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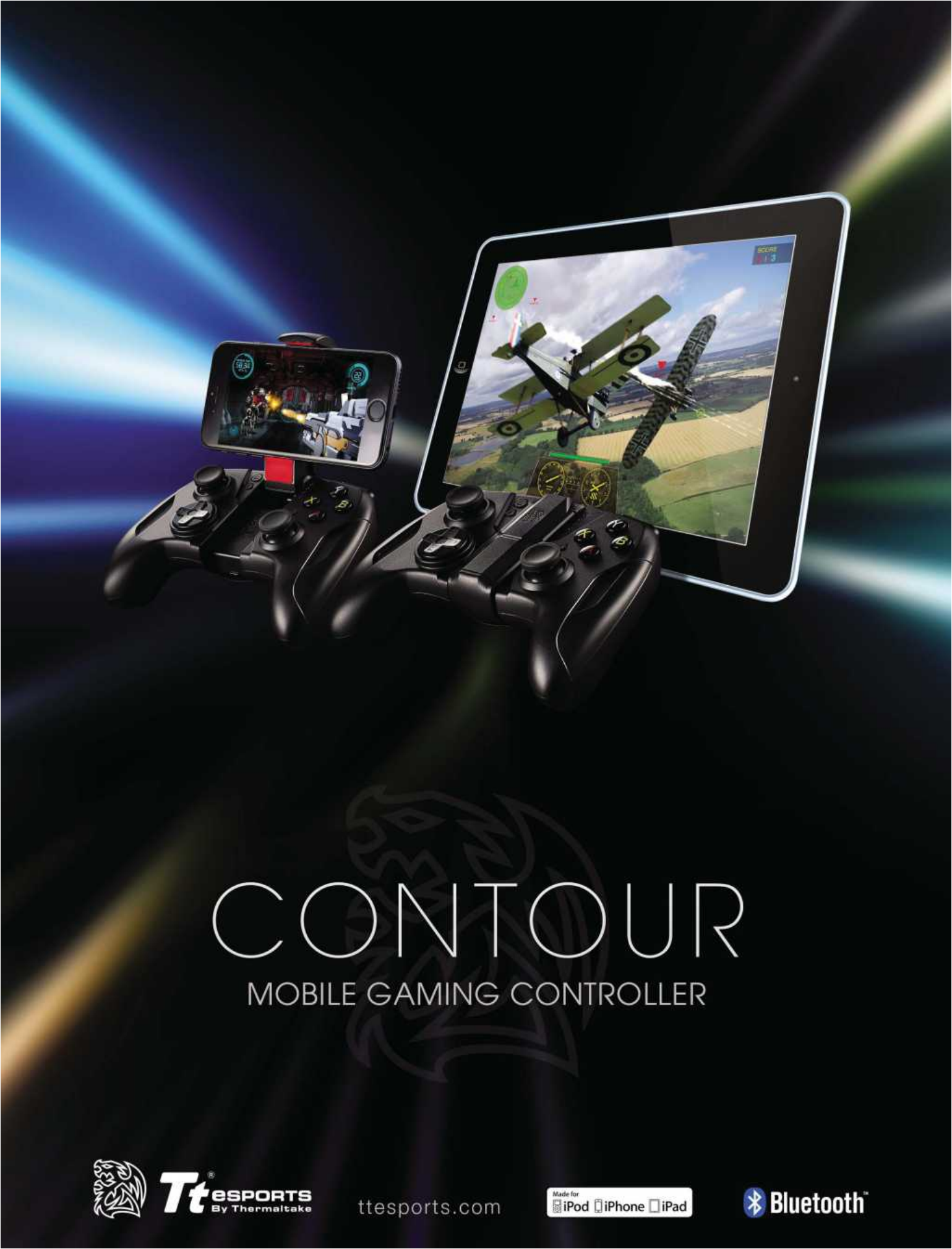
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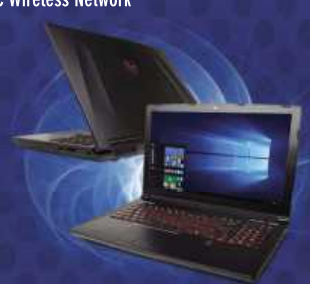

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Tuan Nguyen

YOU CAN NEVER HAVE ENOUGH STORAGE

LET'S BE HONEST: storage companies know what people use their products for. Yes, there are legitimate cases such as storing your photos, work-related files, personal backup, and holiday videos. But a large number of users, those who have multi-terabyte needs for home use, are saving files that are less federally sanctioned. Whatever your cup of tea, there's a real demand for more capacity.

I'm a huge fan of storage. I have multiple PCs at home and do hourly, daily, and weekly backups across multiple NASes. And in case you've been living under a rock and didn't get the memo: You should do regular backups, too. With multi-terabyte drives available on the cheap, there's just no excuse any more. We round up a heap of NAS drives this issue that will satisfy all but the most prolific downloader.

What does my storage infrastructure look like? First, I have three independent eight-bay NASes for different purposes. One of them stores media, another stores my personal and work files, and the last acts as a backup target for the five computers I have at home. All three then back up using Rsync to a 12-bay NAS. All NASes utilize a mix of consumer and enterprise NAS HDDs, depending on the purpose of the NAS.

Having capacious storage isn't enough. You're going to need fast storage as well. Does anyone remember the parallel IDE days with unsightly thick ribbon cables? Solid-state storage was just a concept back then. These days, the domain of speed belongs squarely to SSDs.

In the speed realm, you're going to be looking at more than just capacity. An area of intense development is the actual drive interface, which connects your drive to your PC. The most common is SATA 6Gbps, but M.2 is on the rise. The majority of users won't have an M.2 interface on their motherboard, so breaking through SATA's ceiling requires using RAID.

Don't let yourself be confused by M.2, though. It's an interface that replaces mSATA and supports multiple buses, including SATA, PCI Express, USB 2 and 3, NVMe, and others. Buying an M.2 storage stick doesn't guarantee you the latest NVMe speeds—you could end up with an M.2 drive operating in legacy AHCI mode. You want NVMe.

Then there are some high-end motherboards shipping with Intel's new Thunderbolt 2 interface, delivering a blistering 20Gbps in both directions. With all the options, which is best? We take all four approaches to speed for a spin and figure out which is the right balance between price, performance, and availability.

When it comes down to it, the best setups will have a combination of all types of storage: fast solid-state drives, gigantic HDDs, and NAS solutions.

And in case you were wondering, the 12-bay NAS backs up to Amazon S3.

Tuan Nguyen is Maximum PC*'s editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 19 years.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Microsoft Reboots Mobile With Win 10

There's more at stake than market share

WHEN IT COMES to mobile, Microsoft is a little like Rocky Balboa. The company has taken some hearty blows from heavyweight contenders such as Android and iOS, and even BlackBerry, a former champ that now finds itself on the ropes. But given Microsoft's size and persistence, it's proven a tough opponent to actually knock out. Even now, against all odds and swinging a meager 3 percent share of the smartphone market, Microsoft is back on its feet and looking as though it could be a contender again. Maybe not for the title, but at least for a bigger purse.

That's really the goal at this point. By the time you read this, Microsoft will have launched (or soon will) its new flagship Lumia devices, the 950 and 950 XL, both running a version of Windows 10 for smartphones. It's an important launch for Microsoft because it kicks off a new era in mobile, one that's focused on extending the Windows 10 ecosystem rather than running alongside it.

Microsoft has been trying to do that since Windows 8, only now it's better equipped to execute. The question is, can Microsoft truly compete with Android and iOS when starting from so far behind?

We posed that question to William Stofega, program director of Mobile Device Technology and Trends for IDC, who told us that Microsoft's "focus on enterprise gives them a shot to slowly build up support for Lumia devices." He also pointed out that "market share isn't the ultimate auditor" of success. With Windows 10 now on more than 110 million devices and garnering favorable reviews, Stofega says there's an opportunity for Microsoft to increase its profit on other services through universal apps that work on multiple devices.

Tuong Nguyen, principal research analyst for Gartner, shared a similar perspective, noting that Microsoft's recent hardware event featured a variety of gadgets, not just phones. "I think this is a big indicator in their overall strategy. It's not one specifically focused on any single device (such as the Lumia phones), but rather its positioning in the broader market," Nguyen said.

> "To date, consumers have associated Windows too strongly with PC. Tuong Nguyen

Using a $99 DisplayDock accessory, you can attach certain Windows 10 phones to a monitor and use them like a PC.

Nguyen doesn't see Windows 10 for mobile drastically changing Microsoft's market share position, but thinks it does present an opportunity to expand Windows 10's brand impression across different device types. At the same time, he notes certain challenges Microsoft will need to overcome.

"To date, consumers have associated Windows too strongly with PC. Conversely, they tend to think of Android and iOS when it comes to mobile," Nguyen explained. This could also make it "difficult for Windows to get a foothold within the enterprise."

Carolina Milanesi, chief of research and head of Kantar Worldpanel ComTech US, summed it up nicely in a recent blog post.

"Many will be tempted to look at the Lumia 950 and 950 XL in relation to their potential to convert users from iOS and Android. Yet the focus for Microsoft has changed and these devices have more to do with giving those Windows 10 PC users a phone to go with their PC and complement their experience, rather than feeling they can only use a smartphone on a competing OS," Milaensi stated.

Microsoft declined our request to comment on its mobile strategy and expectations, which isn't surprising as we approached the company pre-launch. We'll just have to wait and see how things develop. **–PL**

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There's a router virus that's helping infected routers fight off malware.

ROUTER VIRUS SEEMS TO FIGHT THE GOOD FIGHT

Great—you have a virus!

CYBER CRIMINALS are beginning to take an increased interest in home routers and the Internet of Things market as a whole. It's not that there's a lot of personal data on such devices, but the allure of controlling all these gadgets is what's attractive, especially when plotting a distributed denial-of-service attack. However, a newly discovered virus that's taken up residence on thousands of routers may have your welfare in mind.

Security firm Symantec is calling the virus Linux.Wifatch (or just Wifatch). It came to light in 2014, when a security researcher noticed unusual activity on his home router. He discovered a sophisticated piece of code that turned his router into a zombie connected to a P2P network of infected devices. Symantec did some digging of its own and found that much of Wifatch's code is in Perl. It targets several architectures and ships its own static Perl interpreter to each. Once a device is infected, it connects to a P2P network that distributes threat updates.

"The further we dug into Wifatch's code, the more we had the feeling that there was something unusual about this threat. For all intents and purposes, it appeared like the author was trying to secure infected devices instead of using them for malicious activities," Symantec explains.

Symantec hasn't found any evidence to suggest Wifatch is shipping payloads for malicious purposes. Just the opposite—it appears that Wifatch is making routers more secure, by blocking outside hacks and attempting to remove any malware it finds.

So it appears there's a vigilante hacker. However, Symantec notes that Wifatch is still being installed without consent. It also contains backdoors that the author could use for malicious purposes, if desired. **–PL**

OCULUS PCs TO FEATURE RADEON GPUs

VR WITHOUT THE MOTION SICKNESS

HEAD OVER TO OCULUS VR'S "Oculus-Ready PCs" page and you'll see three manufacturers listed at the bottom: Alienware, Asus, and Dell. Asus will have the cheapest starting price of the trio at $949, while the other two will sell Oculus-Ready systems for $999 and up.

Dell's been tight-lipped on the specifics, but thanks to an announcement by AMD, we now have a hint of what's to come. The chip designer said it partnered with Oculus and Dell to equip the PC maker's Oculus-Ready line with Radeon GPUs. The VR experience will be backed by AMD's Graphics Core Next architecture and LiquidVR technology, which was introduced back in March as a way to combat motion sickness in VR gaming.

Slated to arrive in Q1 2016, the Oculus Rift is expected to cost more than $350 for the consumer version. **–KP**

MICROSOFT ATTEMPTS TO SOOTHE PRIVACY CONCERNS IN WIN 10

Privacy and Win 10 together?

MICROSOFT'S TERRY MYERSON says that from the very outset, Windows 10 was designed with two straightforward privacy principles in mind. The first is that "Windows 10 collects information so the product will work better for you," and the second is that "you are in control with the ability to determine what information" Microsoft collects.

Expanding on the latter, Myerson says Windows 10 limits data collection to things like anonymous device IDs, types of devices being used, and application crash data. Windows 10 supposedly steers clear of users' personal content and has steps in place to prevent collecting data that can directly identify users.

Myerson's comments aren't likely to sway users who believe Windows 10 is little more than a mass spying platform for Microsoft, but it does show that Microsoft is aware of the negative privacy perception surrounding its OS. **–PL**

Tech Tragedies and Triumphs

A monthly snapshot of what's up and down in tech

TRIUMPHS

ONE BILLION OR BUST
With Windows 10 reaching 110 million devices in just two months, Microsoft may hit its goal of 1 billion installs in two to three years after all.

CARRY-ON COMPUTER
Lian Li created a compact case that, when combined with an optional trolley cart accessory, can be pulled through the airport like a suitcase.

STORAGE WHIPLASH
Samsung's 950 Pro line joins the NVMe M.2 camp, reading and writing at up to 2,500MB/s and 1,500MB/s.

TRAGEDIES

COSMIC BUZZKILL
Edward Snowden says contact with aliens is unlikely as encrypted signals would sound like cosmic microwave background radiation. Drat!

MORE PINK SLIPS
HP plans to slash up to an additional 30,000 jobs on top of 55,000 already planned as it splits into two.

SKYPE GOES SILENT
A Skype bug temporarily broke the service by preventing users from signing in or, if signed in, from making calls or group chatting.

Tom Halfhill

FAST FORWARD

So What if It's Not Pie-in-the-Skylake?

SOME POWER USERS are disappointed that Intel's new Skylake processors aren't crushing the performance of their Haswell predecessors. For typical PC applications, Skylake delivers about 10 percent more throughput at the same clock speed.

That's not a big leap for the high cost of a new processor, motherboard, and the DDR4 memory needed to see those gains. But Skylake is typical of today's processors—it has lots of little improvements that benchmarks don't measure.

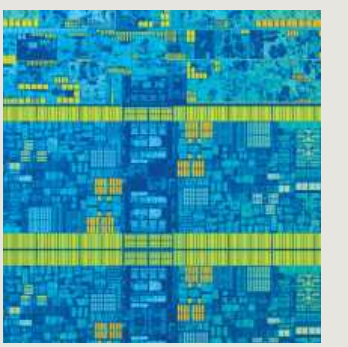
In the first place, 10 percent better performance doesn't stink. It's what we should expect from an improved microarchitecture built in the latest fabrication technology (14nm FinFET). The good old days of big leaps are over. Besides, most people are still using processors based on older technology, such as the 22nm Ivy Bridge or 32nm Sandy Bridge. Intel's CPU performance has more than doubled in the past five years. The PC replacement cycle now averages about seven years, although *Maximum PC* readers are certainly more active than that.

Compared with the Haswell microarchitecture, Skylake can decode more program instructions per clock cycle (five versus four), juggle more instructions while reordering them (224 versus 192), and schedule more instructions for execution (97 versus 60). It can also allocate up to 64 instructions per thread, whereas Haswell could allocate only 56 instructions for both threads. These improvements may be small, but they do add up. Other new features are equally important. By some measures, Skylake's integrated GPU is up to 50 percent faster, reaching one teraflops (one trillion 32-bit floating-point operations per second). That may not matter to avid gamers who scorn integrated graphics in favor of discrete graphics cards, but it competes with entry-level cards and encourages new software to offload tasks to the integrated GPU. Non-gamers will welcome a processor that doesn't need discrete graphics to display some razzle-dazzle.

> The popular languages C and C++ were designed to make it easy for programmers to create bugs and malware. (Not really, but it seems that way.)

Many users (like me) value security and stability over incremental performance. Skylake has goodies for us, too. Its new Software Guard Extensions (SGX) can encrypt a program and its data in a secure section of main memory, which Intel calls an "enclave." New program instructions can transfer control to this code, which can perform vital tasks that must remain secure. Because the enclave is encrypted, malware can't alter the code or read the data without generating errors.

Another feature is Memory Protection Extensions (MPX). The most popular languages for writing commercial software are C and C++, designed to make it easy for programmers to create bugs and malware. (Not really, but it seems that way.) C/C++ programs use lots of pointers: memory locations that point to other memory locations. If a program accidentally or purposefully misuses these pointers, it may crash or gain access to data that should be off limits. MPX sets boundaries that protect the data from buggy or malicious software. It goes beyond the previous XD (eXecute Disable) extension, which prevents malware from executing code in a protected memory region but doesn't prevent it from accessing the data stored there.



What it lacks in speed boosts Skylake makes up for in security.

So Skylake has a little something for everybody, and that's a good thing. Wouldn't you rather have better stability and security than a swifter computer that crashes or steals your identity twice as fast?

Tom Halfhill was formerly a senior editor for *Byte* magazine and is now an analyst for *Microprocessor Report*.

CyberPower recommends Windows.

AMD

Windows 10

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Alex Campbell

OPEN SOURCE

Why You Need OpenPGP

THE BAD SIDE TO ENCRYPTION is that it can seem like a rabbit hole that keeps going down further and further into the obscure realm of advanced mathematics and computer science theory. Choosing an encryption method can be daunting for the newbie.

On the bright side, encryption tools can be fairly easy to use, even if they are a bit inconvenient.

For email and personal communication, there are two main schemes you can use: Open Pretty Good Privacy (OpenPGP) and S/MIME. While there are definitely advantages to using S/MIME, OpenPGP doesn't rely on an X.509 hierarchy for signature validation. (X.509 is the same methodology that OpenSSL/TLS uses for certificate verification.)

To get an idea of how "pretty good" Pretty Good Privacy is, all you have to do is look at a few highlights from history. The author of PGP, Phil Zimmerman, was criminally charged for unauthorized weapons export in 1993 because encryption with more than 40 bits of protection was considered a munition back then. During prosecutions, courts have subpoenaed for keys instead of trying to break the crypto. And famously, OpenPGP was one of the technologies that made Edward Snowden's communications with Glenn Greenwald and Laura Poitras possible. (By the way, if you haven't seen *Citizenfour*, go see it.)

At the end of the day, I think most people should have an OpenPGP keypair made. But if you're like me, you'll rarely use it. To be able to use OpenPGP encryption, the other person you're communicating with must use it as well. That means, the more OpenPGP users you know, the more useful it is.

In its most basic setup, OpenPGP uses a single pair of keys to function: a private key and public key. Public keys are, well, public, while private keys should be closely held secrets. In some people's opinions, private keys and passphrases should be even more secret than your Social Security number.

> In some people's opinions, private keys and passphrases should be more secret than your Social Security number.

GNU Privacy Assistant makes it easy to create OpenPGP keys in Windows.

To encrypt a message or file to Alice, you use Alice's public key. Alice can then only decrypt the message using her private key. If you want to be able to read the message later, you have to encrypt it with your own public key as well.

So, why on earth would you want to use OpenPGP, even if you don't need to hide your communications?

OpenPGP can also let you sign messages using your private key, which can be verified using your public key. This lets you know that a message (or file) came from the person who owns (or has access to) the associated private key. An email signed with OpenPGP can append the signature as a small text attachment (this is called PGP/MIME), or simply add it as inline text at the end of your message. Text or files can be both signed and encrypted, too. Cool, huh?

The fact that you can authenticate messages should, by itself, be a good reason to use OpenPGP. If the recipient doesn't use OpenPGP, the signature can just be ignored. Email could be a little more secure if banks, government agencies, and receipt mailers from places such as Amazon used OpenPGP (or some other cryptographic) signatures. Sure, not everyone uses the technology, but those who do can be more confident that the message comes from the place the From field says it does.

So, how can you get started with OpenPGP? If you're a Linux user, there's a good chance that your distribution comes with GNU's implementation of OpenPGP, called GNU Privacy Guard (GnuPG). Some package managers (e.g. Arch's Pacman program) use OpenPGP public keys to verify the signatures on software packages.

Once OpenPGP is installed on their machine, Linux users just need to run a single command to create a key pair: **gpg --create-key**. Windows users can download GPG4Win from the web (http://gpg4win.org) and use either Kleopatra or GNU Privacy Assistant to create a keypair. Just be sure to use a strong passphrase and a key depth of at least 2,048 bits.

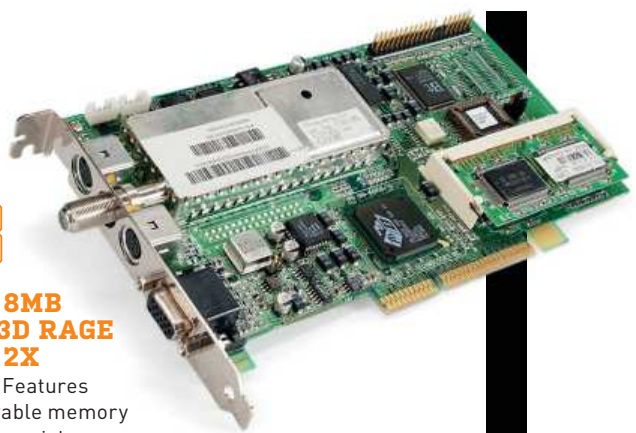
Alex Campbell is a Linux geek who enjoys learning about computer security.

THE LIST

SEVEN OLD EXPANSION CARDS UNEARTHED FROM STORAGE

7 3DFX VOODOO3 2000

(1999) Boasting a whole 16MB of onboard memory, this trusty PCI version could power *Quake III Arena*.



3 AGP 8MB ATI 3D RAGE PRO 2X

(1997) Features removable memory and a coaxial connector. Sweet.

6 NVIDIA GEFORCE2 GTS ES AGP

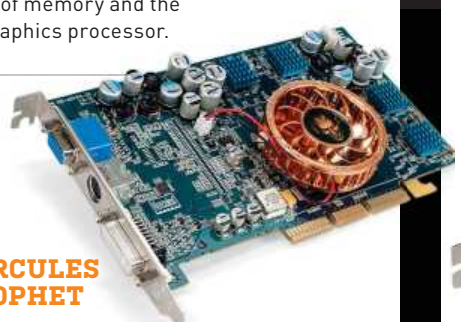
(2000) This natty Nvidia card sports 64MB of memory over the initially-shipped 32MB.

2 AGP 256MB PNY GEFORCE FX 5900 ULTRA

(2003) Check this out—is that a Molex connector?

5 MATROX 576-04 REV.A PCI VIDEO CARD

(1995) A classic. Comprising a whopping 4MB of memory and the IS-Storm R2 graphics processor.

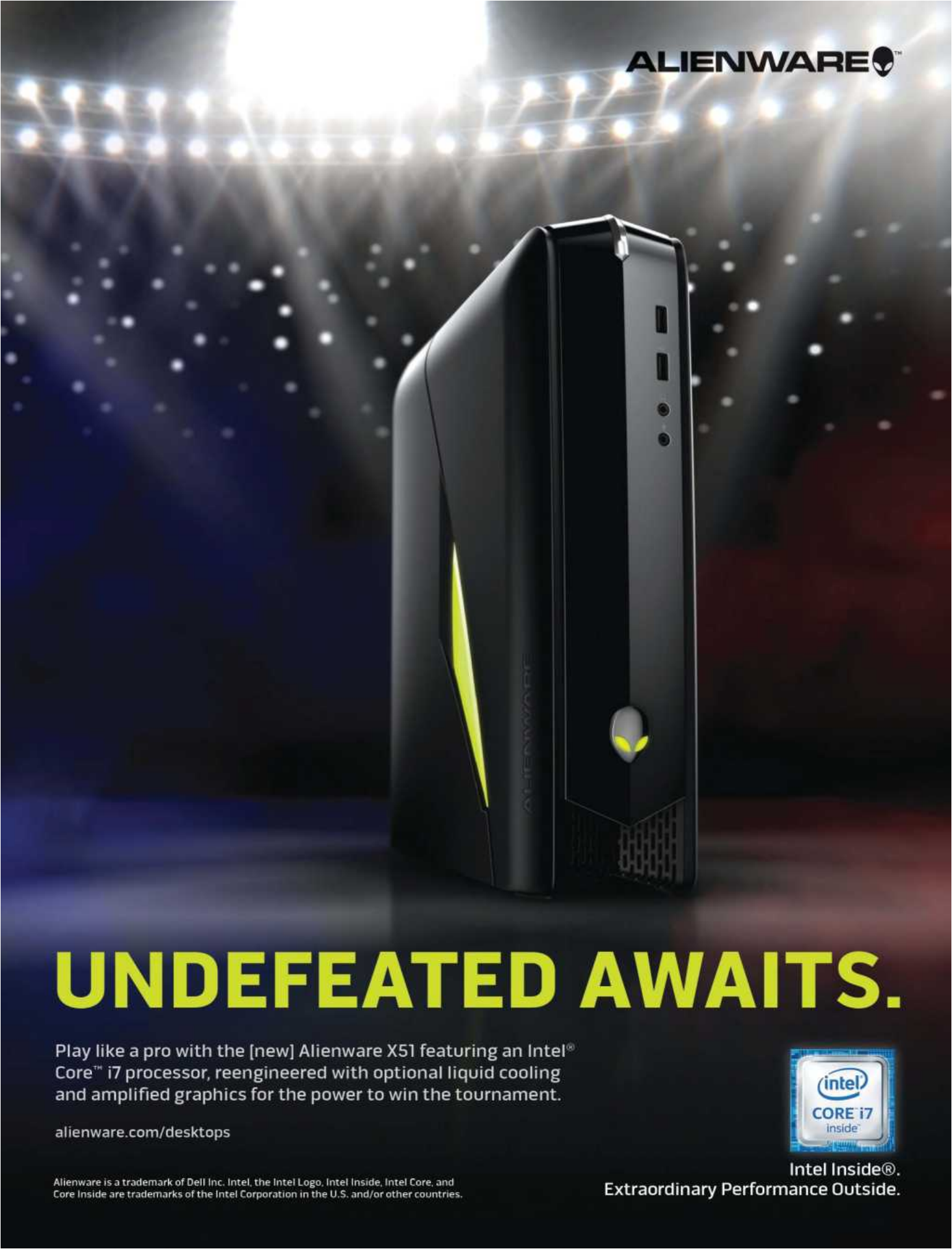


4 128MB HERCULES ATI 3D PROPHET 9700 PRO

(2002) This devilish card came complete with overclocking software.

1 AGP 256MB SAPPHIRE RADEON X800 PRO TOXIC

(2004) Complete with obnoxious orange air cooling.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TALKING

BY ZAC STOREY

Nvidia's console killer

MPC talks to Sridhar Ramaswamy about the Nvidia Shield, what it brings to the living-room marketplace, and if the end of the console is nigh

We've all heard the rumors of gaming directly from the cloud, and with the advantages that cloud storage and processing have brought recently, Nvidia believes it's about time that those whispers became a reality. We spoke with Sridhar Ramaswamy, Nvidia's director of Technical Product Marketing, to see what makes the Shield so special.

"80 percent of the market wants to play games on a big screen without investing in that ecosystem—GeForce Now brings that to them," says Sridhar.

Maximum PC: Can you tell us exactly what we're looking at here with the Nvidia Shield?

Sridhar Ramaswamy: Sure, Shield is the most powerful streaming box in the marketplace. Powered by our Tegra X1 processor, which brings really high-end graphics processing capabilities to the streaming box market, we really designed Shield so that you can enjoy an interesting pool of apps all at 4K 60fps—it brings amazing gaming experiences to the living room. You don't just play your casual Android games, you also play PC and console-quality games you know, like *Contrast, Borderlands Pre Sequel,* and *Half-Life 2.*

In addition to that, we're also bringing out GeForce Now, which is a new way of gaming. It's basically cloud gaming at its best. So you're streaming all these high-end PC games from the cloud, from our GeForce GTX GPUs, into your living room and your Shield. So you get a connected PC gaming experience without spending a lot of money on buying a high-end gaming PC or a console. It's really revolutionizing your living room experience, with 4K, with great apps and a great gaming experience.

MPC: What's the minimum download speed requirements for something like this?

SR: The minimum download speed we recommend for GeForce Now is 10Mbps. So if you have 10Mbps, you get 720p 30fps, but if you want higher frame rates and higher resolutions—for example, 720p 60fps—we recommend 20Mbps, and for 1080p 60fps, we recommend 50Mbps. Although you won't be needing all of that 50—you will probably get a great experience at 25-30Mbps—but if someone else is playing Netflix or downloading stuff in your house, you need to have enough buffer so you can still have that great gaming experience.

MPC: Surely there's going to be a problem with latency? With the games being rendered in the cloud, there must be some lag issues with a product like this?

SR: The latency is actually very good. I have been using GeForce Now for the last three months, and it's perfect for someone like me. I used to be a hardcore PC gamer, but once I had kids, I hardly had time to play on the PC. I get my gaming fix from GeForce Now, and I found that the latency is comparable to most consoles. So what happens is, when you press a button on your controller, that signal goes all the way to our GeForce cloud, gets rendered in the cloud, and gets streamed back to the Shield, and the whole process happens within 150ms, which is comparable to watching it on a console. So it's a very connected experience. You get a great gaming experience—you know, games like *Grid Autosport*

Nvidia's Shield promises to hit 1080p gaming at 60 frames, but how well will it cope outside of Nvidia's testing facilities?

and *Street Fighter* are totally playable and you get a good gaming experience.

MPC: Is this for the PC enthusiast or console gamers?

SR: We are actually targeting this at mainstream gamers, who are just not happy with the casual gaming experience that we have today. Many mainstream gamers are looking for something more, and, you know, mobile gaming basically brought gaming to the masses; in a sense, mobile gaming made it easy for the masses to game. But now that they are used to the casual games like *Angry Birds,* they want something more. They see their gamer friends gaming on consoles and PCs, but they're still kinda hesitant to invest in a high-end gaming PC, or go into the full console experience, so with GeForce Now, the key convenience you get is that it's instant gameplay—you don't have to own an expensive rig, you just pay a monthly subscription fee, and you get to play all 50 games instantly in less than 30 seconds. Even some of the latest games like *Witcher 3* and *Shadow of Mordor.* You can just purchase the game, and start playing the game in under 30 seconds, while your friends are sitting and downloading gigabytes of data for hours at a time.

MPC: Can you tell us a little bit more about the design process behind the Shield?

SR: Sure. It all started with the Tegra X1. It's a really powerful processor. It has eight CPU cores and 256 GPU cores, and the GPU is basically based on our Maxwell GPU architecture, which powers some of our highest-end gaming PCs. We took that chip and we looked at what the competitive landscape is. Today we're living in a smart TV revolution, and it's fundamentally changing the way we interact with our TV. With Android and iOS coming into the living room, with the apps and the channel ecosystem, everything is in the right place for us to bring a device like Shield to the market, so that you can enjoy all those apps in 4K. You can enjoy the best gaming experiences. You'll get to play games straight from the cloud. The Shield is also a media enthusiast's dream, because it supports pretty much all the audio and video codecs. If you have gigabytes of downloaded movies and music in your NAS server, you can stream them at full resolution, original frame rate, through your Shield and enjoy it on your big-screen 4K TV.

MPC: Where is the future of gaming going? Do you see this as the end of the desktop?

SR: Not really—there's always going to be a set of gamers who love playing the latest and greatest games at the best resolution and the best graphics quality. And that segment is thriving, and in fact growing. The number of PC gamers is growing worldwide. So that segment is continuing to grow, and console gamers are going to continue to game on consoles. But the masses—like 80 percent of the market today, who are gaming on Android devices such as tablets and phones—want something more, want to play their games on a big screen, want to get a console or a PC-like experience, without investing in that ecosystem. GeForce Now brings that to them.

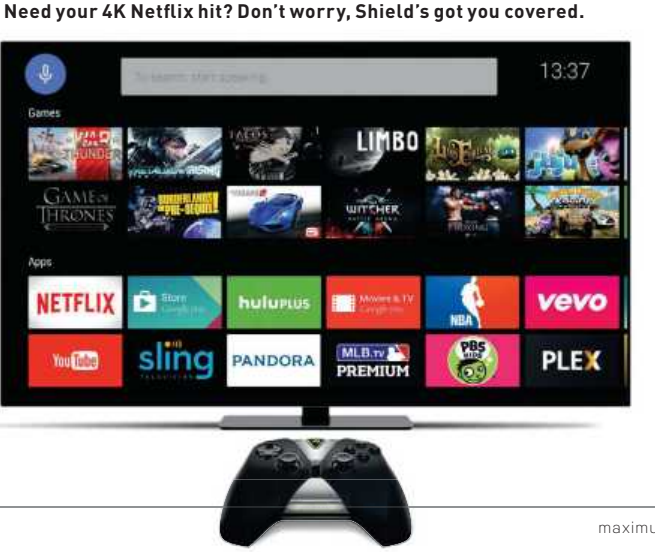
MPC: What about Steam OS? Is that going to be a problem for Nvidia?

