EUROJÄRJESTELMÄ
EUROSYSTEMET

USER MANUAL

Version 3.2.1

17.05.2013

Bank of Finland
PAYMENT AND
SETTLEMENT SYSTEM
SIMULATOR

Contents

1. Introduction

The Bank of Finland Payment and Settlement System Simulator (BoF-PSS2), is analysis software designed for payment and settlement system simulations. The simulator can be used for studying liquidity needs and risks in payment and settlement systems. Special situations, which are often difficult or impossible to test in a real environment, can be simulated with this tool.

This document is the user manual of BoF-PSS2. It describes features of the software and their use. It also provides overview of technical details of the simulator and refers to other documentation, where more details can be found.

The manual is structured as follows.

- Chapter 1 provides this introduction and describes general structure and possible usages of BoF-PSS2.
- Chapter 2 provides instructions for installation of BoF-PSS2 and necessary third party software.
- Chapter 3 presents the user interface of BoF-PSS2 and describes its existing features.
- Chapter 4 presents outline of algorithms, which are the building blocks used in describing simulated payment systems.
- Chapter 5 presents outline of data management and structure of the database.
- Chapter 6 provides screenshots of the graphical user interface.
- Chapter 7 includes references to more detailed technical documentation of the simulator.
- Chapter 8 includes short troubleshooting guide
- Chapter 9 lists acknowledgements of contributors, who have participated in the development of the tool.

1.1. General overview

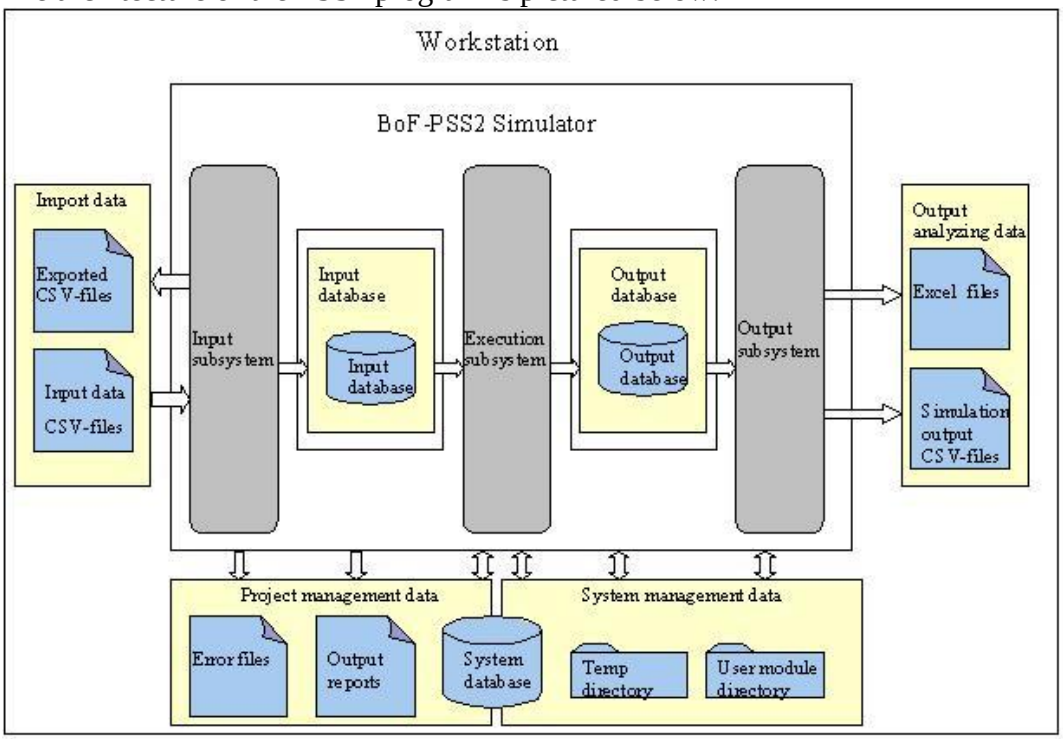
The BoF-PSS2 system structure contains three main subsystems:

a) Input generation subsystem

b) Simulation execution subsystem

c) Output analysing subsystem

The architecture of the PSS2 program is pictured below:



1.1.1. Input generation subsystem

The input generation subsystem includes tools to import and validate transaction data, participant data, as well as data on daily account balances and credit limits. All data are stored in database files. The importer's main task is to check that the input data is formally valid and then transfer it into system database structures. The correctness of the input data is vital. Account numbers or identifiers in the transaction file must correspond to the account or participant data.

All input data must be presented in CSV (comma separated values) format, but it can be entered in a user-defined order. The input data can be edited by exporting them from the input database as CSV files to Excel. They can then be re-imported after the changes. (Current Excel versions can handle about 65,000 rows. If larger files need to be edited, other tools (e.g. Access or SAS) or direct programming is usually needed. In rare situations, splitting tables in sub-tables may be a suitable solution.) The simulator does not include a proprietary editor for this purpose.

1.1.2. Simulation execution subsystem

The simulation execution subsystem includes tools for configuring and running simulations. It also contains the actual simulation and settlement logic. It keeps a log of all events and bookings and makes reports and statistics on simulation runs. A control panel facility is available to set up and manage settlement structures, configure settlement rules and launch, monitor and control simulation runs. The simulator keeps a log file for the user of all simulations made.

1.1.3. Output analysing subsystem

The output analysing subsystem has the functionality for reporting basic statistics for common result parameters. The output database contains the raw data for the booking order of transactions and balances of settlement accounts. The input database contains the transaction flow, while the output database contains the settlement flow, i.e. settlement order and timing of submitted transactions.

An analyser program is used to generate additional reports. Users typically perform many different simulations and want to compare the results of the different runs. The analyser does some comparisons automatically, but additional analyses may require exporting CSV files for use with tools such as Excel. It is thus advisable to create a structure beforehand for simulation runs and determine which results are to be stored in databases for further analysis. The databases can become overly massive when transaction volumes are high and all transaction-level events are retained in the databases.

1.2. Supported system structures and simulation examples

BoF-PSS2 software supports a large variety of general system structures. It can model most payment and settlement structures and processes found in real systems.

