Added more checking to the various arguments that might be passed to *condor_status*, so that in the case of bad input, *condor_status* will print an error message and exit, instead of performing a segmentation fault. Also, when you use the **-sort** option, *condor_status* will only display ClassAds where the attributes you use to sort are defined.
- Fixed a bug in the handling of the config files created by using the **-set** or **-rset** options to *condor_config_val*. Previously, if you manually deleted the files that were created, you could cause the affected Condor daemon to have a segmentation fault. Now, the daemons simply exit with a fatal error but still have a chance to clean up.
- Fixed a bug in the **-negotiator** option for most Condor tools that was causing it to get the wrong address.
- Fixed a couple of bugs in the *condor_master* that could cause improper shutdowns. There were cases during shutdown where we would restart a daemon (because we previously noticed a new executable, for example). Now, once you begin a shutdown, the *condor_master* will not restart anything. Also, fixed a rare bug that could cause the *condor_master* to stop checking the timestamps on a daemon.
- Fixed a minor bug in the **-owner** option to *condor_config_val* that was causing *condor_init* not to work.
- Fixed a bug where the *condor_startd*, while it was already shutting down, was allowing certain actions to succeed that should have failed. For example, it allowed itself to be matched with a user looking for available machines, or to begin a new PVM task.

Known Bugs:

- The `CondorLoadAvg` attribute in the *condor_startd* has some problems in the way it is computed. The CondorLoadAvg is somewhat inaccurate for the first minute a job starts running, and for the first minute after it completes. Also, the computation of CondorLoadAvg is very wrong on NT. All of this will be fixed in a future version.
- There is a serious bug in checkpointing when using Condor's I/O buffering for "standard" jobs. By default, Linux uses Condor buffering in version 6.1.9 for all standard jobs. The bug prevents checkpointing from working more than once. This renders the *condor_vacate* and *condor_checkpoint* commands useless, and jobs will just be killed without a checkpoint when machine owners come back to their machines.

7.3.10 Version 6.1.8

- Added *file_remaps* as command in the job submit file given to STANDARD universe jobs. A Job can now specify that it would like to have files be remapped from one file to another. In addition you can specify that files should be read from the local machine by specifing them. See the *condor_submit* manual page on page 305 for more details.

- Added *buffer_size* and *buffer_block_size* so that STANDARD universe jobs can specify that they wish to have I/O buffering turned on. Without buffering, all I/O requests in the STANDARD universe are sent back over the network to be executed on the submit machine. With buffering, read ahead, write behind, and seek batch buffering is performed to minimize network traffic and latency. By default, jobs do not specify buffering, however, for many situations buffering can drastically increase throughput. See the *condor_submit* manual page on page 305 for more details.
- The *condor_schedd* is much more memory efficient handling clusters with hundreds/thousands of jobs. If you submit large clusters, your submit machine will only use a fraction of the amount of RAM it used to require. NOTE: The memory savings will only be realized for new clusters submitted after the upgrade to v6.1.8 – clusters which previously existed in the queue at upgrade time will still use the same amount of RAM in the *condor_schedd*.
- Submitting jobs, especially submitting large clusters containing many jobs, is much faster.
- Added a **-goodput** option to *condor_q*, which displays statistics about the execution efficiency of STANDARD universe jobs.
- Added FS_REMOTE method of user authentication to possible values of the configuration option `AUTHENTICATION_METHODS` to fix problems with using the **-r** remote scheduler option of *condor_submit*. Additionally, the user authentication protocol has changed, so previous versions of Condor programs cannot co-exist with this new protocol.
- Added a new utility and documentation for *condor_glidein* which uses Globus resources to extend your local pool to use remote Globus machines as part of your Condor pool.
- Fixed more bugs in the handling of the stat() system call and its relatives on Linux with glibc. This was causing problems mainly with Fortran I/O, though other I/O related problems on glibc Linux will probably be solved now.
- Fixed a bug in various Condor tools (*condor_status*, *condor_user_prio*, *condor_config_val*, and *condor_stats*) that would cause them to seg fault on bad input to the **-pool** option.
- Fixed a bug with the **-rset** option to *condor_config_val* which could crash the Condor daemon whose configuration was being changed.
- Added *allow_startup_script* command to the job submit description file which is given to *condor_submit*. This allows the submission of a startup script to the STANDARD universe. See
- Fixed a bug in the *condor_schedd* where it would get into an infinite loop if the persistant log of the job queue got corrupted. The *condor_schedd* now correctly handles corrupted log files.
- The full release tar file now contains a `dagman` subdirectory in the `examples` directory. This subdirectory includes an example DAGMan job, including a README (in both ASCII and HTML), a Makefile, and so on.
- Condor will now insert an environment variable, `CONDOR_VM`, into the environment of the user job. This variable specifies which SMP "virtual machine" the job was started on. It will

equal either vm1, vm2, vm3, . . ., depending upon which virtual machine was matched. On a non-SMP machine, `CONDOR_VM` will always be set to vm1.

- Fixed some timing bugs introduced in v6.1.6 which could occur when Condor tries to simultaneously start a large number of jobs submitted from a single machine.
- Fixed bugs when Condor is told to gracefully shutdown; Condor no longer starts up new jobs when shutting down. Also, the *condor_schedd* progressively checkpoints running jobs during a graceful shutdown instead of trying to vacate all the job simultaneously. The rate at which the shutdown occurs is controlled by the `JOB_START_DELAY` configuration parameter (see page 95).
- Fixed a bug which could cause the *condor_master* process to exit if the Condor daemons have been hung for a while by the operating system (if, for instance, the LOG directory was placed on an NFS volume and the NFS server is down for an extended period).
- Previously, removing a large number of jobs with *condor_rm* would result in the *condor_schedd* being unresponsive for a period of time (perhaps leading to timeouts when running *condor_q*). The *condor_schedd* has been improved to multitask the removal of jobs while servicing new requests.
- Added new configuration parameter `COLLECTOR_SOCKET_BUFSIZE` which controls the size of TCP/IP buffers used by the *condor_collector*. For more info, see section refparam:CollectorSocketBufsize on page pagerefparam:CollectorSocketBufsize.
- Fixed a bug with the **-analyze** option to *condor_q*: in some cases, the RANK expression would not be evaluated correctly. This could cause the output from **-analyze** to be in error.
- When running on a multi-CPU (SMP) Hewlett-Packard machine, fixed bugs computing the system load average.
- Fixed bug in *condor_q* which could cause the RUN_TIME reported to be temporarily incorrect when jobs first start running.
- The *condor_startd* no longer rapidly sends multiple ClassAds one right after another to the Central Manager when its state/activity is in rapid transition. Also, on SMP machines, the *condor_startd* will only send updates for 4 nodes per second (to avoid overflowing the central manager when reporting the state of a very large SMP machine with dozens of CPUs).
- Reading a parameter with *condor_config_val* is now allowed from any machine with Host-IP READ permission. Previsouly, you needed ADMINISTRATOR permission. Of course, setting a parameter still requires ADMINISTRATOR permission.
- Worked around a bug in the StreamTokenizer Java class from Sun that we use in the CondorView client Java applet. The bug would cause errors if usernames or hostnames in your pool contained "-" or "_" characters. The CondorView applet now gets around this and properly displays all data, including entries with the "bad" characters.

7.3.11 Version 6.1.7

NOTE: Version 6.1.7 only adds support for platforms not supported in 6.1.6. There are no bug fixes, so there are no binaries released for any other platforms. You do not need 6.1.7 unless you are using one of the two platforms we released binaries for.

- Added "clipped" support for Alpha Linux machines running the 2.0.X kernel and glibc 2.0.X (such as RedHat 5.X). We do not yet support checkpointing and remote system calls on this platform, but we can start "vanilla" jobs. See section 2.4.1 on page 12 for details on vanilla vs. standard jobs.
- Re-added support for Intel Linux machines running the 2.0.X Linux kernel, glibc 2.0.X, using the GNU C compiler (gcc/g++ 2.7.X) or the EGCS compilers (versions 1.0.X, 1.1.1 and 1.1.2). This includes RedHat 5.X, and Debian 2.0. **RedHat 6.0 and Debian 2.1 are not yet supported, since they use glibc 2.1.X and the 2.2.X Linux kernel.** Future versions of Condor will support all combinations of kernels, compilers and versions of libc.

7.3.12 Version 6.1.6

- Added *file_remaps* as command in the job submit file given to *condor_submit*. This allows the user to explicitly specify where to find a given file (e.g. either on the submit or execute machine), as well as remap file access to a different filename altogether.
- Changed the way that *condor_master* spawns daemons and *condor_preen* which allows you to specify command line arguments for any of them, though a `SUBSYS_ARGS` setting. Previously, when you specified `PREEN`, you added the command line arguments directly to that setting, but that caused some problems, and only worked for *condor_preen*. **Once you upgrade to version 6.1.6, if you continue to use your old `condor_config` files, you must change the `PREEN` setting to remove any arguments you have defined and place those arguments into a separate config setting, `PREEN_ARGS`.** See section 3.3.7, "condor_master Config File Entries", on page 89 for more details.
- Fixed a very serious bug in the Condor library linked in with *condor_compile* to create standard jobs that was causing checkpointing to fail in many cases. Any jobs that were linked with the 6.1.5 Condor libraries should probably be removed, re-linked, and re-submitted.
- Fixed a bug in *condor_userprio* that was introduced in version 6.1.5 that was preventing it from finding the address of the *condor_negotiator* for your pool.
- Fixed a bug in *condor_stats* that was introduced in version 6.1.5 that was preventing it from finding the address of the *condor_collector* for your pool.
- Fixed a bug in the way the **-pool** option was handled by many Condor tools that was introduced in version 6.1.5.
- *condor_q* now displays job *allocation time* by default, instead of displaying CPU time. Job allocation time, or RUN_TIME, is the amount of wall-clock time the job has spent running.

Unlike CPU time information which is only updated when a job is checkpointed, the allocation time displayed by *condor_q* is continuously updated, even for vanilla universe jobs. By default, the allocation time displayed will be the total time across all runs of the job. The new **-currentrun** option to *condor_q* can be used to display the allocation time for solely the current run of the job. Additionally, the **-cputime** option can be used to view job CPU times as in earlier versions of Condor.

- *condor_q* will display an error message if there is a timeout fetching the job queue listing from a condor_schedd. Previously, *condor_q* would simply list the queue as empty upon a communication error.
- The condor_schedd daemon has been updated to verify all queue access requests via Condor's IP/Host-Based Security mechanism (see section 3.8).
- Fixed a bug on platforms which require the *condor_kbdd* (currently Digital Unix and IRIX). This bug could have allowed Condor to start a job within the first five minutes after the Condor daemons had been started, even if there is a user typing on the keyboard.
- *condor_release* now gives an error message if the user tries to release a job which either does not exist or is not in the hold state.
- Added a new config file parameter, `USER_JOB_WRAPPER` , which allows administrators to specify a file to act as a "wrapper" script around all jobs started by Condor. See inside section 3.3.12, on page 98, for more details.
- *condor_dagman* now permits the backslash character ("\") to be used as a line-continuation character for DAG Input Files, just like the condor_config files.
- The Condor version string is now included in all Condor libraries. You can now run *ident* on any program linked with *condor_compile* to view which version of the Condor libraries you linked with. In addition, the format of the version string changed in 6.1.6. Now, the identifier used is "CondorVersion" instead of "Version" to prevent any potential ambiguity. Also, the format of the date changed slightly.
- The SMP startd can now handle dynamic reconfiguration of the number of each type of virtual machine being reported. This allows you, during the normal running of the startd, to increase or decrease the number of CPUs that Condor is using. If you reconfigure the startd to use less CPUs than it currently has under its control, it will first remove CPUs that have no Condor jobs running on them. If more CPUs need to be evicted, the startd will checkpoint jobs and evict them in reverse rank order (using the startd's `Rank` expression). So, the lower the value of the rank, the more likely a job will be kicked off.
- The SMP startd contrib module's *condor_starter* no longer makes a call that was causing warning messages about "ERROR: Unknown System Call (-58) - system call not supported by Condor" when used with the 6.0.X *condor_shadow*. This was a harmless call, but removing the call prevents the error message.
- The SMP contrib module now includes the *condor_checkpoint* and *condor_vacate* programs, which allow you to vacate or checkpoint jobs on individual CPUs on the SMP, instead of checkpointing or vacating everything. You can now use "condor_vacate vm1@hostname" to

just vacate the first virtual machine, or “condor_vacate hostname” to vacate all virtual machines.

- Added support for SMP Digital Unix (Alpha) machines.
- Fixed a bug that was causing an overflow in the computation of free disk and swap space on Digital Unix (Alpha) machines.
- The *condor_startd* and *condor_schedd* now can “invalidate” their classads from the collector. So, when a daemon is shut down, or a machine is reconfigured to advertise fewer virtual machines, those changes will be instantly visible with *condor_status*, instead of having to wait 15 minutes for the stale classads to time-out.
- The *condor_schedd* no longer forks a child process (a “schedd agent”) to claim available *condor_startd*s. You should no longer see multiple condor_schedd processes running on your machine after a negotiation cycle. This is now accomplished in a non-blocking manner within the *condor_schedd* itself.
- The startd now adds an `VirtualMachineID` attribute to each virtual machine classad it advertises. This is just an integer, starting at 1, and increasing for every different virtual machine the startd is representing. On regular hosts, this is the only ID you will ever see. On SMP hosts, you will see the ID climb up to the number of different virtual machines reported. This ID can be used to help write more complex policy expressions on SMP hosts, and to easily identify which hosts in your pool are in fact SMP machines.
- Modified the output for *condor_q* -run for scheduler and PVM universe jobs. The host where the scheduler universe job is running is now displayed correctly. For PVM jobs, a count of the current number of hosts where the job is running is displayed.
- Fixed the *condor_startd* so that it no longer prints lots of ProcAPI errors to the log file when it is being run as non-root.
- `FS_PATHNAME` and `VOS_PATHNAME` are no longer used. AFS support now works similar to NFS support, via the `FILESYSTEM_DOMAIN` macro.
- Fixed a minor bug in the `Condor.pm` perl module that was causing it to be case-sensitive when parsing the Condor submit file. Now, the perl module is properly case-insensitive, as indicated in the documentation.