SR: Anything that helps gaming, I think, is good. I mean Steam—we are partners with Steam, we work closely with them, and we're glad that they're also bringing their solution to the market. GeForce Now is another solution in that market, and we are approaching it in a different way, and we're really excited for the future.

MPC: What about VR? Are there any plans to introduce that at all?

SR: We're heavily invested in VR. I would say that we are the technology leaders in VR, and we work closely with Oculus and all the other VR players in the market. I mean, GeForce GPUs are powering some of the most advanced VR systems. So VR is growing, but for Shield, for now, I think GeForce Now is important, Android gaming is important, and 4K is obviously a big thing, so we're really excited about what Shield offers.

Need your 4K Netflix hit? Don't worry, Shield's got you covered.



DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Upgrade Issues
> Intel Or AMD?
> Three-Way Displays

Time For An Upgrade?

Doctor, I have an older CyberPowerPC Gamer Xtreme GXi240 with an Intel Core i7. Currently, it includes an AMD Radeon HD 6950 video card with 2GB of RAM and 12GB of system memory. What would be a good graphics upgrade for it?

—William R Miller II

THE DOCTOR RESPONDS: All of the links the Doc found for your system reference a Core i7-960, William. That's a quad-core Westmere-based CPU with a 3.2GHz base clock rate. While it's no slouch, the 960 does predate Intel's Sandy Bridge architecture, which is about the oldest platform the Doc would upgrade.

If you're serious about dropping a new card on to the X58 chipset's second-gen PCIe links, a GeForce GTX 960 or Radeon R9 380 for less than $200 should still be playable at 1920x1080. Be aware, though, that your aging processor will increasingly get in the way of optimal performance.

Get The Most From M.2

Hi Doc. I'm going to build my son a gaming PC as soon as he achieves the weight challenge I set for him. He's getting close, so I need to put together a list of parts now (Corsair Graphite 780T case; EVGA SuperNOVA P2 1,200W PSU; X99-PRO/USB 3.1 or Rampage V Extreme motherboard; Intel Core i7-5930K CPU; Corsair Hydro H110 cooler; EVGA GeForce GTX 980 Ti Hybrid 6GB GPU; 4x 4GB Corsair Vengeance LPX DDR4-3000 RAM; 2x 500GB Samsung 850 Pro SSD and/or M.2 SSD; Windows 7 Ultimate 64-bit or Windows 10). I haven't pieced a system together since 1999, and after doing some homework, I realized that there's more reading I need to do in order to catch up with the latest technologies.

I would like to take advantage of an M.2 SSD, installing my operating system there and booting from it. There are some instructions I've found on gaming forums, but I was hoping you could give me a better list to improve my chance of success. I'm also aware that, without an optical drive, I'll need to install the OS using USB. Could you help me prepare a thumb drive for the task, too? Is booting from M.2 really a better way to go or should I leave the slot empty and stick with SATA? **—Joey L**

Expect M.2 SSDs to get more popular, in light of their 1GB/s-plus sequential throughput, blowing past the limits of SATA's 6Gbps.

THE DOCTOR RESPONDS: Congratulations to your son, Joey. The M.2 connector will accept SATA 6Gb/s and PCIe-based drives, depending on the specific implementation. Asus's X99-PRO/USB 3.1 motherboard, as an example, only takes the PCIe-based variety. Its slots are also four lanes wide (indicated by the M key), giving you up to 20Gb/s of throughput. So be sure to pick an SSD matching that description, such as Samsung's XP941, which shows up in the board's compatibility list.

Next, you have to decide between Windows 7 and Windows 10. If you choose the former, you may need to enable the CSM (Compatibility Support Module) in the X99-PRO's firmware. You'll find that under the "Boot" submenu after entering Asus's UEFI. Aside from broader compatibility with PCIe-based storage devices, Windows 10 is also easier to install from a USB thumb drive. Simply jump to www.microsoft.com/en-us/software-download/windows10 and run the media creation tool.

Why go through the trouble of figuring M.2 out at all? In a word, performance. Most of the four-lane drives you'd drop into Asus's board are rated for sequential reads and writes in excess of 1GB/s. Compare that to the fastest SATA 6Gbps-attached SSDs, which are held back by the interface to a max just over 500MB/s.

Alternative Solution

Doctor, a long time ago, there were programs that didn't work correctly on AMD processors. Is this the case in today's world? I only tried AMD one time and ran into issues. But I am tired of paying out the nose for Intel processors. I'm wondering because AMD's CPUs are less expensive. **—Michael Filyaw**

THE DOCTOR RESPONDS: Intel and AMD host processors share a common instruction set, so you should see no difference in application support between them. The issues you refer

↘ submit your questions to: doctor@maximumpc.com

to might have been related to platform drivers. The Doc does remember various times when third-party chipsets from AMD, Nvidia, SiS, and VIA caused headaches. But Intel wasn't immune to problematic hardware either.

The short of it is this: Modern CPUs from both manufacturers enjoy broad compatibility. And you're right in that AMD's portfolio is predominantly less expensive. However, the FX CPUs and A-series APUs don't do as much work per clock cycle. In other words, at any given frequency and core count, expect them to be slower. Enthusiasts looking to get the most from an AMD processor should pick a model with more cores than Intel's equivalent at the same price. There's a good chance you'll see better performance in threaded apps and heavy multitasking.

Gaming At QHD

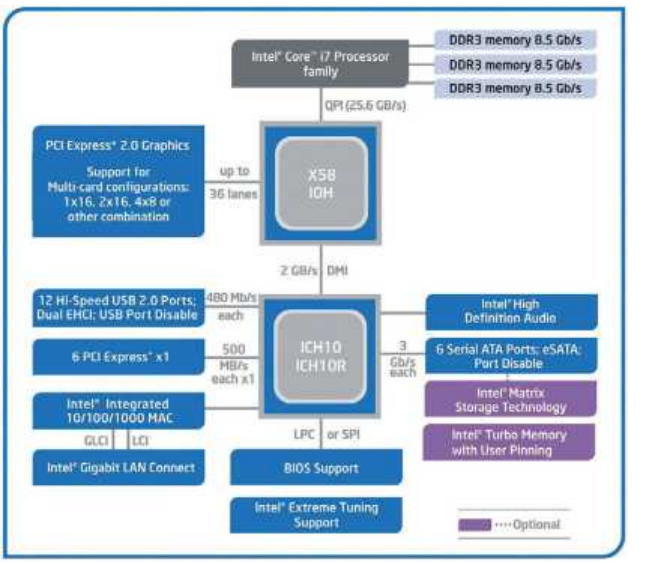
Hi Doc, I have a PC with Intel's Core i7-5820K, 8GB RAM, and a GeForce GTX 970. I want to buy a 27-inch Acer XB270HU G-Sync-capable monitor, but will my system play the latest games smoothly at their highest settings at 2560x1440?

—Bob Ingber

THE DOCTOR RESPONDS: Expect average frame rates in the most graphics-bound titles to fall below 60, Bob. Fortunately, that's where you'll notice G-Sync's variable refresh capability improving your experience—to a point. Should the minimum frame rates become unbearable, consider adding a second 970 in SLI, or dial down your detail settings.

If One SSD Is Good Pt 2

Dear Doctor, I read your reply to "If one SSD is good..." a couple of months back. I noticed that the Doctor put four Crucial M4s in RAID 0 and wondered why you didn't put them in RAID 10 (RAID 1+0) instead? I use quad Seagate 3TB drives in RAID 10 to get the sequential performance benefit of striping and the data security of RAID 1 in my main production rig. RAID 10 has saved my data



Older X58-based platforms have PCI Express controllers in their I/O hubs. Intel architectures that followed integrated this functionality in the CPU dies, improving performance.

when one or even two drives failed, and it's amazing to watch the array rebuild after replacing a failed disk.

Is the sequential performance difference between RAID 0 and 10 such that you'd choose to forgo the extra data security you could get for free? I read that RAID 10 may cause some performance degradation due to parity calculations, but haven't noticed this on my six-core Core i7-3930K at 4.6GHz, even when working with massive multi-gigapixel pano images.

—Mike Iantosca

THE DOCTOR RESPONDS: In the Doc's specific application—capturing uncompressed video at 2560x1440—RAID 0 is necessary. While the loss of one drive takes out the entire array, files are quickly analyzed and deleted. Meanwhile, RAID 0 confers the dual benefit of multiplying capacity and write performance.

RAID 10, a striped set of mirrored drives, would be safer, but the Doc would also give up two SSDs' worth of space and enough throughput to cause dropped/skipped frames in the recordings. It's simply not an option.

The good news in your case, Mike, is that RAID 10 sounds like a reasonable balance of speed and resilience. Processing overhead won't be an issue for you, since there are no parity calculations involved in RAID 10 (perhaps you're thinking of RAID 5 or 6, which do employ distributed parity to protect against drive failures).

Bottlenecks

Dear Doc, A few years ago, I won a PC at CES that included an AMD FX-6100, 16GB of RAM, an MSI 990FXA-GD80 motherboard, and a Diamond Multimedia Radeon HD 7970 video card. I added a Samsung SSD and it now has Windows 10.

My machine was running well until a month or so ago when its graphics card died. After much hemming and hawing, I made the decision to buy Gigabyte's GeForce GTX 970 as a replacement for the 7970. I know the 970 is a respectable upgrade, but now I'm wondering when my CPU becomes a bottleneck. What is meant by bottlenecking, and how would I identify it? Is AMD's FX-6100 too old? If so, do I have any good upgrade options on this platform? I am a gamer, so performance does matter to me.

—Brad Pool

THE DOCTOR RESPONDS: Great question, Brad. It's relatively easy to test for and identify bottlenecks in a lab full of components to swap in and out, but they're more difficult to troubleshoot in the wild.

Based on the Doc's experience, though, there are a couple of scenarios where you'll notice an FX-6100 limiting the performance of a GeForce GTX 970. If you're gaming at 1920x1080 or a resolution lower than that, Nvidia's GPU won't always be fully utilized, shifting the bottleneck to your CPU. The FX-6100 will also slow you down in games heavily reliant on host processing, such as *Battlefield 4's* multiplayer component.

Overclocking the FX won't completely neutralize an imbalance, but if you see average frame rates level off where you'd expect better scaling, try bumping up the CPU's multiplier a couple of notches (provided your cooling setup allows for it). An unlocked ratio is one of the reasons to own an FX processor, after all.

Multi-Monitors

Long-time reader here, Doc—I respect your opinions. I have a laptop application that I want to run on three screens using a Matrox TripleHead2Go device. I know it would work great on a desktop with ample hardware to drive three Full HD displays. But given that I don't need to run at 1920x1080, are there any laptops that would work?

—Theodore Rosenthal

THE DOCTOR RESPONDS: Matrox's system requirements are fairly conservative, Ted. The company sells three versions of its TripleHead2Go, capable of taking dual-link DVI, VGA, and DisplayPort inputs, and outputting the same signals. You need a powered USB port and relatively modern GPU, too.

There is a compatibility wizard to check a specific configuration (www.matrox.com/graphics/en/support/compatibility/gxm/), but Matrox needs to update it. The Doc spent some time looking, though, and even a two-generation-old Intel graphics engine can do 3840x1024.

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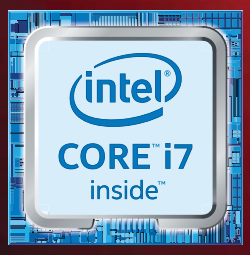

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- Hardware Raid 0,1 Function capable
- Full sized Keyboard with color LED backlight
- Killer™ DoubleShot™ Pro (Killer E2400 LAN + Killer Dual Band Wireless-AC 1525) with Smart Teaming
- USB 3.1 / Thunderbolt Gen3 Combo Port
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Built-in Onkyo Hi-Fi speakers and a subwoofer
- Sound Blaster® X-Fi™ MB5 Sound System

NP9758 Notebook
$1,999

FREE UPS GROUND SHIPPING*

- 6th Generation Intel® Core™ i7-6700 Processor (8MB Smart Cache, 3.40GHz)
- Windows® 10 Home 64-bit Edition
- 15.6" Full HD IPS Matte Display (1920x1080) with NVIDIA® G-SYNC Technology
- Opt. 15.6" 4K QFHD Matte Display with G-SYNC
- 6GB DDR5 NVIDIA® GeForce™ GTX 970M GPU
- 8GB DDR4-2133MHz Memory
- 250GB Samsung 850 EVO M.2 SSD + 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives or 2 M.2 PCIe SSD Drives capable
- Hardware Raid 0,1 Function capable
- Full sized Keyboard with color LED backlight
- Killer™ DoubleShot™ Pro (Killer E2400 LAN + Killer Dual Band Wireless-AC 1525) with Smart Teaming
- USB 3.1 / Thunderbolt Gen3 Combo Port
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Built-in Onkyo Hi-Fi speakers
- Sound Blaster® X-Fi™ MB5 Sound System

NP8658-S Notebook
$1,899

After $190 Instant Savings

- 6th Generation Intel® Core™ i7-6700HQ Processor (6MB Smart Cache, 2.60GHz)
- Opt. Unlocked Intel® Core™ i7-6820HK Processor
- Windows® 10 Home 64-bit Edition
- 15.6" Full HD IPS Matte Display (1920x1080) with NVIDIA® G-SYNC Technology
- Opt. 15.6" 4K QFHD Matte Display with G-SYNC
- 30 days No Dead Pixel Guaranteed Insurance
- 8GB DDR5 NVIDIA® GeForce™ GTX 980M GPU
- 16GB Dual Channel DDR4-2133MHz Memory
- 250GB Samsung 850 EVO M.2 SSD + 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives or 1 M.2 PCIe SSD Drive capable
- Hardware Raid 0,1 Function capable with SATA Interface
- Full sized Keyboard with white-LED backlight
- Intel® Dual Band Wireless-AC 8260 + Bluetooth
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Built-in Onkyo speakers
- Sound Blaster® X-Fi™ MB5 Sound System
- Slim design with only 28.8mm /1.13 inch thin

NP8678 Notebook
$1,799

FREE UPS GROUND SHIPPING*

- 6th Generation Intel® Core™ i7-6700HQ Processor (6MB Smart Cache, 2.60GHz)
- Opt. Unlocked Intel® Core™ i7-6820HK Processor
- Windows® 10 Home 64-bit Edition
- 17.3" Full HD IPS Matte Display (1920x1080) with NVIDIA® G-SYNC Technology
- 8GB DDR5 NVIDIA® GeForce™ GTX 980M GPU
- 8GB DDR4-2133MHz Memory
- 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives Capable with Raid 0, 1 Function
- Full sized Keyboard with white-LED backlight
- Intel® Dual Band Wireless-AC 8260 + Bluetooth
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Built-in Onkyo speakers and a subwoofer
- Sound Blaster® X-Fi™ MB5 Sound System
- Slim design with only 29.9mm /1.18 inch thin

NP8677-S Notebook
$1,599

After $190 Instant Savings

- 6th Generation Intel® Core™ i7-6700HQ Processor (6MB Smart Cache, 2.60GHz)
- Opt. Unlocked Intel® Core™ i7-6820HK Processor
- Windows® 10 Home 64-bit Edition
- 17.3" Full HD IPS Matte Display (1920x1080) with NVIDIA® G-SYNC Technology
- 30 days No Dead Pixel Guaranteed Insurance
- 3GB DDR5 NVIDIA® GeForce™ GTX 970M GPU
- 16GB Dual Channel DDR4-2133MHz Memory
- 250GB Samsung 850 EVO M.2 SSD + 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives Capable with Raid 0, 1 Function
- Full sized Keyboard with white-LED backlight
- Killer™ Dual Band Wireless-AC 1535 + Bluetooth
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Built-in Onkyo speakers and a sub-woofer
- Sound Blaster® X-Fi™ MB5 Sound System
- Slim design with only 29.9mm /1.18 inch thin

NP8657-S Notebook
$1,499

After $190 Instant Savings

- 6th Generation Intel® Core™ i7-6700HQ Processor (6MB Smart Cache, 2.60GHz)
- Opt. Unlocked Intel® Core™ i7-6820HK Processor
- Windows® 10 Home 64-bit Edition
- 15.6" Full HD Matte Display (1920x1080) (NVIDIA® G-SYNC Technology optional)
- 30 days No Dead Pixel Guaranteed Insurance
- 3GB DDR5 NVIDIA® GeForce™ GTX 970M GPU
- 16GB Dual Channel DDR4-2133MHz Memory
- 250GB Samsung 850 EVO M.2 SSD + 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives Capable with Raid 0,1 Function
- Full sized Keyboard with white-LED backlight
- Intel® Dual Band Wireless-AC 8260 + Bluetooth
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Built-in Onkyo speakers
- Sound Blaster® X-Fi™ MB5 Sound System
- Slim design with only 25mm /0.98 inch thin

NP7255 Notebook
$1,199

FREE UPS GROUND SHIPPING*

- 6th Generation Intel® Core™ i7-6700HQ Processor (6MB Smart Cache, 2.60GHz)
- Windows® 10 Home 64-bit Edition
- 15.6" Full HD Matte Display (1920x1080)
- Also available in 17.3" Full HD Matte Display with model NP7270
- 2GB DDR5 NVIDIA® GeForce™ GTX 960M GPU with Optimus™ Technology
- 16GB Dual Channel DDR3-1600MHz Memory
- 250GB Samsung 850 EVO M.2 SSD + 1TB 7200RPM Hard Drive
- 8X DVD±R/RW/4X +DL Super Multi Drive
- 1 Hard Drive + 1 M.2 SATA SSD Drive or M.2 PCIe SSD Drive capable
- Full sized Keyboard with white-LED backlight
- Intel® Dual Band Wireless-AC 3165 + Bluetooth
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Built-in Onkyo speakers

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Network Attached Storage

NAS devices aren't dumb boxes full of hard drives—they're smart servers that can handle data in game-changing ways. Let's take a look *By Alan Dexter and Simon Crisp*

Storage isn't the sexiest topic, we admit, but that doesn't stop it being important. After all, you need somewhere to put all those lovely programs you use on a daily basis. You need space for all those videos, photos, games, and documents you've spent so long working on. So while graphics cards and processors get most of the tech love, there's something fundamental about storage that ensures it's a major part of our computing lives, even if it doesn't tend to set the heart aflutter.

Of course, storage solutions have changed quite a bit recently, thanks to the emergence of the SSD. Storage is no longer something that is measured purely in capacity. Performance is now also a factor. On the flip side, reliability has reared its head as well—early adopters of SSDs will be painfully aware of the downsides of the first batch of drives. This, coupled with the fact that everyone could do more to ensure they have a safe backup, brings us neatly on to the topic of this month's round-up: NAS devices.

Network attached storage used to be the exclusive domain of business types, but as the data needs of all of us have increased, so the NAS has migrated into the home. The good news is that the smarter side of these devices has made the transition, too—these aren't simply dumb devices that look after your files 24/7; they can act as media streamers and torrent servers, and offer up your files for external access as well.

We've looked at high-end NAS devices before, so for this group test we've gone back to the basics—focusing on more affordable, consumer-grade NAS devices. These are the kind of boxes you should look at if you haven't already got a NAS. They're affordable, capable, and expandable. Note that if your data is really important—if it's your livelihood, say—we recommend going up a level in both performance and redundancy, to make sure that your data is indeed safe and secure.

Whatever sort of NAS you go for, let's just reiterate that you need to have a proper backup scheme in place. Having a NAS gives you options, but it isn't the answer in and of itself. A NAS can act as a backup target, but ideally it should be seen as a device that enables you to organise your data. See it as a centralized storage space. A space that is easy to access from any of the machines on your network. Importantly, this is a space that is easy to back up as well. So make sure you do. And so, it's time to look at the state of the current entry-level NAS, see what it offers, and which device is right for you....


ShareCenter
Synology
DS215+
QNAP
STATUS
LAN
USB
HDD1
HDD2
asustor

More ports than you can shake a stick at.

ASUSTOR AS5002T

Meaty two-bay NAS for home or office

ASUSTOR HAS A NUMBER of two-bay NAS units under various guises in its lineup. This model, the AS5002T, sits very near the top of the tree when it comes to both performance and feature set, and although it's aimed at the home/power user, it wouldn't be out of place in a small office.

It certainly doesn't lack for power, as at its heart lies an Intel 2.41GHz (2.58GHz Burst) dual-core Celeron J1800 backed by 1GB of DDR3L memory. There are two easily accessed SO-DIMM slots, allowing the memory to be expanded to 8GB if needed. Straight out of the box, the performance is pretty impressive, with the possible exception of its 4K read performance; however, the 4K write performance is strong in both RAID 0 and RAID 1.

The two drive trays support both 3.5-inch and 2.5-inch drives (including SSDs—ADM 2.4 onward supports the SSD Trim command), although, unfortunately, you'll need a screwdriver to fix them in place. By using 2.4 and above versions of the ADM OS, drives up to 8TB are also supported, making for some hefty storage options.

If you are used to looking at the rear panel of a NAS box and seeing nothing but an Ethernet port, and maybe a USB port, the rear of the AS5002T will certainly get your attention. It's loaded with ports to connect it with any other devices that might be available. There are two Ethernet ports, which support link aggregation for faster transfer speeds and better load balancing, and a couple of USB 3.0 ports—there's a third in the front bezel. The front one can be used for one-touch backups to an external drive. The rest of the ports comprise a pair each of USB 2.0 and eSATA ports, a single HDMI 1.4a output, and last but not least, an S/PDIF port. That's plenty of options.

Once the drives are installed, it takes very little time to set up the unit and load the ADM (Asustor Data Master) software. ADM (at the time of review, it was version 2.4.2) is one of the best GUIs out there, being both graphically rich and easy to navigate—which is good, as there's a lot going on.

OUT AND ABOUT

Need to hook up to the AS5002T on the move? Not a problem. Asustor's AiMaster is its NAS management app, which enables control of the NAS from a mobile device. The unit can be set up, managed, backups performed, files accessed, and even surveillance feeds monitored, all from your mobile device. The app also sends real-time event messages, should problems occur with the NAS.

Remember that HDMI port? Well, by connecting to a TV and using the Kodi 14.2 XBMC home theater software, the AS5002T turns into a media center, supporting up to 1080p output. One nice feature is the ability to preview video files when browsing content with the ADM File Explorer.

As well as all those ports to use to back up data on an external device, the AS5002T also supports the Rsync (Remote Sync) function. This means data can be programmed to automatically back up to another Asustor NAS, or indeed any other Rsync supporting NAS on the network. And with over 100 apps in Asustor's App Central, covering pretty much everything from backups to web hosting, you can customize the AS5002T to your own needs.

VERDICT
9
KICK ASS!

Asustor AS5002T

+ **MEATY** Performance; feature set; ADM OS.

− **VEG** Drive bays not tool-free.

$298, www.asustor.com

SPECIFICATIONS

CPU	Intel Celeron
Cores	2
Speed	2.41GHz
Installed memory	1GB DDR3L
Memory upgradable	Up to 8GB
OS	ADM 2.4.2
USB ports	3x USB 3.0, 2x USB 2.0
HDMI ports	1x 1.4a
Ethernet ports	2x Gigabit
Others	1x S/PDIF, 2x eSATA
Warranty	2 years

It's a stylish-looking NAS with a minimalist design.

D-LINK DNS-327L SHARECENTER+

Surprisingly feature-rich software

D-LINK'S DNS-327L SHARECENTER+ is a no-nonsense two-bay NAS. Indeed, at first glance it appears to be incredibly basic and devoid of features. While that's true of the hardware—there's only a single Ethernet port and just one USB 3.0 port on the rear—the software more than makes up for it. It also looks quite stylish compared to most other NAS boxes. The build quality isn't as good as the rest of the units here, though.

The first thing to notice about the DNS-327L, is the lack of drive bay doors. That's because the drives are loaded from the top. There are no bays or trays, as the drives are just dropped into place. A couple of plastic straps have to be screwed in beforehand, to aid getting the drives back out again. Hard drives up to 6TB are supported—or rather, 6TB drives are the largest capacity listed on the DNS-327L's compatibility list.

Installing the ShareCenter OS can be done via the provided CD or via a web browser, and the process is quick and trouble-free, via a step-by-step wizard. The simple, three-tabbed interface (Home, Applications, and Management) may not be as advanced as some of its competitors, but it's easy and quick to navigate around accounts and their privileges.

UPnP (which is DLNA compliant) and iTunes media servers, along with a BitTorrent server, combine with the neat inclusion of MySurveillance to make for a versatile device. As the name suggests, MySurveillance is a package that enables the DNS-327L to act as the heart of a security center, albeit with support for only four cameras (D-Link Cloud Cameras). Even so, it enables real-time monitoring, recording, and playback, and supports motion detection and scheduled recording. A neat addition to a capable package.

BACKUP BEAUTY

The mydlink Access NAS app enables you to access the NAS from any location using a mobile device to download and upload photos, movies, and music files, as well as backing them up. speaking of backups, the DNS-327L supports local and remote backup, auto backups to a USB storage device, and it supports Time Machine and Amazon S3.

Compared to the vast library of apps that competitors such as Asustor offer, the optional download list for the DNS-327L looks pitifully short, but there are some useful tools. Examples are phpMyAdmin, aMule (P2P file sharing that works with Edonkey), and Transmission, which looks after BitTorrent downloads. Photo Center enables you to share photos over the web, while AjaXplorer does the same for files, as well as supporting video/audio streaming. For website creation, there is Joomla, while Blog is basically just WordPress. D-Link Vault (powered by ElephantDrive) adds another backup tool, which enables automated remote backups of shares or other folders to a secure cloud via the NAS.

With the slowest processor and least amount of memory amongst the units featured here, you might expect to see the DNS-327L fall behind its competitors when it comes to how it performs. For the most part, that's true, but its read performance under the ATTO benchmark sees it almost keep pace with all the other units tested.

VERDICT **6**

D-Link DNS-327L ShareCenter+

STYLE Quiet operation; good software feature set.

VILE Lacks performance against others around this price point.

$259, www.dlink.com

SPECIFICATIONS

CPU	Marvell ARM 88F6707
Cores	1
Speed	1.2GHz
Installed memory	512MB
Memory upgradable	No
OS	ShareCenter 1.0.1
USB ports	1x USB 3.0
HDMI ports	None
Ethernet ports	1x Gigabit
Others	None
Warranty	2 years

If nothing else, it looks the part.

NETGEAR READYNAS RN202

Does away with EX4 in favor of Btrfs

NETGEAR'S READYNAS RN202 is a more powerful successor to the company's popular ReadyNAS RN102. From the outside, it's identical to its predecessor. All the changes are to be found inside, with a more powerful CPU and a lot more memory. The RN202 also has a second Ethernet port supporting link aggregation, and all three USB ports have been uprated to USB 3.0. The new unit also supports 6TB drives, instead of the 4TB limit of the RN102.

At the heart of the RN202 is a dual-core 1.4GHz Cortex A15 processor, backed by 2GB of DDR3 memory. Should you feel that's not enough, tough luck—the four memory chips are soldered directly on to the motherboard.

The drive bays have a novel tool-free mechanism to hold the drives. A catch on the front of the bay releases the inner drive caddy, so it can be pulled out to mount the drives. This caddy is made of plastic, the two side rails being pulled apart to mount the drive. The drive itself is held in place by tiny plastic pins, and although it seems flimsy, it works well. The bays support 2.5-inch drives as well, but these need fixing in place with screws.

Unlike all the other NAS units in this roundup, the RN202 doesn't use the EX4 file system, but instead it uses the latest Btrfs system. Btrfs (B-tree file system) is a copy-on-write file system for Linux that has been around since 2007, and it's been slowly developing ever since. Btrfs offers better data recovery from crashes and better data security, because of the way it writes the data. With traditional file systems, if data is overwritten, the new data is written over the data it's replacing, destroying it. Btrfs works differently—the new data is written to a free space on the drive, keeping the old data in place, and only then does the files' metadata change to point to the new data.

IT'S A RAID

Setting up the RN202 can be done via a web browser with ReadyCLOUD or offline by using Netgear's RAIDar utility. By default, drives are set up using X-RAID, which allows for automatic volume expansion. Choosing Flex-RAID allows manual configuration of traditional RAID arrays—RAID 0 and 1.

The RN202 uses Netgear's ReadyNAS OS 6 (the latest version being 6.3.5), which is an easy-to-use UI. While it doesn't have the immediate impact of, say, Asustor's ADM or Synology's DSM icon-heavy UIs, everything is easy to find from the admin page, thanks to the top navigation bar. Once inside the various sections, there are a lot more detailed settings that can be tinkered with, but everything is laid out in such an uncluttered way that changes can be made quickly and easily. To help the wary, some features even have explanations as to what they are for.

To enhance its business credentials, there's a lot of data protection provided with the RN202. Thanks to Btrfs support of snapshot technology, data can be continuously monitored with point-in-time recovery, should anything nasty happen. Unlike many of its competitors that rely on a third-party app, the RN202 comes with a real-time antivirus scanner too (it has to be enabled), and it also has bitrot protection to protect against random data bits switching from 1 to 0, or the other way around.

VERDICT **7**

Netgear ReadyNAS RN202

READY Good data protection.

UNSTEADY No HDMI or audio ports; memory not upgradable.

$299, www.netgear.com

SPECIFICATIONS

CPU	Annapurna Labs Cortex A15
Cores	2
Speed	1.4GHz
Installed memory	2GB DDR3
Memory upgradable	No
OS	ReadyNAS OS 6.3.5
USB ports	3x USB 3.0 (2 rear, 1 front)
HDMI ports	None
Ethernet ports	2x Gigabit
Others	1x eSATA
Warranty	3 years

A smart NAS for the home or office.

QNAP TS-231+

Feature-rich and easy-to-use OS

QNAP'S TS-231+ is aimed at the SOHO market and is an upgraded version of the company's TS-231 two-bay NAS. This device has a faster processor, twice the memory, and SSD cache support, which is something of a surprise in a NAS in this segment. It looks identical to the TS-231, with the same dual Ethernet LAN ports (which support link aggregation) and three USB 3.0 ports, but surprisingly, the TS-231+ does away with the eSATA port found on the TS-231.

The CPU is an Annapurna Labs Cortex A15 dual-core chip, with a clock speed of 1.4GHz—200MHz faster than the A9 in the TS-231. This is backed by 1GB of DDR3 RAM, and again that's your lot, as the memory is soldered on to the mainboard. Performance is good, with strong read/write figures in the ATTO benchmarks, though it's a bit slow reading 4K files, as shown by the CrystalDiskMark scores. However, its write performance dealing with these small files is strong in both RAID arrays.

This is another front-loading NAS. The drive doors can't be locked, though, and the hot-swappable drive trays are not tool-free, needing screws to fix in the 3.5-inch or 2.5-inch drives it supports (including SSDs). The unit supports up to 8TB drives, and a list of compatible drives is on the QNAP website. The front USB 3.0 port has a one-touch copy button, enabling everything on the plugged-in drive to be copied to the NAS automatically, without powering up a PC.

If there's one thing that all the NAS units in this roundup share, it's ease of set-up, and the TS-231+ doesn't spoil that impression, as it takes hardly any time to get up and running, and QNAP's QTS (v4.2) OS is another impressive icon-rich UI.

FEATURE CREATURE

It not only looks good, it's got some really useful features built in as well. Storage Manager is a powerful tool for volume management, offering storage pooling using multiple RAID groups, thin provisioning including reclamation of any free space, iSCSI, and snapshot support to provide data protection. For further data protection, volumes and folders can be encrypted, and the TS-231+ supports AES-256 encryption of external drives. Also provided is the ClamAV antivirus toolkit.

File Station is a powerful file management tool that supports CIFS, FTP, and WebDAV. Once the Connect to Cloud Drive app has been installed, there is a choice of six cloud-based storage services—Google Drive, Dropbox, Microsoft's OneDrive, Box, Amazon Cloud Drive, and Yandex Disk. File Station also supports smart zonal streaming to a DLNA compatible TV, media player, Apple TV, or Chromecast.