The simulator supports real-time gross settlement (RTGS), continuous net settlement (CNS) and deferred net settlement (DNS) systems. The processing options for these systems are defined by selecting appropriate algorithms. For example, QUE algorithms define how transactions are released from queues, while PNS algorithms define when and how partial net settlement of queued transactions will be invoked.

The simulator also has multi-system capabilities, whereby a large number of interacting systems can be included in the same simulation (see chapter 3.9.4). When transactions occur between systems, they are booked in separate intersystem accounts. There are two types of intersystem transactions:

straightforward participant-to-participant transactions or system invoked injection or settlement transactions between a main and ancillary system. In the straightforward case, the sending system's transaction data include a reference to a receiving participant in another system. It is possible in ancillary systems to define the end-of-day settlement system and accounts for each participant. Intraday injections may also be defined. These transfer liquidity between the main and ancillary system during the day according to participant needs.

Typical interacting system scenarios include:

- Several independent RTGS systems constituting a network of systems, e.g. TARGET,
- A domestic payment system environment consisting of an RTGS system and ancillary systems, e.g. a CNS and a DNS system settling in the RTGS system, and
- RTGS system settlement between an RTGS and a securities settlement system.

The simulator also supports multi-currency and multi-asset processing, which allows simulation of international payment systems and securities settlement systems. Assets are treated as book-entry currencies. Payment-versus-payment (PVP) and delivery-versus-payment (DVP) processing is supported. DVP/PVP transaction pairs should be connected via a DVP/PVP-link code. In addition to single intra-system DVP/PVP processing in RTGS or deferred net settlement mode, the simulator also supports RTGS DVP/PVP settlement between real-time systems.

The focal output factors in simulations are typically counterparty risk and overall risk, liquidity consumption, settlement volumes, gridlock situations and queuing time. Measures for these factors will be stored in the output database. In what-if simulations, the input parameters are modified to distinguish effects on output factors. The following input parameters are often used or modified in simulations:

- Input transaction flow (e.g. testing when a single counterparty or system has problems),
- Available liquidity,
- Credit limit/debit cap restrictions,
- Queuing and netting processes,
- Participant behaviour due to e.g. new pricing patterns,
- New settlement procedures, e.g. new algorithms,
- Structural changes, e.g. the merging of several systems,
- Changes in participant structure (e.g. introducing new participants, merging old participants), and

– New intersystem processes (e.g. a shift to RTGS-based DVP processing from end-of-day batch processing).

Liquidity is introduced the simulations either by defining daily opening balances and/or intraday credit limits. Liquidity can also be introduced via repo-transactions and there are more alternatives available: introducing only the money legs between the participants and the central bank account (with abundant limit), introducing in DVP mode the money legs in the RTGS system and the asset legs in a separate securities settlement system or having a special collateral account (monetary value only) in the RTGS or securities settlement system.

Participant level risk management features can also be directly introduced in simulations by using bilateral limits (bilateral debit caps). These can be defined at bilateral and also at multilateral level separately from other liquidity arrangements.

Simulations may use available data from current systems or fictional, but representative, data. The simulator can be described as a deterministic model with stochastic input.

Data for some examples are distributed with the simulator software, e.g. an RTGS simulation, an RTGS system with an ancillary CNS or DNS system and a real-time DVP securities settlement system. Some correct results are provided for all examples as illustration of what can be obtained as simulation output. All examples are available in two versions: with decimal commas and with decimal points. The data for the examples and system descriptions are found in the directories C:\BoF-PSS2\examples\DECIMAL_COMMA and C:\BoF-PSS2\examples\DECIMAL_POINT.

2 Installation

Before using **BoF-PSS2** software, you need to install the MySQL/MariaDB database server. Instructions for this are given below.

Information on how to order and download the **BoF-PSS2** program is posted at **www.bof.fi/sc/bof-pss**.

2.1. Hardware and software requirements

Hardware

At least a PC Pentium 4 class processor with at least 1 GB of main memory is recommended, even though the simulator can be run with less memory and a slower processor. Sufficient main memory is essential for rapid execution of large transaction volumes. At least 2 GB of main memory is recommended for large simulations and 4 GB or more for very large simulations (>1,2 million transactions and >1000 participants). Note that the 32-bit version of the Java virtual machine is able to use only approximately 1.5 GB of memory. In order to be able to allocate more memory than 1.5 GB to the Java virtual machine and the simulator, 64-bit versions of the Java Runtime Environment and the simulator are needed. Naturally the operating system also needs to be a 64-bit environment.

The **BoF-PSS2** simulator can process massive transaction flows effectively with adequate available main memory resources. The complexity of the algorithms used and the selected output tables to be computed during the simulations strongly influence the running times and memory usage of simulations.

The **BoF-PSS2** simulator keeps all transactions and other input data to be processed during a simulation in the main memory. The amount of transactions is the decisive factor in main memory use. When there are more transactions than space in the main memory, system performance is likely to degrade strongly due to necessary disk swaps. Even then, the simulator continues processing during such circumstances until the limit of 1.5 GB is achieved for the 32-bit version.

Software

Windows XP/Vista/Windows 7

Microsoft Excel installed (required to open reports from the user interface)

MySQL/MariaDB/MS SQL-SERVER database server installed.

Sun Microsystem's Java Runtime Environment (JRE) 1.7.0_09-b05 (distributed and installed with the **BoF-PSS2** program).

The **BoF-PSS2** program should work with limitations in Linux, although this is yet to be tested. Please contact the Bank of Finland if you are interested in running the software in a Linux environment.

2.2. Installing a database server

The **BoF-PSS2** program assumes that Microsoft Excel and either MySQL, MariaDB or MSSQL Server are installed before the installation of the Simulator.

2.2.1. Installing MySQL

This chapter describes how to install MySQL database server, either one with commercial or GPL license. Refer to the the next section if you prefer MariaDB.