7.3.13 Version 6.1.5

- Fixed a nasty bug in *condor_preen* that would cause it to remove files it shouldn’t remove if the *condor_schedd* and/or *condor_startd* were down at the time *condor_preen* ran. This was causing jobs to mysteriously disappear from the job queue.
- Added preliminary support to Condor for running on machines with multiple network interfaces. On such machines, users can specify the IP address Condor should use in the `NETWORK_INTERFACE` config file parameter on each host. In addition, if the pool’s central manager is on such a machine, users should set the `CM_IP_ADDR` parameter to the ip address you wish to use on that machine. See section 3.11.8 on page 174 for more details.

- The support for multiple network interfaces introduced bugs in *condor_userprio*, *condor_stats*, CondorPVM, and the **-pool** option to many Condor tools. All of these will be fixed in version 6.1.6.
- Fixed a bug in the remote system call library that was preventing certain Fortran operations from working correctly on Linux.
- The Linux binaries for GLIBC we now distribute are compiled on a RedHat 5.2 machine. If you're using this version of RedHat, you might have better luck with the dynamically linked version of Condor than previous releases of Condor. Sites using other GLIBC Linux distributions should continue to use the statically linked version of Condor.
- Fixed a bug in the *condor_shadow* that could cause it to die with signal 11 (segmentation violation) under certain rare circumstances.
- Fixed a bug in the *condor_schedd* that could cause it to die with signal 11 (segmentation violation) under certain rare circumstances.
- Fixed a bug in the *condor_negotiator* that could cause it to die with signal 8 (floating point exception) on Digital Unix machines.
- The following shadow parameters have been added to control checkpointing: `COMPRESS_PERIODIC_CKPT` , `COMPRESS_VACATE_CKPT` , `PERIODIC_MEMORY_SYNC` , `SLOW_CKPT_SPEED` . See section 3.3.10 on page 97 for more details. In addition, the shadow now honors the `CkptWanted` flag in a job classad, and if it is set to "False", the job will never checkpoint.
- Fixed a bug in the *condor_startd* that could cause it to report negative values for the CondorLoadAvg on rare occasions.
- Fixed a bug in the *condor_startd* that could cause it to die with a fatal exception in situations where the act of getting claimed by a remote schedd failed for some reason. This resulted in the *condor_startd* exiting on rare occasions with a message in its log file to the effect of `ERROR ''Match timed out but not in matched state''`.
- Fixed a bug in the *condor_schedd* that under rare circumstances could cause a job to be left in the "Running" state even after the *condor_shadow* for that job had exited.
- Fixed a bug in the *condor_schedd* and various tools that prevented remote read-only access to the job queue from working. So, for example, `condor_q -name foo`, if run on any machine other than foo, wouldn't display any jobs from foo's queue. This fix re-enables the following options to *condor_q* to work: **submitter**, **name**, **global**, etc.
- Changed the *condor_schedd* so that when starting jobs, it always sorts on the cluster number, in addition to the date the jobs were enqueued and the process number within clusters, so that if many clusters were submitted at the same time, the jobs are started in order.
- Fixed a bug in *condor_compile* that was modifying the `PATH` environment variable by adding things to the front of it. This would potentially cause jobs to be compiled and linked with a different version of a compiler than they thought they were getting.

- Minor change in the way the *condor_startd* handles the `D_LOAD` and `D_KEYBOARD` debug flags. Now, each one, when set, will only display every `UPDATE_INTERVAL` , regardless of the startd state. If you wish to see the values for keyboard activity or load average every `POLLING_INTERVAL` , you must enable `D_FULLDEBUG`.

7.3.14 Version 6.1.4

- Fixed a bug in the socket communication library used by Condor that was causing daemons and tools to die on some platforms (notably, Digital Unix) with signal 8, SIGFPE (floating point exception).
- Fixed a bug in the usage message of many Condor tools that mentioned a **-all** option that isn't yet supported. This option will be supported in future versions of Condor.
- Fixed a bug in the filesystem authentication code used to authenticate operations on the job queue that left empty temporary files in /tmp. These files are now properly removed after they are used.
- Fixed a minor bug in the totals *condor_status* displays when you use the **ckptsrvr** option.
- Fixed a minor syntax error in the *condor_install* script that would cause warnings.
- the `Condor.pm` Perl module is now included in the `lib` directory of the main release directory.

7.3.15 Version 6.1.3

NOTE: There are a lot of new, unstable features in 6.1.3. PLEASE do not install all of 6.1.3 on a production pool. Almost all of the bug fixes in 6.1.3 are in the *condor_startd* or *condor_starter*, so, unless you really know what you're doing, we recommend you just upgrade SMP-Startd contrib module, not the entire 6.1.3 release.

- Owners can now specify how the SMP-Startd partitions the system resources into the different types and numbers of virtual machines, specifying the number of CPUs, megs of RAM, megs of swap space, etc., in each. Previously, each virtual machine reported to Condor from an SMP machine always had one CPU, and all shared system resources were evenly divided among the virtual machines.
- Fixed a bug in the reporting of virtual memory and disk space on SMP machines where each virtual machine represented was advertising the total in the system for itself, instead of its own share. Now, both the totals, and the virtual machine-specific values are advertised.
- Fixed a bug in the *condor_starter* when it was trying to suspend jobs. While we always killed all of the processes when we were trying to vacate, if a vanilla job forked, the starter would sometimes not suspend some of the children processes. In addition, we could sometimes miss a standard universe job for suspending as well. This is all fixed.

- Fixed a bug in the SMP-Startd's load average computation that could cause processes spawned by Condor to not be associated w/ the Condor load average. This would cause the startd to over-estimate the owner's load average, and under-estimate the Condor load, which would cause a cycle of suspending and resuming a Condor job, instead of just letting it run.
- Fixed a bug in the SMP-Startd's load average computation that could cause certain rare exceptions to be treated as fatal, when in fact, the Startd could recover from them.
- Fixed a bug in the computation of the total physical memory on some platforms that was resulting in an overflow on machines with lots of ram (over 1 gigabyte).
- Fixed some bugs that could cause *condor_starter* processes to be left as zombies underneath the *condor_startd* under very rare conditions.
- For sites using AFS, if there are problems in the *condor_startd* computing the AFS cell of the machine it's running on, the startd will exit with an error message at start-up time.
- Fixed a minor bug in *condor_install* that would lead to a syntax error in your config file given a certain set of installation options.
- Added the **-maxjobs** option to the *condor_submit_dag* script that can be used to specify the maximum number of jobs Condor will run from a DAG at any given time. Also, *condor_submit_dag* automatically creates a "rescue DAG". See section 2.11 on page 46 for details on DAGMan.
- Fixed bug in ClassAd printing when you tried to display an integer or float attribute that didn't exist in the given ClassAd. This could show up in *condor_status*, *condor_q*, *condor_history*, etc.
- Various commands sent to the Condor daemons now have separate debug levels associated with them. For example, commands such as "keep-alives", and the command sent from the *condor_kbdd* to the *condor_startd* are only seen in the various log files if `D_FULLDEBUG` is turned on, instead of `D_COMMAND`, which the default and now enabled for all daemons on all platforms by default. Administrators retaining their old configuration when upgrading to this version are encouraged to enable `D_COMMAND` in the `SCHEDD_DEBUG` setting. In addition, for IRIX and Digital Unix machines, it should be enabled in the `STARTD_DEBUG` setting as well. See section 3.3.3 on page 81 for details on debug levels in Condor.
- New debug levels added to Condor:
  - `D_NETWORK`, used by various daemons in Condor to report various network statistics about the Condor daemons.
  - `D_PROCFAMILY`, used to report information about various families of processes that are monitored by Condor. For example, this is used in the *condor_startd* when monitoring the family of processes spawned by a given user job for the purposes of computing the Condor load average.
  - `D_KEYBOARD`, used by the *condor_startd* to print out statistics about remote tty and console idle times in the *condor_startd*. This information used to be logged at `D_FULLDEBUG`, along with everything else, so now, you can see just the idle times, and/or have the information stored to a separate file.

- Added a **-run** option to *condor_q*, which displays information for running jobs, including the remote host where each job is running.
- Macros can now be incrementally defined. See section 3.3.1 on page 75 for more details.
- *condor_config_val* can now be used to set configuration variables. See the man page on page 254 for more details.
- The job log file now contains a record of network activity. The evict, terminate, and shadow exception events indicate the number of bytes sent and received by the job for the specific run. The terminate event additionally indicates totals for the life of the job.
- `STARTER_CHOOSES_CKPT_SERVER` now defaults to true. See section 3.3.6 on page 88 for more details.
- The infrastructure for authentication within Condor has been overhauled, allowing for much greater flexibility in supporting new forms of authentication in the future. This means that the 6.1.3 schedd and queue management tools (like *condor_q*, *condor_submit*, *condor_rm* and so on) are incompatible with previous versions of Condor.
- Many of the Condor administration tools have been improved to allow you to specify the "subsystem" you want them to effect. For example, you can now use "condor_reconfig -startd" to just have the startd reconfigure itself. Similarly, condor_off, condor_on and condor_restart can now all work on a single daemon, instead of machine-wide. See the man pages (section 8 on page 248) or run any command with **-help** for details. NOTE: The usage message in 6.1.3 incorrectly reports **-all** as a valid option.
- Fixed a bug in the Condor tools that could cause a segmentation violation in certain rare error conditions.

7.3.16 Version 6.1.2

- Fixed some bugs in the *condor_install* script. Also, enhanced *condor_install* to customize the path to perl in various perl scripts used by Condor.
- Fixed a problem with our build environment that left some files out of the `release.tar` files in the binary releases on some platforms.
- *condor_dagman*, "DAGMan" (see section 2.11 on page 46 for details) is now included in the development release by default.
- Fixed a bug in the computation of the total physical memory in HPUX machines that was resulting in an overflow on machines with lots of ram (over 1 gigabyte). Also, if you define "MEMORY" in your config file, that value will override whatever value Condor computes for your machine.
- Fixed a bug in *condor_starter.pvm*, the PVM version of the Condor starter (available as an optional "Contrib module"), when you disabled `STARTER_LOCAL_LOGGING` . Now, having this set to "False" will properly place debug messages from *condor_starter.pvm* into the

ShadowLog file of the machine that submitted the job (as opposed to the StarterLog file on the machine executing the job).

7.3.17 Version 6.1.1

- Fixed a bug in the *condor_startd* where we compute the load average caused by Condor that was causing us to get the wrong values. This could cause a cycle of continuous job suspends and job resumes.
- Beginning with this version, any jobs linked with the Condor checkpoint libraries will use the zlib compression code (used by gzip and others) to compress periodic checkpoints before they are written to the network. These compressed checkpoints are uncompressed at startup time. This saves network bandwidth, disk space, as well as time (if the network is the bottleneck to checkpointing, which it usually is). In future versions of Condor, all checkpoints will probably be compressed, but at this time, it is only used for periodic checkpoints. Note, you have to relink your jobs with the *condor_compile* command to have this feature enabled. Old jobs (not relinked) will continue to run just fine, they just won't be compressed.
- *condor_status* now has better support for displaying checkpoint server ClassAds.
- More contrib modules from the development series are now available, such as the checkpoint server, PVM support, and the CondorView server.
- Fixed some minor bugs in the UserLog code that were causing problems for DAGMan in exceptional error cases.
- Fixed an obscure bug in the logging code when D_PRIV was enabled that could result in incorrect file permissions on log files.

7.3.18 Version 6.1.0

- Support has been added to the condor_startd to run multiple jobs on SMP machines. See section 3.11.7 on page 169 for details about setting up and configuring SMP support.
- The expressions that control the condor_startd policy for vacating, jobs has been simplified. See section 3.6 on page 120 for complete details on the new policy expressions, and section 3.6.10 on page 142 for an explanation of what's different from the version 6.0 expressions.
- We now perform better tracking of processes spawned by Condor. If children die and are inherited by init, we still know they belong to Condor. This allows us to better ensure we don't leave processes lying around when we need to get off a machine, and enables us to have a much more accurate computation of the load average generated by Condor (the CondorLoadAvg as reported by the *condor_startd*).
- The condor_collector now can store historical information about your pool state. This information can be queried with the *condor_stats* program (see the man page on page 296), which is used by the *condor_view* Java GUI, which is available as a separate contrib module.

- Condor jobs can now be put in a "hold" state with the *condor_hold* command. Such jobs remain in the job queue (and can be viewed with *condor_q*), but there will not be any negotiation to find machines for them. If a job is having a temporary problem (like the permissions are wrong on files it needs to access), the job can be put on hold until the problem can be solved. Jobs put on hold can be released with the *condor_release* command.
- condor_userprio now has the notion of *user factors* as a way to create different groups of users in different priority levels. See section 3.5 on page 117 for details. This includes the ability to specify a local priority domain, and all users from other domains get a much worse priority.
- Usage statistics by user is now available from condor_userprio. See the man page on page 320 for details.
- The condor_schedd has been enhanced to enable "flocking", where it seeks matches with machines in multiple pools if its requests cannot be serviced in the local pool. See section 3.11.6 on page 168 for more details.
- The condor_schedd has been enhanced to enable condor_q and other interactive tools better response time.
- The condor_schedd has also been enhanced to allow it to check the permissions of the files you specify for input, output, error and so on. If the schedd doesn't have the required access rights to the files, the jobs will not be submitted, and *condor_submit* will print an error message.
- When you perform a *condor_rm* command, and the job you removed was using a "user log", the remove event is now recorded into the log.
- Two new attributes have been added to the job classad when it begins executing: `RemoteHost` and `LastRemoteHost`. These attributes list the IP address and port of the startd that is either currently running the job, or the last startd to run the job (if it's run on more than one machine). This information helps users track their job's execution more closely, and allows administrators to troubleshoot problems more effectively.
- The performance of checkpointing was increased by using larger buffers for the network I/O used to get the checkpoint file on and off the remote executing host (this helps for all pools, with or without checkpoint servers).