For backing up, there's a comprehensive list of local and remote options, plus a large number of cloud options. Folders can be synchronized between the TS-231+ and the cloud via Microsoft OneDrive for Business, Microsoft Office for Dropbox, Amazon Cloud, and Google Drive for Work. Download Station has a built-in BitTorrent search engine, and any downloads continue to completion if the computer is shut down.

To customize your TS-231+, there is a whole host of downloadable apps available. The list is long enough to give the Asustor download store a run for its money, and there aren't many that can do that.

VERDICT **7**

QNAP TS-231+

QNICE Very feature-rich OS.

QNASTY Memory can't be upgraded.

$285, www.qnap.com

SPECIFICATIONS

CPU	Annapurna Labs Cortex A15
Cores	2
Speed	1.4GHz
Installed memory	1GB DDR3
Memory upgradable	No
OS	QTS 4.2
USB ports	3x USB 3.0
HDMI ports	None
Ethernet ports	2x Gigabit
Others	None
Warranty	2 years

Uses Synology's award-winning DSM OS.

SYNOLOGY DISKSTATION DS215+

The software has plenty going on

AIMED AT SMB USERS, Synology's DiskStation DS215+ comes out swinging. It features dual Ethernet ports that not only support adaptive link aggregation but also feature failover support, leaving the NAS connected to the network should one connection fail. To further enhance its business credentials, it also boasts a hardware encryption engine that offloads the task from the main CPU.

Speaking of which, the DS215+ uses an Annapurna Labs Alpine AL-212, a dual-core processor clocked at 1.4GHz. This comes with 1GB of DDR3-1600 memory to aid multitasking jobs. Unfortunately, that's all it supports because the memory modules are soldered to the mainboard. Looking at the performance figures for the unit shows that it can deal with most things thrown at it in a normal office environment with the standard memory anyway.

It's a consistent performer, producing practically the same 118MB/s figure for reads and writes in the ATTO benchmark in both RAID 0 and RAID 1. It produces figures of over 100MB/s for the HD tests in Intel's NASPT, regardless of whether it was RAID 0 or RAID 1. It's not only quick in synthetic tests—it's one of the fastest units here when tested writing to and reading from it using a 50GB folder of mixed file types.

The DS215+ is a front-loading unit with two hot-swappable drive bays. A neat touch is that the bay doors can be locked for extra security—Synology supplies a pair of keys. The drive trays are tool-free, with the drives being secured by a pair of pinned side panels. It's a very simple but neat design, holding the drives in place without the need for screws. Screws are needed, however, to mount 2.5-inch drives. The DS215+ supports drives up to and including 8TB capacity, and a full list of compatible drives can be found on the Synology website.

EASY PEASY

Synology's award-winning DSM (DiskStation Manager) is one of the best NAS operating systems around, and the icon-rich GUI is very well designed and easy to navigate. To test the DS215+, we used the 5.2.552 version, and setting up accounts is really straightforward and fast.

DSM has a host of really useful features, including File Station, which lets you drag-and-drop files from both Windows and Mac. It has built-in FTP and email clients, with HTTPS and SSL/TLS encryption for secure transfers. FTP, NFS, SMB2, WebDAV, Windows AD, and LDAP all aid local file sharing across a network.

The DS215+ also boasts DLNA support, an iTunes server, and direct support for Samsung TV, Apple TV, Google Chromecast, and Roku players. The Video Station feature enables you to take total control of your movies, home videos, and TV content stored on the DS215+. It also allows sharing of content without the need for any passwords.

There's a full range of mobile apps, including: DS Note, which includes a web clipper so you clip and save content directly; DS Video, which allows streaming to a TV; and DS Audio, which lets your cell phone act as a remote control for music. DS Photo and DS Cam are useful if you have your DiskStation set up as a surveillance center, as they allow monitoring of live streams from any security cameras.

VERDICT **7**

Synology DiskStation DS215+

PLUS DISKO Great OS; data security for business use.

MINUS DIRGE Expensive; no front USB; memory not upgradable.

$400, www.synology.com

SPECIFICATIONS

CPU	Annapurna Labs Alpine AL-212
Cores	2
Speed	1.4GHz
Installed memory	1GB DDR3
Memory upgradable	No
OS	DSM 5.2.552
USB ports	2x USB 3.0
HDMI ports	None
Ethernet ports	2x Gigabit
Others	1x eSATA
Warranty	2 years

Well built NAS for business use.

WD MY CLOUD BUSINESS DL2100

Fully upgradable memory and more...

WD'S MY CLOUD Business DL2100 is a business-oriented two-bay NAS not to be confused with the My Cloud series aimed at the home user. That's not to say it can't be used in the home, but why WD didn't drop the My Cloud moniker for its latest line of business NAS is a mystery.

As you might expect from something aimed at the business end of things, it's a much more solid affair than the consumer My Cloud. Metal replaces the plastic casing, and it comes with more professional features, such as dual Ethernet ports (that support link aggregation) and a pair of power inputs. WD only supplies one power adapter, though, so you will have to buy a second to make use of the power redundancy that having two inputs offers.

Powering the DL2100 is a 1.7GHz dual-core Intel Atom C2350 backed by 1GB of DDR3L memory. The memory is upgradable to 5GB via a full-size DIMM slot. There is no external access to this but the design of the DL2100 makes getting to it simple once the unit's cover is removed. The DL2100 supports DDR3 1,600 or 1,333MHz DIMMs.

Installing hard drives is as easy as it can be, as there are no drive trays; just unlatch a bay door in the front, push the drive in, and shut the door. That's it. It's a very neat design as the drives fit in pretty snugly to reduce the effects of any drive vibration.

At first glance, the My Cloud UI appears pretty simple compared to some of its competitors but that's the beauty of it. It's so easy to use and navigate that you don't feel like you need to have spent years in an IT department to make sense of it all. Setting up user accounts and assigning storage space and access limits takes no time at all, and the same is true of setting up shared folders, which makes the DL2100 ideal for small offices without any dedicated IT staff.

MAKING AN APP-EARANCE

Compared to other NAS boxes in this roundup, and elsewhere, the number of add-on apps for the DL2100 is minimalist, to say the least. The number is growing slowly though, and currently includes WordPress, SqueezeCenter, Dropbox, Joomla, Icecast, the Plex Media Server, and Acronis.

For backing up data, the DL2100 supports WD's SmartWare Pro and Apple's Time Machine, as well as cloud-based backups, such as Amazon S3 and ElephantDrive. The DL2100 supports Milestone ARCUS software, so you could turn it into a pretty powerful surveillance system supporting up to 16 cameras (it comes with two free camera licenses), and is compatible with a huge number of cameras.

Ports to connect up to external devices are limited to a pair of USB 3.0 ports, one in the rear panel and one in the front bezel. The front one has a direct copy function via a button that sits just above it.

What was a surprise was how noisy the thing was when it came to certain tasks. Turning the unit on or rebooting from a firmware update produced one hell of a racket from the fan. Luckily, it doesn't last too long. The fan also makes itself known when the disks are pushed hard, as they are when the unit is being tested. In a similar and perhaps more worrying vein is the weird, grinding noises that were produced when the unit was checking the disks before building an array—very scary to listen to.

VERDICT **7**

WD My Cloud Business DL2100

IN THE CLOUDS Easy drive replacement; My Cloud OS.

DOWN TO EARTH Noisy fan.

$350, www.wdc.com

SPECIFICATIONS

CPU	Intel Atom C2350
Cores	2
Speed	1.7GHz
Installed memory	1GB DDR3L
Memory upgradable	Up to 5GB
OS	WD My Cloud
USB ports	2x USB 3.0
HDMI ports	None
Ethernet ports	2x Gigabit
Others	2x power-in (only one adapter supplied)
Warranty	2 years

HOW WE TESTED

To test these two-bay NAS devices, we used a pair of 4TB Red Pro drives built into RAID 0 and RAID 1 arrays. The latest firmware was installed where possible, and the latest version of the OS installed. To test for outright speed, the latest 3.05 version of the ATTO benchmark was used, and to test how the NAS dealt with the small 4K files of everyday use, they were tested with the 4K read/write test in Crystal Disk Mark 5.0.2. Intel's NASPT was used to give a better idea of the multimedia performance, as well as the write to/read from the NAS of a file directory. Finally, we tested the real-life performance of the NAS by writing a 50GB (36,601 files) folder to and from the NAS using the FileCopy app to give a MB/s figure and the time taken.

BENCHMARKS RAID 0

	Asustor AS5002T	D-Link DNS-327L ShareCenter+	Netgear ReadyNAS RN202	QNAP TS-231+	Synology DiskStation DS215+	WD My Cloud Business DL2100
ATTO 3.05 Read	118	116	118	118	118	118
ATTO 3.05 Write	105	95	97	118	118	117
CrystalDiskMark 5.0.2 4K Read	6.803	6.357	9.485	5.058	9.290	8.407
CrystalDiskMark 5.0.2 4K Write	9.496	5.208	9.566	9.775	9.804	10.03
Intel NASPT HD Playback	108.8	71.2	105.5	99.0	105.5	103.9
Intel NASPT Directory Copy to NAS	10.3	4.0	8.8	14.9	9.7	9.3
Intel NASPT Directory Copy from NAS	14.2	5.3	10.9	13.4	14.0	13.0
Intel NASPT Photo Album	12.3	7.8	11.0	11.6	9.4	9.5
50GB Write to NAS (MB/s)	62.49	43.55	48.73	61.23	61.84	61.31
50GB Read from NAS (MB/s)	48.43	30.46	49.76	48.18	50.57	50.56

BENCHMARKS RAID 1

	Asustor AS5002T	D-Link DNS-327L ShareCenter+	Netgear ReadyNAS RN202	QNAP TS-231+	Synology DiskStation DS215+	WD My Cloud Business DL2100
ATTO 3.05 Read	118	115	116	116	118	117
ATTO 3.05 Write	116	97	97	118	117	114
CrystalDiskMark 5.0.2 4K Read	3.783	5.556	8.930	4.801	8.601	6.231
CrystalDiskMark 5.0.2 4K Write	9.355	5.843	7.223	7.112	9.687	5.261
Intel NASPT HD Playback	105.4	84.6	105.2	100.8	93.3	92.0
Intel NASPT Directory Copy to NAS	10.5	3.8	8.6	12.9	9.4	9.4
Intel NASPT Directory Copy from NAS	12.5	4.7	11.3	11.2	13.5	13.0
Intel NASPT Photo Album	9.9	8.2	9.9	10.4	11.2	8.8
50GB Write to NAS (MB/s)	61.72	42.32	48.75	62.11	62.26	62.59
50GB Read from NAS (MB/s)	44.63	30.04	41.89	45.33	49.43	48.41

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And the winner is...

ASUSTOR AS5002T

ALTHOUGH FOUR-BAY UNITS are making steady inroads into the home, the two-bay NAS is still the weapon of choice for a great number of people in the SOHO (Small Office Home Office) market, especially because the likes of the Asustor AS5002T, QNAP TS-231+, and Synology DiskStation DS215+ support the latest 8TB hard disks.

All the NAS units here, with the exception of the D-Link DNS-327L ShareCenter+, could be used in either the home or the office. The DNS-327L ShareCenter+ just doesn't have the power to be able to deal with the demands an office environment would place on it, and it has a very small list of apps to work with. It isn't a bad place to start if you don't need anything too complex for the home, but there are better offerings out there. Synology's DiskStation DS215+ is the next one you can pass on—it's actually a great NAS, but unfortunately it's yet another unit for which the memory can't be upgraded, despite its hefty price tag.

The Netgear ReadyNAS RN202 is interesting because it's the only NAS in this roundup not to use the EX4 file system, instead using the Btrfs system, which opens up a whole new level of data protection for business use. WD's My Cloud Business DL2100 is, as the name suggests, an out-and-out business NAS, and although it performs well, we can't get over the noise our model made. The Milestone ARCUS software is a very useful inclusion, mind you, which turns the DL2100 into the control center for a pretty impressive surveillance system with its 16-camera support.

QNAP's TS-231+ runs the Asustor AS5002T close, but once again the memory isn't upgradable, and although the OS supports some impressive tools, it doesn't offer the same hardware connectivity to external devices that the AS5002T does. But it does have a very large number of downloadable apps to support it.

Ultimately, it's the Asustor AS5002T that gets our vote. It's a powerful NAS, and although Asustor markets it as a home/power user two-bay device, it would equally serve as the storage backbone in a small office without any problems. This is especially true as the memory can be upgraded to help keep up with the demands of a growing office. The Asustor Data Master OS is just superb, easy to use, and navigate, and its heavy use of icons makes it pleasing on the eye.

The fact that it has an HDMI port so it can connect to a TV and, by using home theater software, be turned into a fully functioning 1080p media center is another string to an already impressive bow. With the support of a huge store of downloadable apps behind it, the great thing about the AS5002T is that it can be tuned and customized to fit anyone's personal needs, and that's what makes it a great all-rounder.

> Marketed as a home/power user device, it would equally serve as the storage backbone in a small office without any problems.

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Super-Speed Storage

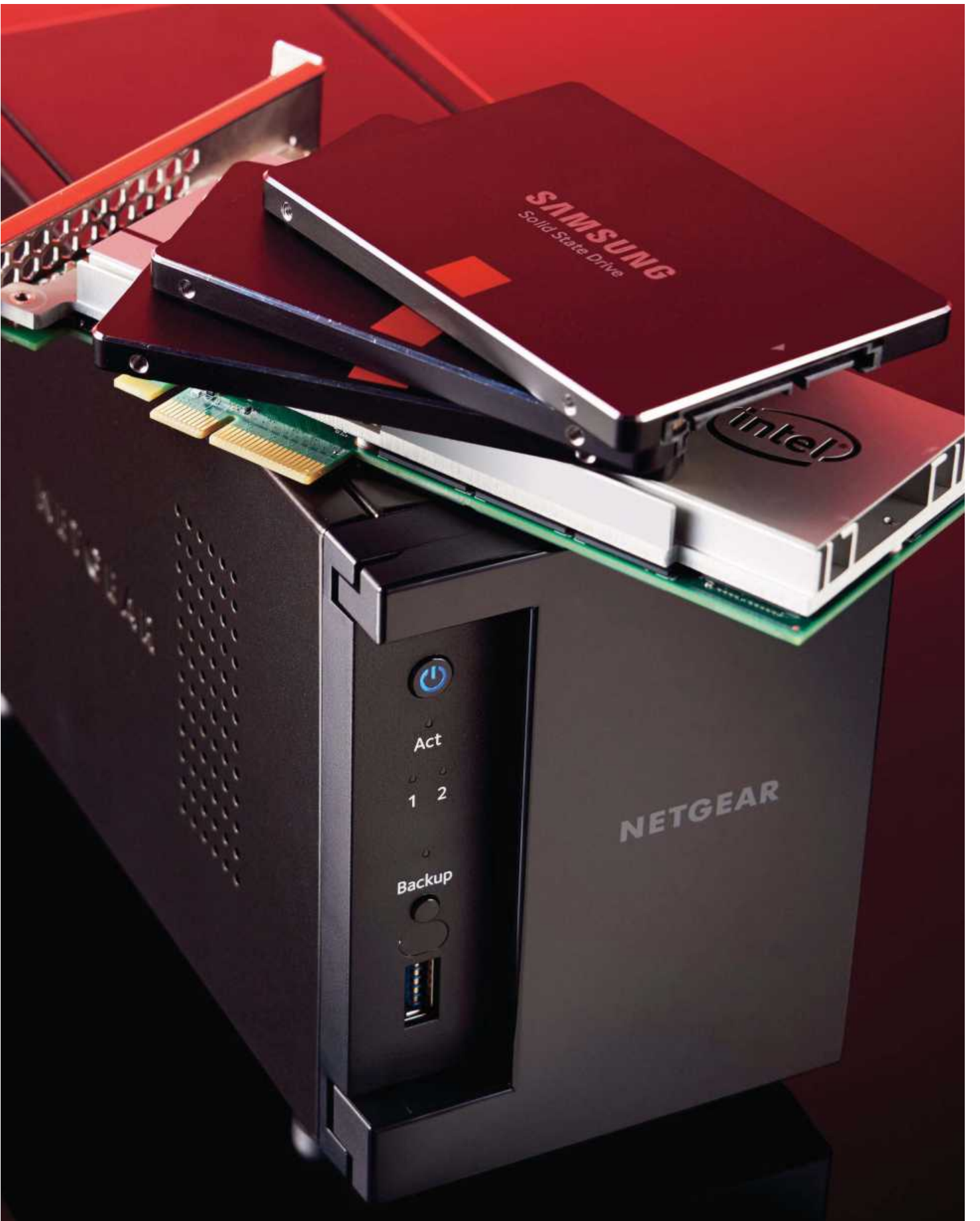
What's the best storage option for you?

Once upon a time, there was just one simple solution when it came to computer storage. The ever-reliable, infallible spinning hard drive. That signature sound of those platters whirring into life undoubtedly roused the spirit of many a gamer, knowing that within mere tens of minutes they would be sitting comfortably, ready to load their favorite 32-bit game. It was a technology that, although archaic by today's standards, developed exponentially for its time. First there was IDE, then there was SATA, then the second generation of SATA, and finally SATA revision 3.0, the pinnacle of SATA technology. An interconnect designed and developed to help support and provide compatibility for all future storage devices and drivers, for the next generation of HDD devices.

But something happened, an event that would shape mankind throughout the ages. An event we like to call SSD-Gate. Actually, no, that was a lie. A bad one. We just made that up. But still, it was pretty revolutionary. In 2008, Intel released the X25-M SSD, one of the first commercially available SSDs. Featuring mind-blowing speeds of up to 250MB/s read and 100MB/s write, PC enthusiasts were hooked, and so the craze began. Soon we would all be running the typical combo—as SSD storage was so ridiculously expensive at the time, the most common setup was to use an SSD for your OS and a traditional hard drive for all your games, media, and other files. However, even SATA 3 had its limits. Eventually SSD speeds would overtake that now aging platform, decrepit well ahead of its time, forcing the powers that be to find new and inventive ways around this annoying problem.

Fast-forward to 2015, and the nature of the beast has changed entirely. It turns out that manufacturers don't like bottlenecks. Indeed, they hate them. We now live in a time when there are RAID 0 arrays, M.2 drives, PCIe cards, and all sorts of future tech right around the corner that makes the revolutionary SSD look as good as Donald Trump's "hair." Forget Moore's law, let's talk about SSD speed and capacity acceleration. And which wonderful and lovely storage options are available to you today? Which one should you choose? And how much bang are you getting for your buck? Read on to find out more....

By Zak Storey


SAMSUNG
Solid State Drive
intel
Act
1 2
Backup
NETGEAR

OVER THE LAST 20 YEARS, storage has changed. A lot. From hard disks and IDE connectors to all three generations of SATA, ultimately it's always been the connection standards that have been the bottleneck

When SATA 6Gbps was first developed, it wasn't expected that we would reach today's speeds so quickly. Indeed, with SSD and NAND flash far outstripping SATA 3's rated connectivity speeds, it seems far-fetched to believe that SATA 3 would have kept us going for this long. And so, as is often the way when PC enthusiasts are presented with a bottleneck, the manufacturers tried to find solutions around this gargantuan wall, to pry our hard-earned cash out of our wallets and into their pockets.

The initial quick-and-easy solution was to use an old trick: the RAID array. More often than not used for redundancy rather than speed, RAID 0 provided break-neck connectivity by splitting data and files in half between two disk drives, theoretically allowing data to be pulled off both of the drives at the same time.

Then came the push to utilize PCIe, an interface that we still haven't managed to saturate. You can easily transfer upward of 120Gbps, nearly 20 times more than SATA 3.

After that came M.2, a smaller form factor laptop drive originally designed to operate in a similar way to mSATA. The M.2 interconnect had one particularly interesting asset: it integrated directly into the PCIe bus, giving it the ability to take full advantage of the expanded bandwidth and increased speeds of that platform, increasing NAND flash performance almost fourfold. Impressive.

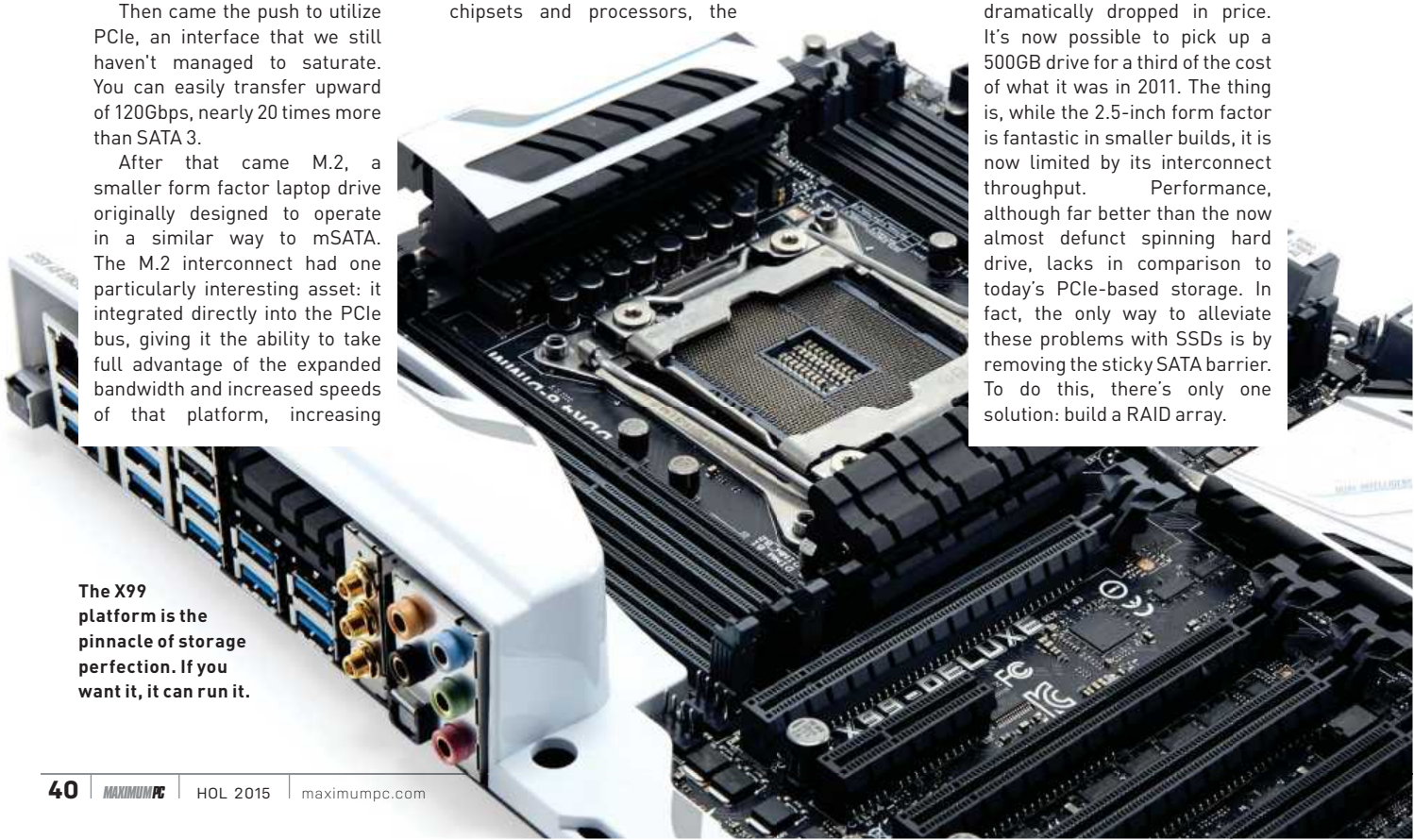
DEPENDENCY

Ultimately, storage connectivity has always depended on one component—the motherboard. The more modern the motherboard, the more likely you are to be able to support these new storage standards. Intel's latest Skylake chipset, the Z170, supports 20 PCIe 3.0 lanes. This is in direct response to the increased number of people using those same PCIe lanes for storage as well as graphical horsepower. Because the storage utilizes PCIe lanes, you lose out on the number of lanes available for your GPUs—in some scenarios, if you're using SLI or Crossfire, it may not be possible to install an M.2 PCIe card without the additional lanes provided in the latest Z170 chipset. With Intel increasing the number of PCIe lanes in its chipsets and processors, the uptick of PCIe storage seems almost inevitable.

There are always limitations when it comes to storage. Don't believe what they tell you—you can't download more RAM.

OLD-SKOOL SSDS

Unless you've been stuck under a rock for the last three years, you're probably aware that 2.5-inch SATA SSDs have dramatically dropped in price. It's now possible to pick up a 500GB drive for a third of the cost of what it was in 2011. The thing is, while the 2.5-inch form factor is fantastic in smaller builds, it is now limited by its interconnect throughput. Performance, although far better than the now almost defunct spinning hard drive, lacks in comparison to today's PCIe-based storage. In fact, the only way to alleviate these problems with SSDs is by removing the sticky SATA barrier. To do this, there's only one solution: build a RAID array.



The X99 platform is the pinnacle of storage perfection. If you want it, it can run it.

RAID 0 ARRAY There's a plethora of RAID arrays to choose from—however, the most common ones you'll come across are RAID 0, 1, 5, and 10. RAID 0, possibly the most interesting of the four, requires a minimum of two drives

Essentially, the principle is fairly basic: split the data across both hard drives, then read or write off both of them simultaneously to provide an impressive performance boost. The one major downside to this is that if one of your drives fails, you lose all of your information with no chance of recovery. Although in today's climate that's a pretty rare occurrence, it's still advisable to keep the vast majority of your valued files offsite. After all, you want to make sure that you've got at least one backup, and ideally you want to have a backup for your backup as well—we wouldn't want to be around when your primary system and your backup fails. Heh, *Star Trek*.

Anyway, back to the point: keeping your OS and some games on your array is often the best solution, especially in today's modern age of cloud storage and super-fast download speeds, when reinstalling an OS doesn't take a week.

To set up and install a RAID 0 system, you need to use your BIOS, Intel's Rapid Storage Technology, and at least two drives. Instructions can be found in your motherboard's user manual, however, changing the "PCH Storage" option from "AHCI "to "RAID" should do the trick. Then it's a simple case of rebooting and mashing Ctrl-I to get into the Intel Rapid Storage Driver, and creating your RAID array from there.

SPEED SPECS

As you can see from our benchmarks on page 44, our array performance is right around where we'd expect to find it. Three Samsung 850 Pros in RAID 0 provide us with a grand total of 384GB of storage, and performance speeds in synthetic benchmarks ranging anywhere from 1,200MB/s to 1,500MB/s read and 1,000MB/s to 1,100MB/s write. This solution really shines in desktop copies and transfers, reducing overall copy time by half, making for a much smoother experience, and an instantaneous response when moving folders with photos.

ALTERNATIVE RAID

But wait, there's more. RAID 0 isn't your only option. RAID 1 uses exactly two drives, and mirrors your data across both at the same time. The benefit here is that if one of your devices fails, there's always a backup. A hardware RAID controller can also potentially read from both drives for improved speeds too.

RAID 5 is a little more complex. It requires a minimum of three drives, and stripes the data across the drives along with a rotating parity block. It detects when there may be problems on either of the other drives and migrating system-critical information from the damaged or decaying drive on to one of the others. This is often used in NAS devices or servers, where multiple people may be using the array at any given time.

Then there's RAID 10, the king of money spending, storage, and dependability. It takes the best parts of both RAID 0 and RAID 1, and merges them together, simultaneously mirroring and striping the data between the number of drives you have available. You need a minimum of four disks to do this, and you lose half of your storage capacity in the process, but it's the most effective and efficient way to use SSDs—just not for those looking at cost-effective storage solutions.

RAID 0 provides a rapid alternative to storage woes.

Setting up a RAID is as easy as it comes nowadays.

RAID REASONING

Ultimately, RAID 0 provides a cheap, fast, easy, eye-pleasing solution to modern-day storage woes. Although the synthetic benchmark speeds often don't transfer well into gaming scenarios, the snappiness you'll find on desktop file transfers will be enough to make any PC enthusiast crumble. The only problem with it is boot times. If you're looking for a super-fast startup, you're more than likely still going to want to utilize just a single SSD. Intel's rapid storage boot manager does take a considerable amount of time to get past, and even though you benefit from those speedy read times, you're still going to suffer because of it.

PCIE SSDS The most exciting advancement that we've seen over the last year or so has been the continued push into the PCIe SSD—allow us to explain why

Utilizing the PCI Express interconnect to deliver stunning storage speeds is a fantastic step forward, and undoubtedly where the future of storage lies. Originally hampered by insane levels of cost, the price of the PCIe SSD has dropped dramatically over the last year. Indeed, per gigabyte, it's now half the cost of the most expensive SSD. Still sounds like a lot, but ultimately it's far cheaper than when it debuted back in 2012.

Currently, it's around 92 cents per gigabyte for an Intel 750 SSD, or 86 cents per gigabyte on Samsung's OEM SM951 versus 54 cents per gigabyte for a Samsung 850 Pro SSD. But considering you're getting almost four times the performance by using an M.2 drive, it's more than cost-effective and, if SSD prices are anything to go by, it's not going to be long until these drives cost the same as SSDs do today.

AVAILABILITY

Hardware and connection speeds haven't been the only problems manufacturers have had to face. In fact, they're only the start. The biggest conundrum has been how to surpass the aging AHCI protocol. Essentially a software interface to help convert the physical interface's information, AHCI was designed for spinning drives and high-latency devices—nothing comparable to today's NAND flash storage. Although SSDs still work quite efficiently on this, a new software interface was needed. Welcome to NVMe, a collaborative project worked on by over 80 members of a consortium, directed by Samsung and Intel. NVMe (Non-Volatile Memory Express) was designed to work with both SSDs and PCIe going forward.

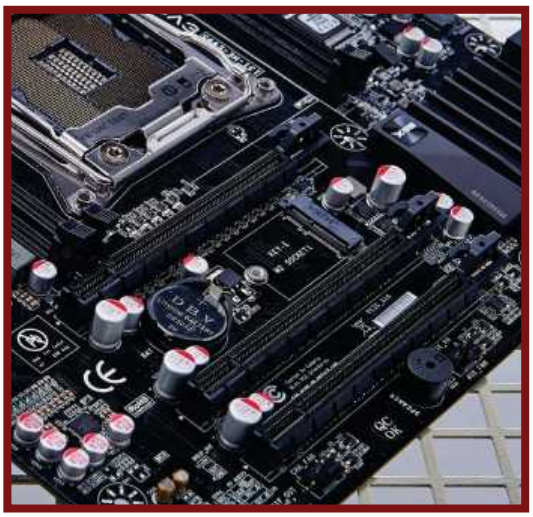
AESTHETICS

Ultimately, the biggest problem in the enthusiast arena has been aesthetics. When manufacturers first introduced their lineups of PCIe SSDs, they came covered in a lovely shade of green PCB. On top of this, you lose out on a PCIe slot, which for more aesthetically minded system builders, can ruin the look of a good build.

M.2 PCIe drives do little to alleviate the situation. Raised above the board, they suffer from the same drawbacks, with the vast majority including that signature shade of grass-green PCB. Indeed, it's only recently, with the launch of Samsung's 950 Pro, that the first all-black consumer-grade PCB has been seen in this department.

U.2 AND 2.5-INCH

So, for a while now, the industry has been looking for a way to improve the connectivity speeds of the traditional 2.5-inch drive, and although M.2 drives are incredibly powerful and efficient, they still have flaws—namely, thermal limitations and drive capacity. Although Samsung has just announced its first 1TB M.2 drive, these devices will no doubt come at a great cost to the user and aren't going to be available in the market until some time later next year.