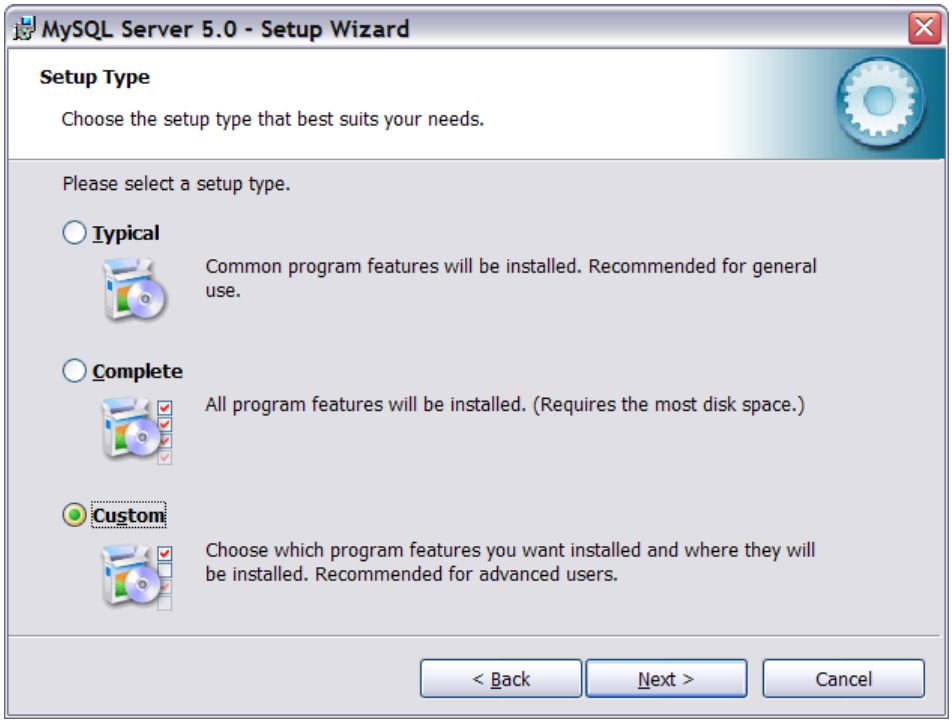
The basic environment for the simulator is assumed to be a stand-alone PC or a server in which the MySQL database is installed separately. If you employ a PC or a server in which MySQL is already installed and used by other applications, it is advisable to contact your in-house technical support persons or consult the MySQL manual on multi-application parallel use.

MySQL versions tested with the simulator are 4.1 and 5.0. Installation procedures of these two versions are identical. Necessary steps for the installation of MySQL 5.0 are listed below. Newer versions of MySQL are not yet supported.

1. Extract the archive containing the MySQL setup program (e.g. mysql-classic-5.0.83-win32.zip) and run Setup.exe. Click next in the Setup Wizard window.

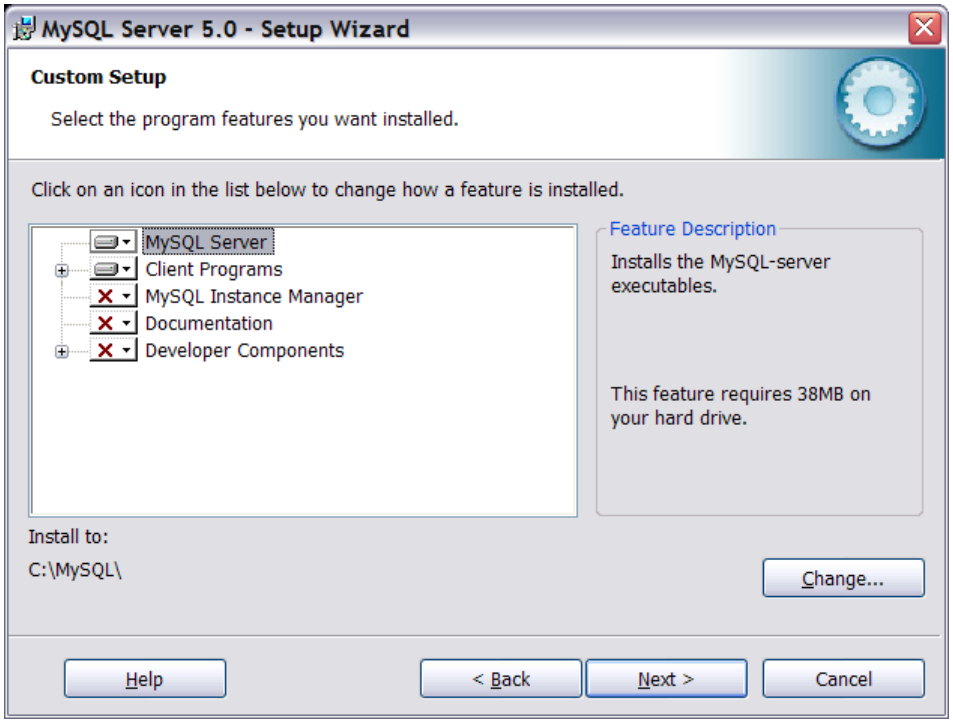
2. You have to accept the license agreement to proceed with the installation. Please consult your commercial MySQL license or the GPL license.

3. Select "Custom" and click next.



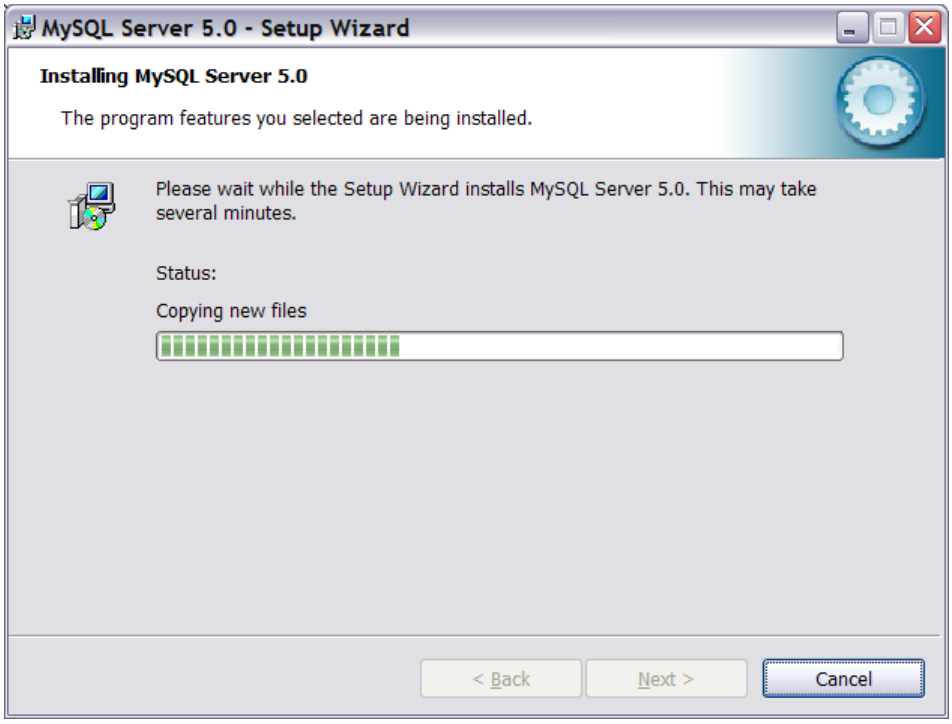
4. It is recommended to install to either C:\MySQL\ or C:\Program Files\MySQL\. The simulator installation program is able to automatically detect these folders and will configure the database.bat database_shutdown.bat and C:\my.cnf files accordingly.