7.4 Stable Release Series 6.0

6.0 is the first version of Condor with *ClassAds*. It contains many other fundamental enhancements over version 5. It is also the first official stable release series, with a development series (6.1) simultaneously available.

7.4.1 Version 6.0.3

- Fixed a bug that was causing the hostname of the submit machine that claimed a given execute machine to be incorrectly reported by the *condor_startd* at sites using NIS.

- Fixed a bug in the *condor_startd*'s benchmarking code that could cause a floating point exception (SIGFPE, signal 8) on very, very fast machines, such as newer Alphas.
- Fixed an obscure bug in *condor_submit* that could happen when you set a requirements expression that references the "Memory" attribute. The bug only showed up with certain formations of the requirement expression.

7.4.2 Version 6.0.2

- Fixed a bug in the `fcntl()` call for Solaris 2.6 that was causing problems with file I/O inside Fortran jobs.
- Fixed a bug in the way the `DEFAULT_DOMAIN_NAME` parameter was handled so that this feature now works properly.
- Fixed a bug in how the `SOFT_UID_DOMAIN` config file parameter was used in the *condor_starter*. This feature is also documented in the manual now (see section 3.3.5 on page 86).
- You can now set the RunBenchmarks expression to "False" and the *condor_startd* will never run benchmarks, not even at startup time.
- Fixed a bug in `getwd()` and `getcwd()` for sites that use the NFS automounter. his bug was only present if user programs tried to call `chdir()` themselves. Now, this is supported.
- Fixed a bug in the way we were computing the available virtual memory on HPUX 10.20 machines.
- Fixed a bug in *condor_q* -analyze so it will correctly identify more situations where a job won't run.
- Fixed a bug in *condor_status* -format so that if the requested attribute isn't available for a given machine, the format string (including spaces, tabs, newlines, etc) is still printed, just the value for the requested attribute will be an empty string.
- Fixed a bug in the *condor_schedd* that was causing *condor_history* to not print out the first ClassAd attribute of all jobs that have completed
- Fixed a bug in *condor_q* that would cause a segmentation fault if the argument list was too long.

7.4.3 Version 6.0.1

- Fixed bugs in the `getuid()`), `getgid()`, `geteuid()`, and `getegid()` system calls.
- Multiple config files are now supported as a list specified via the `LOCAL_CONFIG_FILE` variable.
- `ARCH` and `OPSYS` are now automatically determined on all machines (including HPUX 10 and Solaris).

- Machines running IRIX now correctly suspend vanilla jobs.
- *condor_submit* doesn't allow root to submit jobs.
- The *condor_startd* now notices if you have changed `COLLECTOR_HOST` on reconfig.
- Physical memory is now correctly reported on Digital Unix when daemons are not running as root.
- New `$(SUBSYSTEM)` macro in configuration files that changes based on which daemon is reading the file (i.e. STARTD, SCHEDD, etc.) See section 3.3.1, "Condor Subsystem Names" on page 77 for a complete list of the subsystem names used in Condor.
- Port to HP-UX 10.20.
- `getrusage()` is now a supported system call. This system call will allow you to get resource usage about the entire history of your condor job.
- Condor is now fully supported on Solaris 2.6 machines (both Sparc and Intel).
- Condor now works on Linux machines with the GNU C library. This includes machines running RedHat 5.x and Debian 2.0. In addition, there seems to be a bug in RedHat that was causing the output from *condor_config_val* to not appear when used in scripts (like *condor_compile*). We put in explicit calls to flush the I/O buffers before *condor_config_val* exits, which seems to solve the problem.
- Hooks have been added to the checkpointing library to help support the checkpointing of PVM jobs.
- Condor jobs can now send signals to themselves when running in the standard universe. You do this just as you normally would:

  ```
          kill( getpid(), signal_number )
  ```

  Trying to send a signal to any other process will result in `kill()` returning -1.
- Support for NIS has been improved on Digital Unix and IRIX.
- Fixed a bug that would cause the negotiator on IRIX machines to never match jobs with available machines.

7.4.4 Version 6.0 pl4

NOTE: Back in the bad old days, we used this evil "patch level" version number scheme, with versions like "6.0pl4". This has all gone away in the current versions of Condor.

- Fixed a bug that could cause a segmentation violation in the *condor_schedd* under rare conditions when a *condor_shadow* exited.

- Fixed a bug that was preventing any core files that user jobs submitted to Condor might create from being transferred back to the submit machine for inspection by the user who submitted them.
- Fixed a bug that would cause some Condor daemons to go into an infinite loop if the ”ps” command output duplicate entries. This only happens on certain platforms, and even then, only under rare conditions. However, the bug has been fixed and Condor now handles this case properly.
- Fixed a bug in the *condor_shadow* that would cause a segmentation violation if there was a problem writing to the user log file specified by ”log = filename” in the submit file used with *condor_submit*.
- Added new command line arguments for the Condor daemons to support saving the PID (process id) of the given daemon to a file, sending a signal to the PID specified in a given file, and overriding what directory is used for logging for a given daemon. These are primarily for use with the *condor_kbdd* when it needs to be started by XDM for the user logged onto the console, instead of running as root. See section 3.11.4 on “Installing the *condor_kbdd*” on page 162 for details.
- Added support for the `CREATE_CORE_FILES` config file parameter. If this setting is defined, Condor will override whatever limits you have set and in the case of a fatal error, will either create core files or not depending on the value you specify (”true” or ”false”).
- Most Condor tools (*condor_on*, *condor_off*, *condor_master_off*, *condor_restart*, *condor_vacate*, *condor_checkpoint*, *condor_reconfig*, *condor_reconfig_schedd*, *condor_reschedule*) can now take the IP address and port you want to send the command to directly on the command line, instead of only accepting hostnames. This IP/port must be passed in a special format used in Condor (which you will see in the daemon’s log files, etc). It is of the form: <ip.address:port>. For example: <123.456.789.123:4567>.

7.4.5 Version 6.0 pl3

- Fixed a bug that would cause a segmentation violation if a machine was not configured with a full hostname as either the official hostname or as any of the hostname aliases.
- If your host information does not include a fully qualified hostname anywhere, you can specify a domain in the `DEFAULT_DOMAIN_NAME` parameter in your global config file which will be appended to your hostname whenever Condor needs to use a fully qualified name.
- All Condor daemons and most tools now support a ”-version” option that displays the version information and exits.
- The *condor_install* script now prompts for a short description of your pool, which it stores in your central manager’s local config file as `COLLECTOR_NAME` . This description is used to display the name of your pool when sending information to the Condor developers.

- When the *condor_shadow* process starts up, if it is configured to use a checkpoint server and it cannot connect to the server, the shadow will check the `MAX_DISCARDED_RUN_TIME` parameter. If the job in question has accumulated more CPU minutes than this parameter, the *condor_shadow* will keep trying to connect to the checkpoint server until it is successful. Otherwise, the *condor_shadow* will just start the job over from scratch immediately.
- If Condor is configured to use a checkpoint server, it will only use the checkpoint server. Previously, if there was a problem connecting to the checkpoint server, Condor would fall back to using the submit machine to store checkpoints. However, this caused problems with local disks filling up on machines without much disk space.
- Fixed a rare race condition that could cause a segmentation violation if a Condor daemon or tool opened a socket to a daemon and then closed it right away.
- All TCP sockets in Condor now have the ”keep alive” socket option enabled. This allows Condor daemons to notice if their peer goes away in a hard crash.
- Fixed a bug that could cause the *condor_schedd* to kill jobs without a checkpoint during its graceful shutdown method under certain conditions.
- The *condor_schedd* now supports the `MAX_SHADOW_EXCEPTIONS` parameter. If the *condor_shadow* processes for a given match die due to a fatal error (an exception) more than this number of times, the *condor_schedd* will now relinquish that match and stop trying to spawn *condor_shadow* processes for it.
- The ”-master” option to *condor_status* now displays the `Name` attribute of all *condor_master* daemons in your pool, as opposed to the `Machine` attribute. This helps for pools that have submit-only machines joining them, for example.

7.4.6 Version 6.0 pl2

- In patch level 1, code was added to more accurately find the full hostname of the local machine. Part of this code relied on the resolver, which on many platforms is a dynamic library. On Solaris, this library has needed many security patches and the installation of Solaris on our development machines produced binaries that are incompatible with sites that haven't applied all the security patches. So, the code in Condor that relies on this library was simply removed for Solaris.
- Version information is now built into Condor. You can see the `CondorVersion` attribute in every daemon's ClassAd. You can also run the UNIX command ”ident” on any Condor binary to see the version.
- Fixed a bug in the ”remote submit” mode of *condor_submit*. The remote submit wasn't connecting to the specified schedd, but was instead trying to connect to the local schedd.
- Fixed a bug in the *condor_schedd* that could cause it to exit with an error due to its log file being locked improperly under certain rare circumstances.

7.4.7 Version 6.0 pl1

- *condor_kbdd* bug patched: On Silicon Graphics and DEC Alpha ports, if your X11 server is using Xauthority user authentication, and the *condor_kbdd* was unable to read the user's `.Xauthority` file for some reason, the *condor_kbdd* would fall into an infinite loop.
- When using a Condor Checkpoint Server, the protocol between the Checkpoint Server and the *condor_schedd* has been made more robust for a faulty network connection. Specifically, this improves reliability when submitting jobs across the Internet and using a remote Checkpoint Server.
- Fixed a bug concerning `MAX_JOBS_RUNNING` : The parameter `MAX_JOBS_RUNNING` in the config file controls the maximum number of simultaneous *condor_shadow* processes allowed on your submission machine. The bug was the number of shadow processes could, under certain conditions, exceed the number specified by `MAX_JOBS_RUNNING` .
- Added new parameter `JOB_RENICE_INCREMENT` that can be specified in the config file. This parameter specifies the UNIX nice level that the *condor_starter* will start the user job. It works just like the *renice*(1) command in UNIX. Can be any integer between 1 and 19; a value of 19 is the lowest possible priority.
- Improved response time for *condor_userprio*.
- Fixed a bug that caused periodic checkpoints to happen more often than specified.
- Fixed some bugs in the installation procedure for certain environments that weren't handled properly, and made the documentation for the installation procedure more clear.
- Fixed a bug on IRIX that could allow vanilla jobs to be started as root under certain conditions. This was caused by the non-standard uid that user ”nobody” has on IRIX. Thanks to Chris Lindsey at NCSA for help discovering this bug.
- On machines where the `/etc/hosts` file is misconfigured to list just the hostname first, then the full hostname as an alias, Condor now correctly finds the full hostname anyway.
- The local config file and local root config file are now only found by the files listed in the `LOCAL_CONFIG_FILE` and `LOCAL_ROOT_CONFIG_FILE` parameters in the global config files. Previously, `/etc/condor` and user condor's home directory (c̃ondor) were searched as well. This could cause problems with submit-only installations of Condor at a site that already had Condor installed.

7.4.8 Version 6.0 pl0

- Initial Version 6.0 release.

CHAPTER

EIGHT

Command Reference Manual (man pages)

condor_checkpoint

checkpoint jobs running on the specified hosts

Synopsis

condor_checkpoint [**-help**] [**-version**] [**hostname ...**]

Description

condor_checkpoint causes the startd's on the specified hosts to perform a checkpoint on any running jobs. The jobs continue to run once they are done checkpointing. If no host is specified, only the current host is sent the checkpoint command.

A periodic checkpoint means that the job will checkpoint itself, but then it will immediately continue running after the checkpoint has completed. *condor_vacate*, on the other hand, will result in the job exiting (vacating) after it checkpoints.

If the job being checkpointed is running in the Standard Universe, the job is checkpointed and then just continues running on the same machine. If the job is running in the Vanilla Universe, or there is currently no Condor job running on that host, then *condor_checkpoint* has no effect.

Normally there is no need for the user or administrator to explicitly run *condor_checkpoint*. Checkpointing a running condor job is normally handled automatically by Condor by following the policies stated in Condor's configuration files.

Options

Supported options are as follows:

-help Display usage information

-version Display version information

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_compile

create a relinked executable for submission to the Standard Universe

Synopsis

condor_compile *cc* | *CC* | *gcc* | *f77* | *g++* | *ld* | *make* | . . .

Description

Use *condor_compile* to relink a program with the Condor libraries for submission into Condor's Standard Universe. The Condor libraries provide the program with additional support, such as the capability to checkpoint, which is required in Condor's Standard Universe mode of operation. *condor_compile* requires access to the source or object code of the program to be submitted; if source or object code for the program is not available (i.e. only an executable binary, or if it is a shell script), then the program must submitted into Condor's Vanilla Universe. See the reference page for *condor_submit* and/or consult the ”Condor Users and Administrators Manual” for further information.

To use *condor_compile*, simply enter ”condor_compile” followed by whatever you would normally enter to compile or link your application. Any resulting executables will have the Condor libraries linked in. For example:

```
        condor_compile cc -O -o myprogram.condor file1.c file2.c ...
```

will produce a binary ”myprogram.condor” which is relinked for Condor, capable of checkpoint/migration/remote-system-calls, and ready to submit to the Standard Universe.