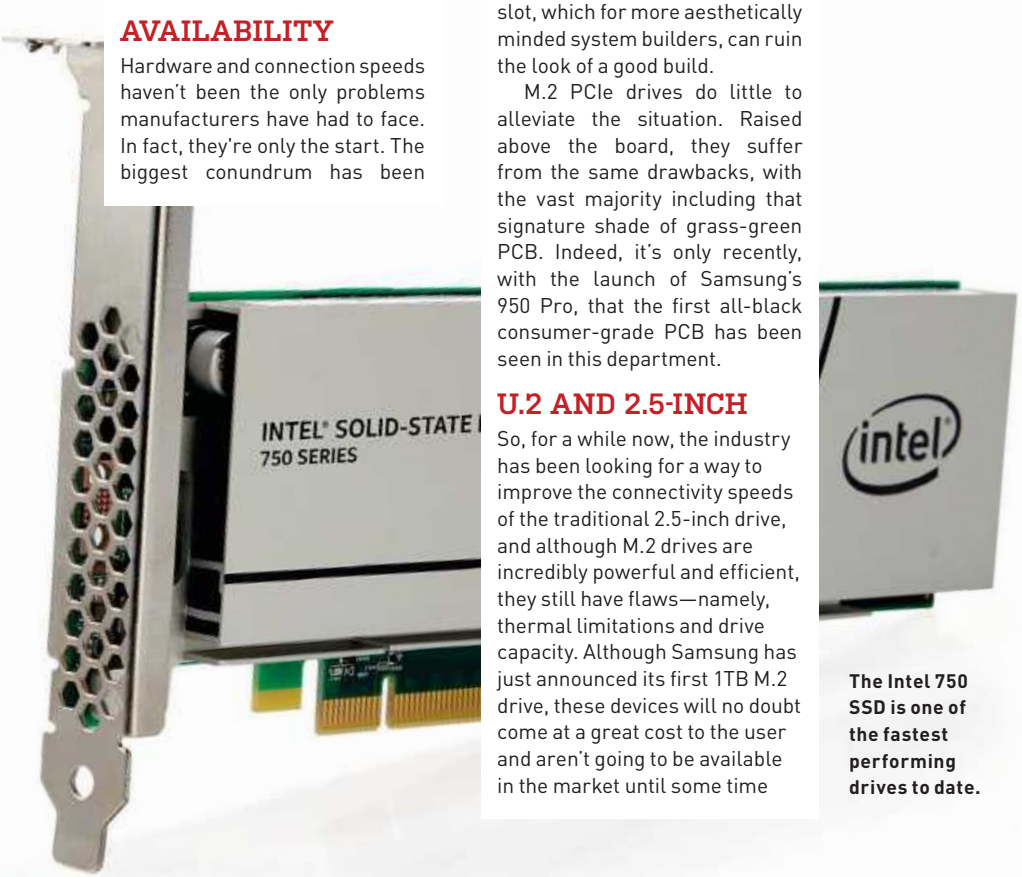


It's all about utilizing those PCIe lanes. Who'd have thunk?

Welcome to SFF-8639. A connection standard that's been used in enterprise-grade systems for some time now, it's finally making its way to the consumer side. Notably with a rename: U.2 (not the band; it's pronounced you-dot-two), bringing it more in line with M.2 and making it a little easier to remember. U.2 still features the same access that M.2 has, utilizing four PCIe 3.0 lines, and still promises the same speed, just in the traditional 2.5-inch form factor. The only downside is that, for the time being at least, the cable is rather bulky, and Intel plus a few other select board partners are the only ones supporting it.

PCIE PERORATION

In the end, these drives are no doubt the future of storage expansion. As more memory chip manufacturers migrate to PCIe-based devices, it's inevitable that these devices, especially those utilizing NVMe, will become the SSDs of tomorrow. With stunning performance, low cost, low power usage, and small form factors, is there any doubt as to which storage solution has won the war?



The Intel 750 SSD is one of the fastest performing drives to date.

M.2 FORM FACTOR Ahhh, the M.2 form factor, the golden era of computing, following Moore's law admirably—as transistors get smaller and smaller, memory follows suit

With companies such as Samsung and other storage conglomerates pushing memory chips with up to 48-layer V-NAND, it was surely only a matter of time before a smaller form factor storage device was achieved.

Indeed, long gone are the days of clunky 3.5-inch drives. In fact, if you were to buy any modern Ultrabook, there's no doubt that you'd be picking up one of these bad boys with it, whether you knew it or not.

CONSIDER COST

Although we've spoken about M.2 in depth already, there's more than just the traditional all-out speed demons. In fact, you can get M.2 drives that are as fast as today's standard SSDs. Now, we know what you're thinking—why on earth would you want that? Well, simply put, M.2 drives are ridiculously less complicated to build than their 2.5-inch form factor counterparts, and because of this, it makes them extremely affordable and accessible to the vast majority of us. Indeed, you can get your grubby little hands on a Crucial BX100 500GB M.2 SSD for roughly $160, making it the cheapest out of all our storage solutions, at just 32 cents per gigabyte. Alternatively, the speedier MX200 250GB can be had for $95, or 38 cents/GB.

The downside is motherboard and device compatibility. You'll need to ensure your motherboard has at least one M.2 slot, that it can support the size of M.2 drive that you're going to purchase, and that you're willing to give up those PCIe lanes as necessary. Additionally, there's a whole assortment of NGFF (next-generation form factor) sizes, depending on your needs, ranging from 2242, 2260, and 2280, all the way up to 22110—although, to be honest with you, we haven't even seen the latter sized drive.

Don't let its size fool you—M.2 is more than enough to take on any 2.5-inch drive.

M.2 MATTERS

There's another downside to M.2, and that's how it looks. With only a select few companies utilizing black PCBs, they can stand out rather dramatically in comparison to the more traditional SSD. They do, however, provide a fantastic solution if you're not bothered about appearances, have a non-windowed case, or are utilizing a NUC or some other small form factor device.

WAIT! WHAT HAPPENED TO SATA EXPRESS?

Well, as you probably already know, SATA 3 has always been the problem child of storage speeds. Hell, we've hit on that enough during this very feature. However, M.2 and tapping into PCIe lanes wasn't the first solution to the problem. An additional physical interface came in the form of SATA Express. Essentially taking up two SATA 6Gbps lanes and some additional power, it's an interface that enables speeds of up to 1,959MB/s read and write by utilizing the same PCIe lanes that M.2 and U.2 now occupy. Unfortunately, as a standard, it just never took off, certainly not in the way that PCIe storage or SATA originally did.

There were a couple of SATA Express SSDs out there, but nowhere near enough to provide any form of available market. Indeed, companies such as Asus have now taken that interface and even created front-bay devices using USB 3.1 and providing up to 100W of power to find at least something to do with it.

To wrap up serial ATA, we've got to look at mSATA, which stands for mini-SATA. Essentially a smaller form factor SSD, mSATA was most commonly found in notebooks and early small form factor devices before being replaced by the higher speed M.2 devices. It does, however, utilize the SATA host controller, as opposed to the PCIe host controller, meaning you don't lose out on those valuable PCIe lanes in smaller form factor builds. Something that's become null and void over the last year or so.

CONCLUSION And there you have it, folks—that's the vast majority of super-fast storage solutions available to you today, and wow, does it look like a doozie

RAID 0 provides some impressive figures for its low price, but PCIe storage solutions will be the clincher going forward. If it wasn't for the innovations we've seen with manufacturers using the PCIe physical interface, RAID 0 may have taken the win. Alas, its limitations have been reached and spooling more and more drives together isn't a viable solution to our speed woes.

With SSD capacity ever increasing (say hello to 4TB Samsung drives coming soon), it's only a matter of time before they replace the aging hard disks of yesteryear. They're far more responsive, energy-saving, and noise-reducing than their ancient counterparts, and even using the SATA 3 interface, still very potent.

PERSONAL CHOICE

What it comes down to is personal preference and what you need. A 1.2TB Intel PCIe card might be ideal for a workstation-grade computer, rendering 3D models every day, but if you don't need the horsepower or detest the ugliness of the drive consuming another of your cherished PCIe slots, it's probably not the solution for you. M.2 is great for small form factors, but again suffers from the same problem—currently, the only way of hiding these drives is by using a motherboard with thermal armor (here's looking at you, Asus), otherwise you're stuck with it staring you in the face.

RAID arrays are another great solution, less useful for gamers but, all in all, quite easy to set up, and in today's climate, exceedingly stable. In fact, some of our writers have used RAID 0 SSD arrays for years, with little to no problems whatsoever.

FUTURE TECH

All of that being said, this isn't the end of storage speed, and indeed this year saw Intel and Micron announce 3D Xpoint, the first new memory storage technology invented within the last four decades. Touting performance figures 1,000 times greater than traditional NAND flash, and endurance to match, these devices are set to hit the stage sometime in 2016. Although Intel hasn't let on as to how exactly 3D Xpoint works (no doubt in an attempt to fend off potential competitors), roughly speaking, it forsakes the transistor in favor of a resistive material, where the resistance between two points indicates whether the bit of information is a 1 or a 0. Although still not as fast as today's DDR4 (just), the fact it's non-volatile and stackable makes it a potentially revolutionary invention—depending, of course, on whether Intel can bring it to the consumer market. And, of course, we'll need an additional storage interface to be able to even transfer that amount of information, because read and write speeds topping a whopping 550,000MB/s might be a bit much, even for PCI Express.

Traditional SSDs are cheap, and readily available for you to take advantage of.

SSD STILL BEST

So, SSD is still king of the hill. It's still the most diverse storage solution out there today. It has successfully supplanted the old-school HDD and cemented its way into our hearts by being the stealthiest good-looking drive out there. As an interface, U.2 is still far too clunky looking, and for gaming, honestly, you don't need more than that, certainly not for the time being. Perhaps today the best setup is a RAID 0 array for your OS, and then a standard 500GB-1TB drive for your games and media.

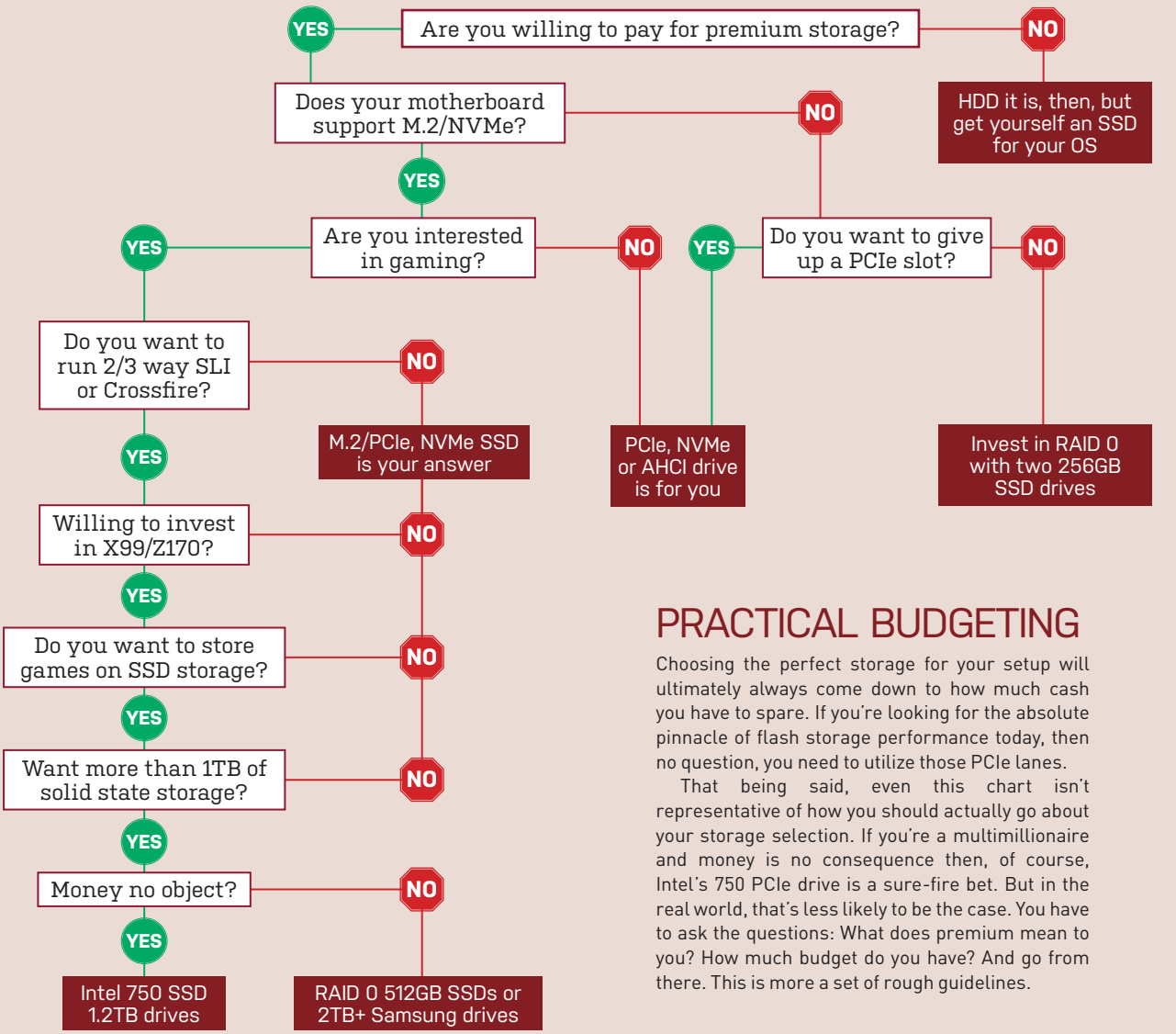
What ever happens, we'll be glad to hear the last of the inevitable whir of a mechanical drive as it spins into history, alongside the great noises of our technological past. Farewell platters, farewell dial-up, farewell motherboard beeps!

BENCHMARKS

	AS SSD Sequential Read	AS SSD Sequential Write	AS SSD 4K 64Thr Read	
3x Samsung 850 Pro 128GB SSD RAID 0	1,505MB/s	1,258MB/s	728MB/s	
Samsung 950 Pro NVMe SSD	2,063MB/s	901MB/s	1,021MB/s	
Intel 750 SSD 1.2TB	**2,201MB/s**	**1,315MB/s**	**1,445MB/s**	
Samsung 850 Pro 2TB	496MB/s	477MB/s	371MB/s	

Best scores are in bold.

Pick the perfect desktop storage for your machine



PRACTICAL BUDGETING

Choosing the perfect storage for your setup will ultimately always come down to how much cash you have to spare. If you're looking for the absolute pinnacle of flash storage performance today, then no question, you need to utilize those PCIe lanes.

That being said, even this chart isn't representative of how you should actually go about your storage selection. If you're a multimillionaire and money is no consequence then, of course, Intel's 750 PCIe drive is a sure-fire bet. But in the real world, that's less likely to be the case. You have to ask the questions: What does premium mean to you? How much budget do you have? And go from there. This is more a set of rough guidelines.

	AS SSD 4K 64Thr Write	PC Mark 8 Storage Bandwidth	File Transfer Copy Speed	IOMeter 128K Sequential Average	IOMeter 4K Random Average
	645MB/s	260MB/s	334MB/s	1,019MB/s	124MB/s
	254MB/s	**622MB/s**	560MB/s	1,008MB/s	267MB/s
	1,067MB/s	495MB/s	**564MB/s**	**1,605MB/s**	**454MB/s**
	292MB/s	280MB/s	190MB/s	496MB/s	222MB/s

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TECH PORN

Origin PC Millennium

THERE ARE MOMENTS in a gamer's life when time itself freezes. Moments when the world stands still as awe-inspiring graphical fiction parades across our screens. When the game world truly comes to life, in ways we could only ever imagine. All it takes is a stunning title and a potent rig.

And, thankfully, Origin PC has provided one hell of a solution to bring that concept to life. Welcome, the Millennium. It's bold, it's beautiful, and it's brave. Featuring Intel's Core i7-6700K Skylake CPU, clocked at a phenomenal 4.8GHz, 16GB of DDR4, and not one but two overclocked Nvidia GeForce GTX 980 Tis, it has more than enough processing power for any of today's most immersive titles.

The future of gaming hinges on the success of VR and 4K, and the Millennium completely dominates both of those fields. If you're seeking a good-looking, powerful, easy to maintain, high-end system, Origin has provided just that.

–ZAK STOREY

1 NVIDIA GeForce GTX 980 Ti SLI

Looking to game at 4K? No problem. Just take a look at these two stunning GTX 980 Tis, more than enough to power any AAA title at 1440p, and even 4K.

2 Skylake overclock

Now the dust has settled over Skylake, we know that it's just not quite the overclocker we dreamed of. Alas, 5GHz simply isn't a thing. That being said, the 4.8GHz Origin has thrown at this CPU is about as high as we can get ours to run, too.

3 Custom Origin PC chassis

Although this case is identical to the Genesis, it's still stunning. Littered with RGB remote-control LED lighting, and a sleek elegant design, despite the plastic build quality, it'll look gorgeous practically anywhere you need to sit it.

AND THEY CALL THIS A MINE!

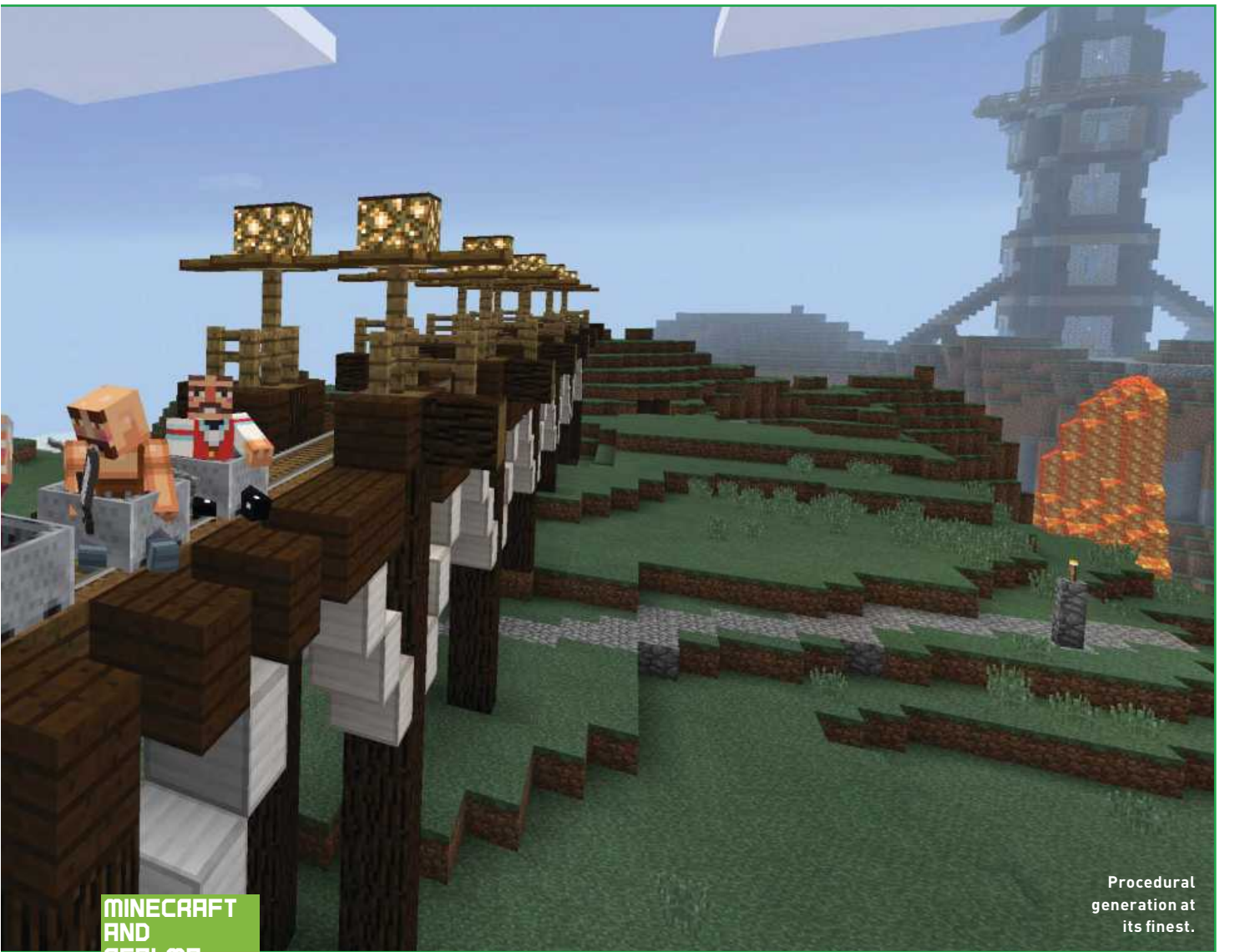
Minecraft has now sold over 70 million copies and is the biggest-selling one-man game of all time. Where next for the Swedish behemoth?

BY DAN GRILIOPOULOS

No one expected that the dominant game of the early 21st century would be a retro exploration game from a shy, obscure Swedish developer. But then, *Minecraft* surprises everyone who plays it. You start in on it, and it seems a bucolic little world you've dropped into. It's a joy to run around punching animals and trees for a couple of hours, and marveling at all the stuff you're collecting.

Then the sun starts to set. And it seems very, very dark without it. If you're a big wuss, you'll crank up the gamma on your screen, but that doesn't help much when the daytime farmyard noises give way to creepier sounds. Distant hisses and groans can be heard all around you. You can see things moving between the trees, and before you know it, there's a strange snicker behind you. You turn to see what looks like a walking hedgerow for a second before it explodes. You're badly hurt, and you need to find shelter while you heal up. But there are groans all around you, which turn into humanoids walking relentlessly, aggressively toward you. Running in the dark, you fall into a hole in the ground, possibly the one from which the creature exploded, and a whole new array of items are in your inventory—bits of wood and stone. Using the crafting panel, you hurriedly make a workbench, and with the workbench, you then make a pick. You start digging....

That's the classic *Minecraft* experience we all know. But it's set to change, and change fast. Microsoft's purchase of *Minecraft* and its developer, Mojang, has worked like Disney's purchase of LucasArts—it's rejuvenated a much-loved project that was in danger of getting stagnant. Many new projects are coming, which are expanding *Minecraft* in familiar and unfamiliar directions, and we're going to take a closer look at them all.



Procedural generation at its finest.

MINECRAFT AND REALMS

Rather amazingly, considering it started development in 2009, basic *Minecraft* still receives updates every few days. That's because when it was deemed finished in 2011, way before the creator Markus 'Notch' Persson left, he handed over development to Jens Bergenstern, who originally worked on two other Mojang games: *Cobalt* and *Scrolls*. Jens has led a small development team building on Notch's work for the last four years.

So, if you don't know, the game now has an ending, where you fight a giant Ender Dragon. This is located in a new airy region, The End, which has End cities, End ships, and strange beasts called Shulkers that are disguised as blocks and make the player levitate. It also has the Nether, an underground world of lava, horror, and pigmen, that you can only get to by building an obsidian portal, but which allows you to travel between distant areas of the overworld much more quickly. Players can craft a huge amount of new stuff, and can fly, sail, teleport, and map everything automatically as they go.

The game has been heavily improved, too, including differentiation into five modes. There's traditional Survival mode, where you have to fight off monsters, explore the world for resources, and deal with thirst and hunger. Creative mode lets you fly and do anything you want with limitless resources. Adventure mode has you play on a map made by another player, where editing the world is extremely limited, but you can explore it. Spectator mode makes you invisible and able to move anywhere in the world by flying. And Hardcore mode is a version of Survival mode, where the difficulty level is set to Hard and the map is deleted when the player dies, or if everyone on a server dies.

Most significantly, the team released an update enabling Realms in 2013. This was a server-hosting system that enables players to run server multiplayer games easily, without having to set them up by themselves. Unlike the existing servers, Realms is invite-only, can host a maximum of 10 players, and doesn't support user-made plugins. A Realms server costs $13 a month and is only available for original *Minecraft*.

Realms also has an interesting optional feature, where players can replace their server-saved world with two different types of map. The first is a permanent replacement, where you can use an established map template or an adventure map built by the community. The second is for mini games, which are temporary replacement maps, and change the game entirely. These range from a version of *Solitaire*, to a version of *Bomberman*, to a version of *Platoon*, and are all fun and original.

"Realms is also going to come to Pocket and Windows 10 soon!" Mojang's lead


It's beginning to look a lot like Christmas.


Nothing like mounting your trusty steed.


The easiest way to survive is through farming.

Minecraft Pocket developer Tommaso Checchi told us. "After a beta that was very well received a long time ago, we've been pretty silent on it, but finally we're working to reintroduce Realms as soon as possible. It's very important to us because Pocket players don't even have dedicated servers (yet) or true online play, so it's a way for them to play together when not in the same room."

Of course, traditional multiplayer is still there as well—it wouldn't be the same without the large public servers that allow players to recreate the entire *Game of Thrones* world, or build the USS *Enterprise,* or create working microcomputers in-game.

WINDOWS 10, POCKET, AND OTHER PLATFORMS

Users of Microsoft's new Windows 10 (we say new, but it's an upgrade to Windows NT via Windows 7 and 8) will have noticed something strange about the games setup. Sure, the usual *Solitaire* is there (though *Minesweeper* is sadly absent), and it's heavily upgraded, but it's part of the new Xbox gaming application. And all official gaming on Windows 10 is meant to go through this always-online application.

Similarly, existing users of *Minecraft* can go to the Mojang website and get a code, which they can put into the Xbox gaming application on Windows 10, and download the *Minecraft Windows 10 Beta.* And if they do, they'll find something very strange—because it's not the same *Minecraft* we know of yore.

Now, of course *Minecraft* has been on other platforms—from the PlayStation 4 to the iPhone, there's a version of *Minecraft* for it—but the *Windows 10 Beta* is unusual. Firstly, you can only play it when you have signed in online. Secondly, it hasn't been built on the original *Minecraft,* but on the Pocket version.

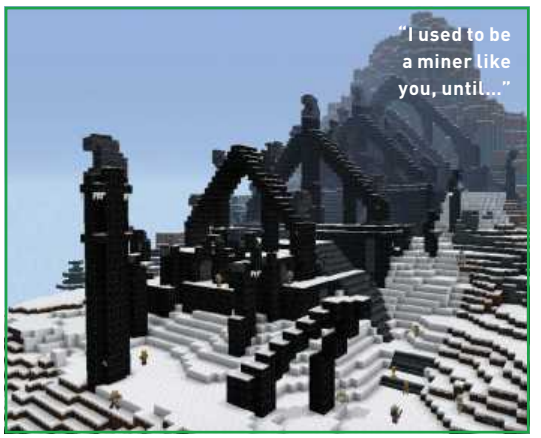
Mojang's Checci, who runs the Pocket development, tells us why it's just a beta. "It's doing OK, but there is a lot to fix.... People have complained about the UI not being PC friendly, and some other omissions, like key remapping being missing, and we're working on that stuff, which unfortunately we didn't have enough time to work on before. But the good news is that it's a beta, so it will improve over time!"

Pocket Edition has been around since 2011, and is actually the biggest selling version of *Minecraft,* having sold over 30 million copies by January 2015. It's available on iOS, Android, Smart TVs, and Windows Phone. The latter is significant, because Windows Phone is now Windows 10, which explains why that's the version we've got on Windows 10—though you can, of course, still run the original *Minecraft* on Windows 10 instead, for the moment.

There are big limitations to this edition of *Minecraft.* It doesn't support modding, and would be harder to mod even if it did, being built on C++ rather than Java code. It only allows you to play with seven other players—compared with a theoretical cap on original *Minecraft* of 2,147,483,647. It's also not up to the same feature level as original *Minecraft*, with the team endlessly playing catch-up. However, it does have the bonus that it supports a good range of inputs—Xbox controller, keyboard and mouse, or touch, because Windows 10 is going to be running on all those platforms.

"Eventually, we'd like it to reach feature parity with the original *Minecraft*, and gain some modding support, while remaining able to play with *Pocket Edition,* and Xbox too when that gets Windows 10." Yes, that's a reminder that the Xbox One user interface is undergoing a substantial redesign to look like Windows 10, so that every platform—console, PC, and phone—looks the same.

So that's three separate editions of *Minecraft* out there, all running on different code and being developed in parallel by three different teams: core *Minecraft*, by Jens Bergenstern's team; *Minecraft Pocket Edition,* by Tommaso Checchi's team; and *Minecraft Console Edition,* by 4J. There are two more editions we know of that



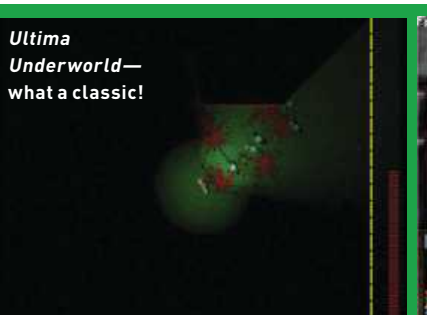
are incoming: *Minecraft Story Mode* and *Minecraft Hololens Edition.*

TELLING TALES

Telltale Games has established its credentials over the past 10 years. Starting as a bunch of ex-designers from LucasArts, it's made itself known as the specialist studio creating digitally-distributed episodic adventure games, mostly from famous licensed properties. Now it's working on *Minecraft.*

Telltale's background is working on extensions of old LucasArts series, such as *Sam & Max* and *Monkey Island,* but it has also worked on adventure game series based on movies, such as *Back to The Future* and *Jurassic Park,* comics such as *The Walking Dead* and *Fables,* and TV series like *Game of Thrones.* It was when it started working on a spin-off of the *Borderlands* series of co-op shooting games that it realized it could do a *Minecraft* game—and Mojang was delighted.

So is the Mojang team excited that someone else has got their hands on *Minecraft*, finally? "Yes!" said chief word officer, Owen Hill, when we spoke with him. "Seeing new interpretations of the *Minecraft* world is a great thing for us, whether they



INSPIRATIONS

Ultima Underworld, Dwarf Fortress, and Left4Dead

As well as looking at the future of *Minecraft,* it's worth looking at where it came from. There were three key games that inspired Notch: first-person RPG *Ultima Underworld,* chaos management sim *Dwarf Fortress,* and multiplayer FPS *Left4Dead.*

Underworld was an early true 3D RPG with crafting and exploration. It was one of Notch's older loves, so he'd spent some time building similar titles for game jams. The first of these was *Legend of the Chambered,* an unfinished RPG. If you look at screenshots of it, you can see that many of the items in *Minecraft* were simply ported straight across.

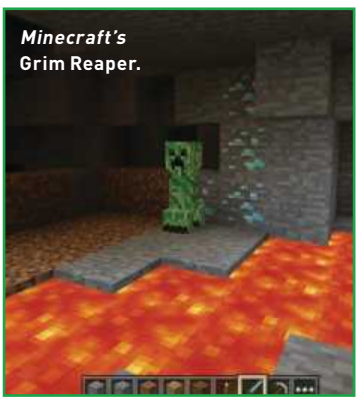
Dwarf Fortress is a work of love from two brothers, Zach and Tarn Adams. The game is immensely deep, simulating the lives of dwarfs in a fantasy world. Unusually, it's all displayed in ASCII characters, and it simulates the entire prehistory of the world before you get anywhere near playing with your colony. Notch made a short-lived attempt to create a similar sim, *Rubydung,* and its engine became the engine of *Minecraft.*

Finally, Notch had a thing for "demaking" *Left4Dead.* Repeatedly. He's made two 2D versions that fit in less than 4kb of memory. He was planning a 3D version, *Zombietown,* and the blocky look of its zombies ended up in *Minecraft,* and helped define its art style.


Yeah, we're not even sure what this is either.


Minecraft: approved by Daleks.


Is that a giant pumpkin?


Minecraft's Grim Reaper.


Like dwarves, you never see a female villager.


"This isn't the mod you are looking for."

MINECON
A meeting of mines

Since 2010, the *Minecraft* community has been holding MineCon, a huge convention with all the developers and many players meeting up to swap stories and reveal new content.

The first, MinecraftCon 2010, was a simple get-together of around 50 people in Washington state, where Notch was on business with Valve. However, a separate virtual convention happened online on the *Minecraft* forums, with competitions including building contests, obstacle courses, and a spleef tournament, where players are trapped in a room with a destructible floor above lava, and try to be the last one still alive.

The second convention was a big step up, with 4,500 attendees and a free concert featuring world-famous DJ Deadmau5. The game was also officially released there.

Skip forward to 2015, and the convention was held in London, England. The change in scale was a sign of how far the game and community have come. From the 50 attendees of the first free convention, there were 10,000 tickets on sale at £129 (around $200), which sold out within three minutes. (Some of which will have been because the tickets came with an exclusive cape...) There was also much, much more to see, hear, and do. Famous YouTubers such as Stampy Longnose and the Yogscast were in attendance, whilst the Mojang team briefed the audience about all-new upcoming features.

come from a piece of machinima, a music parody, or a narrative-driven video game."

Although the project was only formally announced in December 2014, it's been going on in the background for quite a while, according to Hill—as far back as 2012. "Telltale Games have had their hands on the IP for some time now, though we've worked closely with the studio to ensure Story Mode is something that's going to be fun for both new and existing players."