MySQL Server and Client Programs should be selected for installation. The other items are not necessary for the simulator.



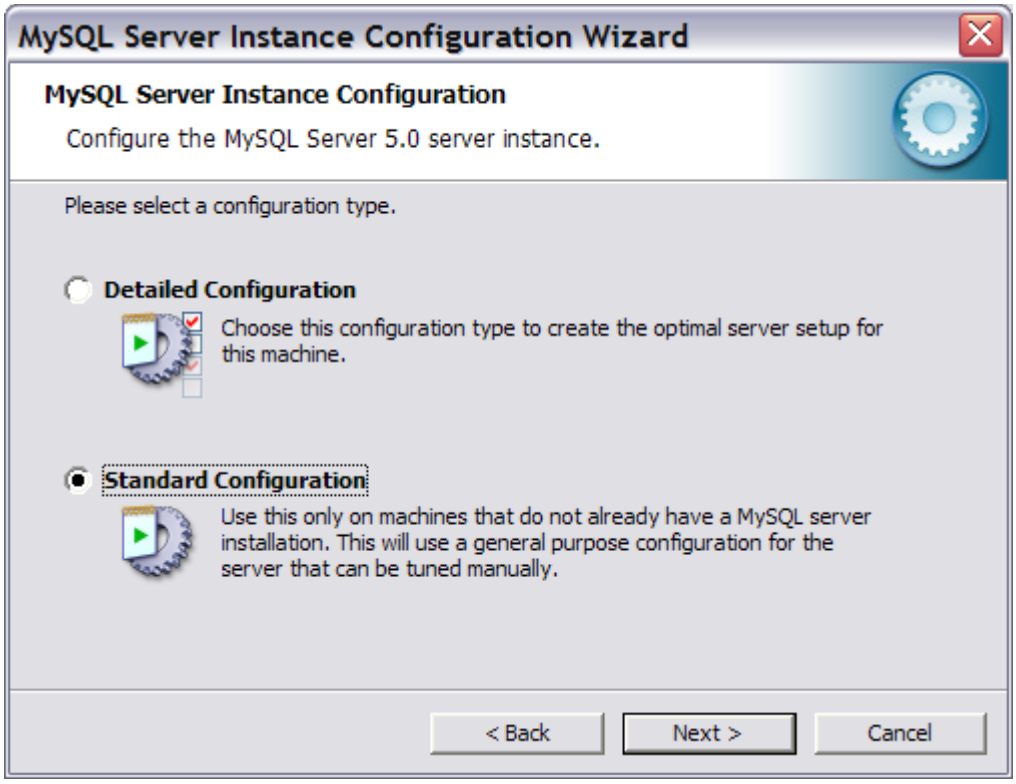
Using the default location for MySQL (C:\MySQL\ ) is advisable.

5. Click next and install the MySQL server.



6. After completing the installation wizard select the option "Configure the MySQL Server now" and click Finish.

7. Select "Standard Configuration" and click next.



8. **Unselect** "Install As Windows Service" and **select** "Include Bin Directory in Windows PATH".

9. Click next and execute, and the setup of MySQL is finished.

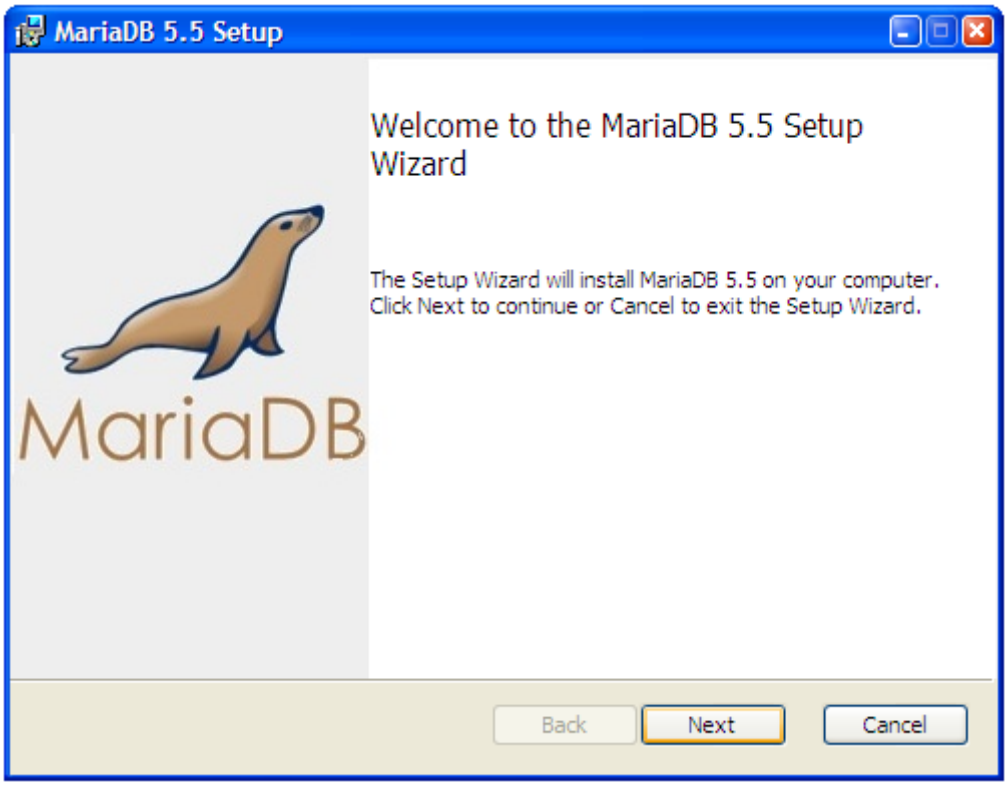
If you have problems, please consult the MySQL manual at http://dev.mysql.com/doc/refman/5.0/en/index.html.