If the Condor administrator has opted to fully install *condor_compile*, then *condor_compile* can be followed by practically any command or program, including make or shell-script programs. For example, the following would all work:

```
        condor_compile make

        condor_compile make install

        condor_compile f77 -O mysolver.f

        condor_compile /bin/csh compile-me-shellscript
```

If the Condor administrator has opted to only do a partial install of *condor_compile*, the you are restricted to following *condor_compile* with one of these programs:

```
        cc (the system C compiler)

        acc (ANSI C compiler, on Sun systems)

        c89 (POSIX compliant C compiler, on some systems)

        CC (the system C++ compiler)

        f77 (the system FORTRAN compiler)

        gcc (the GNU C compiler)

        g++ (the GNU C++ compiler)

        g77 (the GNU FORTRAN compiler)

        ld (the system linker)

f90 (the system FORTRAN 90 compiler)
```

NOTE: If you use explicitly call "ld" when you normally create your binary, simply use:

```
        condor_compile ld <ld arguments and options>
```

instead.

NOTE: f90 (FORTRAN 90) is only supported on Solaris and Digital Unix.

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_config_val

Query or set a given condor configuration variable

Synopsis

condor_config_val [*options*] **variable** [**variable** . . .]

condor_config_val [*options*] **-set** *string* [**string** . . .]

condor_config_val [*options*] **-rset** *string* [**string** . . .]

condor_config_val [*options*] **-unset** *variable* [**variable** . . .]

condor_config_val [*options*] **-runset** *variable* [**variable** . . .]

condor_config_val [*options*] **-tilde**

condor_config_val [*options*] **-owner**

Description

condor_config_val can be used to quickly see what the current condor configuration is on any given machine. Given a list of variables, *condor_config_val* will report what each of these variables is currently set to. If a given variable is not defined, *condor_config_val* will halt on that variable, and report that it is not defined. By default, *condor_config_val* looks in the local machine's configuration files in order to evaluate the variables.

condor_config_val can also be used to quickly set configuration variables for a specific daemon on a given machine. Each daemon remembers settings made by *condor_config_val*. The configuration file is not modified by this command. Persistent settings remain when the daemon is restarted. Runtime settings are lost when the daemon is restarted. Modifying a hosts configuration with *condor_config_val* requires the `CONFIG` access level, which is disabled on all hosts by default. See section 3.8.2 on page 145 for more details.

NOTE: The changes will not take effect until you perform a *condor_reconfig*.

NOTE: It is generally wise to test a new configuration on a single machine to ensure you have no syntax or other errors in the configuration before you reconfigure many machines. Having bad syntax or invalid configuration settings is a fatal error for Condor daemons, and they will exit. Far better to discover such a problem on a single machine than to cause all the Condor daemons in your pool to exit.

Options

Supported options are as follows:

-name *daemon_name* Query the specified daemon for its configuration.

-pool *hostname* Use the given central manager to find daemons.

-address <*ip:port*> Connect to the given ip/port.

-master | **-schedd** | **-startd** | **-collector** | **-negotiator** The daemon to query (if not specified, master is default).

-set *string* Set a persistent config file entry. The string must be a single argument, so you should enclose it in double quotes. The string must be of the form "variable = value".

-rset *string* Set a runtime config file entry. See the description for **-set** for details about the string to use.

-unset *variable* Unset a persistent config file variable.

-runset *variable* Unset a runtime config file variable.

-tilde Return the path to the Condor home directory.

-owner Return the owner of the *condor_config_val* process.

variable . . . The variables to query.

Examples

```
% condor_config_val -name perdita -schedd MAX_JOBS_RUNNING
500
% condor_config_val -name perdita -schedd -set ‘‘MAX_JOBS_RUNNING = 10’’
Successfully set configuration "MAX_JOBS_RUNNING = 10" on
schedd perdita.cs.wisc.edu <128.105.73.32:52067>.
```

```
% condor_reconfig -schedd perdita
Sent "Reconfig" command to schedd perdita.cs.wisc.edu
% condor_config_val -name perdita -schedd MAX_JOBS_RUNNING
10
% condor_config_val -name perdita -schedd -unset MAX_JOBS_RUNNING
Successfully unset configuration "MAX_JOBS_RUNNING" on
schedd perdita.cs.wisc.edu <128.105.73.32:52067>.
% condor_reconfig -schedd perdita
Sent "Reconfig" command to schedd perdita.cs.wisc.edu
% condor_config_val -name perdita -schedd MAX_JOBS_RUNNING
500
```

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_findhost

find machine(s) in the pool that can be used with minimal impact on currently running Condor jobs and best meet any specified constraints

Synopsis

condor_findhost [**-help**] [**-m**] [**-n** *num*] [**-c** *c_expr*] [**-r** *r_expr*] [**-p** *pool*]

Description

condor_findhost searches a Condor pool of machines for the best machine or machines that will have the minimum impact on running Condor jobs if the machine or machines are taken out of the pool. The search may be limited to the machine or machines that match a set of constraints and rank expression.

condor_findhost returns a fully-qualified domain name for each machine. The search is limited (constrained) to a specific set of machines using the *-c* option. The search can use the *-r* option for rank, the criterion used for selecting a machine or machines from the constrained list.

Options

Supported options are as follows:

-help Display usage information and exit

-m Only search for entire machines. Virtual machines within an entire machine are not considered.

-n *num* Find and list up to *num* machines that fulfill the specification. *num* is an integer greater than zero.

-c *c_expr* Constrain the search to only consider machines that result from the evaluation of *c_expr*. *c_expr* is a ClassAd expression.

-r *r_expr* *r_expr* is the rank expression evaluated to use as a basis for machine selection. *r_expr* is a ClassAd expression.

-p *poolname* Specify the name of the pool to be searched. Without this option, the current pool is searched.

General Remarks

condor_findhost is used to locate a machine within a pool that can be taken out of the pool with the least disturbance of the pool.

And administrator should set preemption requirements for the Condor pool. The expression

```
(Interactive =?= TRUE )
```

will let *condor_findhost* know that it can claim a machine even if Condor would not normally preempt a job running on that machine.

The exit status of *condor_findhost* is zero on success. If not able to identify as many machines as requested, it returns one more than the number of machines identified. For example, if 8 machines are requested, and *condor_findhost* only locates 6, the exit status will be 7. If not able to locate any machines, *condor_findhost* will return the value 1.

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_history

View log of condor jobs completed to date

Synopsis

condor_history [**-help**] [**-l**] [**-f** *filename*] [*-constraint expr* | *cluster* | *cluster.process* | *owner*]

Description

condor_history displays a summary of all condor jobs listed in the specified history files. If no history files are specified (with the **-f** option), the local history file as specified in Condor's configuration file (condor/spool/history by default) is read. The default listing summarizes each job on a single line, and contains the following items:

ID The cluster/process id of the condor job.

OWNER The owner of the job.

SUBMITTED The month, day, hour, and minute the job was submitted to the queue.

CPU_USAGE Remote CPU time accumulated by the job to date in days, hours, minutes, and seconds.

ST Completion status of the job (C = completed and X = removed).

COMPLETED The time the job was completed.

PRI User specified priority of the job, ranges from -20 to +20, with higher numbers corresponding to greater priority.

SIZE The virtual image size of the executable in megabytes.

CMD The name of the executable.

If a job ID (in the form of cluster_id or cluster_id.proc_id) or an owner is provided, output will be restricted to jobs with the specified IDs and/or submitted by the specified owner. The -constraint option can be used to display jobs that satisfy a specified boolean expression.

Options

Supported options are as follows:

-help Get a brief description of the supported options

-f *filename* Use the specified file instead of the default history file

-constraint *expr* Display jobs that satisfy the expression

-l Display job ads in long format

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_hold

put jobs in the queue in hold state

Synopsis

condor_hold [**-n** *schedd_name*] [*-help*] [*-version*] [*job identifiers*]

Description

condor_hold places one or more jobs from the Condor job queue in hold state. If the **-n** option is specified, the named *condor_schedd* is targeted for processing. Otherwise, the local *condor_schedd* is targeted. The jobs to be held are identified by one or more job identifiers, as described below. For any given job, only the owner of the job or one of the queue super users (defined by the `QUEUE_SUPER_USERS` macro) can place the job on hold.

Options

Supported options are as follows:

-*help* Display usage information and exit

-*version* Display version information and exit

-n *schedd_name* Target jobs in the queue of the named schedd

cluster (Job identifier.) Hold all jobs in the specified cluster

cluster.process (Job identifier.) Hold the specific job in the cluster

name (Job identifier.) Hold jobs belonging to specified user

-a (Job identifier.) Hold all the jobs in the queue

-*constraint* constraint (Job identifier.) Hold jobs matching specified constraint

See Also

condor_release (on page 285)

General Remarks

To put a PVM universe job on hold, you must put each "process" in the PVM job cluster on hold. (In the PVM universe, each PVM job is assigned its own cluster number, and each machine class is assigned a "process" number in the job's cluster.) Putting a subset of the machine classes for a PVM job on hold is not supported.

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_master

The master Condor Daemon

Synopsis

condor_master

Description

condor_master This daemon is responsible for keeping all the rest of the Condor daemons running on each machine in your pool. It spawns the other daemons, and periodically checks to see if there are new binaries installed for any of them. If there are, the master will restart the affected daemons. In addition, if any daemon crashes, the master will send email to the Condor Administrator of your pool and restart the daemon. The *condor_master* also supports various administrative commands that let you start, stop or reconfigure daemons remotely. The *condor_master* will run on every machine in your Condor pool, regardless of what functions each machine are performing.

See section 3.1.2 in Admin Manual for more information about *condor_master* and other Condor daemons.

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_master_off

Shutdown Condor and the *condor_master*

Synopsis

condor_master_off [**-help**] [**-version**] [**hostname ...**]

Description

condor_master_off shuts down all of the condor daemons running on a given machine. It does this cleanly without a loss of work done by any jobs currently running on this machine, or jobs that are running on other machines that have been submitted from this machine. At the end of the shutdown process, unlike *condor_off*, *condor_master_off* also shuts down the *condor_master* daemon. If you want to turn condor back on on this machine in the future, you will need to restart the *condor_master*.

Options

Supported options are as follows:

-help Display usage information

-version Display version information

hostname ... Turn shutdown condor on this list of machines

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_off

Shutdown condor daemons

Synopsis

condor_off [**-help**] [**-version**] [**hostname ...**]

Description

condor_off shuts down all of the condor daemons running on a given machine. It does this cleanly without a loss of work done by any jobs currently running on this machine, or jobs that are running on other machines that have been submitted from this machine. The only daemon that remains running is the *condor_master*, which can handle both local and remote requests to restart the other condor daeomns if need be. To restart condor running on a machine, see the *condor_on* command.

Options

Supported options are as follows:

-help Display usage information

-version Display version information

hostname ... Turn condor off on this list of machines

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_on

Startup condor daemons

Synopsis

condor_on **[-help] [-version] [hostname ...]**

Description

condor_on starts up all of the condor daemons running on a given machine. This command assumes that the *condor_master* is already running on the machine. If this is not the case, *condor_on* will fail complaining that it can't find the address of the master. *condor_on* will tell the *condor_master* to start up the condor daemons specified in the configuration variable DAEMON_LIST.

Options

Supported options are as follows:

-help Display usage information

-version Display version information

hostname ... Turn condor on on this list of machines

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_preen

remove extraneous files from Condor directories

Synopsis

condor_preen [**-mail**] [**-remove**] [**-verbose**]

Description

condor_preen examines the directories belonging to Condor, and removes extraneous files and directories which may be left over from Condor processes which terminated abnormally either due to internal errors or a system crash. The directories checked are the LOG, EXECUTE, and SPOOL directories as defined in the Condor configuration files. *condor_preen* is intended to be run as user root (or user condor) periodically as a backup method to ensure reasonable file system cleanliness in the face of errors. This is done automatically by default by the *condor_master*. It may also be explicitly invoked on an as needed basis.

When *condor_preen* cleans the SPOOL directory, it always leaves behind the files specified in the `VALID_SPOOL_FILES` list in your config file. For the log directory, the only files removed or reported are those listed in the `INVALID_LOG_FILES` list. The reason for this difference is that, in general, you want to leave all files in the LOG directory alone, with a few exceptions (namely, core files). *condor_preen* still works if you supply a `VALID_LOG_FILES` list instead, but this usage is depricated. There are new log files for different things introduced all the time, and you wouldn't want to have to keep updating the list of files to leave alone in the LOG directory. For example, the SMP startd can spawn an arbitrary number of *condor_starter* processes, each with its own log file. On the other hand, there are only a small, fixed number of files in the SPOOL directory that the *condor_schedd* needs to keep around, so it is easier to specify the files you want to keep instead of the ones you want to get rid of.

Options

Supported options are as follows:

-mail Send mail to the `PREEN_ADMIN` as defined in the Condor configuration files instead of writing to the standard output

-remove Remove the offending files and directories rather than just reporting on them

-verbose List all files found in the Condor directories, even those which are not considered extraneous

Author

Condor Team, University of Wisconsin–Madison

Copyright

See the *Condor Version 6.1.17 Manual* for additional notices.

condor_prio

change priority of jobs in the condor queue

Synopsis

condor_prio [**-p** *priority*] [**+** | **-** *value*] [**-n** *schedd_name*] *cluster* | *cluster.process* | *username* | *-a*

Description

condor_prio changes the priority of one or more jobs in the condor queue. If a cluster_id and a process_id are both specified, *condor_prio* attempts to change the priority of the specified process. If a cluster_id is specified without a process_id, *condor_prio* attempts to change priority for all processes belonging to the specified cluster. If a username is specified, *condor_prio* attempts to change priority of all jobs belonging to that user. If the -a flag is set, *condor_prio* attempts to change priority of all jobs in the condor queue. The user must specify a priority adjustment or new priority. If the -p option is specified, the priority of the job(s) are set to the next argument. The user can also adjust the priority by supplying a + or - immediately followed by a digit. The priority of a job ranges from -20 to +20, with higher numbers corresponding to greater priority. Only the owner of a job or the super user can change the priority for it.