The story, ahem, of *Minecraft: Story Mode* seems very traditional. The protagonist is Jesse, a newbie player who sets off with his friends to find The Order of the Stone—four adventurers who slew an Ender Dragon, one of *Minecraft's* newer end bosses—in the hope of enlisting them to prevent the destruction of the video game world.

Players will travel throughout the *Minecraft* world, including to The End and the Nether, in a game that's very similar to Telltale's previous work, such as award-winning *The Walking Dead,* but also draws much from the 1980s, a golden age of PG-13 films. The tone, according to Job Stauffer, Telltale's director of communications, should be reminiscent of *The Goonies* or *Ghostbusters,* but with Telltale's branded hard choices—you will have to make decisions to leave friends behind—even if it's not as violent as the studio's *Game of Thrones* or *Wolf Among Us* titles.

The cast is an interesting mix, including Paul Reubens (aka Pee Wee Herman), Corey Feldman *(The Goonies, Gremlins),* John

Own up, everyone loves steampunk.

Hodgman *(Coraline, The Daily Show),* Ashley Johnson *(What Women Want, Avengers Assemble),* and Martha Plimpton *(The Goonies, Parenthood),* with either comedian Patton Oswalt or actress Catherine Taber as Jesse (depending on which gender you choose). Billy West *(Futurama, Ren & Stimpy)* acts as a narrator.

Minecraft: Story Mode is going to consist of five episodes, initially, and the first should be out by the time you read this. It'll be on all the consoles, PC, Mac, and mobile phones.

HOLOLENS, OCULUS, AND THE FUTURE.

Microsoft's Hololens is an experimental project, designed to compete with the wow factor of the forthcoming VR revolution. Revealed at GDC in 2014, it consists of a headset connected to a powerful computer, much like the Oculus Rift. The difference is that this is augmented reality, not virtual reality, so the headset isn't opaque but transparent. Its big trick is detecting your location and head position, and overlaying what appears to be a 3D image in the room, which moves as you move. Essentially, it makes you hallucinate.

So, of course, the killer app Microsoft has demonstrated for it is *Minecraft.* In the E3 demo, players got to look at a beautiful 3D representation of the world they were playing with—the detail was astounding: smoking chimneys, wandering tiny cows. In this "reality" mode, the player was limited to voice commands tied to their point of focus—so looking at a cow and saying "lightning strike" would zap the poor bovine beastie.

There are problems. The simulation only works in the center of the headset's visual field, so as you get closer to its adorable world, it disappears at the edges of the headset. And while it looks amazing, it's more challenging to play, so a second, more interactive version was accessed via an Xbox controller and a separate Hololens-projected screen on the wall.

Was this just a demo or something we'll get to play one day? "It's definitely meant to be a full product," says Checci. "In fact, it's based on the Windows 10/Pocket edition from the start, so it will also be compatible with those versions when it comes out."

Minecraft is also due to arrive on Facebook's Oculus Rift platform, using the Windows 10 edition, early next year. We've got very few details on that, but it's guaranteed to be working in true 3D—presumably, given the prep from the Hololens work, that's relatively easy.

That's all we know is coming to *Minecraft* in the near future—beyond the *Minecraft* movie, which is still in pre-production. Unless Mojang's Owen Hill knows anything else? "Of course, we're still focussed on maintaining *Minecraft*, and there are lots of exciting things to come, but the studio is packed with talent, so who knows what we might create in the future?"

COPYCATS

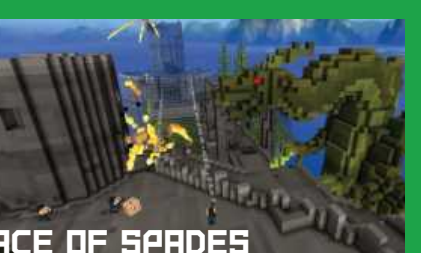
A colorful quartet of Minecraft wannabes

TROVE

Trion is better known for its F2P MMOs than for its creative games, but the open-ended voxel-based adventure *Trove* is a definite *Minecraft* clone, at least in appearance—it's more combat-oriented in practice.

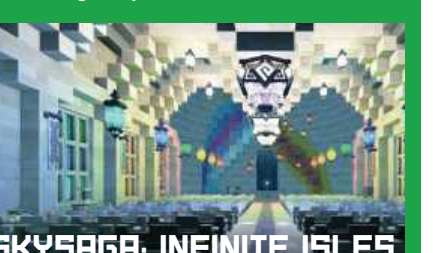
TERRARIA

This was the first *Minecraft* clone, turning the game into a 2D side-scrolling platformer—albeit with the same mechanics of smash anything, craft anything, then go cave-diving. It's a lot faster, but combat is harder.



ACE OF SPADES

Mingling *Minecraft* with *Call of Duty* was a no-brainer, so *Ace of Spades* did well at release, though it has faded since. Players are equipped with heavy weaponry, capable of blowing away each other's defences.



SKYSAGA: INFINITE ISLES

Another MMO version of *Minecraft,* with procedurally generated floating islands to explore and loot, and enemies to kill. Once you've got a bunch of loot, it's time to get crafting, and selling the resulting loot.

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HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

WINDOWS TIP OF THE MONTH

FIND THE BEST WIRELESS CHANNEL FOR YOU

There's nothing more annoying than getting home, throwing your laptop on to your 75Mbps Wi-Fi, and achieving a connection comparable to dial-up. A quick way to alleviate this is to move your router across to another wireless channel. To get a glimpse of which channels are busiest, go to http://bit.ly/WiFiAn, and download Acrylic's WiFi analyzer. This will reveal which channel is least occupied—move across accordingly.

MAKE – USE – CREATE

ZAK STOREY
STAFF WRITER

WIN 10 STILL CLUNKY?

Do you remember Windows 7? How nice it was booting up for the first time and having that slimline interface? No awful tiles, or confusingly located power options? Those were the days. Although Windows 10 has taken the best of that world and merged it with the pinnacle of Windows 8.1, it still has plenty of room for improvement.

Take the Start menu—it's the cornerstone of Microsoft's operating systems. A crucial tool for providing quick, easy access to a wide array of features at the click of a button. Unfortunately, Windows 10 has to make do with dragging 8.1's wanton tiles kicking and screaming to the gates of modern interface design, making it still clunky at times. Be honest—when was the last time you clicked one of them?

So what can we do to make Windows 10 more like Windows 7, while keeping the features we do enjoy, such as task view and DX12? First thing is removing those pesky Windows 8 cast-offs. Right-click and unpin the lot of them. Then hover the mouse over the right-hand edge of the Start menu, and pull it to the left. This gives you a very functional, compact Start menu, just like the good old days, but with fewer links. Then, of course, it's time we removed Cortana's cumbersome search box, too. Right-click the taskbar, head up to Cortana and select "Hidden" from the drop-down menu. Voila—a clean, simple taskbar.

↘ submit your How To project idea to: comments@maximumpc.com

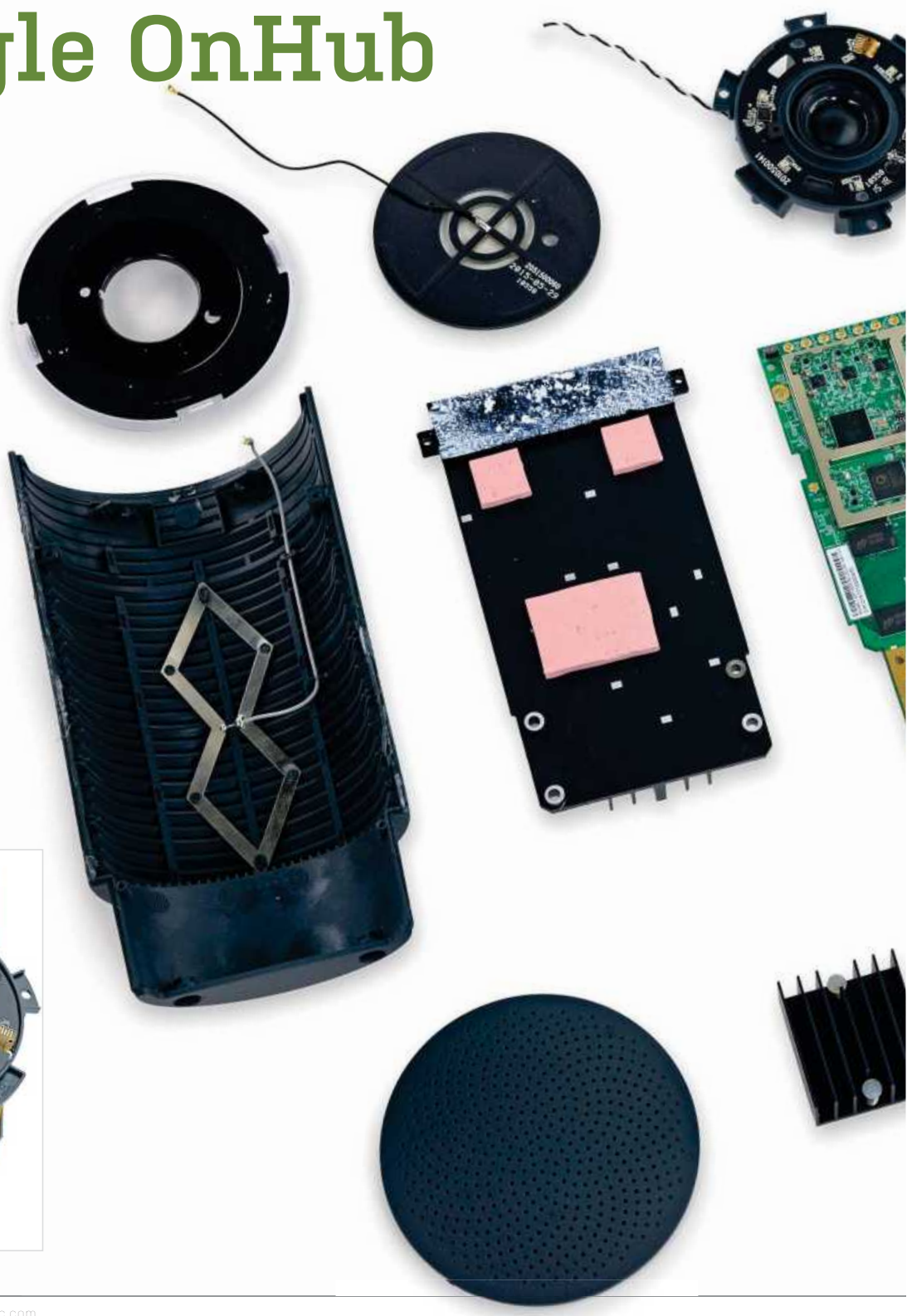
IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

Google OnHub

The guts and glory of Google and TP-Link's in-home Wi-Fi hub.



The world's largest speaker for a router. Wait... what?

Stunningly good-looking for a router.

BACKGROUND:

Google is on a mission to reinvent the router, and we got our hands on its first foray into the home-networking market—the Google OnHub. With a sleek design, hefty price tag, and a host of unique features, we're excited to see what it's rockin'.

MAJOR TECH SPECS:

- Dual-core 1.4GHz CPU
- 4GB e-MMC flash storage
- IEEE 802.11b/g/n/ac
- Dual-band 2.4GHz and 5GHz 12-antenna array
- Congestion-sensing radio and antenna
- USB 3.0 port and Bluetooth 4.0
- 1GB DDR3L RAM

KEY FINDINGS:

- Luckily, the outer cowling comes off with a simple twist. As you can't plug any cables in without shucking that shield, it has to be simple. Under the hood we see the real branding on this guy—Google has contracted with TP-Link for the first iteration of the OnHub. We also get a peek at some of the components—there are plenty of antennas here.
- There are 12 cables across the top of the device (six 2.4GHz antennas and six 5GHz), plus the congestion antenna along the side, and a final coax cable on the other side. Google seems to have some kind of color coding system, which might help for repair, but the board markings give no hints
- Peeling off the second half of the shell, we find an interesting antenna arrayed in a double diamond. The OnHub's antenna array is revealed in all its Lovecraftian glory, the antenna leads looking spookily like tentacles.
- Look at that enormous speaker. Why does Google's router need a 3-watt speaker? Turns out, OnHub uses a loud tone to pair with Android devices running Google's companion app—but will it feature sick beats in the future? The hexagonal speaker enclosure has disturbing similarities to the Galactic Empire's logo.
- The heatsink serves as a reflector dish, pushing that extra bit of Wi-Fi to the far corner of your house where you need it most. The components in this thing have been pretty big so far, and the heatsink is no different. Prizing up the metal mass reveals some equally hefty thermal pads.
- OnHub Repairability Score: 4 out of 10 (10 is easiest to repair). The speaker is replaceable. The device is mostly assembled with clips—better than adhesive but can break during disassembly. With all ports on a single board, fixing a loose USB port means soldering. Tiny antenna connectors are fragile and prone to breaking during disassembly. This is a fairly complex device—and with no repair documentation, disassembly and reassembly are especially difficult.

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

Stream TV with a Raspberry Pi

YOU'LL NEED THIS

RASPBERRY PI 2
The brilliant mini-computer costs under $45. See www.raspberrypi.org.

USB PORTABLE DISK
Ideally a self-powered disk that doesn't draw power from the Raspberry Pi.

MANY OF THOSE SET-TOP BOXES hidden under televisions are already running Linux. And despite their lack of CPU power, they're all more than capable of recording and playing several channels at the same time, as well as streaming the data across your local network. The Raspberry Pi is perfectly suited to this, too, and with the appropriate hardware it can be turned into a powerful low-cost digital video recorder, complete with media streaming, scheduling and time shift.

The appropriate hardware is the key phrase in the previous paragraph, because a painless installation is mostly dependent on your television-grabbing hardware 'just working'. Fortunately, Linux has support for a great many such devices built in to the kernel, so many will work without modification. And while these instructions start from the command line, we've split the entire tutorial into 10 different steps, hopefully making the project as easy to follow as possible. –GRAHAM MORRISON


A

1 THE HARDWARE

We tested and configured two USB receiver devices, one for grabbing terrestrial digital television through an aerial and another for grabbing the data from a satellite feed. We'll include instructions for both. For DVB-T (terrestrial) reception, we used a Sundtek MediaTV Pro, for DVB-S (satellite) reception, we used the Sundtek SkyTV Ultimate. The latter includes a 12v power adaptor that also needs to be connected. But here's the most important requirement: these USB devices must be attached to the Raspberry Pi [**Image A**] through a powered USB hub.

» We wasted two days trying to configure the system, firstly without a hub and secondly with an incompatible hub. In both cases, everything appeared to work but the devices wouldn't find any television channels in a scan. Switching to a powered hub compatible with the Raspberry Pi solved the problem, so we can't emphasise this point enough. Plug a hub into a power supply, connect your USB receiver to the hub and the hub to the Pi. And don't forget to connect the aerial or satellite feed to your receiver.

2 EXTERNAL STORAGE

We're assuming you've got a Raspberry Pi pre-configured and updated with the Raspbian distribution. We're also assuming it's connected to the internet and that you're typing your commands into the console directly or over an SSH session. Our next consideration is going to be where you store the television recordings. We'd recommend connecting an external USB hard drive, as the constant read/write access will test the average SD card to its limits. To add storage like this, simply plug the device into a spare USB port and check the output from the system logs by typing

```
tail /var/log/messages
```

You'll see output similar to usb 1-1.3.4.2: New USB device, and you'll need to look for the device identifier, which should look something like sda: sda1, where sda is the device itself, and sda1 is a partition. Type:

```
sudo mkdir /mnt/storage
```

to create a mount point and

```
sudo mount /dev/sda1 /mnt/storage/
```

to connect it to your external device [**Image B**].

3 INSTALL THE DRIVERS

Depending on the television hardware you're using, this step might be unnecessary. If you've chosen a device that's compatible with Linux and requires no additional driver files, then you can simply plug in your device and move on to the next step. For our Sundtek devices, we need to download and install a driver. This is easy. From the Raspberry Pi command line, type:

```
wget http://www.sundtek.de/media/sundtek_netinst.sh
chmod 777 sundtek_netinst.sh
sudo ./sundtek_netinst.sh
```

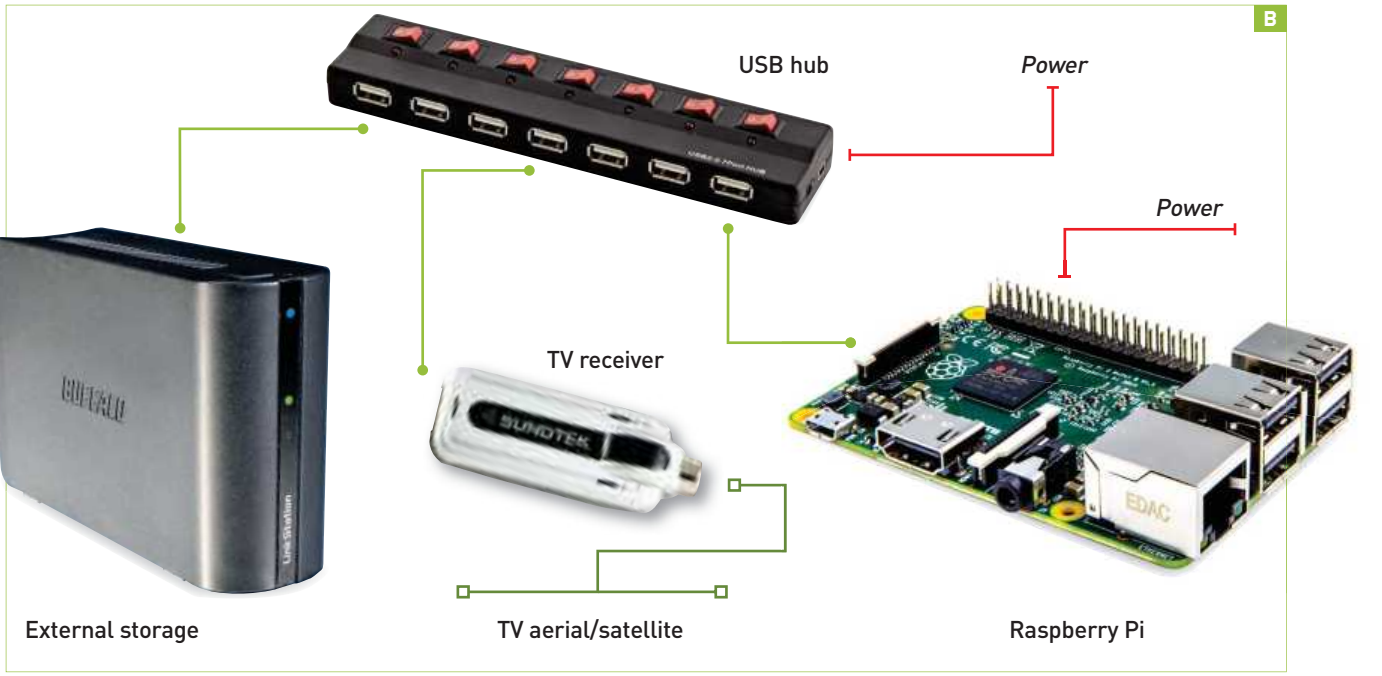
The final line will execute the script that's downloaded in the first line. It will then detect the system you're running and install the latest version of the drivers. It will leave the drivers running and configured to launch at boot. For users of the DVB-T version, you will also need to execute this command:

```
/opt/bin/mediaclient --setdtvmode=DVBT
```

This will ensure the card is configured for terrestrial reception, rather than a 'cable' source, which the device is also capable of.

4 INSTALL TVHEADEND

The piece of software we're going to use to record and stream the digital television signal is called Tvheadend. There's a plugin for Kodi (http://kodi.wiki/view/Tvheadend_PVR) that will turn this awesome media player into a fully-fledged digital video recorder, with Tvheadend doing the hard work in the background from



your Raspberry Pi. Because Tvheadend is a tool that's constantly being developed, we used the development version, but you could just as easily use the OpenElec distribution instead of Raspbian if you wanted to skip this step. Fortunately, building it is easy. First, install the development and DVB tools:

```
sudo apt-get update
sudo apt-get install unzip libcurl4-openssl-dev pkg-config git build-essential dvb-apps gcc-4.7
```

›› The final step you need to perform here is to download the latest version of Tvheadend from the developer's repository using git. You'll then be able to build it using the build trinity of ./configure, make and sudo make install:

```
CC=gcc-4.7 ./configure; make; sudo make install
```

5 CONFIGURING TVHEADEND

Now we need to start the actual program. As this is the first time, we're going to run the service in Configuration mode, and as a daemon, which means it becomes a background process. To do this, type the following:

```
tvheadend -C -d
```

Now open a browser, preferably from another machine on the network, and enter http://ip_of_rpi:9981/extjs.html [**Image C**] You can discover the IP address of your Raspberry Pi by typing ifconfig and looking for the value next to the 'inet addr' field for the 'eth1' device. Your browser will load the default front-end to Tvheadend. This is where you'll eventually see all your program data and set up and view recordings. We need to tell it how to use the TV hardware we've connected. This can be done by clicking Configuration → TV Adaptors and selecting your device from the drop-down menu on the left.

›› As the next steps are going to depend on whether you're receiving a satellite signal or a signal through your aerial, we're going to briefly separate the next steps for more clarity. For satellite receivers, carry on. For terrestrial reception, jump to step 7.

ADD KODI AS A FRONTEND

In our opinion, the best way to use Tvheadend is with Kodi. It includes a plugin that can talk with Tvheadend directly, downloading the EPG from your Raspberry Pi, and enabling you to watch live channels, and schedule and watch recordings. It's simple to set up – just visit Kodi's PVR plugin page at http://kodi.wiki/view/PVR.

One of the better things about Kodi is that it's truly cross-platform. Not only are there versions for Windows, OS X, Linux, and Android, but there are also versions available for the first two generations of the Apple TV and even jailbroken iOS devices.

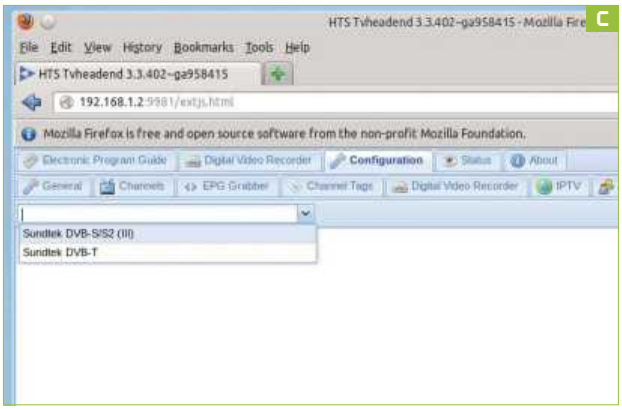
The best way of getting Kodi onto your Pi though, is through the OpenELEC (Open Embedded Linux Entertainment Center) distribution. The version at the time of writing is the third release candidate of version 3.0, so there's a good chance the final version of 3.0 will be out by the time you read this. The download is a tar.bz2 file, and you should first decompress this with a double-click on your desktop, or

```
tar xvf OpenELEC-RPi.arm.tar.bz2
```

on the command line. Insert your SD card reader into your Linux box, and use the output from dmesg to ascertain which device it's been given. It's usually something like /dev/sdc, but you need to be certain, because if you get it wrong you will lose valuable data, as OpenELEC is written directly to a different device. When you know the name of the device, enter the folder that was decompressed and type

```
sudo ./create_sdcard /dev/sdX
```

replacing the device node with your own. After the process has finished, you'll have a working version of Kodi booting directly off your Raspberry Pi. It doesn't get much easier than that.



6 SATELLITE RECEPTION

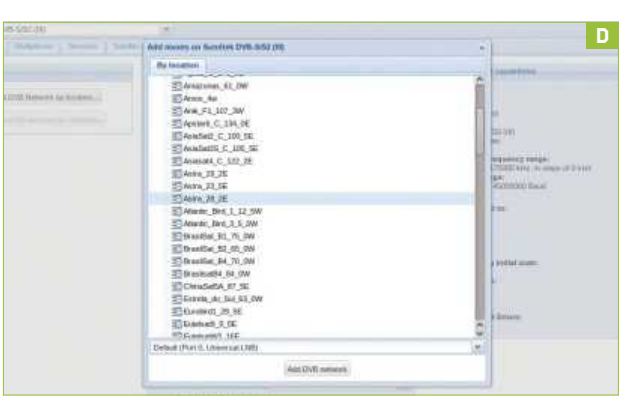
Satellite TV reception is easiest to configure. With the adapter selected, the General page will show an overview of the configuration. First, click on the Enable tick box, followed by Save. We want to add some channel information, and this is done by adding the data for finding a satellite and the multiplexes it provides and then searching these multiplexes for channels that can be received. Tvheadend bundles the data for satellite location, so you just need to click the Add DVB Network by location button on the left. This will open a window containing a global list of satellites [**Image D**].

» After selecting the satellite, Tvheadend will add a list of multiplexes associated with that satellite to the Multiplexes tab. These will now be scanned for channels, and you can watch the scanning progress in the Capabilities box on the right of the General page.

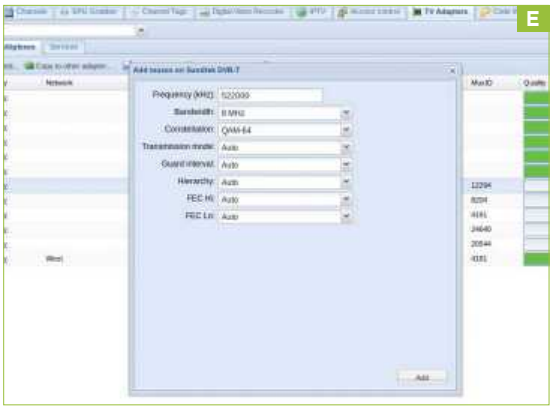
» If everything is working properly, you should see plenty of services (channels) detected and added to the Services page. For our chosen satellite, we detected 970 services from 98 muxes. Unless you want to also configure your system for terrestrial viewing, skip to step 8.

7 TERRESTRIAL RECEPTION

First, enable the receiver in the general page. Tvheadend includes a broad database of transmitters pre-configured with the details for each multiplex. You'll need to know which transmitter your aerial is pointing at. We've found that www.antennapoint.com is a convenient site for telling you which transmitter you're likely to be using. When you know, you simply need to click on the Add DVB Network button from the adaptor's General tab and find the transmitter "By location". Our local transmitter wasn't listed. If you're not sure what you need to recieve digital TV transmissions, the FCC has a guide at http://www.fcc.gov/guides/antennas-and-digital-television.



ANOTHER RPi TUTORIAL NEXT MONTH



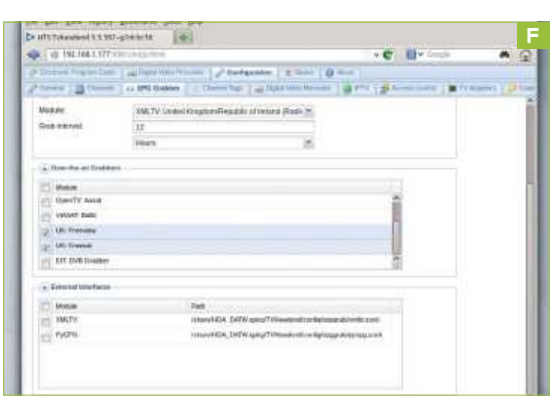
» If you already know the details for each multiplex, you can add them manually. This can be done from the Multiplexes tab for the adaptor by clicking on "Add mux(es) manually." In the window that appears, you will need to enter the frequency, bandwidth and constellation for each multiplex, while setting everything else as Auto. This data can be gleaned from the FCC website. You'll typically need to do this for three or four muxes, depending on your location. Tvheadend will scan them for services and add them to your configuration [**Image E**].

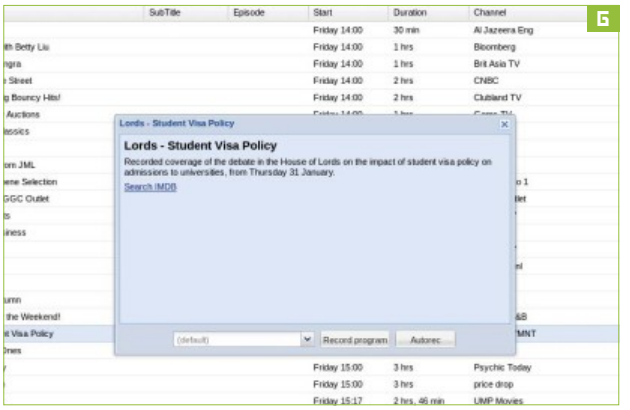
8 ADDING CHANNELS

You've hopefully got a healthy list of services extracted from the multiplexes. The next step is to allow Tvheadend to divine TV channels from those services, and this can be done from the adaptor's General tab by clicking on the Map DVB Services To Channels button. You'll hopefully be left with a list of channels to watch in the Channels page outside of the adaptor configuration area.

» The default location for recordings will need to be changed—probably to the mount point we created at the beginning. The location can be changed by selecting the Digital Video Recorder page and changing the Recording System path. You must save the configuration on this page for any changes to take effect [**Image F**].

» You will also need to configure the electronic program guide. There's usually a minimum of What's On Now and What's On Next embedded within each channel, but plenty of services transmit a much more comprehensive seven-day EPG. These can be enabled by selecting the EPG Grabber page, followed by clicking on either service in the Over-The-Air-Grabbers section. Don't forget to click on Save Configuration.





G

H

9 RECORD A PROGRAM

After a while, you should notice the Electronic Program Guide page starts to populate itself with the broadcasts you can now watch or schedule to record. Clicking on any program will open another window, allowing you to set up a recording. A secondary option, labelled Autorec, is more interesting. It sets up a search based on the same program data so you can record a full series without relying on series link data being embedded within the EPG [**Image G**].

›› Depending on the number of channels and the amount of EPG data, this view can get unwieldy quickly. To solve this, you can filter what's shown using the row of options at the top of the list. You can search for part of a title, or limit the list to a single channel or filter tag. If you find a filter you like, clicking on the Create Autorec button will add that search to Tvheadend, which will then record everything it finds that matches the search. To remove scheduled recordings, click on the Digital Video Recorder tab. Upcoming recordings can be removed from the first page, while Autorec filters can be removed from the last. The centre pages can be used to play or delete recordings that have been made, or check why a recording might not have worked.

10 WATCHING RECORDINGS AND LIVE TV

Install the VLC browser plugin, and you can watch your recordings and live TV in your browser. We've only tried this feature in Firefox, but when you click on a program that's being broadcast, you get the option to Play. If the VLC plugin isn't installed, you'll be asked if you want to install it.

›› With the plugin installed, an embedded window appears showing the program. With the controls at the top of this window, you can watch full-screen or pause the current broadcast. You can watch programs you've recorded in the same way from the DVR page [**Image H**].

›› If you'd rather not use a browser, drag and drop the network URL into VLC on a different machine, or read one of our file sharing tutorials to learn how to share the recordings folder across your network.

TAKE REMOTE CONTROL OF KODI

One essential component you'll need when connecting Kodi to a television is a remote control. This being Linux, there are as many different solutions as there are distributions. You can configure infrared receivers and transmitters using LIRC, for example, or buy devices that can be programmed to send keyboard controls. But the easiest is to use your mobile phone. This is because there's an official app for both Apple and Android devices that's free to download and install, and it will send control signals to Kodi without you having to worry about things like line-of-sight or signal strength.

For the Android remote to work, you first need to enable Allow control of Kodi via HTTP in the Settings→Services→Webserver menu. This actually launches a web server running from Kodi, so you can now use any web browser pointed at port 8080 of the IP address on your Kodi machine, such as http://localhost:8080.

When the app is installed on your Android device, all you need to do is press the Add Host button. This opens a new window to configure the Kodi server. It looks intimidating, but it's actually easy. Just enter something descriptive into the Description field, plus the IP address of the machine running the client. The IP address can be divined by either using your machine's networking applet or by typing ifconfig on the command line. You also need to make sure the ports are set to 8080 and 9090. Click on Save and you should now be able to control your Kodi session remotely. We've found the Remote Control option from the main menu is the most useful, as this turns your phone into a physical remote control, but the other options can be used for managing your content.