2.2.2. Installing MariaDB

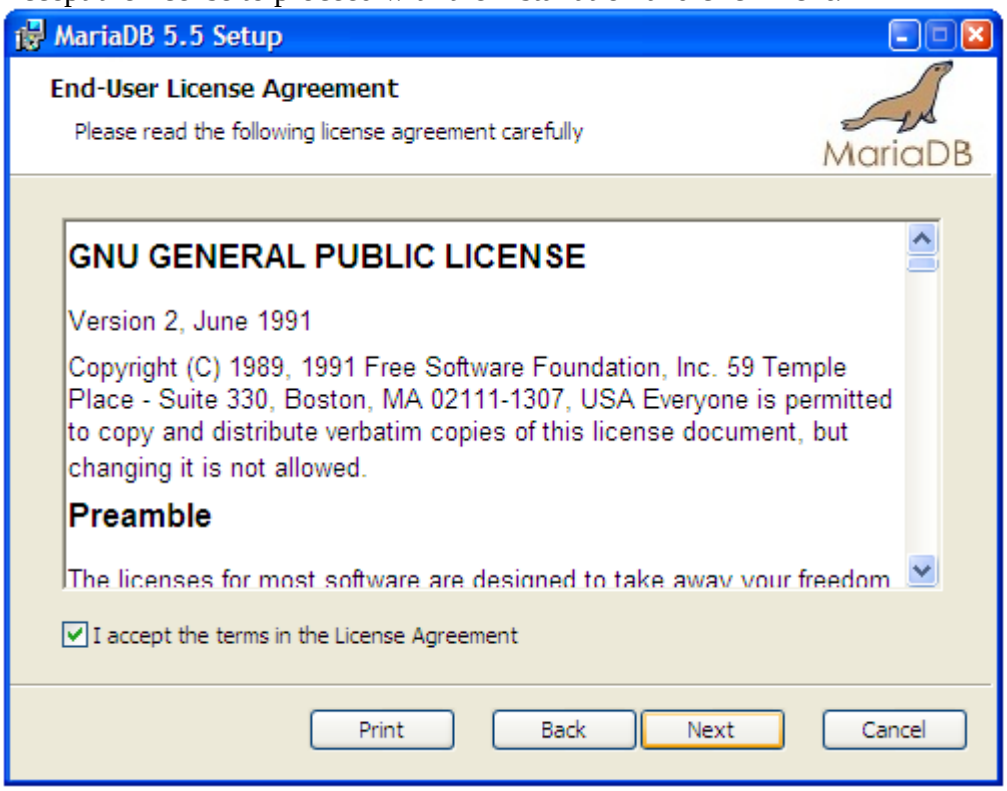
MariaDB database server offers a drop-in replacement functionality for MySQL. It is built by some of the original authors of MySQL together with assistance of free and open source software developers. MariaDB versions 5.2 and 5.3 (both 32bit and 64bit) are expected to work equally well as the commercial MySQL software. Note that MariaDB version 5.5 does not yet work properly with current release of **BoF-PSS2**.

Installation steps of the MariaDB database server:

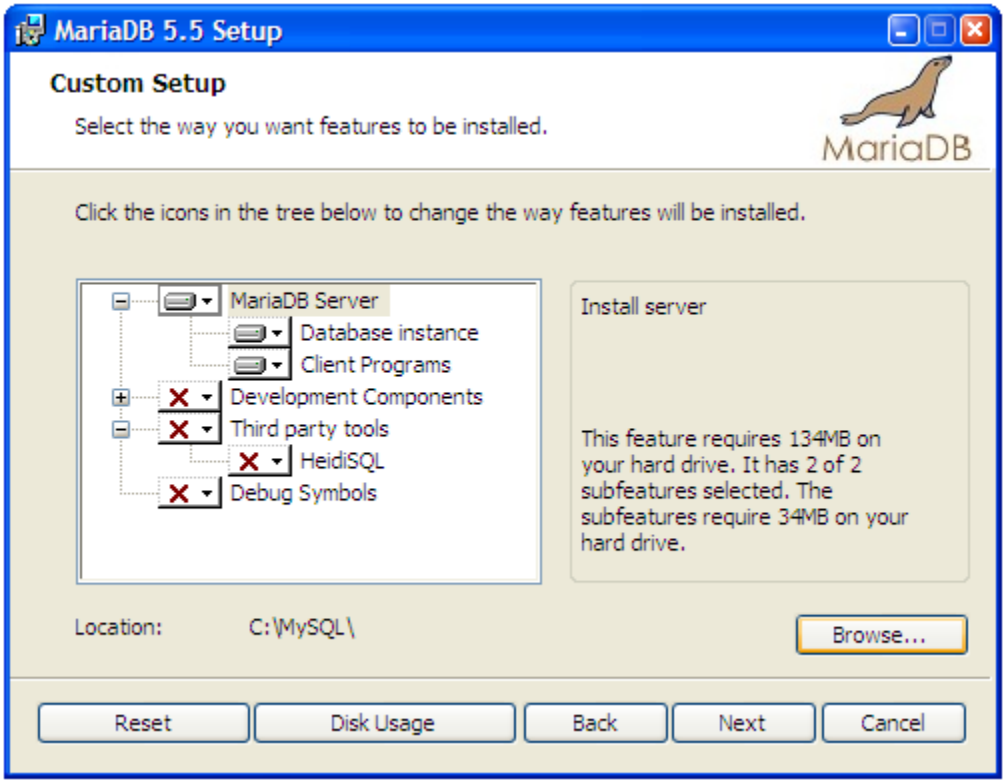
1. Download the MariaDB installation utility corresponding to your operation system from http://downloads.mariadb.org/mariadb/5.3/ . For 32-bit Windows the file name is of the format mariadb-5.3.7-win32.msi and for 64-bit Windows it is of the format mariadb-5.3.7-winx64.msi.
2. Double click the msi-installation file to start the installation and click **Next** in the setup wizard window.