The priority changed by *condor_prio* is only compared to the priority of other jobs owned by the same user and submitted from the same machine. See the "Condor Users and Administrators Manual" for further details on Condor's priority scheme.

Options

Supported options are as follows:

-p *priority* Set priority to the specified value

+ | **- *value*** Change priority by the specified value

-n *schedd_name* Change priority of jobs queued at the specified schedd

-a Change priority of all the jobs in the queue

Author

Condor Team, University of Wisconsin–Madison

Copyright

See the *Condor Version 6.1.17 Manual* for additional notices.

condor_q

Display information about jobs in queue

Synopsis

condor_q [**-help**] [**-global**] [**-submitter** *submitter*] [**-name** *name*] [**-pool** *hostname*] [**-analyze**] [**-run**] [**-goodput**] [**-io**] [**-long**] [**-format** *formatter attribute*] [**-cputime**] [**-currentrun**] [{*cluster* | *cluster.process* | *owner* | ***-constraint*** *expression* . . .}]

Description

condor_q displays information about jobs in the Condor job queue. By default, *condor_q* queries the local job queue but this behavior may be modified by specifying:

- the **-global** option, which queries all job queues in the pool
- a schedd name with the **-name** option, which causes the queue of the named schedd to be queried
- a submitter with the **-submitter** option, which causes all queues of the named submitter to be queried

To restrict the display to jobs of interest, a list of zero or more restrictions may be supplied. Each restriction may be one of:

- a *cluster* and a *process* matches jobs which belong to the specified cluster and have the specified process number
- a *cluster* without a *process* matches all jobs belonging to the specified cluster
- a *owner* matches all jobs owned by the specified owner
- a **-constraint** *expression* which matches all jobs that satisfy the specified ClassAd expression. (See section 4.1 for a discussion of ClassAd expressions.)

If no *owner* restrictions are present in the list, the job matches the restriction list if it matches at least one restriction in the list. If *owner* restrictions are present, the job matches the list if it matches one of the *owner* restrictions *and* at least one non-owner restriction.

If the **-long** option is specified, *condor_q* displays a long description of the queried jobs by printing the entire job classad. The attributes of the job classad may be displayed by means of the **-format** option, which displays attributes with a `printf(3)` format. (Multiple **-format** options may be specified in the option list to display several attributes of the job.) If neither **-long** or **-format** are specified, *condor_q* displays a a one line summary of information as follows:

ID The cluster/process id of the condor job.

OWNER The owner of the job.

SUBMITTED The month, day, hour, and minute the job was submitted to the queue.

RUN_TIME Wall-clock time accumulated by the job to date in days, hours, minutes, and seconds.

ST Current status of the job. U = unexpanded (never been run), H = on hold, R = running, I = idle (waiting for a machine to execute on), C = completed, and X = removed.

PRI User specified priority of the job, ranges from -20 to +20, with higher numbers corresponding to greater priority.

SIZE The virtual image size of the executable in megabytes.

CMD The name of the executable.

If the **-run** option is specified, the ST, PRI, SIZE, and CMD columns are replaced with:

HOST(S) The host where the job is running. For PVM jobs, a host count is displayed instead.

If the **-goodput** option is specified, the ST, PRI, SIZE, and CMD columns are replaced with:

GOODPUT The percentage of RUN_TIME for this job which has been saved in a checkpoint. A low GOODPUT value indicates that the job is failing to checkpoint. If a job has not yet attempted a checkpoint, this column contains `[?????]`.

CPU_UTIL The ratio of CPU_TIME to RUN_TIME for checkpointed work. A low CPU_UTIL indicates that the job is not running efficiently, perhaps because it is I/O bound or because the job requires more memory than available on the remote workstations. If the job has not (yet) checkpointed, this column contains `[??????]`.

Mb/s The network usage of this job, in Megabits per second of run-time.

If the **-io** option is specified, the ST, PRI, SIZE, and CMD columns are replaced with:

READ The total number of bytes the application has read from files and sockets.

WRITE The total number of bytes the application has written to files and sockets.

SEEK The total number of seek operations the application has performed on files.

XPUT The effective throughput (average bytes read and written per second) from the application's point of view.

BUFSIZE The maximum number of bytes to be buffered per file.

BLOCKSIZE The desired block size for large data transfers.

These fields are updated when a job checkpoints or completes. If a job has not yet checkpointed, this information is not available.

If the **-cputime** option is specified, the RUN_TIME column is replaced with:

CPU_TIME The remote CPU time accumulated by the job to date (which has been stored in a checkpoint) in days, hours, minutes, and seconds. (If the job is currently running, time accumulated during the current run is *not* shown. If the job has not checkpointed, this column contains 0+00:00:00.)

The -*analyze* option may be used to determine why certain jobs are not running by performing an analysis on a per machine basis for each machine in the pool. The reasons may vary among failed constraints, insufficient priority, resource owner preferences and prevention of preemption by the `PREEMPTION_REQUIREMENTS` expression. If the -*long* option is specified along with the -*analyze* option, the reason for failure is displayed on a per machine basis.

Options

Supported options are as follows:

-help Get a brief description of the supported options

-global Get queues of all the submitters in the system

-submitter *submitter* List jobs of specific submitter from all the queues in the pool

-pool *hostname* Use hostname as the central manager to locate schedds. (The default is the `COLLECTOR_HOST` specified in the configuration file.

-analyze Perform an approximate analysis to determine how many resources are available to run the requested jobs

-run Get information about running jobs.

-goodput Display job goodput statistics.

-io Display job input/output summaries.

-name *name* Show only the job queue of the named schedd

-long Display job ads in long format

-format *fmt attr* Display attribute *attr* in format *fmt*

-cputime I
nstead of wall-clock allocation time (RUN_TIME), display remote CPU time accumulated by the job to date in days, hours, minutes, and seconds. (If the job is currently running, time accumulated during the current run is *not* shown.)

-currentrun N
ormally, RUN_TIME contains all the time accumulated during the current run plus all previous runs. If this option is specified, RUN_TIME only displays the time accumulated so far on this current run.

Restriction list The restriction list may have zero or more items, each of which may be:

cluster match all jobs belonging to cluster

cluster.proc match all jobs belonging to cluster with a process number of *proc*

-constraint *expression* match all jobs which match the ClassAd expression constraint

A job matches the restriction list if it matches any restriction in the list Additionally, if *owner* restrictions are supplied, the job matches the list only if it also matches an *owner* restriction.

General Remarks

Although *-analyze* provides a very good first approximation, the analyzer cannot diagnose all possible situations because the analysis is based on instantaneous and local information. Therefore, there are some situations (such as when several submitters are contending for resources, or if the pool is rapidly changing state) which cannot be accurately diagnosed.

-goodput, *-cputime*, and *-io* are most useful for STANDARD universe jobs, since they rely on values computed when a job checkpoints.

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_qedit

modify job attributes

Synopsis

condor_qedit [**-n** *schedd-name*] {*cluster* | *cluster.proc* | *owner* | *-constraint constraint*} *attribute-name attribute-value* . . .

Description

condor_qedit modifies job attributes in the Condor job queue. The jobs are specified either by cluster number, cluster.proc job ID, owner, or by a ClassAd constraint expression. The attribute-value may be any ClassAd expression (integer, floating point number, string, expression).

Options

Supported options are as follows:

-n *schedd-name* Modify job attributes in the queue of the specified schedd

Examples

```
% condor_qedit -name perdita 1849.0 In ’"myinput"’
Set attribute "In".
% condor_qedit jbasney NiceUser TRUE
Set attribute "NiceUser".
% condor_qedit -constraint ’JobUniverse == 1’ Require-
ments ’(Arch == "INTEL") && (OpSys == "SOLARIS26") && (Disk >= Ex-
ecutableSize) && (VirtualMemory >= ImageSize)’
Set attribute "Requirements".
```

General Remarks

You can view the list of attributes with their current values for a job with *condor_q* **-long**.

Strings must be specified with quotes (for example, ’”String”’).

If a job is currently running, modified attributes for that job will not take effect until the job restarts.

condor_qedit will not allow modification of the following attributes to ensure security and correctness: `Owner`, `ClusterId`, `ProcId`, `MyType`, `TargetType`, and `JobStatus`.

Please use *condor_hold* to place a job "on hold" and *condor_release* to release a held job, instead of attempting to modify `JobStatus` directly.

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_reconfig

Reconfigure condor daemons

Synopsis

condor_reconfig [**-help**] [**-version**] [**hostname ...**]

Description

condor_reconfig reconfigures all of the condor daemons in accordance with the current status of the condor configuration file(s). Once reconfiguration is complete, the daemons will behave according to the policies stated in the configuration file(s). The only exception is with the DAEMON_LIST variable, which will only be updated if the *condor_restart* command is used. In general, *condor_reconfig* should be used when making changes to the configuration files, since it is faster and more efficient then restarting the daemons.

Options

Supported options are as follows:

-help Display usage information

-version Display version information

hostname ... Reconfigure condor on this list of machines

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_reconfig_schedd

Reconfigure condor schedd

Synopsis

condor_reconfig_schedd [**-help**] [**-version**] [**hostname ...**]

Description

condor_reconfig_schedd reconfigures the condor_schedd in accordance with the current status of the condor configuration file(s). Once reconfiguration is complete, the daemon will behave according to the policies stated in the configuration file(s). This command is similar to the *condor_reconfig* command except that it only updates the schedd. The schedd is the condor daemon responsible for managing user's jobs submitted from this machine.

Options

Supported options are as follows:

-help Display usage information

-version Display version information

hostname ... Reconfigure condor on this list of machines

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_release

release held jobs in the condor queue

Synopsis

condor_release [**-n** *schedd_name*] [-*help*] [-*version*] [*job identifiers*]

Description

condor_release releases one or more jobs from the Condor job queue that were previously placed in hold state. If the **-n** option is specified, the named *condor_schedd* is targeted for processing. Otherwise, the local *condor_schedd* is targeted. The jobs to be released are identified by one or more job identifiers, as described below. For any given job, only the owner of the job or one of the queue super users (defined by the `QUEUE_SUPER_USERS` macro) can release the job.

Options

Supported options are as follows:

-help Display usage information and exit

-version Display version information and exit

-n *schedd_name* Remove jobs in the queue of the specified schedd

cluster (Job identifier.) Remove all jobs in the specified cluster

cluster.process (Job identifier.) Remove the specific job in the cluster

name (Job identifier.) Remove jobs belonging to specified user

-a (Job identifier.) Remove all the jobs in the queue

***-constraint* constraint** (Job identifier.) Remove jobs matching specified constraint

See Also

condor_hold (on page 261)

General Remarks

When releasing a held PVM universe job, you must release the entire job cluster. (In the PVM universe, each PVM job is assigned its own cluster number, and each machine class is assigned a "process" number in the job's cluster.) Releasing a subset of the machine classes for a PVM job is not supported.

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_reschedule

Update scheduling information to the central manager

Synopsis

condor_reschedule [**-help**] [**-version**] [**hostname ...**]

Description

condor_reschedule updates the information about a given machines resources and jobs to the central manager. This can be used if one wants to see the current status of a machine. In order to do this, one would first run *condor_reschedule*, and then use the *condor_status* command to get specific information about that machine. *condor_reschedule* also starts a new negotiation cycle between resource owners and resource providers on the central managers, so that jobs can be matched with machines right away. This can be useful in situations where the time between negotiation cycles is somewhat long, and an administrator wants to see if a job they have in the queue will get matched without waiting for the next negotiation cycle.

Options

Supported options are as follows:

-help Display usage information

-version Display version information

hostname ... Reconfigure condor on this list of machines

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_restart

Restart the *condor_master*

Synopsis

condor_restart [**-help**] [**-version**] [**hostname ...**]

Description

condor_restart restarts the *condor_master* on the local machine, or all the machines specified in the hostname list. If, for some reason, the *condor_master* needs to be restarted again with a fresh state, this is the command that should be used to do so. Also, if the DAEMON_LIST variable in the condor configuration file has been changed, one must restart the *condor_master* in order to see these changes. A simple *condor_reconfigure* is not enough in this situation. *condor_restart* will safely shut down all running jobs and all submitted jobs from the machine being restarted, shutdown all the child daemons of the *condor_master*, and restart the *condor_master*.

Options

Supported options are as follows:

-help Display usage information

-version Display version information

hostname ... A list of machines to restart the *condor_master* on.

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_rm

remove jobs from the condor queue

Synopsis

condor_rm [**-n** *schedd_name*] [**-help**] [**-version**] [**job identifiers**]

Description

condor_rm removes one or more jobs from the Condor job queue. If the **-n** option is specified, the named *condor_schedd* is targeted for processing. Otherwise, the local *condor_schedd* is targeted. The jobs to be removed are identified by one or more job identifiers, as described below. For any given job, only the owner of the job or one of the queue super users (defined by the `QUEUE_SUPER_USERS` macro) can remove the job.