Turn your PC into an Android tablet

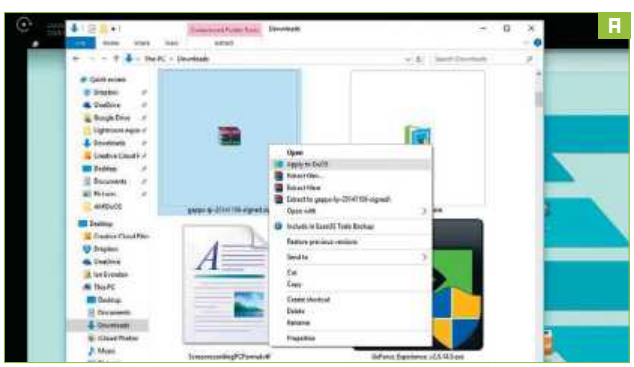
YOU'LL NEED THIS

WINDOWS 7 OR NEWER
HDD or SSD with additional unused space, AMIDuOS, and Google account.

THERE ARE SOME THINGS YOU CAN DO WITH A PC that may not serve a great deal of practical use, but are just satisfying to do. Guest operating systems and virtual machines come under this header for most people—although there are serious applications of the technology for those developing phone or tablet apps and looking for a safe environment to test them in.

AMIDuOS is one such thing. It's a paid-for app ($10) that comes with a 30-day free trial, and it simply runs an Android session as a desktop app on your PC. You interact with the app just as you would with your phone, tapping and sliding your way across the screen as though the mouse and keyboard somehow weren't the finest way to interact with an electronic device.

PC users of a certain age will be delighted to see the program is made by venerable BIOS manufacturer American Megatrends too. **–IAN EVENDEN**


A

1 HIT THE BIOS

Just like running multiple copies of Windows inside one another, like a Russian doll of Bill Gates, you can only run AMIDuOS if your CPU supports virtualization and has it enabled in the BIOS. Any recent Intel or AMD chip should manage this, but it's worth checking that it's switched on. Poking about in the Z77 chipset of an old PC we use to keep the door open on warm days, we found the option nestling under "Advanced → CPU Configuration". Other motherboards will almost certainly differ.

2 DOWNLOAD AND INSTALL

What sounds like it's going to be a torturous procedure has actually been made extremely easy, as long as you've followed step one. Point your browser at www.amiduos.com, download the latest version of AMIDuOS (you'll want Android Lollipop unless there's a reason to go for an older version), download the file, install it, then double-click the shortcut. It's that simple. You're taken through the first-time setup procedure as if you'd got a new Android device for Christmas, which involves signing in with a Google account, creating a new one if—like a Frenchman in a castle—you've not already got one.

3 GET SOME APPS

By default, your new virtual Android tablet will have a minimum of apps installed—there's a web browser, email app, calculator... and that's about it. Happily, it also comes with the Amazon App Store app, which often gives away free apps via its new Underground cousin, and this is your initial gateway to Android functionality. You need an Amazon account to get anywhere, though, but it's a simple matter of signing up with an email address and password.

4 GET GOOGLE PLAY

You can get the Google Play app store too, and it's only a bit more complex—this involves downloading a ZIP file to your PC, right-clicking it in Windows, and


B

THE GOOD SHIP LOLLIPOP

Lollipop is Android 5. Google's habit of naming its OS releases after sweet treats is seen by some as friendly, and by others as teeth-gnashingly awful.

If given the choice between installing Lollipop or its predecessor KitKat as you download AMIDuOS, you should always choose the newer operating system, unless you have a very good reason for stepping back in time.

One such reason might be app testing. While Google's statistics show that around 20 percent of Android users are on Lollipop, almost 40 percent use KitKat, and another 30 percent still use the even older Jelly Bean iteration, and these users need to be supported.

If you're just using it to run apps on your PC, though, stick to the latest version—it's a much better-looking and slicker-running experience all round.

selecting "Apply to DuOS" [Image A]. It then installs just like any other Android app. Speaking of which...

5 INSTALL APK FILES

Should you find yourself with any legally acquired Android apps in the form of APK files—perhaps ones you've developed yourself—you can apply them to AMIDuOS in exactly the same way.

6 SHARE FOLDERS WITH WINDOWS

Within your virtual Android tablet's Settings app is an "AMIDuOS" section that allows Android to access folders on your PC. Tell it the location of your music, photos, and videos, and they appear as if they were saved on the tablet's built-in storage—you can even edit pictures and save them back to your PC. The virtual machine hives off 16GB of storage for itself, but anyone who's bought an iPhone recently will know that's not enough, and this feature allows it to use your expensive, high-speed PC storage as a giant microSD card [Image B].

7 ACTUALLY USING THE THING

Anyone with a Surface or other touchscreen laptop can interact with Android as God intended, but those with a mouse or trackpad have to use the pointer as a finger substitute. Pinch to zoom is a little more complex, because you need to activate gestures using Ctrl-Alt-T, then use I and O to zoom.

8 SCREEN ORIENTATION

Android is displayed by default as if a tablet was being held in the portrait orientation. A button in the top-left corner allows you to switch it to landscape. If you're using it on a Windows tablet with tilt controls, however, you might find they don't have any effect, as this is an area of ongoing development—instead, you can map keyboard commands to do the job using the Input Mapper you'll find in the Settings. This is the best way to play games that rely on tilt inputs, such as *Real Racing 3* [Image C]. Support for mapping controls to gamepad inputs is currently being worked on.

9 CAMERAS AND OTHER INPUTS

AMIDuOS can use your PC's camera, microphone, and speakers if they're connected, using them just as it would on a phone. Your PC's keyboard is fully supported too, so you don't have to try to use a touchscreen keyboard with a mouse, and if your PC is hooked up to Ethernet, it appears to the emulated OS as the strongest of Wi-Fi signals.

10 PIN TO START MENU

For a speedy way to access an Android app, you can add a shortcut to Windows. Tap and hold an app, and the "Android Uninstall" and "Info" buttons appear, with a new addition. Drag the app to "Pin to Windows", and a shortcut is made.

ELECTRIC SHEEP

1. ARC WELDER

This Chrome extension allows Android apps to run in the browser window, but don't expect to head over to the Play Store and start loading up on games. It's aimed at those who develop their own apps, and have them available as an APK or ZIP file. It only supports one app at a time, and is a tiny bit buggy too.

2. BLUESTACKS

Very similar to AMIDuOS, Bluestacks comes with more apps installed by default but is slightly more annoying to run, as it constantly bugs you for $2 a month, or to install apps promoted by its partners. The focus is on running Android games, and the program acts more like a simple app launcher than a full-fledged operating system.

3. VISUAL STUDIO EMULATOR FOR ANDROID

Now available as a standalone product, Microsoft's Android emulator is easy to install and runs fast —but doesn't come with Google Play, so you're stuck with using apps you've written yourself or are able to acquire as an APK file.

Making Minecraft Beautiful

YOU'LL NEED THIS

MINECRAFT ACCOUNT
You need a legitimate account—version 1.7.10.

WINDOWS OS
Whatever version of Windows you're running, it needs to be on a powerful gaming PC.

POSSIBLY ONE OF THE MOST POPULAR GAMES of all time, *Minecraft* has provided a platform to make all sorts of weird and wonderful constructions. However, in comparison to some games power users play today, it seriously lacks graphical fidelity. Vanilla *Minecraft*, even with the most high of high-resolution texture packs, is hardly comparable to any modern graphical wonder. Until now. You've probably seen shader and light packs in *Skyrim*, *Witcher*, even *GTA*, but have you seen them in *Minecraft?* It's a game that can benefit the most from an increase in graphical fidelity. After all, when your entire game consists of square blocks, the opportunity for shadows and other lighting to affect this voxel-based universe is astronomical. It can change your experience entirely.

If you're looking to really max out your system, there's no better way than throwing shaders into *Minecraft*. Our test system for *Minecraft* shenanigans consists of a lowly Core i5-4670K, running alongside 16GB of RAM, and a GTX 980. We still only managed to pull 20fps at 1440p with some of the best shader packs out there. –ZAK STOREY

1 GET A FRESH COPY OF MINECRAFT

You're going to want to get yourself a legitimate copy of *Minecraft*. Unless you already have an account, head over to https://minecraft.net and purchase a copy of the game. Once you have done this, download the .exe. If you already have an install, it's advisable to remove the entirety of the .minecraft folder by typing "%appdata%" in the file explorer and deleting the .minecraft folder. (Remember, this will delete your local saves, too, but you can back these up by copying the save folder found in the .minecraft folder to your desktop, then returning it after the clean install.)

2 RUN THE .EXE AND SET UP VERSION.

Next you want to run the Minecraft.exe. To make life easier on yourself, move the executable somewhere you won't lose it—My Documents is a good start. Once you've run the .exe and logged in, click "Edit profile" at the bottom-left of the window. This should open a new window with a whole range of options. Two-thirds of the way down the page, you should see a drop-down menu called "Use version." You need to change this to 1.7.10 [**Image A**]. This is currently by far the most up-to-date and easiest version to set up shaders on. After you've changed the version to 1.7.10, hit "Save profile" and load up the game.

3 SHADER TIME!

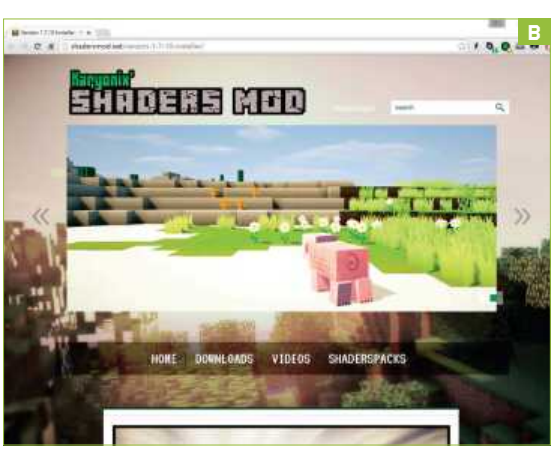
Once you're at the main menu, close the game. Now you want the core shader mod. You're going to have to traverse your way through shark-infested waters, filled with advertising and AdFlys. Head to http://bit.ly/MCShader1710 [**Image B**] to go to the Minecraft Shaders website. Then you want to scroll down to the bottom and select the "Download" tab. Next, simply hit "Link 1 Shaders Mod v2.3.29 Non-Forge Edition." This takes you to an AdFly page—simply wait five seconds and hit "Skip ad" in the top right-hand corner, then the ShadersMod file downloads.

4 FALLING IN LOVE WITH JAVA

You need to open these files with the Java applet. If you don't have this on your system, get yourself over to http://ninite.com, select "Java 8" from the "Runtimes" tab and click "Get Installer." Run the installer and let Ninite install the latest version of the Java applet for you. Ensure *Minecraft* (both game and launcher) is closed, then right-click on the Shaders Mod file you downloaded earlier, and select "Open with Java." It asks you whether you want to install it into your Minecraft directory—click "Yes." Hit "OK" at the license screen, and then "OK" one more time as it informs you what profiles it has added. And you're done.

5 DOWNLOAD THE RIGHT SHADER PACK

Now you have the mod installed, you need to grab yourself some shader packs. The easiest way to



do this is to head back to http://bit.ly/MCShader1710 and click the "Shaderspack" tab in the top-right. Continuum Shaders are incredibly taxing on your system (remember our 20fps earlier?). Sonic Ether's Unbelievable Shaders are the standard go-to shaders—they're quite the system drain but nowhere near as severe as Continuum, and they still look stunning. Sildur's shaders are a little less system draining, yet still make the game much more enjoyable, and so on. Head over to each of the forum links and take a look to see which ones appeal to you the most. Then download as many as you like, as you can actively swap between them in-game.

6 INSTALL SHADER PACKS

After traversing through myriad AdFly browsers and other garbage to retrieve your downloads, head back over to your %appdata% minecraft folder. Create a folder inside the .minecraft directory called "shaderpacks," then inside this folder place the zipped downloaded shader packs (but do not unzip them).

7 HEADING BACK IN-GAME

Open up the *Minecraft* launcher. This time, hit the drop-down menu next to "Profile," select "1.7.10-ShadersMod," and launch the game. Load up a new world, or one of your previous ones, and hit Escape. Select "Options" and you should have a new tab below "Video Settings" called "Shaders." Click that, then choose which shader pack you wish to try out from the list on the left, and you're good to go [**Image C**]!


C

8 AVOID GRAPHICAL ERRORS

If you encounter any graphical errors when playing *Minecraft*, it may be that the shader pack just doesn't support the graphics drivers you're using. If this is the case, you're going to have to swap them out for a different set. In our testing, using a GTX 980, we found that Continuum and Sildur's shaders worked best, while Sonic Ether's were a little hit and miss, depending on which version we used. Additionally, we did try to get it to work with OptiFine but found more bugs than answers.

RESOURCE PACKS

What better way to top off all of this lovely creativity, than with a nice high-resolution texture pack? These are all down to personal taste, of course, but you can find a wide selection over at www.curse.com, and there is no annoying advertising that needs to be circumnavigated either. However, if you're looking for the pack we used in the screenshots for this tutorial, head on over to http://atherys.com/pack.

A quick word of warning though—due to the nature of all these mods being mostly community supported, programs such as OptiFine MCPatcher and other such mods can conflict with both ShaderMods and other HD texture packs. You may ultimately have to decide between one and the other, at least until OptiFine releases a variant of its add-on with the shaders mod included.

BUILD IT

ALEX CAMPBELL **ASSOCIATE EDITOR**

Caged Power: All on Display

If you've spent loads of cash on cool components, why hide them away in an enclosed case?

LENGTH OF TIME: **2 HOURS** | LEVEL OF DIFFICULTY: **MEDIUM**

ASSEMBLING THE CAGE

IT'S BEEN A GOOD YEAR for new PC products, and we thought that including some of them in our end-of-the-year issue would be more than appropriate. It also helped that Max, from our video team, wanted to build a new rig into an open-air case by In Win that he'd bought. So we figured: Why not? This is the Holiday issue, after all, so we decided to get into the spirit.

Most of the time, our builds end up in PC cases that enclose the guts on all six sides. Even if there is a side panel window, five out of six sides remain mostly or totally opaque. That means that the case is on display, not the parts inside. Seeing as the case costs only a fraction of the price of the PC, it's a shame to hide all those parts away behind sheets of black steel and aluminum.

We wanted to try out this open-air case because it gives us a chance to look at those parts that are too often hidden away. But with beauty comes pain. An open-air case like this one presented some unique challenges for our build.

Even with those challenges, we were happy with the final result, and hope that Max isn't too upset when we have to take back some of the parts and keep them in our lab. Sorry, Max.

ROUNDING UP THE PARTS

WHEN WE SET OUT to do this build, we wanted to include some shiny, new parts. This, of course, meant we had to go with Skylake; we've been overdue for a build that used Intel's latest architecture. For graphics, though, we had a choice: We could go lower-end with the recently released GTX 950, or go bigger with the AMD's R9 Nano.

Guess which way we went. More power is sexier, so we chose the Nano, which fitted well in this mini-ITX build. The CPU and GPU found a home on the Gigabyte GA-Z170N motherboard, which supports DDR4 and offers wireless networking too, with its mini-PCIe Wi-Fi card. We had an EVGA Z170 board, but the included Wi-Fi was a good reason to pick this board over the other. We just wish that the mobo came with on-board power and reset buttons, like the EVGA model. As this is a Z170 board, we had to go with DDR4 memory. We got a couple of 8GB sticks of 2,666MHz Corsair Dominator.

All of our parts found a comfy, airy home in the In Win D-Frame Mini. While Max chose the orange and blue frame, it also comes in black and red. The cool thing about it is that there's no clear top or bottom; you only need to worry about access to ports and buttons.

The 750W power supply is plenty for the parts we chose, and as mini-ITX is limited to one GPU, there's no need to worry about extra headroom for SLI or Crossfire. However, the extra wattage does allow for single-GPU upgrades, or the addition of spinning drives.

INGREDIENTS

PART		STREET PRICE
Case	In Win D-Frame Mini (orange)	$250
Motherboard	Gigabyte GA-Z170N	$165
CPU	Intel Core i7-6700K	$360
Memory	16GB (2x 8GB) Corsair Dominator Platinum DDR4 2666	$170
GPU	AMD Radeon R9 Nano	$650
PSU	BitFenix Fury 750G 80 Plus Gold	$121
SSD	Samsung 850 EVO 2TB	$800
CPU Cooler	Deepcool Maelstrom 240	$177
Total		$2,693

1 HOT STUFF

THE RADEON R9 NANO is quite a powerful GPU, given its tiny form factor. However, we noticed that it got pretty toasty when we ran our graphics benchmarks. While normal closed cases could solve this by channeling air through the case, we were low on options because there was no way to effectively push extra air over the card. The air coming from our CPU radiator was nice and cool, but the slight offset of the motherboard meant that the Nano wouldn't get any of the cool breezes. Placing the "front" glass panel on the case helped a little bit, but the Nano breathes best with a little extra air flow from a case fan.

If we were to redesign the case, we'd like to see an extra removable bracket for a case fan, just below the GPU mount. This would better support the use of extra-toasty GPUs, which would usually have more forced air, to stay a little cooler under load.

2 SIDE MOUNTED

THE PSU is the heaviest component in nearly any build, so mounting it on the side of the case might seem counter-intuitive. Not so, with the D-Frame. The PSU happily occupies a bracket on the side of the cage, but doesn't make the cage feel off-balance.

To make things neater, we went with individually sheathed cables, which are easier to manipulate. Routing the cables was a bit tricky with a smooth aluminum plate, instead of a motherboard tray rife with cable-management tie loops. Luckily, the cage came with a few accessories that helped.

We used a modular power supply, so there's no need to stash unused cables. That's a big deal in a case where there are no hiding places for your cabling.

3 USB 3.0 WOES

IF THERE WAS ONE BEEF we had with this motherboard, it was the positioning of the USB 3.0 front panel connection. After you figure in the presence of a GPU, it became clear that there was no sexy, clean way to attach the cable.

To the left, you have the R9 Nano, and routing under the GPU between the PCIe slot and the "back" panel was too tight a squeeze. If we came from below, the cable would have routed across the memory and CPU. We decided to run the cable over the "top," which places it over a pair of USB ports and the Wi-Fi antenna connectors. The result was the best of a bunch of less-than-ideal options. If there's an upside, it's that the USB cable is braided, which makes it at least look good, even if it is in the way. Then again, some may like the appearance of cables jutting out of the mobo, giving it a cybernetic look. We won't judge.

4 SILENT STORAGE

WITH THE RECENT RELEASE of the 2TB Samsung 850 EVO, we thought it would be perfect for a mini-ITX build. Having two whole terabytes available on an SSD is pricey, but it has its advantages: It eliminates the need for a small HDD for Steam games or media files, and there's one less moving part to fail from frequent moves to and from LAN parties or events.

It's easy to forget that an enclosed case muffles the sound of fans, and hard drives searching for, reading, and writing data. The high-speed clicks of the hard drive disappear when using an SSD, leaving only the CPU cooler and GPU as noise sources.

The black finish on the 850 EVO is similar to the finish of the aluminum mount of the D-Frame, which makes the slim SSD seem to disappear. The downside is that the drive is a little too far from the edge of the plate (two or three millimeters), which made it a bit hairy when we tried using an L-shaped SATA cable.

5 DOMINATING THE CAGE

WHEN WE LOOKED for memory, we wanted to go big on capacity but we noticed that most of our DDR4 kits are 16GB, but in 4x 4GB kits. Bummer. As we searched, we remembered: We had a machine that could donate a few sticks. We grabbed two 8GB sticks of Corsair Dominator RAM from our 2015 Dream Machine, and used them.

As with most X99 systems, our Z170 board from Gigabyte defaulted to setting the RAM clocks of the 2,666MHz sticks at 2,133MHz. The problem was solved by upping the multiplier for the RAM clock. Leaving it at 2,133MHz wouldn't have hurt performance much, as RAM clocks are rarely a bottleneck now. In other mini-ITX builds, going with 2,133MHz DDR4 RAM would be fine in most cases, and you'll save a little coin by forgoing higher RAM clocks.

6 ONE COOL CAGE

ONE OF THE NEAT THINGS about this build was the way the cage accommodated our cooling solution. It comes with a bracket for a 240mm closed-loop cooler, which sits out of the way at the "bottom" of the cage. We were able to get our Deepcool Maelstrom 240 snugly in the bracket, with nary a screw to secure it in place. Other coolers might not stay put with friction alone, so the eight screw holes can be used.

The Deepcool chiller was our backup choice, though. We tried using a bigger cooler, but for some reason it wouldn't have good enough contact with our CPU, which resulted in some problems booting.

The main gripe we had using a 240mm cooler with this mobo was the lack of PWN pinouts. There's no CPU_OPT or second case fan pinout, meaning we had to do something to get three PWM connectors fit on two pinouts.

1 **The blue rubber bumpers on the D-Frame Mini enable you to position the cage in any orientation you like. They also stop the case from sliding around in your car's trunk on the way to a LAN party.**

2 **The extra room below the PCIe slot allows for full-length video cards. In our build, the Nano leaves this area sparse and clear.**

3 **Thumb screws allow for the attachment and removal of hard drive and cooler brackets, for tons of modularity.**

4 **The "front panel" is a bit of a misnomer in this cage, where there is no clear front, back, up, or down.**

BREAKING OUT

THROWING ALL OF THESE PARTS together in a cage was a lot of fun and was quite a different building experience. Such a build requires you to think more about the aesthetics of the build's entirety, since there's no hiding of cables or extraneous accessories here.

Like we said, though, an open-air case build is not without its challenges. One of those was the cooling system. We started off with a larger cooler that ended up not maintaining good contact with our CPU for some reason, so we had to go with the Deepcool we had on standby. Once we had the radiator and pump in place, we had three PWM connectors to plug in, but only two pinouts to work with.

We solved this in a roundabout way. First, we plugged the two fans for the radiator into the CPU and case fan pinouts. We then connected the pump to a two-pin Molex-to-PWM adapter. This had two consequences, which we weren't fond of. First, the two fans ran at different speeds, since each PWM pinout runs as a function of a different temperature sensor. The CPU fan is a function of CPU temps, as you'd expect, but the case fan takes temps from the motherboard itself. While we stayed at acceptably cool temperatures due to the large radiator, we wouldn't do this when overclocking, as the fan plugged into the case fan connector wouldn't rev up as temperatures increase. Not good.

The other side effect was that the water pump runs at full speed while connected to the two-pin adapter. Normally, you'd connect the pump to a four-pin pinout for the same reason you'd attach the radiator fans to them. However, we needed the pump to work, so we put up with this while we ran our benchmarks.

Our caged rig did pretty well in some aspects, while relatively poorly in others. In the single-threaded CPU benchmarks, the i7-6700K Skylake performed well, outpacing the i7-5960X in our zero-point. With a 240mm cooling setup, we believe this CPU could score even higher with overclocking. When we reviewed the CPU, the 6700K got a 17 percent boost from overclocking. Not bad at all.

When it came to the 3D application benchmarks, the little R9 Nano put up a good fight. Considering our beefy zero-point machine has three GTX 980s in SLI, a single GPU can hardly expect to beat it.

Despite having less than half the 3DMark score in Fire Strike Ultra, the Nano delivered playable frame rates in *Tomb Raider* and *Shadow of Mordor* at 4K. In *Batman: Arkham City* at 1440p, the 92fps means that there's plenty of power there to keep a FreeSync 1440p monitor synced and happy at 60Hz.

In the multithreaded test, x.264, the octa-core 5960X still reigns supreme, but for most gamers and enthusiasts who don't encode video all day, this build would perform nicely. And with its portable, unique form factor, it can be quite the conversation starter.

BENCHMARKS

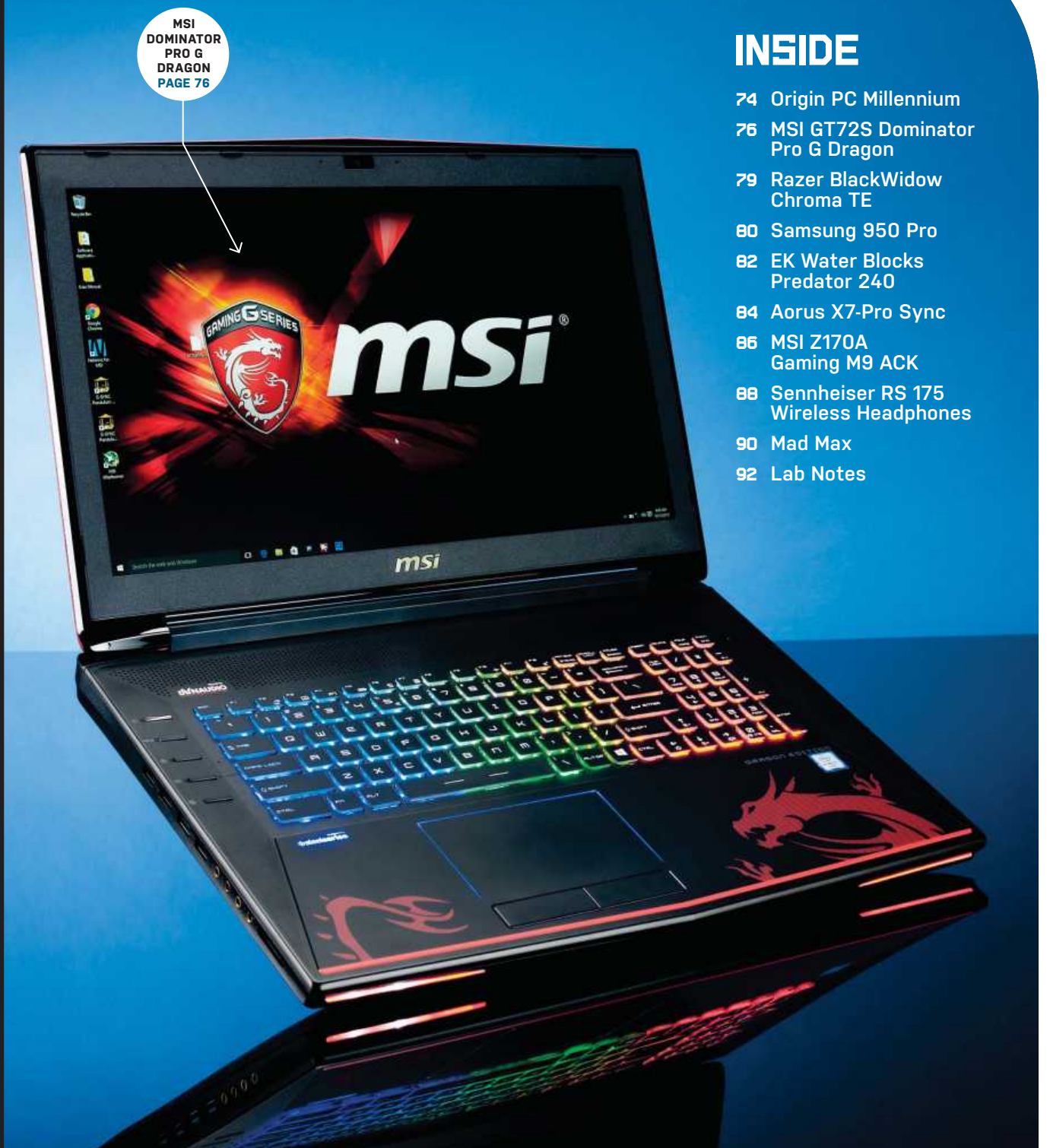
	ZERO-POINT	
Stitch.Efx 2.0 (sec)	806	781 (3.1%)
ProShow Producer 5.0 (sec)	1,472	1,442 (2.0%)
x264 HD 5.0 (fps)	33.8	19.54 (-42.9%)
Batman: Arkham City 1440p (fps)	204	92 (-54.9%)
Tomb Raider 2160p (fps)	87.5	36.6 (-58.2%)
Shadow of Mordor 2160p (fps)	70.1	40.2 (-42.7%)
3DMark FireStrike Ultra	8,016	3,362 (-58.1%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses a 5960X CPU, three GTX 980s, and 16GB of RAM. *Arkham City* tested at 2560x1440 max settings with PhysX off. *Tomb Raider* at Ultimate settings. *Shadow of Mordor* at Max settings.

REVIEWS

TESTED. REVIEWED. VERDICTIZED.



INSIDE

Origin PC Millennium

The Skylake's the limit

AS THIS MAGAZINE GOES TO PRINT, Intel's new, high-end Core i7-6700K (Skylake) CPU is still hard to track down. You can, however, find it in prebuilt OEM machines, and Origin PC proudly sent us its new Millennium Skylake system to test.

The system uses the same chassis, designed by Origin PC, as the Genesis we reviewed back in April. The key difference is that, unlike the Genesis, it does not include the bottom bay expansion with radiator and extra fans, and is thus a midtower build to the Genesis's full-tower setup. You can still orient the motherboard 90 degrees, or have it reverse-mounted (to face the other door), but ours has a traditional setup.

The case comes in a wide variety of colors; ours is black and grey. The Origin PC logo in the front glows red, and to top it off, there are RGB lights inside the chassis that you can tweak through a variety of 16 colors with a wireless remote. The front of the case has a swinging door that opens to reveal the Blu-ray burner and five 5.25-inch front bays, which is pretty cool. Inside our particular configuration was a single 6TB WD Red drive.

On top of the case, you've got a fan controller and four USB 3.0 ports. Inside the chassis, the cable management and wiring is top notch. This isn't to say the case is perfect, however. While the chassis uses a steel frame, the doors are plastic, feel flimsy, and are a huge pain to take off and put back on. To open up the case, you have to lift up a latch on the back, and the doors just fall off without warning. On top of that, we felt as though we were weakening the doors every time we took them off.

INSIDE JOB

Once you're inside the case, you'll notice the new star of the show. Intel's Core i7-6700K is a 95-watt TDP processor based on the 14nm production process. While the CPU carries a base frequency of 4GHz and a turbo speed of 4.2GHz, it's a heavily overclockable part; Origin PC pushed this chip to 4.8GHz. While we've experienced some over-aggressive overclocking from Origin PC in the past, this time around we encountered no blue screens.

For cooling, Origin has gone with a 360mm closed-loop cooler designed by Asetek. While it keeps the PC cool and quiet, it's a little disappointing to pay over four grand for a computer and not get a custom loop. Regardless, all of this sits atop an Asus Maximus VIII Hero. With this mobo, we're getting USB 3.1 and USB Type-C. Filling the RAM slots you'll find 16GB of DDR4 clocked at 2,666MHz in a dual-channel configuration. For speedy storage, Origin PC outfitted our config with a 512GB Samsung SM951 PCIe M.2 SSD. And, of course, who could forget the pair of GeForce GTX 980 Tis in SLI? These cards are overclocked to carry a base GPU clock of 1,195MHz, a memory clock of 1,853MHz, and a boost clock of 1,271MHz. Powering all of this is a 1,000W PSU from Corsair.

Now for the most pressing question: How does the Skylake CPU perform? Quite well, as it turns out. Its aggressive 4.8GHz overclock enables it to beat our zero-point's eight-core 5960X CPU by about 21–28 percent in our single-threaded benchmarks. In our multithreaded CPU benchmark, however, the octa-core was able to flex its extra cores to thrash the quad-core part by roughly 30 percent. If you're wondering how it compares to Devil's Canyon, we saw roughly a -2 to 12 percent difference in single-threaded tests compared to the Digital Storm Bolt 3's quad-core part we reviewed recently. We surprisingly saw a 14 percent bump in our multithreaded benchmark as well.

GPU performance was good, too. The two overclocked 980 Tis were able to best our ZP's three 980s by roughly 3–20 percent in all of our game tests. It did fall behind 5 percent in 3DMark Firestrike, but that's most likely due to the fact that the test leverages multiple CPU cores in its physics tests.

There's a lot to like about this Millennium, but there are a few things that keep us from wholeheartedly recommending it. Aside from the terrible doors, the PC is overpriced. For $4,370, you'd think you'd get a Haswell-E processor with more physical cores and a custom loop cooler. As it is, it should be a couple of hundred dollars cheaper, but perhaps that's just pie-in-the-Skylake wishful thinking. –**JIMMY THANG**

VERDICT 8

Origin PC Millennium

+ LAKE SUPERIOR Bold styling; good performance; plenty of storage.

– LAKE ERIE Overpriced; terrible doors; no custom loop.