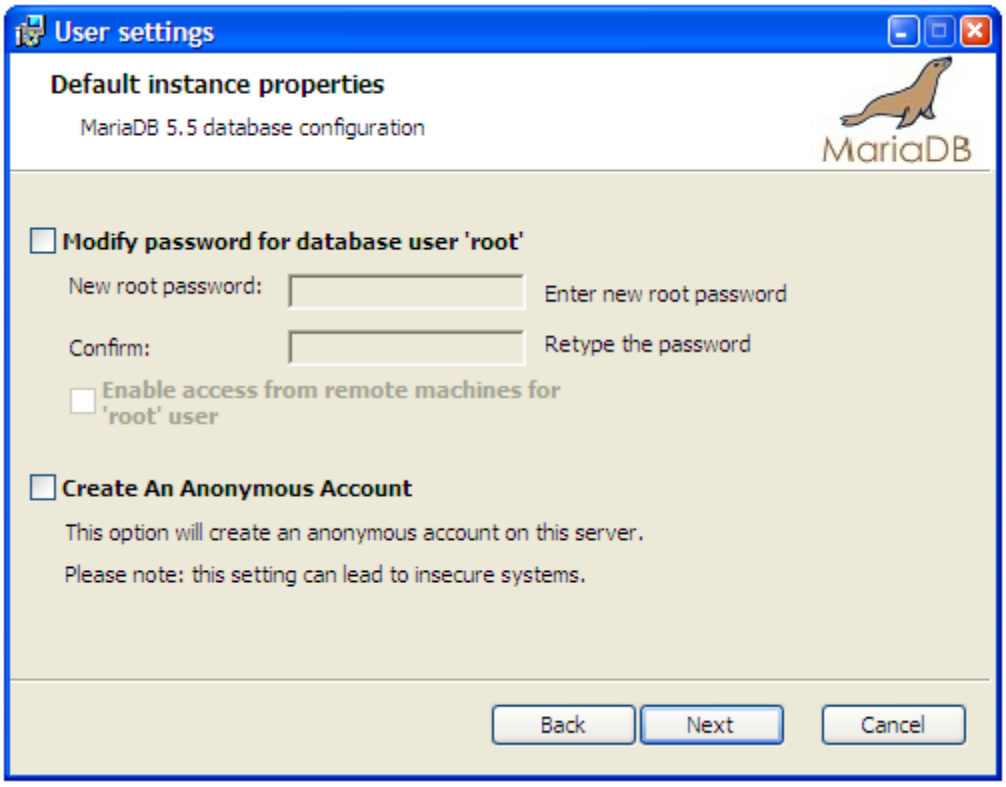
3. Accept the license to proceed with the installation and click **Next**.



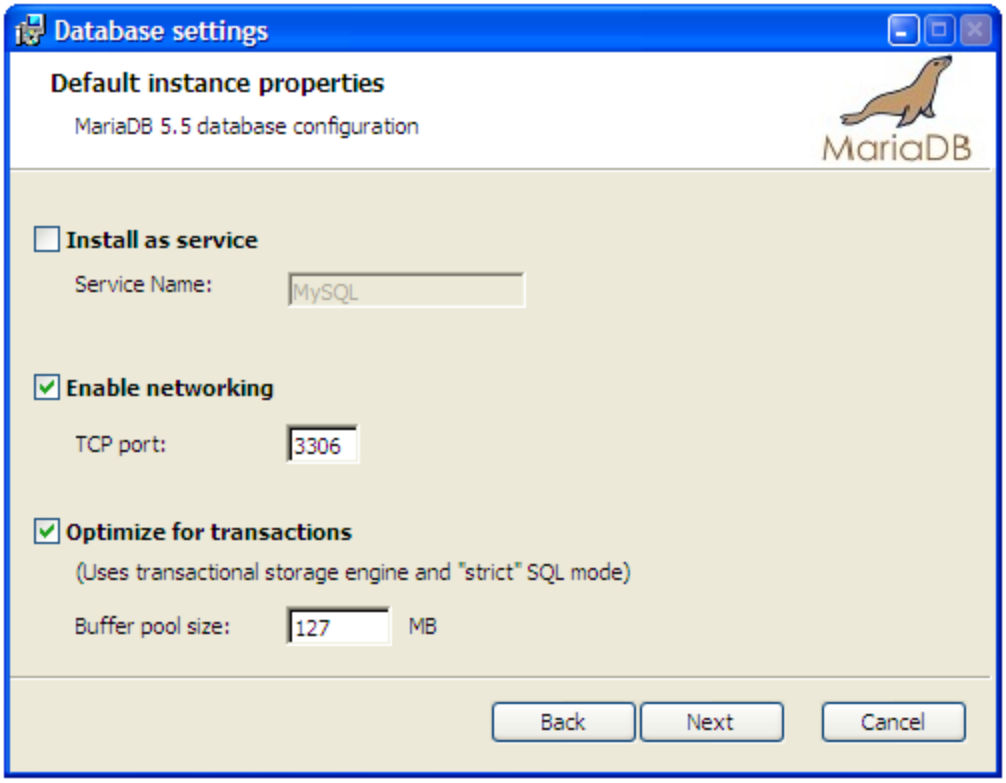
4. At the Custom Setup screen, select at least the MariaDB Server "Database instance" and "Client Programs" to be installed. Install additional parts according to your preference. The BoF-PSS2 setup will automatically detect MariaDB installed in C:\MySQL though any location is acceptable.