Options

Supported options are as follows:

-help Display usage information and exit

-version Display version information and exit

-n *schedd_name* Remove jobs in the queue of the specified schedd

cluster (Job identifier.) Remove all jobs in the specified cluster

cluster.process (Job identifier.) Remove the specific job in the cluster

name (Job identifier.) Remove jobs belonging to specified user

-a (Job identifier.) Remove all the jobs in the queue

-*constraint* constraint (Job identifier.) Remove jobs matching specified constraint

General Remarks

When removing a PVM universe job, you should always remove the entire job cluster. (In the PVM universe, each PVM job is assigned its own cluster number, and each machine class is assigned a "process" number in the job's cluster.) Removing a subset of the machine classes for a PVM job is not supported.

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_run

Submit a shell command-line as a Condor job.

Synopsis

condor_run *"shell-cmd"*

Description

condor_run is a simple front-end to the *condor_submit* command for submitting a shell command-line as a vanilla universe Condor job. The *condor_run* command waits for the Condor job to complete, writes the job's output to the terminal, and exits with the exit status of the Condor job. No output will appear until the job completes. The shell command-line should be enclosed in quotes so it is passed directly to *condor_run* without modification by the invoking shell.

condor_run will not read any input from the terminal while the job executes. If the shell command-line requires input, you must explicitly redirect the input from a file to the command, as illustrated in the example.

You can specify where *condor_run* should execute the shell command-line with three environment variables:

CONDOR_ARCH Specifies the architecture of the execution machine (from the "Arch" field in the output of *condor_status*).

CONDOR_OPSYS Specifies the operating system of the execution machine (from the "OpSys" field in the output of *condor_status*).

CONDOR_REQUIREMENTS Specifies any additional requirements for the Condor job (as described in manual page for *condor_submit* on page 305). It is recommended that `CONDOR_REQUIREMENTS` always be enclosed in parenthesis.

If one or more of these environment variables is specified, the job is submitted with:

```
  requirements = $CONDOR_REQUIREMENTS && Arch == $CONDOR_ARCH && \
                 OpSys == $CONDOR_OPSYS
```

Otherwise, the job receives the default requirements expression, which requests a machine of the same architecture and operating system of the machine on which *condor_run* is executed.

All environment variables set when *condor_run* is executed will be included in the environment of the Condor job.

condor_run will remove the Condor job from the Condor queue and delete its temporary files if it is killed before the Condor job finishes.

Examples

condor_run can be used to compile jobs on architectures and operating systems to which the user doesn't have login access. For example:

```
$ setenv CONDOR_ARCH "SGI"
$ setenv CONDOR_OPSYS "IRIX65"
$ condor_run "f77 -O -o myprog myprog.f"
$ condor_run "make"
$ condor_run "condor_compile cc -o myprog.condor myprog.c"
```

Since *condor_run* does not read input from the terminal, you must explicitly redirect input from a file to the shell command. For example:

```
$ condor_run "cat input.dat | myprog > output.dat"
```

Files

condor_run creates the following temporary files in the user's working directory (replacing "pid" with *condor_run*'s process id):

.condor_run.pid This is the shell script containing the shell command-line which is submitted to Condor.

.condor_submit.pid This is the submit file passed to *condor_submit*.

.condor_log.pid This is the Condor log file monitored by *condor_run* to determine when the job exits.

.condor_out.pid This file contains the output of the Condor job (before it is copied to the terminal).

.condor_error.pid This file contains any error messages for the Condor job (before they are copied to the terminal).

The script removes these files when the job completes. However, if the script fails, it is possible that these files will remain in the user's working directory and the Condor job will remain in the queue.

General Remarks

condor_run is intended for submitting simple shell command-lines to Condor. It does not provide the full functionality of *condor_submit*. We have attempted to make *condor_run* as robust as possible, but it is possible that it will not correctly handle some possible *condor_submit* errors or system failures.

condor_run jobs have the same restrictions as other vanilla universe jobs. Specifically, the current working directory of the job must be accessible on the machine where the job runs. This typically means that the job must be submitted from a network file system such as NFS or AFS. Also, since Condor does not manage AFS credentials, permissions must be set to allow unauthenticated processes to access any AFS directories used by the Condor job.

All processes on the command-line will be executed on the machine where Condor runs the job. Condor will not distribute multiple processes of a command-line pipe across multiple machines.

condor_run will use the shell specified in the `SHELL` environment variable, if one exists. Otherwise, it will use */bin/sh*(t)o execute the shell command-line.

By default, *condor_run* expects perl to be installed in `/usr/bin/perl`. If perl is installed in another path, you can ask your Condor administrator to edit the path in the *condor_run* script or explicitly call perl from the command line:

```
$ perl [path-to-condor]/bin/condor_run "shell-cmd"
```

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_stats

Display historical information about the Condor pool

Synopsis

condor_stats [**-f** *filename*] [**-orgformat**] [**-pool** *hostname*] [*query-type*] [**time-range**]

Description

condor_stats is a tool that is used to display historic information about a Condor pool. Based on the type of information requested (by specifying it using the command line arguments), a query is sent to the collector, and the information received is displayed using the standard ouptut. If the -f option is used the information will ne written to a file instead of the standard output. The -pool option can be used to get information from other pools, instead of the local (default) pool. Condor pool. The *condor_status* tool can be used to query resource information (single or by platform), submitter and user information, and checkpoint server information. When a time range is not specified, the query retrieves information for the last day. Otherwise, information can be retrieved for other time ranges such as the last specified number of hours, last week, last month, or a specified date range.

The information is diplayed in columns separated by tabs. The first column always reresents the time, as a percentage of the range of the query (for example, a value of 50 in the first column indicates that the information on that line corresponds to a time in the middle of the query time range). If the -orgformat option is used, the time is displayed as number of seconds since the beginning of 1970. The information in the rest of the columns depends on the query type.

The possible query types and the information they provide:

- **Single resource query** requested using the -resourcequery option and provides information about a single machine. The information displayed includes the keyboard idle time (in seconds), the load average, and the machine state.
- **Single resource list** requested using the -resourcelist option and provides a list of all the machines for which the collector has historic information in the query's time range.
- **Resource group query** requested using the -resgroupquery option and provides information about a group of machines (based on operating system and architecture). The information displayed includes number of machines in unclaimed state, matched state, claimed state, preempting state, owner state, and total number of machines.
- **Resource group list** requested using the -resgrouplist option and provides a list of all the group names for which the collector has historic information in the query's time range.

- **Submitter query** requested using the -userquery option and provides information about a submitter (a user submitting from a specific machine). The information displayed includes the number of running jobs and the number of idle jobs.
- **Submitter list** requested using the -userlist option and provides a list of all the submitters for which the collector has historic information in the query's time range.
- **User query** requested using the -usergroupquery option and provides information about a user (for all jobs submitted by that user, regardless of the machine they were submitted from). The information displayed includes the number of running jobs and the number of idle jobs.
- **User list** requested using the -usergrouplist option and provides a list of all the users for which the collector has historic information in the query's time range.
- **Checkpoint server query** requested using the -ckptquery option and provides information about a checkpoint server. The information displayed includes the number of bytes received (in Mb), bytes sent (Mb), average receive bandwidth (in Kb/s), and average send bandwidth (Kb/s).
- **Checkpoint server list** requested using the -ckptlist option and provides a list of all the checkpoint servers for which the collector has historic information in the query's time range.

One of the above query types must be specified on the command line. Note that logging of pool history must be enabled in the collector, otherwise no information will be available and the query will not be responded to.

Options

Supported options are as follows:

-f *filename* Write the information to a file instead of the standard output.

-pool *hostname* Contact the specified central manager instead of the local one.

-orgformat Display the information in the same format it is actually stored.

-lastday Get information for the last day.

-lastweek Get information for the last week.

-lastmonth Get information for the last month.

-lasthours *n* Get information for the n last hours.

-from *m d y* Get information for the time since the specified date.

-to *m d y* Get information for the time up to the specified date, instead of up to now.

-resourcequery *name* Perform a single resource query for the specified resource.

-resourcelist Get the list of resources.

-resgroupquery *name* Perform a resource group query for the specified group.

-resgrouplist Get the list of groups.

-userquery *name* Perform a submitter query for the specified submitter.

-userlist Get the list of submitters.

-usergroupquery *name* Perform a user query for the specified user.

-usergrouplist Get the list of users.

-ckptquery *name* Perform a checkpoint server query for the specified checkpoint server.

-ckptlist Get the list of checkpoint servers.

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_status

Display status of the Condor pool

Synopsis

condor_status [*help options*] [*query options*] [*display options*] [*custom options*] [*hostname* . . .]

Description

condor_status is a versatile tool that may be used to monitor and query the Condor pool. The *condor_status* tool can be used to query resource information, submitter information, checkpoint server information, and daemon master information. The specific query sent and the resulting information display is controlled by the query options supplied. Queries and display formats can also be customized.

The options that may be supplied to *condor_status* belong to five groups:

- **Help options** provide information about the *condor_status* tool.
- **Query options** control the content and presentation of status information.
- **Display options** control the display of the queried information.
- **Custom options** allow the user to customize query and display information.
- **Host options** specify specific machines to be queried

At any time, only one *help option*, one *query option* and one *custom option* may be specified. Any number of *custom* and *host options* may be specified.

Options

Supported options are as follows:

-help (Help option) Display usage information

-diagnose (Help option) Print out query ad without performing query

-avail (Query option) Query *condor_startd* ads and identify resources which are available

-claimed (Query option) Query *condor_startd* ads and print information about claimed resources

-ckptsrvr (Query option) Query *condor_ckpt_server* ads and display checkpoint server attributes

-direct *hostname* (Query option) Go directly to the given hostname to get the ads to display

-master (Query option) Query *condor_master* ads and display daemon master attributes

-pool *hostname* Query the specified central manager. (*condor_status* queries `COLLECTOR_HOST` by default)

-schedd (Query option) Query *condor_schedd* ads and display attributes

-server (Query option) Query *condor_startd* ads and display resource attributes

-startd (Query option) Query *condor_startd* ads

-state (Query option) Query *condor_startd* ads and display resource state information

-submitters (Query option) Query ads sent by submitters and display important submitter attributes

-verbose (Display option) Display entire classads. Implies that totals will not be displayed.

-long (Display option) Display entire classads (same as **-verbose**)

-total (Display option) Display totals only

-constraint *const* (Custom option) Add constraint expression

-format *fmt attr* (Custom option) Register display format and attribute name. The *fmt* string has the same format as `printf(3)`, and *attr* is the name of the attribute that should be displayed in the specified format.

General Remarks

- The information obtained from *condor_startds* and *condor_schedds* may sometimes appear to be inconsistent. This is normal since startds and schedds update the Condor manager at different rates, and since there is a delay as information propagates through the network and the system.
- Note that the `ActivityTime` in the `Idle` state is *not* the amount of time that the machine has been idle. See the section on *condor_startd* states in the *Administrator's Manual* for more information.
- When using *condor_status* on a pool with SMP machines, you can either provide the hostname, in which case you will get back information about all virtual machines that are represented on that host, or you can list specific virtual machines by name. See the examples below for details.
- If you specify hostnames, without domains, Condor will automatically try to resolve those hostnames into fully qualified hostnames for you. This also works when specifying specific nodes of an SMP machine. In this case, everything after the "@" sign is treated as a hostname and that is what is resolved.
- You can use the **-direct** option in conjunction with almost any other set of options. However, at this time, the only daemon that will allow direct queries for its ad(s) is the *condor_startd*. So, the only options currently not supported with **-direct** are **-schedd** and **-master**. Most other options use startd ads for their information, so they work seamlessly with **-direct**. The only other restriction on **-direct** is that you may only use 1 **-direct** option at a time. If you want to query information directly from multiple hosts, you must run *condor_status* multiple times.
- Unless you use the local hostname with **-direct**, *condor_status* will still have to contact a collector to find the address where the specified daemon is listening. So, using a **-pool** option in conjunction with **-direct** just tells *condor_status* which collector to query to find the address of the daemon you want. The information actually displayed will still be retrieved directly from the daemon you specified as the argument to **-direct**.

Examples

Example 1 To view information from all nodes of an SMP machine, just use the hostname. For example, if you had a 4-CPU machine, named "vulture.cs.wisc.edu", here's what you might see:

```
% condor_status vulture

Name          OpSys       Arch   State      Activity   Loa-
dAv Mem   ActvtyTime

vm1@vulture.c SOLARIS26   INTEL  Owner      Idle       0.020  128   0+00:57:13
vm2@vulture.c SOLARIS26   INTEL  Claimed    Busy       1.006  128   0+01:16:03
```

```
vm3@vulture.c SOLARIS26   INTEL  Claimed    Busy       0.978  128   0+03:32:53
vm4@vulture.c SOLARIS26   INTEL  Claimed    Busy       1.001  128   0+02:21:07

                     Machines Owner Claimed Un-
claimed Matched Preempting

     INTEL/SOLARIS26        4     0       4         0       0          0

               Total        4     0       4         0       0          0
```

Example 2 To view information from a specific nodes of an SMP machine, specify the node directly. You do this by providing the name of the *virtual machine*. This has the form `vm#@hostname`. For example:

```
% condor_status vm2@vulture

Name          OpSys       Arch   State      Activity   Loa-
dAv Mem   ActvtyTime

vm2@vulture.c SOLARIS26   INTEL  Claimed    Busy       1.006  128   0+01:16:03

                     Machines Owner Claimed Un-
claimed Matched Preempting

     INTEL/SOLARIS26        1     0       1         0       0          0

               Total        1     0       1         0       0          0
```

Author

Condor Team, University of Wisconsin–Madison

Copyright

condor_submit

Queue jobs for execution on remote machines

Synopsis

condor_submit [**–**] [**-v**] [**-n** *schedd_name*] [**-r** *schedd_name*] *submit-description file*

Description

condor_submit is the program for submitting jobs to Condor. *condor_submit* requires a submit-description file which contains commands to direct the queuing of jobs. One description file may contain specifications for the queuing of many condor jobs at once. All jobs queued by a single invocation of *condor_submit* must share the same executable, and are referred to as a "job cluster". It is advantageous to submit multiple jobs as a single cluster because:

- Only one copy of the checkpoint file is needed to represent all jobs in a cluster until they begin execution.
- There is much less overhead involved for Condor to start the next job in a cluster than for Condor to start a new cluster. This can make a big difference if you are submitting lots of short running jobs.