$4,370, www.originpc.com

SPECIFICATIONS

Processor	Intel Core i7-6700K @ 4.8GHz
Mobo	Maximus VIII Hero
RAM	16GB of DDR4/2666
Graphics	2x GeForce GTX 980 Ti
Storage	512GB M.2
Optical	Blu-ray burner
Case/PSU	Origin Millennium

BENCHMARKS

	ZERO-POINT	
Stitch.Efx 2.0 (sec)	806	627 (28.5%)
Proshow Producer 5 (sec)	1,472	1,216 (21.1%)
x264 HD 5.0	33.8	23 (-32%)
Batman Arkham City GOTY (fps)	204	214 (4.9%)
Tomb Raider (fps)	87.5	90.7 (3.7%)
3DMark Firestrike	8,016	7,566 (-5.6%)
Shadow of Mordor	70.1	84.5 (20.5%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses an Intel 5960X CPU, three GTX 980s, and 16GB of RAM. *Arkham City* tested at 2560x1440 max settings with PhysX off. *Tomb Raider* at Ultimate settings. *Shadow of Mordor* at Max settings.

The Millennium uses a great chassis, but has terrible doors.

MSI GT72S Dominator Pro G Dragon

The red-hot GT72S is ready to dominate

The GT72S comes with eye-catching MSI Dragon Army styling, devouring our benchmark suite.

FOR THE PAST YEAR, the fastest notebook GPU has been the GTX 980M. With AMD and Nvidia both stuck on the 28nm process node for 2015, most didn't expect to see any significant changes until 2016. Shoehorning a mobile version of GM200 into a notebook seemed unlikely, as the 980M isn't even using a fully enabled GM204, and yet it still runs into the 100W TDP limit of mobile GPUs. Faced with such an obstacle, Nvidia decided to change the game and release a notebook version of the desktop GTX 980, using a fully enabled GM204 chip.

How has this been accomplished? Simple: The TDP for the notebook GTX 980 is quite a bit higher than the previous 100W target. Nvidia won't disclose precisely how much higher, but we estimate it's in the 130–140W range. MSI is first out of the gate with GTX 980 in a notebook, with updated GT72 and GT80 models (see December 2015 review, p. 74), but select Asus and Clevo-based notebooks will also support the new GPU. The GTX 980 is a $500 upgrade over the GTX 980M, but Nvidia is also giving notebook vendors a lot of leeway in terms of what they do with the GPU, and MSI takes its newfound freedom and runs with it.

Sporting a multiplier unlocked Skylake i7-6820HK processor, MSI allows for BIOS overclocking of the CPU, and GPU overclocking via utilities such as MSI Afterburner. The latter comes pre-installed, and on our test notebook the GTX 980 came from the factory with a modest 110MHz bump in core clocks. Even with a 230W AC adapter, the combination of CPU and GPU overclocking will push the power limits—we measured over 220W peak power draw during gaming tests, without overclocking the CPU, though PSU efficiency means there's still another 50W or so before the system truly hits its theoretical limit.

When it comes to gaming performance in a notebook, the GTX 980 is the new champion, and memory isn't a problem, as most vendors will be using the 8GB model. The GT72S smokes our zero-point laptop and leaves it sucking dust, but even a high-end GTX 980M SLI rig like MSI's GT80 will be hard pressed—the GT80 we looked at last month is only 10–20 percent faster in two of our graphics tests, but it trails by 12 percent in *Metro: Last Light*. Even against desktops like our GPU testbed, which uses an overclocked 4.2GHz i7-5930K, the GT72S holds its own. Our desktop with a GTX 980 card posted average performance that's only 7 percent faster than the GT72S, albeit with the factory overclock.

A THIN REDLINE

Not content with the out-of-box performance, we set out to see how far we could push both the CPU and GPU with overclocking. We were basically redlining the system, and stability wasn't totally there, but a 4GHz CPU clock with +220/300 GPU core/RAM was close. The factory overclock netted a 5 percent increase in gaming performance, and we increased that to a 15 percent boost. The system can get moderately noisy under load (48dB from 18 inches away), but that's actually better than other gaming notebooks, and it also stays surprisingly cool.

And it's not just great performance. The GT72S is loaded with extras, such as multicolored backlighting, switchable graphics with five hours of video playback, a USB 3.1 Type-C connector for future-proofing, and a 75Hz G-SYNC enabled display, elevating the GT72S to lust-worthy status. It's a true desktop replacement that you can drop into the included backpack for some intense gaming away from home. The GT72S isn't the sort of system you want to lug around as a daily driver, and a higher resolution display might be nice, but for the target audience, it doesn't get much better. The only thing faster would be two GTX 980 cards in SLI, or wait for the next-generation GPUs in 2016. –JARRED WALTON

VERDICT
9
KICK ASS!

MSI GT72S Dominator Pro G Dragon

+ REDLINE Insanely fast; good build quality; overclockable; great features.

– MELTDOWN Insanely expensive; large and heavy; only 1080p.

$3,099, www.msi.com

SPECIFICATIONS

CPU	Intel Core i7-6820HK
RAM	4x 8GB DDR4-2133
GPU	GeForce GTX 980 8GB
Display	17.3-inch, 1920x1080 Matte 75Hz G-SYNC enabled IPS
Storage	2x 128GB Samsung SM951 RAID 0, 1TB Hitachi 7,200rpm HDD, BD-Combo
Connectivity	1x Mini-DP, 1x HDMI, Ethernet, SD reader, 6x USB 3.0 (one charging), 1x USB 3.1 Type-C, Killer 802.11ac Wi-Fi, Bluetooth 4.0
Dimensions	16.85x11.57x1.89 inches
Weight (Lap/Carry)	8 lb 5.9 oz / 10 lb 6.3 oz

BENCHMARKS

	ZERO-POINT	
Stitch.Efx 2.0 (sec)	962	875 (10%)
ProShow Producer 5 (sec)	1,629	1,784 (-9%)
x264 HD 5.0 2nd (fps)	13.5	14.96 (11%)
BioShock Infinite (fps)	36.1	140.7 (290%)
Metro: Last Light (fps)	30.4	123.8 (307%)
3DMark 11 Perf	4,170	14,115 (238%)
Battery Life (min)	234	302 (29%)

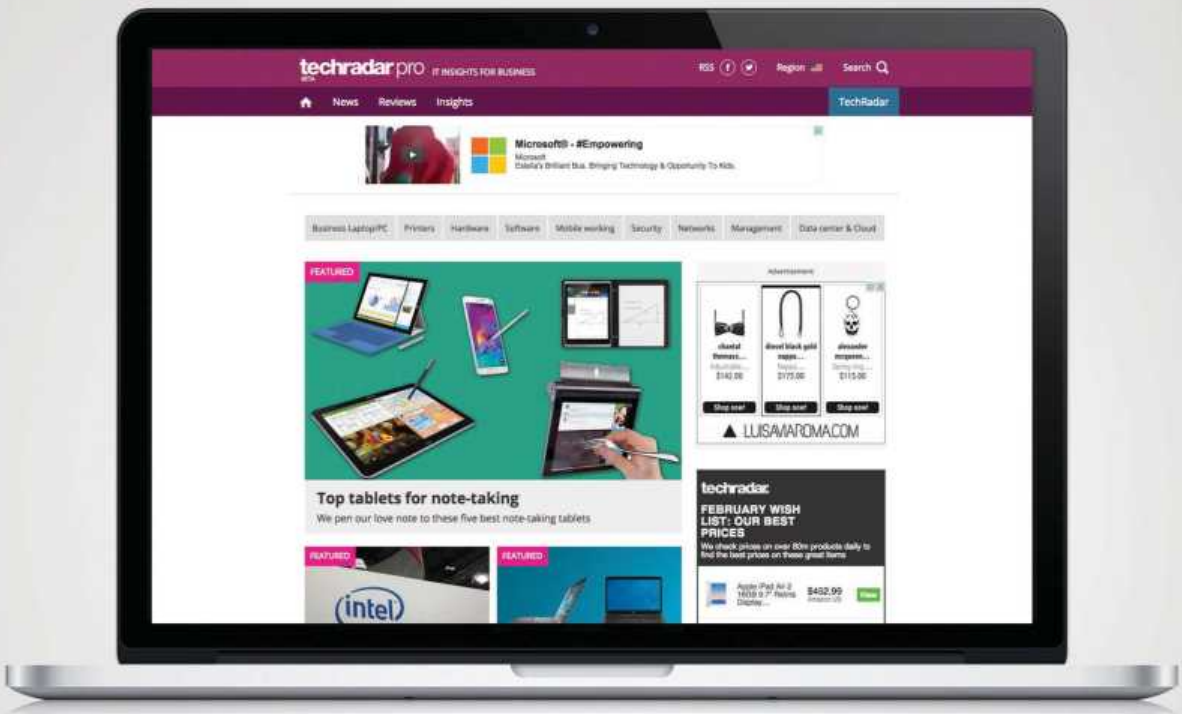
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point notebook is an Alienware 14 with a 2.4GHz Intel Core i7-4700MQ, 16GB DDR3-1600, 256GB mSATA SSD, 750GB 5,400rpm HDD, GeForce GTX 765M, and Windows 7 Home Premium 64-bit. *BioShock Infinite* tested at 1920x1080 at Ultra DX11 settings; and *Metro: Last Light* tested at 1920x1080 at DX11 medium quality settings with PhysX disabled.

Future

techradar.pro

IT INSIGHTS FOR BUSINESS



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http://www.techradar.com/pro

Razer BlackWidow Chroma TE

Best keyswitch known to man... probably.

IF THERE WAS EVER a switch that's made us go "holy macaroni!," it's this one. Razer has deviated from its traditional choice of Cherry key switches and instead gone with its own custom-designed mechanical switch—a switch that you'll currently find in all the mechanical keyboards in its range. It provides a highly responsive, soft, tactile typing experience that's ideal for gamers and typists alike.

Admittedly, this isn't the quietest key on the market, as it still retains the signature click of a mechanical switch. But, honestly, the pleasure your fingers are going to feel from these little things is second to none. It has a higher actuation point when compared to Cherry's world famous red switch, yet it's still more responsive than the blue while retaining that tactile click. This gives it a classy feel and a beautiful noise.

Razer provides four different editions of the BlackWidow Chroma line-up: The TE edition, which is a tenkeyless variant, a "stealthed" version of the TE, which is presumably a great deal quieter than its clicky cousin, and both clicky and stealthed full-sized Chromas, featuring all the doohickies you'd expect.

The TE cuts the nonsense, however. For the price and size you lose out on both USB and audio passthroughs as well as an additional five macro keys (although, honestly, how often do you use those things?). In addition there's no wrist rest—at this price point, it would've been nice to have seen Razer include one.

The keyboard naturally sits at a fairly high angle when resting on a flat surface. No doubt in part to the large amount of hardware buried inside of this miniature behemoth. Yet the Chroma still has more to give, with the traditional pair of angled risers found at the back of the keyboard as well. This is all a bit inconsequential when compared to the biggest, and by far the most impressive, feature on the entire Chroma line-up: the way Razer has handled the lighting.

CUE-WERTY

Following the current trend for lighting individual key switch—yes, you get the standard 16.8 million colors—what is interesting here is the lighting controller itself. Similar to Corsair's latest CUE iteration, it features a wide variety of modes from reactive, to ripples and waves, color cycling, breathing, and the traditional static. Unfortunately, what it does lack is the in-depth customization that Corsair's RGB tech is well known for. You won't be able to code any fancy coruscating color combos into the Chroma.

What Razer has brought to the table, though, is a fantastic user interface experience. For the less code-savvy users you can simply change what colors you want to see, how fast or slow you want the color options to cycle and which keys you want to have the effects on and then you're all set. For day to day use it's perfect.

On top of that, despite the fact each key is lit up using one single LED below each switch, the base of the board is coated in a thin translucent white plastic layer. This means that when the LED activates it not only illuminates the key cap but also the surrounding area with it. It's a feature that looks great when used with reactive type mode.

As far as negatives go, there's not a great deal that can be said against the Chroma TE, it all comes down to personal preference. Can you handle a tenkeyless keyboard? Can you deal with not having the additional macro keys? And do you really need the audio and USB passthroughs found on its bigger brother?

On top of that Razer has still yet to implement dedicated media keys across the range, instead sticking with merged F keys and the Fn modifier. Apart from this, the finish, feel and overall build quality of the Chroma TE is fantastic. Enough said. **–ZAK STOREY**

VERDICT **9** KICK ASS!

Razer BlackWidow Chroma TE

KNIFE'S EDGE Affordable; excellent key-switches; great LED lighting; highly responsive; compact; good software UI experience.

RUSTY SAW Lack of dedicated media keys; no USB passthrough; no wrist-rest.

$139, www.razerzone.com

SPECIFICATIONS

Switch	Razer Mechanical Switch
Connectivity	USB
Size	14.4x6.1x1.2 inches
LEDs	Individually lit—RGB 16.8 million colors
Macro Keys	All of them
Matrix	100% anti ghosting with 10 key rollover

The 950 Pro is Samsung's first retail NVMe drive. Yes, it's tiny.

Samsung 950 Pro

M.2 SSDs don't get the short end of the stick

NEVER MIND THE SMALL SIZE: M.2 drives have the potential to deliver a ton of performance in a compact form factor. This makes them ideal for Ultrabooks and thin and light laptops, and desktop motherboards are getting in on the action as well. With SATA topping out at a theoretical 6Gbps, PCIe is the way forward, and M.2 leverages the PCIe bus to deliver up to 32Gbps. Add in support for NVMe (Non-Volatile Memory Express), an optimized protocol designed to let SSDs reach their full potential, and this looks like the way of the future.

So what's the problem? Until now, finding retail M.2 NVMe drives has been difficult and expensive. Samsung was the first to offer an M.2 PCIe SSD with its XP941, and it followed that with the SM951 earlier this year. Then it released the SM951 NVMe, a second iteration of the drive with NVMe support. Unfortunately, these were designed as OEM-only products, going primarily to laptop vendors, where the OEM was responsible for ensuring the necessary features were in place. You could find those drives online, but without a warranty and at high prices.

The Samsung 950 Pro aims to change all that, with a five-year warranty plus some stellar performance for good measure. The change of heart likely stems from Intel's launch of Skylake and the Z170 chipset, which allows desktop M.2 to reach its potential. For optimal performance, you need a Z170 motherboard with an M.2 slot that supports x4 PCIe Gen3 lanes—anything less and you'll potentially run into a performance ceiling.

STORAGE TUG O' WAR

The 950 Pro is fast, but it can't quite top the Intel SSD 750 in many of our benchmarks. Part of the reason for this is the smaller form factor of M.2, part of it is due to capacity, and some of it just comes down to controllers and features. The SSD 750 is a performance monster, but it also takes up a PCIe slot and has a heatsink. In contrast, the 950 Pro is tiny and tucks away between PCIe slots on most motherboards. The 512GB 950 Pro also improves performance thanks to the increased parallelism the additional V-NAND chips offer. Even at 256GB, however, Samsung wins out in the real-world file copy and PCMark 8 tests.

Both the earlier SM951 and the new 950 Pro have a feature called Dynamic Thermal Guard. In heavy workloads, it's possible for the NAND chips and controller to heat up and potentially malfunction, so the 950 Pro can throttle to avoid overheating. Samsung states that it does "not anticipate any performance drops due to thermal throttling," but we found that performance was up to 10 percent higher in random write tests when we had a fan blowing at the drive. Something to keep in mind.

Samsung's 950 Pro may not win out in pure performance, but with better pricing and availability than the SM951, it's an easy win for anyone looking for an M.2 NVMe drive. It's a jump in pricing compared to SATA offerings, and it's clearly geared toward recent hardware platforms, but if you've got the funds and the necessary connector, it can make even the best SATA drive look sluggish. **–JARRED WALTON**

VERDICT **9**

Samsung 950 Pro

+ GREAT FIND Great performance; good warranty; retail availability.

– NEVER MIND Expensive; requires M.2 slot and NVMe BIOS; needs Z170 motherboard.

$200, www.samsung.com

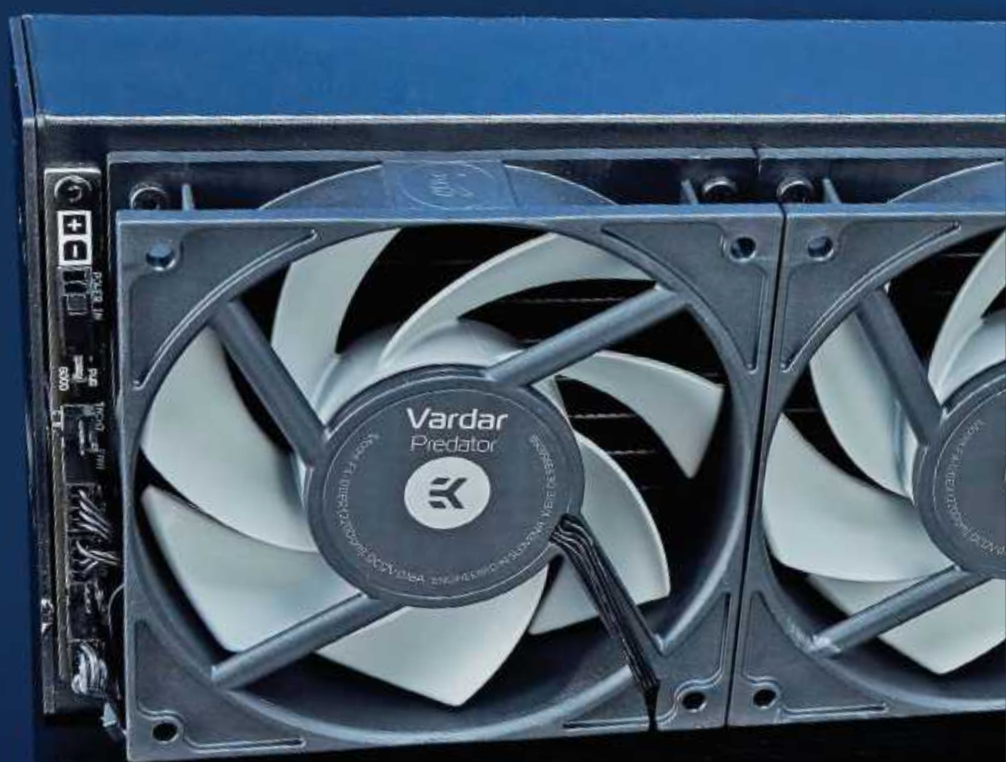
SPECIFICATIONS

Interface	M.2 PCIe x4 Gen3
Form Factor	M.2 2280
Capacity	256GB
Controller	Samsung UBX
Memory Type	Samsung V-NAND
Max IOPS Read/Write	270,000/85,000
Endurance	200TB
Warranty	Five years

BENCHMARKS

	Samsung 950 Pro 256GB	Intel SSD 750 1.2TB	Samsung SM951 256GB	Kingston HyperX Predator 480GB	Samsung 850 Pro 1TB
AS SSD Sequential Read/Write	2,063/901	**2,362/1,320**	1,973/1,155	1,008/743	525/496
AS SSD Random Read/Write	**52**/160	36/**205**	49/140	39/92	29/76
AS SSD QD64 Random Read/Write	1,021/254	**1,446/1,041**	1,105/338	446/247	380/279
IOmeter Mixed Read/Write Sequential	1,008	**1,605**	1,200	580	502
IOmeter Mixed Read/Write Random	267	**454**	350	84	177
File Copy (20GB)	560	564	**629**	429	242
PCMark 8 Storage Score/Bandwidth	5,089/622	5,069/511	**5,092/654**	5,010/324	4,987/284

Best scores are in bold; all figures except PCMark 8 Score are in MB/s. The test platform consists of an Intel Core i7-6700K processor, Asus Z170-A motherboard, and 2x 8GB G.Skill DDR4-3000.



EK Water Blocks Predator 240

Could this be the new king of the water-cooling jungle?

IF YOU'VE SPENT any amount of time around the depths of the custom water-cooling world, you'll have come across one name in particular—EK Water Blocks. Along with Bitspower, EK is one of the most popular water-cooling componentry firms globally. And for good reason. Providing top-notch cooling capacity and an aesthetic design style so clean you could eat your dinner off of it, it's easy to stick with EKWB throughout any of your water-cooling projects.

That being said, not everyone is into water-cooling an entire system. Despite that, however, offloading our woes into an all- in-one closed-loop cooler has become undeniably popular. So let's leave the worry and the warranty to companies such as Corsair, NZXT and Thermaltake, all of which provide some very impressive and easy-to-install cooling solutions. Indeed, it's about time EKWB finally tapped into that market. And boy, has it.

The Predator is the culmination of everything that enthusiasts have ever wanted from a 240mm all-in-one liquid cooler. You get one of EK's 240mm radiators, coming in at 38mm thick. The radiator boasts a fin density of 38 FPI (fins per inch). That means you'll need some seriously beefy fans to power it. But don't worry, EK has you covered, with the inclusion of two of its custom-designed Vardar high-static-pressure fans. Plus, an integrated pump and reservoir unit is situated at the top of the radiator, while an Evo Supremacy CPU block is connected to the bottom of the expandable tubing, complementing the whole unit nicely.

MOD MAX

The design of the Predator has some nifty new features, a few of which we haven't seen in the CLC world before.

One of the more innovative additions is, in part, thanks to the positioning of the pump and the fans. All of the power cables, fan connectors and pump controls are located on the radiator itself. This means you can avoid all that awful cable management nonsense around your CPU block, and route the cables around the back of your chassis instead.

Also, the loop is entirely expandable. If you want to change the tubing for clear tubing, you can. Fancy putting some better fittings on there? You can do that, too. You can also grab a GPU water-block and

throw that into the mix if you really want. Additionally if a dual radiator isn't enough for you, EK is also bringing a 360mm edition to the US market, which also includes quick disconnect fittings.

Ultimately though, it's the performance that matters most. We tested the Predator against our current favorite, the NZXT Kraken X61, and saw, at most, one or two degrees difference between the two. When you consider the Kraken has a total surface area of 280mm, versus the Predator's 240mm, that's a serious achievement.

Sounds like this is heading for a top score, right? Not quite. On our Skylake CPU, we found you had to remove the backplate from the motherboard entirely (which also included removing the socket brace). You then had to reattach it with EKWB's included backplate. It remains uncertain whether this will be the final mounting system, but it's incredibly fiddly and has the potential to damage your pins while you're fiddling.

The Predator is a phenomenal piece of hardware. Although the mounting system could do with some improvement, it's nice to see EKWB expand and improve in an enthusiast area that's otherwise become a little stagnant.. **–ZAK STOREY**

BENCHMARKS

	EKWB Predator 240mm @ 4.8GHz	EKWB Predator 240mm	NZXT Kraken X61
Idle temp (°C)	23	22	**21**
Prime 95 load temp (°C)	86	**66**	67
Cinebench R15 load temp (°C)	74	**55**	56
FireStrike Ultra (4K) load temp (°C)	64	**52**	**52**
Star Citizen Hangar Walk (°C)	61	**51**	**51**
Shadow of Mordor (°C)	63	**50**	**50**

Best scores are bolded. Tested using an Intel Core i7-6700K and Windows 10 64-bit, all power saving turned off. Temperatures measured after five minutes or after benchmark completion.

VERDICT **8**

EK Water Blocks Predator 240

+ PREDATOR Powerful performer; innovative and interesting design; silent; expandable

– PREDATORS Mounting setup.

$200, http://predator.ekwb.com

SPECIFICATIONS

Dimensions (Including fans)	11.61"x5.24"x4.72"
Stock fans	2x 120mm PWM EKWB Vardar Fans
Socket support	Intel Only
Additional fan support	2x 120mm
Noise level	29.5 dBA


NVIDIA
G-SYNC
AORUS

Aorus X7-Pro Sync

As loud as it is beautiful

LADIES AND GENTLEMEN, a new dawn is upon us. G-SYNC laptops are coming thick and fast, so it's with great pleasure that we introduce the Aorus X7-Pro Sync. Unearthed from the heart of Gigabyte's notorious Aorus factories, comes this marvelous wonder of a tiny gaming powerhouse. Arguably the noisiest dual-GPU laptop ever witnessed, the X7 packs two Nvidia GeForce GTX 970M processors alongside an Intel Core i7-5850HQ, 16GB of DDR3L RAM, and a RAID 0 setup. This is the kind of laptop dreams are made of.

Let's start with the good. The design of the Aorus is stunning. It's clean, it's sharp, and it's low. All traits we normally see from the Ultrabook side of the divide, as opposed to the pro-gamer. That being said, the Aorus is a total of 0.9-inches thick, in comparison to the Asus ROG G751JY, which comes in at more than 0.8-inches thicker when closed. The keyboard, although featuring the scissored variety of key switch, is backlit, and contains five dedicated macro keys to top it all off—it's quick, responsive, and easily set to purpose.

And now, the bad. If you're looking for a silent stealthy laptop, this isn't the one for you. Although the X7-Pro packs a wonderful amount of hardware into its sleek, stealthy body, the one thing it hasn't managed to control is the fan speed. The fans are so phenomenally loud and sporadic, that even when sitting on the desktop, they have a habit of whirring into life as soon as you open any program worth its salt. At first glance, this seems to be due to the method Gigabyte has used to chill those mighty processors. Both GPUs and the CPU are cooled using one single system, heatpipes and all, meaning that if the CPU temp ramps up, the fans that are designed to cool both of the two GPUs also spring into life, regardless of the temperature of the graphics processors.

THE GOOD, THE BAD, AND...

Gigabyte has included a fan controller, but unless you enjoy switching back and forth between the two constantly, you're going to encounter some serious thermal throttling in-game. Headsets, headsets, headsets, and closed back ones at that—that's what you'll need. Although God forbid anyone else is in the room with you at the same time as you do anything with this wee beastie. And, finally, back to the good. The screen—it's stellar. In short, Aorus has thrown in a 17.7-inch 1080p AH-IPS G-SYNC panel, and it sure does look good. It's crisp, easy to use, and comes with plenty of screen real estate to really take advantage of that dual-GPU SLI solution. The two GTX 970Ms are a powerhouse when it comes to gaming. If you're looking for that perfectly smooth gaming experience from today's latest AAA titles, the Aorus won't let you down.

This makes the Aorus X7-Pro a stunning all-round laptop, jam-packed with enough hardware to make your eyes bleed. It could easily run as either a workstation or a gaming laptop, depending on your preference. And that really brings us round to who exactly this laptop was designed for. It's the gamers (duh!), but more specifically the streamers. If you're the kind of person who travels a lot, but just can't resist the temptation to get yourself out there into the digital stream, the Aorus X7-Pro Sync is a solid choice. It'll act as your rendering station, your gaming platform, and your traveling partner. Just remember to make sure your microphone is facing away from the cacophony that is the X7's fans, and you're all set. **–ZAK STOREY**

VERDICT **8**

Aorus X7-Pro Sync

+ PRO-GAMER Powerful; sleek; G-SYNC; IPS screen; chunky RAID 0 array.

– BOTTER It's so loud; so, so loud.

$3,399, www.aorus.com

BENCHMARKS

	Aorus X7-Pro Sync	Gigabyte P55K V4
Cinebench (Index)	**677**	658
Heaven (avg fps)	**83**	27
Bioshock Infinite (avg fps)	**82**	52
Metro Last Light (avg fps)	**51**	23
Shadow of Mordor (avg fps)	**73**	33

Best scores are in bold.

SPECIFICATIONS

CPU	Intel Core i7-5850HQ
RAM	16GB DDR3L 1,866MHz
Chipset	Intel HM97
GPU	2x Nvidia GeForce GTX 970M SLI
Screen	17.3-inch, IPS, 1920x1080, G-SYNC
Storage	2x 256GB RAID 0 mSATA SSDs, 1TB HDD
Weight	6lb 10oz

Smooth as a baby's butt.
As loud as a screaming toddler.

MSI Z170A Gaming M9 ACK

Fantastic feature set at a phenomenal price

MSI'S Z170A GAMING series has impressed us. It's a solid lineup, boasting a variety of feature-rich gaming motherboards at a fairly sensible range of prices. The M9 ACK sits at the top end of this spectrum, but can it possibly warrant such a high price tag? Well, that's what we're here to find out.

Let's start with the M9's biggest selling point, namely its audio. Undeniably stunning, the M9 ACK features multiple headphone amplifiers, a high quality audio processor, and insane audio capacitors, all rounded off with a nice chunk of high-spec EMI shielding. The sound quality is beautiful. If you've ever thought your headphones are too quiet, this board will quickly jump to the rescue. On top of that, MSI has collaborated with Nahimic to provide an audio enhancing software suite, similar to THX's now long-antiquated Crystallizer software, except a lot, lot better. Honestly, it isn't easy to get across how impressive this audio solution is, so we'll sum it up this way instead: Unless you have an external DAC, your audio is terrible in comparison. And honestly, that's high praise for an integrated sound solution.

This isn't the only area where the M9 shines. On top of all of this audio wizardry, MSI has an incredibly well thought-out network subsystem. Partnering with Killer, Micro Star International has developed software that utilizes both 802.11ac and traditional Ethernet. What this does is successfully prioritize application bandwidth effectively between the two data streams, ensuring your games are transmitted via Ethernet, and your VoIP, web pages, and other less important applications are sent over wireless. Admittedly, this does feel like a solution to a problem that doesn't exist. After all, who's transmitting 1Gbps of data down an Ethernet cable at any given one time anyway?

Even Killer's advertising for its shield tech states that it has a 0.2 millisecond edge over its competitor. But we'd be surprised if you ever noticed that. Like seriously no, you won't, don't even joke, it's not a thing. To give you some clarity here, that's essentially 1/5,000 of a second advantage over the non-Killer users for latency. Just seriously, stop.

WATER-COOLING YOUR JAM?

Taking a leaf from the Asus Maximus Formula, the M9 also features integrated water-cooling connectors for the voltage regulators. They may look stupidly jazzy, but they feature G1/4 threads, which means you can use any fitting you like to cool your VRMs. The flexibility on this one is great—props to MSI for ensuring that the water-cooling enthusiasts are taken care of.

The big downside is the price. At $400, it needs to deliver on all fronts, and there's a small problem with performance—you don't get as much overclocking potential as you would from the more-affordable Z170A Gaming M7. This should give you pause for thought as to whether the additional features are worth the drop in overall overclock stability. On top of that, you're limited to two-way SLI or three-way CrossFire, in contrast to the vast majority of competitor boards at this price point that support three-way Nvidia graphics solutions and quad CrossFire setups.

This M9 doesn't come without flaws, but the integrated audio solution is second to none. And although the Killer networking solution won't see much advantage over gigabit Ethernet sockets, it's a fantastic innovation in an area that's otherwise not seen a great deal of advancement beyond 802.11ac in the last few years. If you've got the money, and really want the best audio you can get outside of an external DAC setup, and a stunning motherboard to boot, the MSI Z170 Gaming M9 ACK is the board for you. **–ZAK STOREY**

VERDICT 8

MSI Z170A Gaming M9 ACK

+ HANS ZIMMER Fantastic audio solution; water-cooling support; stunning heatsinks; strong UEFI experience.

– ONE DIRECTION Lack of support for tri-SLI; phenomenal price; isn't as stable for overclocking as the M7.

$400, http://us.msi.com

BENCHMARKS

	MSI Z170 Gaming M9 ACK	Asus Maximus VIII Hero
Cinebench R15 (Index)	**928**	911
x264 HD Video Encoding (fps)	**58**	57
Memory Bandwidth (GB/s)	28	**29**
Shadow of Mordor (min/avg)	33/89	**61/93**
Maximum Overclock (GHz)	**4.8GHz**	**4.8GHz**
Cinebench R15 at max OC (Index)	**1,044**	1,033

Best scores are in bold.

SPECIFICATIONS

Chipset	Intel Z170
Socket	LGA 1151
Form factor	ATX
Memory support	DDR4/3600
Storage	6x SATA, 2x M.2, 2x SATA Express
USB	5x USB 2.0, 6x USB3.0, 6x USB 3.1 Type-A, 2x USB 3.1 Type-C

You got yourself a pretty mou...therboard.

Sennheiser RS 175 Wireless Headphones

Gaming jargon: no. Hi-fi: yes

IF YOU WERE TO ASK us about gaming headsets, we wouldn't be able to give you a definitive answer as to what they really are. Essentially, they're just headphones with a mic attached, and usually, it's a pretty bad mic at that. Instead, what we tend to do is focus on getting a really good set of headphones. When it comes down to it, the auditory part of a game is just as crucial as what you see on the screen. In some cases, it could be even more important.