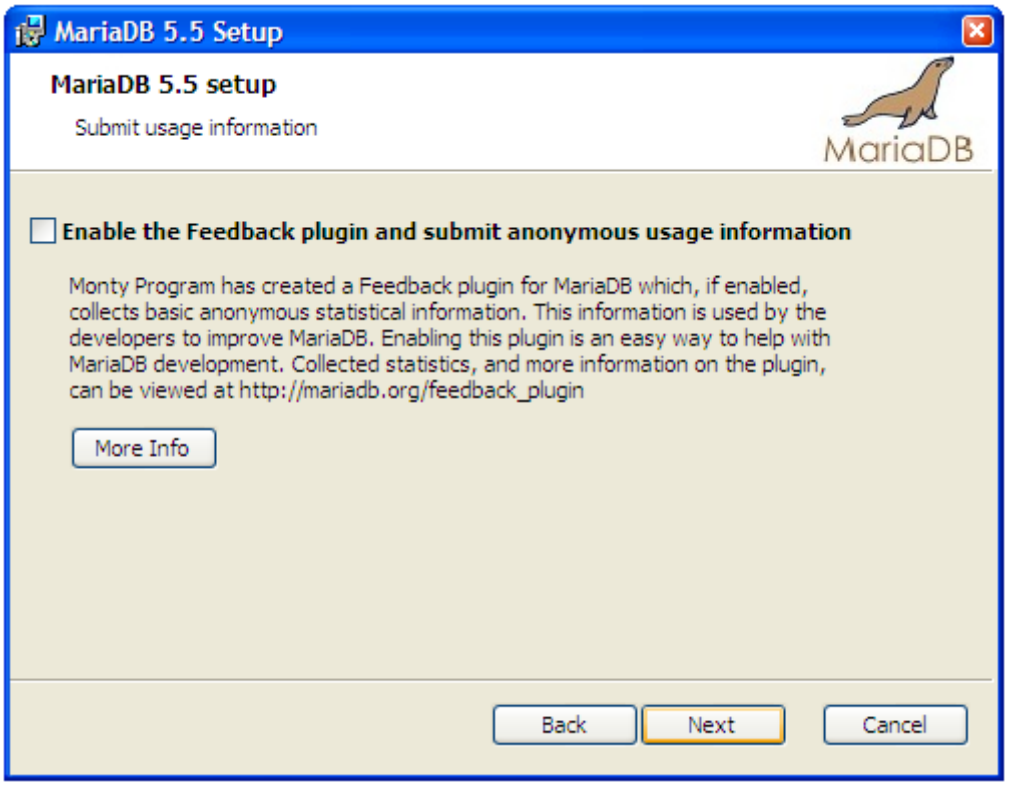
5. **Untick** the option “Modify password for database user ‘root’“.



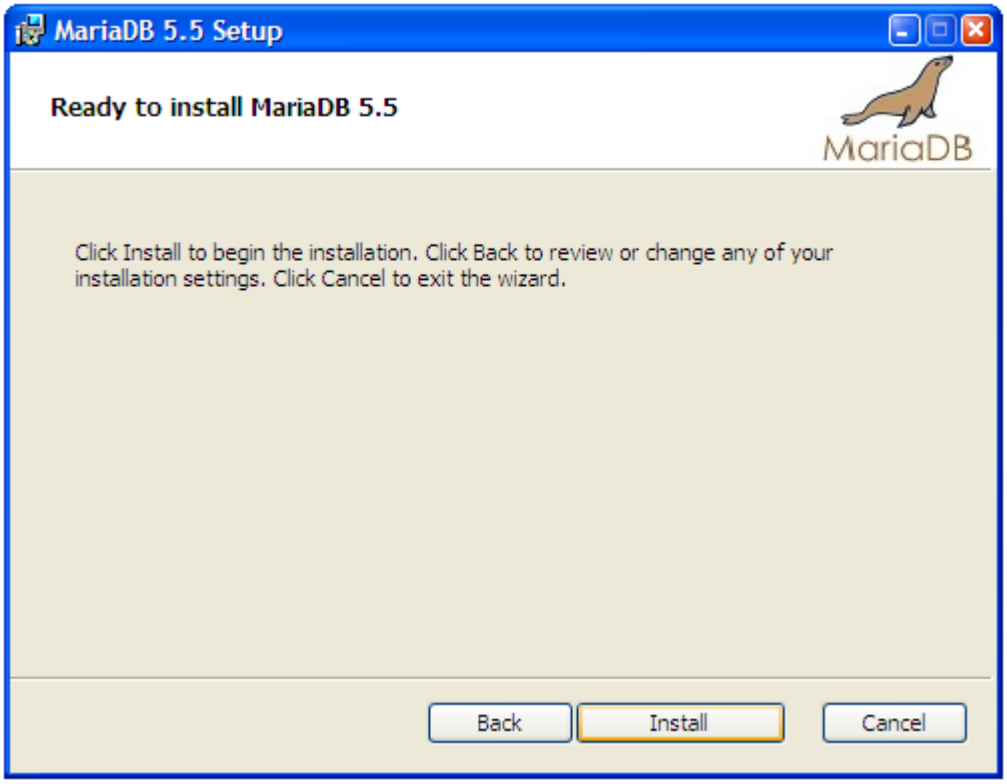
6. **Untick** the “Install as service” option.



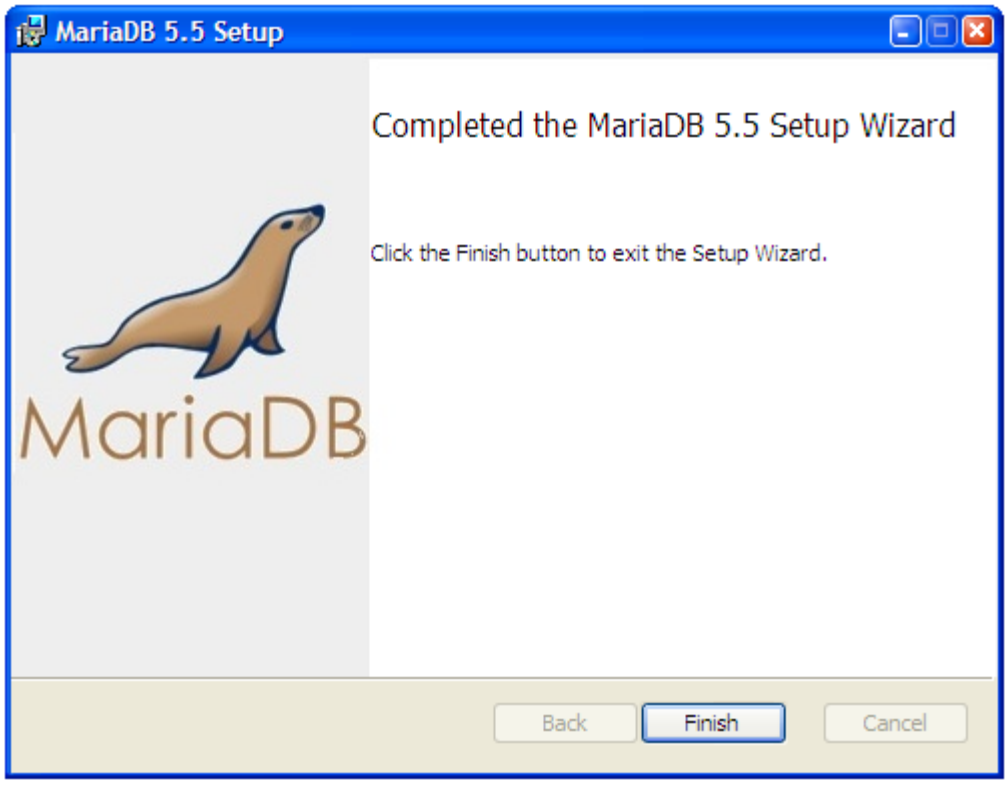
7. Enable or disable the Feedback plugin.