SUBMIT DESCRIPTION FILE COMMANDS

Each condor job description file describes one cluster of jobs to be placed in the condor execution pool. All jobs in a cluster must share the same executable, but they may have different input and output files, and different program arguments, etc. The submit-description file is then used as the only command-line argument to *condor_submit*.

The submit-description file must contain one *executable* command and at least one *queue* command. All of the other commands have default actions.

The commands which can appear in the submit-description file are:

executable = <name> The name of the executable file for this job cluster. Only one executable command may be present in a description file. If submitting into the Standard Universe, which is the default, then the named executable must have been re-linked with the Condor libraries (such as via the *condor_compile* command). If submitting into the Vanilla Universe, then the named executable need not be re-linked and can be any process which can run in the background (shell scripts work fine as well).

input = <pathname> Condor assumes that its jobs are long-running, and that the user will not wait at the terminal for their completion. Because of this, the standard files which normally access the terminal, (stdin, stdout, and stderr), must refer to files. Thus, the filename specified with **input** should contain any keyboard input the program requires (i.e. this file becomes stdin). If not specified, the default value of /dev/null is used.

output = <pathname> The **output** filename will capture any information the program would normally write to the screen (i.e. this file becomes stdout). If not specified, the default value of /dev/null is used. More than one job should not use the same output file, since this will cause one job to overwrite the output of another.

error = <pathname> The **error** filename will capture any error messages the program would normally write to the screen (i.e. this file becomes stderr). If not specified, the default value of /dev/null is used. More than one job should not use the same error file, since this will cause one job to overwrite the errors of another.

arguments = <argument_list> List of arguments to be supplied to the program on the command line.

initialdir = <directory-path> Used to specify the current working directory for the Condor job. Should be a path to a preexisting directory. If not specified, *condor_submit* will automatically insert the user's current working directory at the time *condor_submit* was run as the value for **initialdir**.

requirements = <ClassAd Boolean Expression> The requirements command is a boolean ClassAd expression which uses C-like operators. In order for any job in this cluster to run on a given machine, this requirements expression must evaluate to true on the given machine. For example, to require that whatever machine executes your program has a least 64 Meg of RAM and has a MIPS performance rating greater than 45, use:

```
requirements = Memory >= 64 && Mips > 45
```

Only one requirements command may be present in a description file. By default, *condor_submit* appends the following clauses to the requirements expression:

1. Arch and OpSys are set equal to the Arch and OpSys of the submit machine. In other words: unless you request otherwise, Condor will give your job machines with the same architecture and operating system version as the machine running *condor_submit*.
2. Disk > ExecutableSize. To ensure there is enough disk space on the target machine for Condor to copy over your executable.
3. VirtualMemory >= ImageSize. To ensure the target machine has enough virtual memory to run your job.
4. If Universe is set to Vanilla, FileSystemDomain is set equal to the submit machine's FileSystemDomain.

You can view the requirements of a job which has already been submitted (along with everything else about the job ClassAd) with the command *condor_q -l*; see the command reference for *condor_q* on page 274. Also, see the Condor Users Manual for complete information on the syntax and available attributes that can be used in the ClassAd expression.

rank = <ClassAd Float Expression> A ClassAd Floating-Point expression that states how to rank machines which have already met the requirements expression. Essentially, rank expresses preference. A higher numeric value equals better rank. Condor will give the job the machine with the highest rank. For example,

```
requirements = Memory > 60
rank = Memory
```

asks Condor to find all available machines with more than 60 megabytes of memory and give the job the one with the most amount of memory. See the Condor Users Manual for complete information on the syntax and available attributes that can be used in the ClassAd expression.

priority = <priority> Condor job priorities range from -20 to +20, with 0 being the default. Jobs with higher numerical priority will run before jobs with lower numerical priority. Note that this priority is on a per user basis; setting the priority will determine the order in which your own jobs are executed, but will have no effect on whether or not your jobs will run ahead of another user's jobs.

notification = <when> Owners of condor jobs are notified by email when certain events occur. If *when* is set to Always, the owner will be notified whenever the job is checkpointed, and when it completes. If *when* is set to Complete (the default), the owner will be notified when the job terminates. If *when* is set to Error, the owner will only be notified if the job terminates abnormally. If *when* is set to Never, the owner will not be mailed, regardless what happens to the job. The statistics included in the email are documented in section 2.6.5 on page 31.

notify_user = <email-address> Used to specify the email address to use when Condor sends email about a job. If not specified, Condor will default to using :

```
job-owner@UID_DOMAIN
```

where `UID_DOMAIN` is specified by the Condor site administrator. If `UID_DOMAIN` has not been specified, Condor will send the email to :

```
job-owner@submit-machine-name
```

copy_to_spool = <True | False> If **copy_to_spool** is set to *True*, then *condor_submit* will copy the executable to the local spool directory before running it on a remote host. Oftentimes this can be quite time consuming and unnecessary. By setting it to *False*, *condor_submit* will skip this step. Defaults to *True*.

getenv = <True | False> If **getenv** is set to *True*, then *condor_submit* will copy all of the user's current shell environment variables at the time of job submission into the job ClassAd. The job will therefore execute with the same set of environment variables that the user had at submit time. Defaults to *False*.

hold = <True | False> If **hold** is set to *True*, then the job will be submitted in the hold state. Jobs in the hold state will not run until released by *condor_release*.

environment = <parameter_list> List of environment variables of the form :

```
<parameter> = <value>
```

Multiple environment variables can be specified by separating them with a semicolon (" ; "). These environment variables will be placed into the job's environment before execution. The length of all characters specified in the environment is currently limited to 4096 characters.

log = <pathname> Use **log** to specify a filename where Condor will write a log file of what is happening with this job cluster. For example, Condor will log into this file when and where the job begins running, when the job is checkpointed and/or migrated, when the job completes, etc. Most users find specifying a **log** file to be very handy; its use is recommended. If no **log** entry is specified, Condor does not create a log for this cluster.

universe = <vanilla | standard | pvm | scheduler | globus | mpi> Specifies which Condor Universe to use when running this job. The Condor Universe specifies a Condor execution environment. The *standard* Universe is the default, and tells Condor that this job has been re-linked via *condor_compile* with the Condor libraries and therefore supports checkpointing and remote system calls. The *vanilla* Universe is an execution environment for jobs which have not been linked with the Condor libraries. *Note:* use the *vanilla* Universe to submit shell scripts to Condor. The *pvm* Universe is for a parallel job written with PVM 3.4. The *scheduler* is for a job that should act as a metascheduler. The *globus* universe translates the submit description file to a Globus RSL string and passes it to the *globusrun* program for execution. The *mpi* universe is for running mpi jobs made with the MPICH package. See the Condor User's Manual for more information about using Universe.

image_size = <size> This command tells Condor the maximum virtual image size to which you believe your program will grow during its execution. Condor will then execute your job only on machines which have enough resources, (such as virtual memory), to support executing your job. If you do not specify the image size of your job in the description file, Condor will automatically make a (reasonably accurate) estimate about its size and adjust this estimate as your program runs. If the image size of your job is underestimated, it may crash due to inability to acquire more address space, e.g. malloc() fails. If the image size is overestimated, Condor may have difficulty finding machines which have the required resources. *size* must be in kbytes, e.g. for an image size of 8 megabytes, use a *size* of 8000.

machine_count = <min..max> | <max> If **machine_count** is specified, Condor will not start the job until it can simultaneously supply the job with *min* machines. Condor will continue to try to provide up to *max* machines, but will not delay starting of the job to do so. If the job is started with fewer than *max* machines, the job will be notified via a usual PvmHostAdd notification as additional hosts come on line. **Important:** only use **machine_count** if an only if submitting into the PVM or MPI Universes. Use min..max for the PVM universe, and just max for the MPI universe.

coresize = <size> Should the user's program abort and produce a core file, **coresize** specifies the maximum size in bytes of the core file which the user wishes to keep. If **coresize** is not specified in the command file, the system's user resource limit "coredumpsize" is used (except on HP-UX).

nice_user = <True | False> Normally, when a machine becomes available to Condor, Condor decides which job to run based upon user and job priorities. Setting **nice_user** equal to *True* tells Condor not to use your regular user priority, but that this job should have last priority amongst all users and all jobs. So jobs submitted in this fashion run only on machines which no other non-nice_user job wants — a true “bottom-feeder” job! This is very handy if a user has some jobs they wish to run, but do not wish to use resources that could instead be used to run other people’s Condor jobs. Jobs submitted in this fashion have “nice-user.” pre-appended in front of the owner name when viewed from *condor_q* or *condor_userprio*. The default value is **False**.

kill_sig = <signal-number> When Condor needs to kick a job off of a machine, it will send the job the signal specified by *signal-number*. *signal-number* needs to be an integer which represents a valid signal on the execution machine. For jobs submitted to the Standard Universe, the default value is the number for `SIGTSTP` which tells the Condor libraries to initiate a checkpoint of the process. For jobs submitted to the Vanilla Universe, the default is `SIGTERM` which is the standard way to terminate a program in UNIX.

buffer_size = <**bytes-in-buffer**> Condor keeps a buffer of recently-used data for each file an application opens. This option specifies the maximum number of bytes to be buffered for each open file at the executing machine.

The buffer size and its effect on throughput may be viewed with the `-io` option to *condor_status*. In this version of Condor, the default buffer size is 512 KB, unless the configuration file macro `DEFAULT_IO_BUFFER_SIZE` has been set to a different default by your administrator on your submission machine.

This option only applies to standard-universe jobs.

buffer_block_size = <**bytes-in-block**> When buffering is enabled, Condor will attempt to consolidate small read and write operations into large blocks. This option specifies the block size Condor will use. A very small block size may actually decrease I/O performance. The block size should definitely be larger than any of the I/O operations your program performs.

The buffer block size and its effect on throughput may be viewed with the `-io` option to *condor_status*. In this version of Condor, the default buffer block size is 32 KB, unless the configuration file `DEFAULT_IO_BUFFER_BLOCK_SIZE` has been set to a different default by your administrator on your submission machine.

This option only applies to standard-universe jobs.

file_remaps = < **“ name** = **newname ; name2** = **newname2 ... ”**> Directs Condor to use a new filename in place of an old one. *name* describes a filename that your job may attempt to open, and *newname* describes the filename it should be replaced with. *newname* may include an optional leading access specifier, `local:` or `remote:`. If left unspecified, the default access specifier is `remote:`. Multiple remaps can be specified by separating each with a semicolon.

If you wish to remap file names that contain equals signs or semicolons, these special chracaters may be escaped with a backslash.

This option only applies to standard-universe jobs.

Example One: Suppose that your job reads a file named `dataset.1`. To instruct Condor to force your job to read `other.dataset` instead, add this to the submit file:

```
file_remaps = "dataset.1=other.dataset"
```

Example Two: Suppose that your run many jobs which all read in the same large file, called `very.big`. If this file can be found in the same place on a local disk in every machine in the pool, (say `/bigdisk/bigfile`,) you can instruct Condor of this fact by remapping `very.big` to `/bigdisk/bigfile` and specifying that the file is to be read locally, which will be much faster than reading over the network.

```
file_remaps = "very.big = local:/bigdisk/bigfile"
```

Example Three: Several remaps can be applied at once by separating each with a semicolon.

```
file_remaps = "very.big = local:/bigdisk/bigfile ; dataset.1 = other.dataset'
```

rendezvousdir = <directory-path> Used to specify the shared-filesystem directory to be used for filesystem authentication when submitting to a remote scheduler. Should be a path to a preexisting directory.

x509directory = <directory-path> Used to specify the directory which contains the certificate, private key, and trusted certificate directory for GSS authentication. If this attribute is set, the environment variables X509_USER_KEY, X509_USER_CERT, and X509_CERT_DIR are exported with default values. See section 3.9 for more info.

x509userproxy = <full-pathname> Used to override the default pathname for X509 user certificates. The default location for X509 proxies is the /tmp directory, which is generally a local filesystem. Setting this value would allow Condor to access the proxy in a shared filesystem (e.g., AFS). See section 3.9 for more info.

globusscheduler = <scheduler-name> Used to specify the Globus resource to which the job should be submitted. More than one scheduler can be submitted to, simply place a *queue* command after each instance of globusscheduler. Each instance should be a valid Globus scheduler, using either the full Globus contact string or the host/scheduler format shown below: NOTE: Submit attributes which start with ”globus” are not macro expanded

Example: To submit to the LSF scheduler of the Globus gatekeeper on lego at Boston University:

```
...
GlobusScheduler = lego.bu.edu/jobmanager-lsf
queue
```

globusarguments = <argument-list> This space-separated list of arguments is copied into the *globusrun* arguments attribute To have Condor expand the macros before passing the arguments on to *globusrun*, use the arguments attribute rather than globusarguments. NOTE: Submit attributes which start with ”globus” are not macro expanded

globusexecutable = <executable-path> Similar to the executable attribute, but without macro expansion. The [globus]executable argument is passed to *globusrun* to be executed on the remote Globus node.

globusrsl = <RSL-string> Used to provide any additional Globus RSL string attributes which are not covered by globusexecutable, globusarguments, and globusscheduler. NOTE: Submit attributes which start with "globus" are not macro expanded

+<attribute> = <value> A line which begins with a '+' (plus) character instructs *condor_submit* to simply insert the following *attribute* into the job ClasssAd with the given *value*.

queue [number-of-procs] Places one or more copies of the job into the Condor queue. If desired, new **input**, **output**, **error**, **initialdir**, **arguments**, **nice_user**, **priority**, **kill_sig**, **coresize**, or **image_size** commands may be issued between **queue** commands. This is very handy when submitting multiple runs into one cluster with one submit file; for example, by issuing an **initialdir** between each **queue** command, each run can work in its own subdirectory. The optional argument *number-of-procs* specifies how many times to submit the job to the queue, and defaults to 1.