Gaming aside, we want headphones to perform exceptionally well with a variety of other content, too, such as music and movies. For these purposes, we've yet to find any gaming headsets that are fully up to the task. Which is why we are more likely to go with something like Sennheiser's RS 175 wireless headphones.

Sennheiser's name has been synonymous with high-quality audio since the company's beginnings, and that still holds true today. The RS 175 is a middle-range unit in the company's line of wireless headphones, but it performs like it's at the top tier. At $280 at the time of publication, you wouldn't expect anything less.

The first thing we noticed is that the unit is big and well made. Construction feels thoughtful and solid, and the same is true of the base, though we found ourselves wishing it was weightier. The headphones themselves are over-ears and fit comfortably for long hours of use. There are replaceable, rechargeable batteries in each ear compartment, and the headphones charge when on the station.

WI-FI WOES

The RS 175 headphones have exceptionally long range. In a 2,000–square-feet home, they can easily go from end to end, provided you have line of sight. Sennheiser claims a range of up to 100 meters, and we can believe that, but in a real-world scenario, it's much less unless you live in an entirely open space. Another drawback was that we experienced disrupted audio when the station was placed in the vicinity of a wireless router. With a dual-band AC router in the same room, the RS 175 dropped signals depending on the direction our head was facing in relation to the station. And for the record, we were only five feet away from the station in this setup. If your RS 175 transmission station is in the same room as your wireless router, you may have to play around with your router's settings. It was annoying enough that we moved ours into a different room altogether.

So, how does the RS 175 sound? In a word: fantastic. These headphones are of the closed circumaural variety, which means the sound stage is not as expansive as open headphones. Those who game a lot might want to consider open headphones instead—and, of course, don't forget a decent mic too. But the RS 175 set does the job well in almost every situation. In a variety of music, bass is not overbearing and boomy. Low frequencies are tight and never overpower vocals either. If you need extra thump, there's a bass mode that can be triggered.

For most people, the RS 175 is a big step up in terms of sound quality, especially if you're a gamer and want to upgrade beyond puny "gaming headsets." There's the issue of signal interruption in some situations but it's not a show-stopper. Besides, the RS 175 base enables you to share the love with another person. We'll take two head units, please. **–TUAN NGUYEN**

VERDICT **9**

Sennheiser RS 175 Wireless Headphones

+ HIGHS High-quality sound; good battery life; very comfy.

– LOWS Can be affected by Wi-Fi routers; pricey.

$280, http://en-us.sennheiser.com

The RS 175 headphones look great, fit comfortably, and sound great no matter what you're listening to.

Vehicle combat is reminiscent of *Rage*, but it's a more reactive world.

Mad Max

The Road Warrior returns to prove he's Hardy enough

LET'S GET ONE THING out of the way first: this is not *Fury Road: The Game*. And that's a shame, because if there's one thing this desert wasteland needs, it's lunatics with guitars strapped to the front of lorries, or convoys of motivated female characters. What you do get is movie bad guy Immortan Joe's son, Scabrous Scrotus, who wasn't hugged enough when he was younger, and a whole lot of War Boys looking like Moby wearing Marcus Fenix's pants.

Taking a little of *Assassin's Creed*, a chunk of *Shadow of Mordor*, and a sprinkling of *Arkham City*, *Mad Max* sets you loose in an open desert world on a quest to get your car back. Because if one thing can be guaranteed to survive the end of the world, it's the concept of private property. There's a plot of sorts, with Max's desire to reach the Plains of Silence being what gets him into trouble in the first place, as well as the motivation to get out of it.

You're fairly soon introduced to Chumbucket, a mechanic-cum-hanger-on who will repair your car when parked but spends much of the game telling you what to do, to the point where you start to wonder who's playing what. Happily, this disgusting mechanic—literally the first person you run into after losing your Interceptor—has a car he needs a driver for. It's not much to look at, however, and a lot of the game after that is spent seeking out upgrades for it, such as boosters, spikes, exploding harpoons, and flamethrowers.

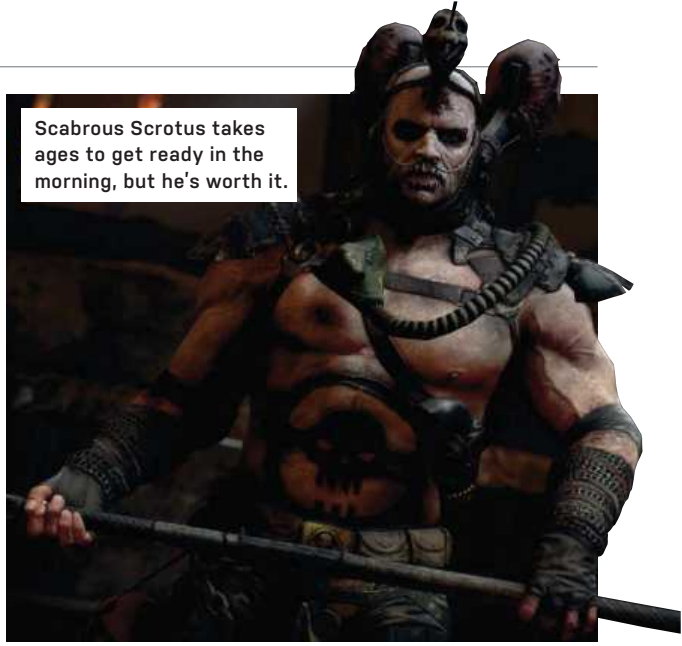
There's also a lot of punching in the face, as the food, fuel, ammo, and scrap metal you need to collect is guarded by gangs of War Boys, who attack without a second thought. While this incarnation of Max may look more gentle than Mel Gibson's, with his Nathan Drake good looks and genuine Australian accent, courtesy of an actor appearing in tedious Adam Baldwin vehicle *The Last Ship* (and who played two characters in Aussie soap *Home and Away*), he's still handy in a fight, with an upgradeable punch, a range of finishing moves, and a shotgun that is a one-hit-kill for low-level enemies.

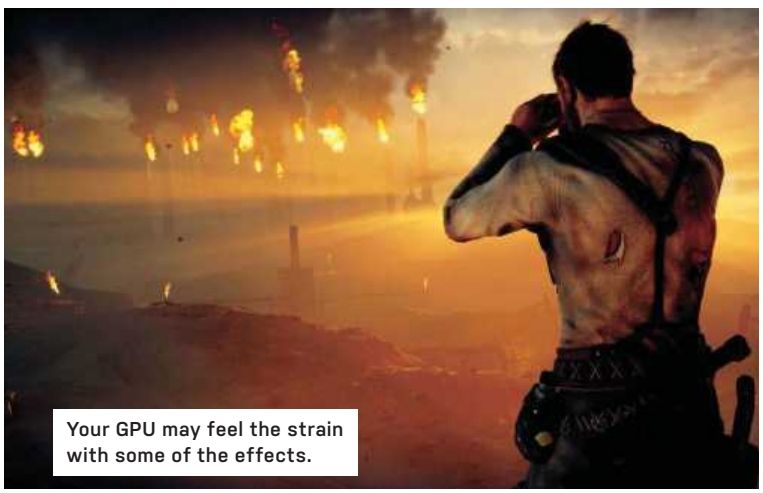
Voice acting elsewhere is, sadly, something of a mixed bag. If your series is set in Australia, with an Aussie protagonist, why would you decide to randomly sprinkle the world with Americans?

While the melee combat system owes a debt to the *Arkham* games, it has little of their finesse or fluidity. Dodge, parry, attack, combo, special.... The notes are all there but it doesn't settle into a satisfying rhythm until enough upgrades have been found to turn Max into an iron-fisted brawler, capable of taking apart a gang of War Boys in seconds. The same is true of the car combat, as the first hours of the game pit your underpowered jalopy against some stiff opposition.

Fuel, the precious commodity coveted by everyone in this vehicle-obsessed playpen, is sprayed around, set on fire, and used to blow stuff up with wild abandon, rather than being hoarded as a scarce resource. You'll need it, though, as the map is a Ubisoft-style riot of objectives, item pickups, races, and missions that can feel overwhelming. The main plot can happily be ignored, despite Chumbucket's nagging, leaving you to explore the environment and pick up side

Their sightseeing vacation wasn't what they'd expected.


Scabrous Scrotus takes ages to get ready in the morning, but he's worth it.


Your GPU may feel the strain with some of the effects.


Color coordination never was Max's strong point.

missions. In many ways, this is where the game is at its best—there are some fine sights to be seen in the ugly beauty of the wasteland, with terrifying storms testing your GPU's ability with particle effects, and the smoking towers of Gastown looking like nothing more than a cut-price Mordor. The side missions also provide welcome upgrades to both Max and his weapons.

BEYOND THUNDERPOON

The harpoon quickly becomes the game's signature weapon, used to pluck snipers out of nests, drag down the "scarecrow towers" that War Boys use to mark their territory, and when upgraded becomes a rocket launcher, the Thunderpoon, that makes a mess of vehicles. It opens up an all-guns-blazing approach to objectives that's highly satisfying, although sneaky options are still available—friendly locals are mysteriously well informed about the secret back doors into bandit camps.

This shouldn't come as too much of a surprise when you consider that *Mad Max* was engineered by Avalanche, maker of the *Just Cause* games, which equipped their protagonist with a grappling hook, a parachute, and an explosive tropical playground. That parachute, with its odd ability to drag its wearer up into the sky rather than just dropping round his feet like a discarded tutu, would come in damn handy in *Mad Max,* scooping him out of situations where he's outnumbered. You can use a flare gun to summon Chumbucket and your vehicle for an extraction, however.

Sharing a release date, as well as an open-world approach to mayhem, and a sandy setting, with *Metal Gear Solid V* was always going to make life difficult for *Mad Max*. They are very different games, though, with *Metal Gear's* missions a front for a base-building metagame rather than the plot drivers they are in *Mad Max,* but they are doomed to be compared to each other. *Metal Gear* is the deeper experience, the collection of parts for Mother Base and its online multiplayer base-raiding gifting it longevity beyond the main thrust of the story, something *Mad Max* claims through its bewildering supply of side missions. Gibbering homunculus Chumbucket is no Quiet, either—although, horrifyingly, he wears almost as little clothing.

This is certainly a good stab at *Mad Max,* more engaging than an '80s action movie of an FPS would have been. For all its lack of direction and occasionally inconsistent world, it's a solid take on a great story, which doesn't do anything particularly new, but does it with a level of heart and honesty that, in a parched landscape, can be refreshing. –IAN EVENDEN

VERDICT **7**

Mad Max

MAGNUM OPUS Huge map; loads to do; plenty of explosions.

JUST HOPELESS You'll have seen a lot of it before elsewhere.

RECOMMENDED SPECS Intel Core i7-3770 (3.4GHz) or AMD FX-8350 (4.0GHz); 8GB RAM; Nvidia GeForce GTX 760 or AMD Radeon HD 7970 (3GB VRAM or higher); 32GB hard drive space.

$60, www.madmaxgame.com, M-rated

LAB NOTES

JIMMY THANG **ONLINE MANAGING EDITOR**

M.2 Stick It to the Man

Not huge, but super fast

I RECENTLY TRAVELED to Seoul to attend Samsung's 2015 SSD Summit, and while I was largely impressed by the company's offerings, a part of me also felt slightly let down. I was really hoping that the Korean technology giant would reveal a 16TB SSD for consumers, considering that only a few short months ago, the company revealed that it had one in the works for enterprise. Yes, it's true that the cost would be insane, so perhaps it was simply wishful thinking on my part.

What the company did reveal, however, was its new 950 Pro SSD, which is a beast in and of itself (check out Jarred's review on page 80 for more details). While the newest offerings will be limited to 256GB and 512GB capacities out of the gate (which are paltry numbers compared to the aforementioned 16TB enterprise drive), they are much faster than traditional SATA drives using the NVMe protocol over M.2—up to 4.5 times as fast, to be precise. These aren't your grandmother's SSDs, folks.

While the speed is super nice, Samsung also revealed that its V-NAND technology, aka 3D-NAND, will enable the company to have a 4TB consumer SATA SSD out in 2016. Truth be told, from my perspective, I'd rather have the 4TB SATA drive over the 512GB M.2 SSD any day of the week. It's true that speed kills, but bigger is always better.

Why isn't Samsung releasing the M.2 drive in higher capacities? I was told that the M.2's smaller size simply makes it very difficult to fit that much storage in a drive without the drive getting too expensive. Samsung also told me that, according to its data, 256GB and 512GB are its two best-selling SSD sizes, so the company wanted to tackle those first. Regardless, it will be really interesting to see how this stacks up against Intel and Micron's recently announced 3D XPoint SSDs, which purport to be 1,000 times faster and more reliable than traditional NAND solutions.

No 16TB SSD on the horizon for consumers, but there's still plenty to get excited about.

ALEX CAMPBELL

Associate Editor

One of the items on my to-do list lately has been to replace my home Arch Linux server with a lower-power model. My current server's running an old AMD Phenom II Black Edition, which draws too much power for something I'd like to keep running 24/7. I found an old Celeron and P67 board to replace it, and I'll be taking a look at FreeNAS to see whether it should supplant my trusty Arch install.

The real hassle will be taking my encrypted volume and transferring its contents to the new set of drives. That means keeping the old server alive long enough for the transfer, and for checksums to be run on the copied files. It's a good thing someone invented rsync.

JARRED WALTON

Senior Editor

I spent much of the past month revising our SSD testing and working on reviews of new M.2 NVMe SSDs.

Of course, I love the speed that comes with PCIe NVMe drives—but, honestly, having a gigantic SSD in my machine, so that I never have to worry about whether there's enough room to install another new game, is simply awesome. Samsung's 950 Pro may be the new hotness, but bang for buck, the 1TB Samsung 850 EVO is really tough to beat, and the 2TB model is big enough for my entire current gaming collection—and then some.

With 50GB-plus game installs becoming increasingly common (nom, nom, nom), I need every gigabyte I can lay my hands on!

Editor's Picks: Updaters

Jimmy Thang, online managing editor and Zak Storey, staff writer, introduce two time-saving tools

DRIVERUPDATE

If you build new PCs, or install Windows as much as I do, DriverUpdate from SlimWare Utilities can be a godsend. The software tool automatically scans your system for the latest drivers, and you can update all of them with a press of a button. Sure, motherboards come with a CD with the basic drivers, but they're often out of date out of the box. With DriverUpdate, you get the latest drivers without having to dig around your motherboard's maze-like website. According to SlimWare Utilities, it has a library of "millions of drivers."

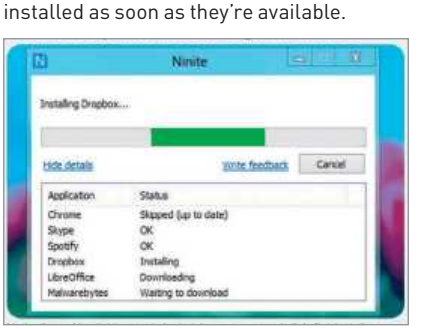
DriverUpdate also keeps an eye out and notifies you when there are newer drivers for your system as they become available, and again allows you to update to the latest version with a simple button press. While SlimWare Utilities offers a free SlimDrivers equivalent, which is super helpful in its own right, that app has an issue: You have to manually download each driver separately, which can be a bit of a chore. The full version of DriverUpdate costs $30 a year, which I acknowledge isn't nothing, but I think it's totally worth it if you build a lot of systems and value your time. That $30 is really just chump change in comparison to the time you'll save hunting around for drivers.

NINITE

Oh Ninite, you beautiful thing. As you can imagine, we do our fair share of benchmarking. In fact, this issue is jam-packed with a massive array of storage reviews, and every device required extensive testing, with a fresh OS on each and every one. Ninite.com helped out no end, and is a personal favorite of mine. Choose what programs you want on your new clean OS, click the "Get installer" button, and Ninite installs the latest versions of those programs, bloatware-free, to your default operating system directory.

This way, you can save time and avoid messing about heading to each individual website. It's great if you're regularly corrupting OS installs like we do. Or if you have a habit of overclocking things just a little further than they really want to go.

Sound too good to be true? Don't worry, there's nothing malicious about it. Ninite earns its living by operating a more premium subscription-based update service for larger corporations, including NASA and Harvard Medical School. And if you really want, you can opt for its customer-facing premium option, ensuring you get all the latest updates for the programs you've installed as soon as they're available.



GEEK TESTED & APPROVED

UE Boom 2

IT WASN'T LONG AGO that we gave the original UE Boom our Geek Tested seal of approval, but Ultimate Ears apparently isn't one to rest on its laurels. The company has upped the ante with its UE Boom 2. How do you make arguably the best portable Bluetooth speaker better? Simple: make it louder and tougher.

The original UE Boom was plenty loud, but the UE Boom 2 really, well, booms. The sequel ups its volume by 25 percent, and it's definitely noticeable. In a small room, the speaker can be almost deafening; it's certainly loud enough to keep a small house party going all night long. And all night long it will go, because the battery life is still rated to last up to 15 hours on a full charge, despite the extra oomph.

The device is also sturdier this time around. Not only is it IPX 7–rated (which enables it to stay one meter under water for up to 30 minutes), but its chassis can also survive five-foot drops. In conjunction with the revised hardware, Ultimate Ears has updated its UE Boom app, which enables you to power on/off your UE Boom 2 and adjust EQ, set an alarm, and pair multiple UE Booms, if you please.

It isn't cheap—$200 is lot for a speaker, but you're getting a ton of high-quality firepower out of a very portable speaker, which is sturdy enough to survive some pretty rugged adventures. **–JT**

$200, www.ultimateears.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> First Build
> Drivers For Windows 10
> Media Center PCs

First Timer

I thought I might try to build my own computer. I'm reasonably competent, with programming skills, tools, and boxes of spare parts. My only hesitancy is what to do if it doesn't work after I put all the parts together. Who do people call when the computer has been put together from off-the-shelf parts with no one responsible for the whole?

—Bob Tamarin

SENIOR EDITOR JARRED WALTON RESPONDS: Hi, Bob. Many people are hesitant for the same reason, but there's no way to get over it other than to dive right in. Should you find problems, the standard troubleshooting steps consist of checking all connections, reseating the memory and add-in boards, and clearing the BIOS settings (unplug from wall power first!). Problems range from minor (a BIOS setting needs to be changed) to catastrophic (the system won't turn on), but the former is often more difficult to diagnose. If you press power and nothing happens, there are only so many things that could be wrong. A missed cable, a dead power supply, or a bad motherboard are pretty much the only options.

One thing that can help is to buy a motherboard with a POST code/debug LED on it. Examples for Skylake include the Gigabyte GA-Z170X-UD3 and the ASRock Z170 Extreme4. The debug LED shows codes as the system boots, and if something goes wrong and the system fails to boot, looking at the POST code, then checking the motherboard manual gives an idea of where things went awry. Even without a debug LED, most motherboards beep in a pattern if something is amiss.

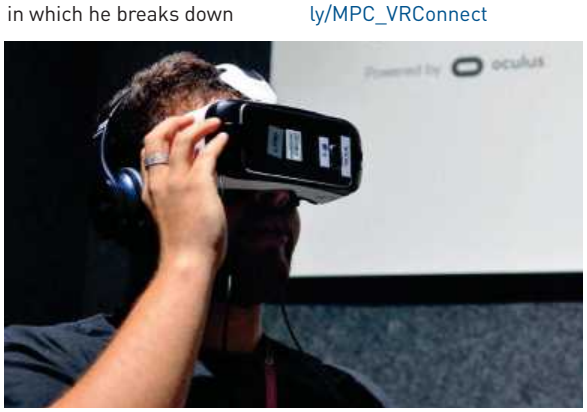
There's not a lot that can go wrong if you follow the components' instructions. The most difficult part can be connecting the case's front panel wires (power, reset, and power/storage activity LEDs). If you forget to connect the power switch wires to the mobo (or connect wires to the wrong pins), nothing happens.

If you do have problems, drop me an email and I'll be happy to help. There's a small chance you might get a flaky part and have to do an RMA, but over the past 20 or so years, I can count on one hand the number of new components I bought that were DOA.

[NOW ONLINE]

WHAT I LEARNED ABOUT VR AT OCULUS CONNECT

Are you into virtual reality, but are bummed that you couldn't get to Oculus's second annual Connect event? No worries, because associate editor Alex Campbell attended and wrote an in-depth article in which he breaks down some of the technical talks, shares his experience sculpting in VR with Oculus's new Medium application, and ponders the amazing potential (and negative repercussions) of VR. You can check it out here: http://bit.ly/MPC_VRConnect



Alex shares his thoughts and experience of VR online.

Windows 10 Drivers

I upgraded to Windows 10. I know I should have waited but I had a new SSD and I was itching to install, not realizing I had to upgrade first then do a clean install—oh, well. Of course, there are loads of driver issues, so much so that I am getting a new soundcard because Creative Labs always drops the ball with driver releases. Without proper driver support, my front panel

↘ submit your questions to: comments@maximumpc.com

connections don't work. I took out the SB card and enabled onboard audio to get my front panel connections working. Gigabyte released proper drivers for the onboard audio and it works fine, but it hammered home what I've said all along—onboard sound sucks.

With that said, the PCIe interface doesn't appear to be the end-all of interfaces; we need something else. PCIe SSDs, M.2, PCIe soundcards, PCIe RAID controllers, and multiple video cards. A dedicated storage interface is in order or a new video interface, or something.

—Paul

SENIOR EDITOR JARRED WALTON RESPONDS: Hi, Paul. Creative drivers are often a concern; so much so that many people have abandoned ship. Whether they're worth the cost of an add-in card is another matter. It's something we should look into again, but for many, the onboard audio is now "good enough," and some of the better motherboards even have Creative audio onboard. I can't recall the last time I used anything besides onboard audio....

PCI Express is most certainly going to hit a limit at some point, but for most of what we do, it's not so much the speed of PCI Express that's a problem; rather, it's the total number of lanes available. If you're trying to push a bunch of data to a couple of NVMe SSDs while running two GPUs in SLI/CF, you'll hit a bottleneck. Most likely, it will be on the SSDs, since they usually come off the PCH rather than the CPU PCIe lanes.

For home users, it's rarely a problem, but for supercomputers it can be serious. That's why Nvidia has a solution in the works. NVLink (www.nvidia.com/object/nvlink.html) enables up to 12x the amount of data to be sent between the CPU and GPU. Games don't need that yet, but if you have a cluster of Tegra GPUs working on a scientific problem, in some workloads Nvidia is reporting more than a doubling of performance over PCIe Gen3. Note that NVLink is still in the works—it's being developed for a future supercomputer, and is not yet available. It sounds like the upcoming Pascal architecture will include NVLink, and it might even make it into consumers' hands, but we'll have to wait until some time in 2016 to see.

How Much Oomph?

Every TV in my home has a media center hooked up to it—two TVs upstairs and one in the living room. Recently, we bought a 4K TV for the upstairs living room/gaming room and the video lag (Netflix, Amazon, etc.) was atrocious. We have a 50MB/s connection through the house, so I know it's not a speed bottleneck, especially when all the other TVs are seamless. It had to be the video card. I had an extra gaming system in the attic with an Nvidia GTX 780, i7 950 processor, and 12GB of RAM. I hooked it up and it worked perfectly. However, that's a hefty system just to hook up to a TV. I want to upgrade all my TVs and I can't justify that kind of cost in building media centers for them all. What do you recommend?

—Lora Shanks

SENIOR EDITOR JARRED WALTON RESPONDS: Hi, Lora. What GPU and CPU did you use initially? If you're hoping to run 4K displays on $300 hardware, you're likely to have problems.

If you want to stream a high-quality 4K video, you need a good network connection. You also need sufficient hardware to decode and view the video stream. Most modern GPUs are sufficient for 4K H.264 content (see below), but the new H.265 (HEVC—High Efficiency Video Coding) videos are a beast to decode.

The latest Skylake processors and AMD APUs are supposed to be able to handle 4K HEVC using the processor graphics, but older systems need a modern and fairly potent GPU. In fact, from Nvidia only the GM206 processor (GTX 960/950) has full hardware support for 4K HEVC decode—all the other Maxwell GPUs use a hybrid mode where some of the work has to be done on the CPU.

If all you need is 4K AVC (H.264) support, Nvidia has PureVideo. Anything in the Fermi or later generations of Nvidia hardware should work, but lower-end GPUs may struggle at times; Kepler and later should be fine for most content. With AMD, UVD is the decoder hardware, and the HD 7000/Rx 200 and later GPUs should be able to do 4K video. If you want 4Kp60, I think only the R9 285 and Fury GPUs support that in hardware, though it might work on the Hawaii GPUs. There are levels associated with AVC, however, and sometimes hardware only supports up to a certain level (e.g., Main 4.1 AVC). If the level you want to decode exceeds your hardware capabilities, you'll get stuttering.

Facebook Polls

What do you want to find in your stocking this holiday season?

Patrick McCullough: 850 EVOs are under a hundred bucks now, so almost into stocking stuffer territory. Amazon, Newegg or pizza gift cards work well. Low-end Kindles, thumb drives, Plantronics folding USB headset....

Michael Flynn: Hoping for another 970, but considering nobody in my family knows what that is, I'm probably out of luck.

Yi Long: A 27-inch Wacom Cintiq would be mighty swell, Santa....

Matthew Blevins: Maybe a nicer card to max out *Fallout 4*. My 760 is a little weak, though at least it's a 4GB model.

Montana Webb: I would love just about anything that's not my GTX 570.

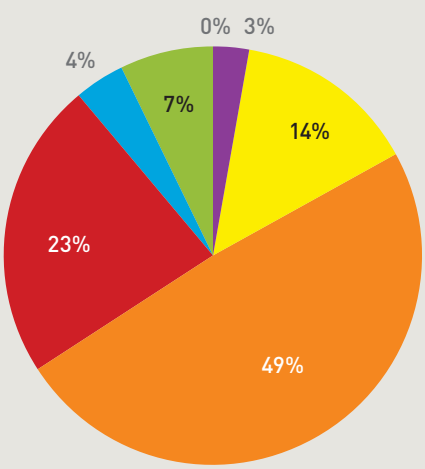
John Kevin Marquez: I want a whole new system. I need to retire my X58 setup.

James Williams: 16GB of Crucial Ballistix Sport RAM; 2x 8GB for my Gigabyte GA-X99-UD4. The 16GBs that are now installed look awfully lonely and could use some friends.

Terry Matthews: If I could find an affordable one, I'd like another 770 GTX, or one of the newer Titans.

Patrick Mienke: AMD R9 Nano.

How big will your next SSD be?



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THE BUILDS

BUDGET GAMER

INGREDIENTS

PART			PRICE
Case	Cooler Master Elite 110		$40
PSU	EVGA GS 550W 80 Plus Gold		$70
Mobo	ASRock H170M-ITX/ac	NEW	$100
CPU	Intel Core i5-6400	NEW	$190
GPU	EVGA 3962-KR GeForce GTX 960 SC		$230
RAM	Kingston HyperX Fury 8GB DDR4 2133	NEW	$57
SSD	500GB Crucial MX200	NEW	$140
OS	Ubuntu Desktop Linux 14.04 LTS 64-bit		$16

Approximate Price: $843

PRICES FOR MOST COMPONENTS stayed the same, so the Cooler Master Elite and EVGA parts return. However, with the release of more Skylake SKUs, we updated this rig with the latest Intel architecture. With modernity comes price, and we had to spend a little more for our motherboard and RAM. While the switch from ASRock's H97M model to the H170M model was only $4 more, upgrading from DDR3 (8MB of Crucial Ballistix at $45) to DDR4 added $12. We did save some big money by steering clear of Skylake K-model SKUs, and settling for locked clocks. The Core i5-6400 will still serve users well. One big change was to ditch the 1TB of storage and opt for a bigger SSD. By going with Ubuntu 14.04 LTS, users have a lower storage requirement for the OS. At time of writing, the 500GB Crucial MX200 was priced lower than the less desirable BX100, so we took advantage of the better performance at a good price point.

MIDRANGE

INGREDIENTS

PART			PRICE
Case	Corsair Carbide 500R		$110
PSU	EVGA SuperNOVA G2 850W		$140
Mobo	Gigabyte Z170X-Gaming 3		$150
CPU	Intel Core i5-6600K		$260
Cooler	Corsair H100i		$110
GPU	Asus Radeon R9 390 Strix	NEW	$320
RAM	G.Skill Ripjaws V Series 8GB DDR4 2133 (red)		$55
SSD	500GB Samsung 850 EVO M.2	NEW	$175
HDD	Western Digital Black Series 1TB	NEW	$70
OS	Windows 8.1 64-bit OEM		$100

Approximate Price: $1,490

AT THE TIME OF WRITING, most prices were holding steady, so we had to find a way to change things up a bit. We hoped we could finagle in a Core i7-6700K, but the extra $110 just wouldn't fit in our $1,500 budget. The Core i5-6600K is still a sexy new unlocked Skylake, so we don't feel too bad on that count. One thing that did change was the prices of R9 390 implementations. EVGA's prices went up by about $10. Luckily, the Asus Strix version of the GPU landed at $320, the price point we saw last month. One thing we changed quite a bit was storage. While we stayed with the Samsung 850 EVO, we decided to double the capacity and go with the M.2 form factor. This particular SSD model sports the same specs as the 2.5-inch SATA 850 EVO, so don't get too excited about speeds. To afford the bigger EVO, we had to decrease the capacity in our spinning drive. One terabyte is still plenty, and hard drives are cheap to add if the need arises.

TURBO

WHEN WE SET OUT TO CREATE our Turbo build, the goal was to keep it under $3,000. We came close, really close. But we wanted to do something truly awesome. We kept the Core i7-5820K and Asus X99-A as the base, and went with EVGA's GTX 980Tis, due to price fluctuations. While we can get this rig up and running with the 850W power budget, things will get a bit tighter when overclocking. To keep things under 850W, staying with modest overclocks or prioritizing overclocks (GPU versus CPU) will keep power demands under control. We also changed up the cooler, from the NZXT Kraken X61 to the Corsair H100i. We wish we could have gotten an H110i, but we pulled back to make room for our storage solution.

If there's one theme in this month's builds, it's an emphasis on SSD storage. With a 1TB 850 EVO, you'll be able to fit most, if not all, of your programs, OS, and games. This lets us get away with a smaller HDD, so we scaled back to 1TB on the spinning drive. We felt this was justified because fewer people are cramming their desktop hard drives with music and movies when NAS and external HDD solutions are plentiful. Still, a spinning drive is useful for backups and archiving less-often used items in a Steam library. We were unwilling to drop one of the 980Tis in this build iteration, so we weren't sure we could hit our budget target. But, at the time of writing, we found the 850 EVO on sale. Going over budget by one dollar is close enough for us.

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

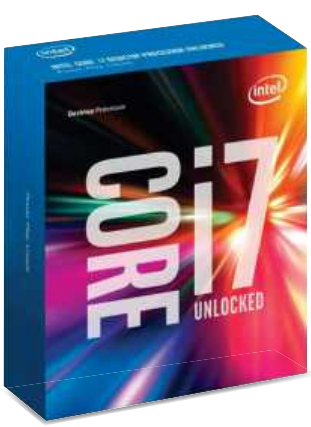
INGREDIENTS

PART			PRICE
Case	Corsair Graphite 780T		$190
PSU	EVGA SuperNOVA G2 850W		$140
Mobo	Asus X99-A/USB 3.1	NEW	$250
CPU	Intel Core i7-5820K		$390
Cooler	Corsair H100i	NEW	$110
GPU	2x EVGA GTX 980Ti 4991-KR ACX 2.0	NEW	$1,300
RAM	16GB (4x 4GB) G.Skill Ripjaws 4 Series DDR4 2133		$107
SSD	1TB Samsung 850 EVO	NEW	$344
HDD	1TB WD Black	NEW	$70
OS	Windows 8.1 64-bit OEM		$100

Approximate Price: $3,001

UPGRADE OF THE MONTH

INTEL CORE i5-6700K (SKYLAKE)



Last month, we featured the Core i5-6600K as our upgrade of the month. The i7-6700K is the bigger, i7 brother to the i5, so you get a higher clock (4GHz) and more threads (eight). You'll also spend about $120 more for those features, and $30 more than the i7-4790K Devil's Canyon. Just make sure you know that going with Skylake means upgrading to an 1151 socket and DDR4 as well.

$370, www.intel.com

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