In addition to commands, the submit-description file can contain macros and comments:

Macros Parameterless macros in the form of `$(macro_name)` may be inserted anywhere in condor description files. Macros can be defined by lines in the form of

```
<macro_name> = <string>
```

Two pre-defined macros are supplied by the description file parser. The `$(Cluster)` macro supplies the number of the job cluster, and the `$(Process)` macro supplies the number of the job. These macros are intended to aid in the specification of input/output files, arguments, etc., for clusters with lots of jobs, and/or could be used to supply a Condor process with its own cluster and process numbers on the command line. The `$(Process)` macro should not be used for PVM jobs.

Comments Blank lines and lines beginning with a '#' (pound-sign) character are ignored by the submit-description file parser.

Options

Supported options are as follows:

– Accept the command file from stdin.

-v Verbose output - display the created job class-ad

-n *schedd_name* Submit to the specified schedd. This option is used when there is more than one schedd running on the submitting machine

-r *schedd_name* Submit to a remote schedd. The jobs will be submitted to the schedd on the specified remote host. On Unix systems, the Condor administrator for you site must override the default AUTHENTICATION_METHODS configuration setting to enable remote filesystem (FS_REMOTE) authentication.

Exit Status

condor_submit will exit with a status value of 0 (zero) upon success, and a non-zero value upon failure.

Examples

Example 1: The below example queues three jobs for execution by Condor. The first will be given command line arguments of '15' and '2000', and will write its standard output to 'foo.out1'. The second will be given command line arguments of '30' and '2000', and will write its standard output to 'foo.out2'. Similarly the third will have arguments of '45' and '6000', and will use 'foo.out3' for its standard output. Standard error output, (if any), from all three programs will appear in 'foo.error'.

```
####################
#
# Example 1: queueing multiple jobs with differing
# command line arguments and output files.
#
####################

Executable     = foo

Arguments      = 15 2000
Output  = foo.out1
Error   = foo.err1
Queue

Arguments      = 30 2000
Output  = foo.out2
Error   = foo.err2
Queue

Arguments      = 45 6000
Output  = foo.out3
Error   = foo.err3
Queue
```

Example 2: This submit-description file example queues 150 runs of program 'foo' which must have been compiled and linked for Silicon Graphics workstations running IRIX 6.x. Condor will not attempt to run the processes on machines which have less than 32 megabytes of physical memory, and will run them on machines which have at least 64 megabytes if such machines are available. Stdin, stdout, and stderr will refer to "in.0", "out.0", and "err.0" for the first run of this program (process 0). Stdin, stdout, and stderr will refer to "in.1", "out.1", and "err.1" for process 1, and so forth. A log file containing entries about where/when Condor runs, checkpoints, and migrates processes in this cluster will be written into file "foo.log".

```
####################
#
# Example 2: Show off some fancy features including
# use of pre-defined macros and logging.
#
####################

Executable     = foo
Requirements   = Memory >= 32 && OpSys == "IRIX6" && Arch =="SGI"
Rank           = Memory >= 64
Image_Size     = 28 Meg

Error   = err.$(Process)
Input   = in.$(Process)
Output  = out.$(Process)
Log = foo.log

Queue 150
```

General Remarks

- For security reasons, Condor will refuse to run any jobs submitted by user root (UID = 0) or by a user whose default group is group wheel (GID = 0). Jobs submitted by user root or a user with a default group of wheel will appear to sit forever in the queue in an idle state.
- All pathnames specified in the submit-description file must be less than 256 characters in length, and command line arguments must be less than 4096 characters in length; otherwise, *condor_submit* gives a warning message but the jobs will not execute properly.
- Somewhat understandably, behavior gets bizzare if the user makes the mistake of requesting multiple Condor jobs to write to the same file, and/or if the user alters any files that need to be accessed by a Condor job which is still in the queue (i.e. compressing of data or output files before a Condor job has completed is a common mistake).
- To disable checkpointing for Standard Universe jobs, include the line:

```
+WantCheckpoint = False
```

in the submit-description file before the queue command(s).

See Also

Condor User Manual

Author

Condor Team, University of Wisconsin–Madison

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condor_submit_dag

Manage and queue jobs within a specified DAG for execution on remote machines

Synopsis

condor_submit_dag [**-no_submit**] [**-verbose**] [**-force**] [**-maxjobs** *NumberOfJobs*] [**-log** *LogFileName*] [**-notification** *value*] *DAGInputFile*

Description

condor_submit_dag is the program for submitting a DAG (directed acyclic graph) of jobs for execution under Condor. The program enforces the job dependencies defined in the *DAGInputFile*. The *DAGInputFile* contains commands to direct the submission of jobs implied by the nodes of a DAG to Condor. See the Condor User Manual, section 2.11 for a complete description.

Options

Supported options are as follows:

-no_submit Produce the Condor submit description file for DAGMan, but do not submit DAGMan as a Condor job.

-verbose Give verbose error messages.

-force Require *condor_submit_dag* to overwrite the files that it produces, if the files already exist.

-maxjobs *NumberOfJobs* Sets the maximum number of jobs within the DAG that may be submitted to Condor at one time. *NumberOfJobs* is a positive integer.

-log *LogFileName* Forces *condor_submit_dag* to omit the check of Condor submit description files for nodes within the DAG to verify that they all use the same log file. The argument *LogFileName* is used as the single, common log file.

-notification *value* Sets the e-mail notification for DAGMan itself. This information will be used within the Condor submit description file for DAGMan. This file is produced by *condor_submit_dag*. See **notification** within the section of submit description file commands in the *condor_submit* manual page on page 305 for specification of *value*.

See Also

Condor User Manual

Author

Condor Team, University of Wisconsin–Madison

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condor_userlog

Display and summarize job statistics from job log files.

Synopsis

condor_userlog [**-help**] [**-total** | **-raw**] [**-debug**] [**-evict**] [**-j** *cluster* | *cluster.proc*] [**-all**] [**-hostname**] *logfile* . . .

Description

condor_userlog parses the information in job log files and displays summaries for each workstation allocation and for each job. See the manual page for *condor_submit* on page 305 for instructions for specifying that Condor write a log file for your jobs.

If **-total** is not specified, *condor_userlog* will first display a record for each workstation allocation, which includes the following information:

Job The cluster/process id of the Condor job.

Host The host where the job ran. By default, the host's IP address is displayed. If **-hostname** is specified, the hostname will be displayed instead.

Start Time The time (month/day hour:minute) when the job began running on the host.

Evict Time The time (month/day hour:minute) when the job was evicted from the host.

Wall Time The time (days+hours:minutes) for which this workstation was allocated to the job.

Good Time The allocated time (days+hours:min) which contributed to the completion of this job. If the job exited during the allocation, then this value will equal "Wall Time." If the job performed a checkpoint, then the value equals the work saved in the checkpoint during this allocation. If the job did not exit or perform a checkpoint during this allocation, the value will be 0+00:00. This value can be greater than 0 and less than "Wall Time" if the application completed a periodic checkpoint during the allocation but failed to checkpoint when evicted.

CPU Usage The CPU time (days+hours:min) which contributed to the completion of this job.

condor_userlog will then display summary statistics per host:

Host/Job The IP address or hostname for the host.

Wall Time The workstation time (days+hours:minutes) allocated by this host to the jobs specified in the query. By default, all jobs in the log are included in the query.

Good Time The time (days+hours:minutes) allocated on this host which contributed to the completion of the jobs specified in the query.

CPU Usage The CPU time (days+hours:minutes) obtained from this host which contributed to the completion of the jobs specified in the query.

Avg Alloc The average length of an allocation on this host (days+hours:minutes).

Avg Lost The average amount of work lost (days+hours:minutes) when a job was evicted from this host without successfully performing a checkpoint.

Goodput This percentage is computed as Good Time divided by Wall Time.

Util. This percentage is computed as CPU Usage divided by Good Time.

condor_userlog will then display summary statistics per job:

Host/Job The cluster/process id of the Condor job.

Wall Time The total workstation time (days+hours:minutes) allocated to this job.

Good Time The total time (days+hours:minutes) allocated to this job which contributed to the job's completion.

CPU Usage The total CPU time (days+hours:minutes) which contributed to this job's completion.

Avg Alloc The average length of a workstation allocation obtained by this job in minutes (days+hours:minutes).

Avg Lost The average amount of work lost (days+hours:minutes) when this job was evicted from a host without successfully performing a checkpoint.

Goodput This percentage is computed as Good Time divided by Wall Time.

Util. This percentage is computed as CPU Usage divided by Good Time.

Finally, *condor_userlog* will display a summary for all hosts and jobs.

Options

Supported options are as follows:

-help Get a brief description of the supported options

-total Only display job totals

-raw Display raw data only

-debug Debug mode

-j Select a specific cluster or cluster.proc

-evict Select only allocations which ended due to eviction

-all Select all clusters and all allocations

-hostname Display hostname instead of IP address

General Remarks

Since the Condor job log file format does not contain a year field in the timestamp, all entries are assumed to occur in the current year. Allocations which begin in one year and end in the next will be silently ignored.

Author

Condor Team, University of Wisconsin–Madison

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See the *Condor Version 6.1.17 Manual* for additional notices.

condor_userprio

Manage user priorities

Synopsis

condor_userprio [**-pool** *hostname*] [**-all**] [**-usage**] [**-setprio** *username value*] [**-setfactor** *username value*] [**-resetusage** *username*] [**-resetall**] [**-getreslist** *username*] [**-allusers**] [**-activefrom** *month day year*] [**-l**]

Description

condor_userprio with no arguments, lists the active users (see below) along with their priorities, in increasing priority order. The -all option can be used to display more detailed information about each user, which includes the following columns:

Effective Priority The effective priority value of the user, which is used to calculate the user's share when allocating resources. A lower value means a higher priority, and the minimum value (highest priority) is 0.5. The effective priority is calculated by multiplying the real priority by the priority factor.

Real Priority The value of the real priority of the user. This value follows the user's resource usage.

Priority Factor The system administrator can set this value for each user, thus controlling a user's effective priority relative to other users. This can be used to create different classes of users.

Res Used The number of resources currently used (e.g. the number of running jobs for that user).

Accumulated Usage The accumulated number of resource-hours used by the user since the usage start time.

Usage Start Time The time since when usage has been recorded for the user. This time is set when a user job runs for the first time. It is reset to the present time when the usage for the user is reset (with the -resetusage or -resetall options).

Last Usage Time The most recent time a resource usage has been recorded for the user.

The -usage option displays the username, accumulated usage, usage start time and last usage time for each user, sorted on accumulated usage.

The -setprio, -setfactor options are used to change a user's real priority and priority factor. The -resetusage and -resetall options are used to reset the accumulated usage for users. The usage start time is set to the current time when the accumulated usage is reset. These options require administrator privilages.

By default only users for whom usage was recorded in the last 24 hours or whose priority is greater than the minimum are listed. The -activefrom and -allusers options can be used to display users who had some usage since a specified date, or ever. The summary line for last usage time will show this date.

The -getreslist option is used to display the resources currently used by a user. The output includes the start time (the time the resource was allocated to the user), and the match time (how long has the resource been allocated to the user).

Note that when specifying usernames on the command line, the name must include the uid domain (e.g. user@uid-domain - exactly the same way usernames are listed by the userprio command).

The -pool option can be used to contact a different central-manager instead of the local one (the default).

Options

Supported options are as follows:

-pool *hostname* Contact the specified hostname instead of the local central manager. This can be used to check other pools.

-all Display detailed information about each user.

-usage Display usage information for each user.

-setprio *username value* Set the real priority of the specified user to the specified value.

-setfactor *username value* Set the priority factor of the specified user to the specified value.

-resetusage *username* Reset the accumulated usage of the specified user to zero.

-resetall Reset the accumulated usage of all the users to zero.

-getreslist *username* Display all the resources currently allocated to the specified user.

-allusers Display information for all the users who have some recorded accumulated usage.

-activefrom ***month day year*** Display information for users who have some recorded accumulated usage since the specified date.

-l Show the class-ad which was received from the central-manager in long format.

Author

Condor Team, University of Wisconsin–Madison

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See the *Condor Version 6.1.17 Manual* for additional notices.

condor_vacate

Vacate jobs that are running on the specified hosts

Synopsis

condor_vacate [**-help**] [**-version**] [**-fast**] [**hostname ...**]

Description

condor_vacate causes the condor startd to checkpoint any running jobs and make them vacate the machine. The job remains in the submitting machine's job queue, however.

If the job on the specified host is running in the Standard Universe, then the job is first checkpointed and then killed (and will then restart somewhere else where it left off). If the job on the specified host is running in the Vanilla Universe, then the job is not checkpointed but is simply killed (and will then restart somewhere else from the beginning). If there is currently no Condor job running on that host, then *condor_vacate* has no effect. Normally there is no need for the user or administrator to explicitly run *condor_vacate*. Vacating a running condor job off of a machine is handled automatically by Condor by following the policies stated in Condor's configuration files.

Options

Supported options are as follows:

-help Display usage information

-version Display version information

-fast Hard-kill jobs instead of checkpointing them

Author

Condor Team, University of Wisconsin–Madison

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