8. Click **Next** when Ready to install MariaDB.



9. Copying the files file will take about half a minute.
10. Click **Next** to finish the installation.

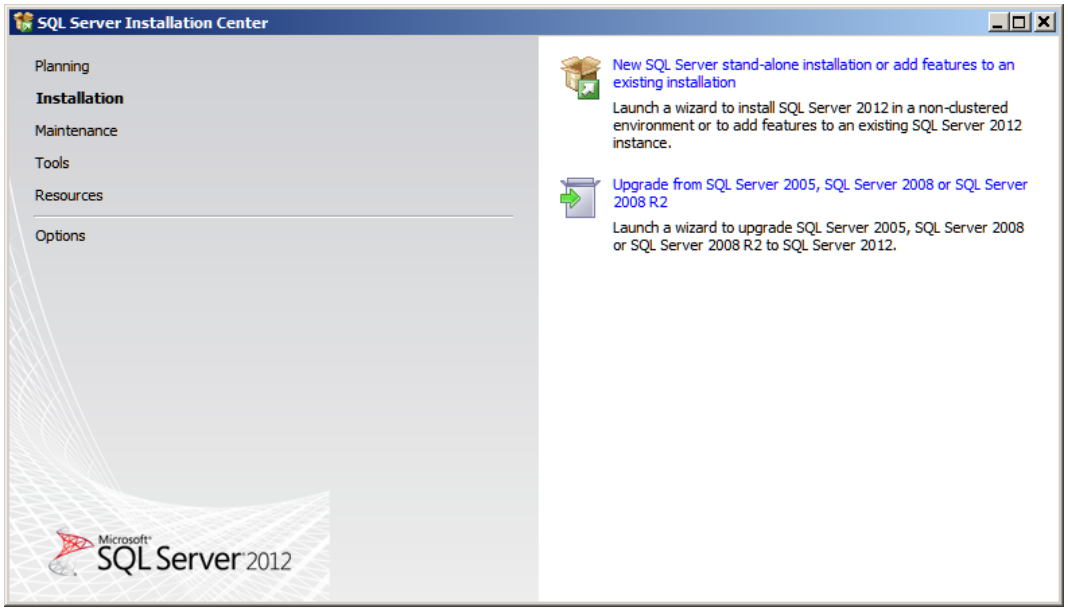


2.2.3. Installing MS SQL-Server

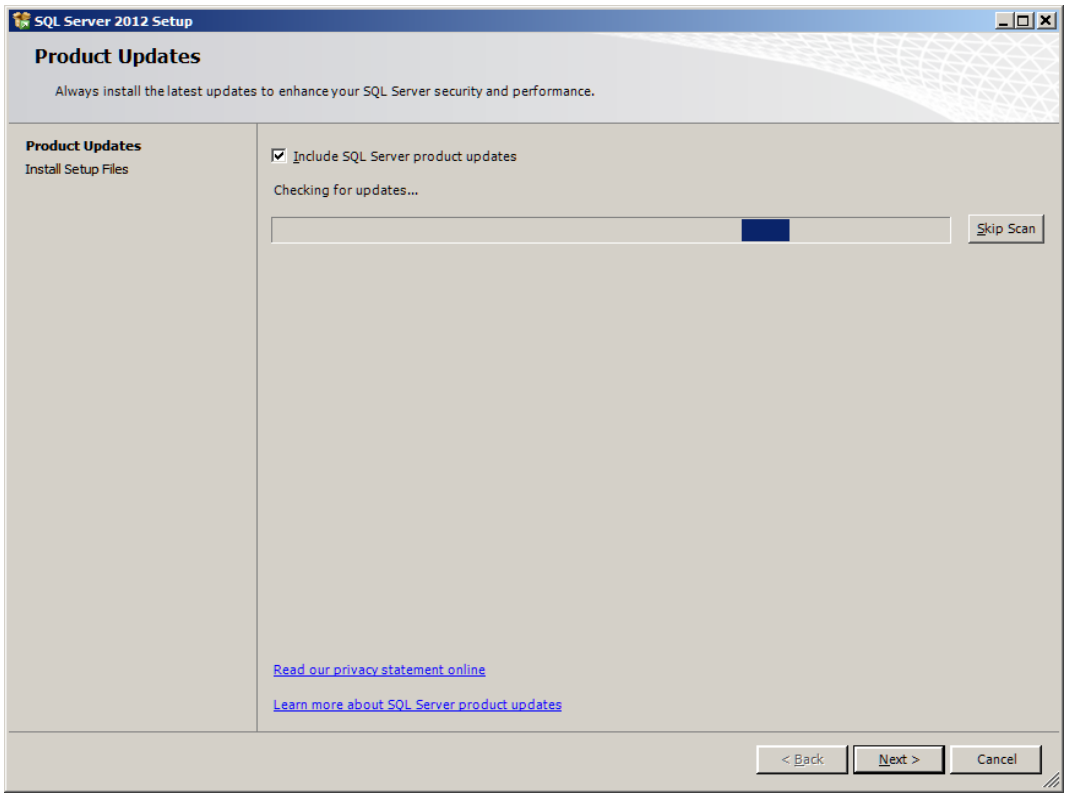
These instructions aplly to Microsoft's SQL-server 2012.EXPRESS. MS SQL server 2012 requires either .NET 3.5 SP1 or .NET 4 framworks and service pack 1 to be installed on your computer. Depending on the upgrade status of your computer theses might or might not be installed on your computer. The installation software is likely to inform the user if one of these is missing.

1. Download the MS-SQL Server correspondin to your system requirements from http://www.microsoft.com/en-us/download/details.aspx?id=29062.

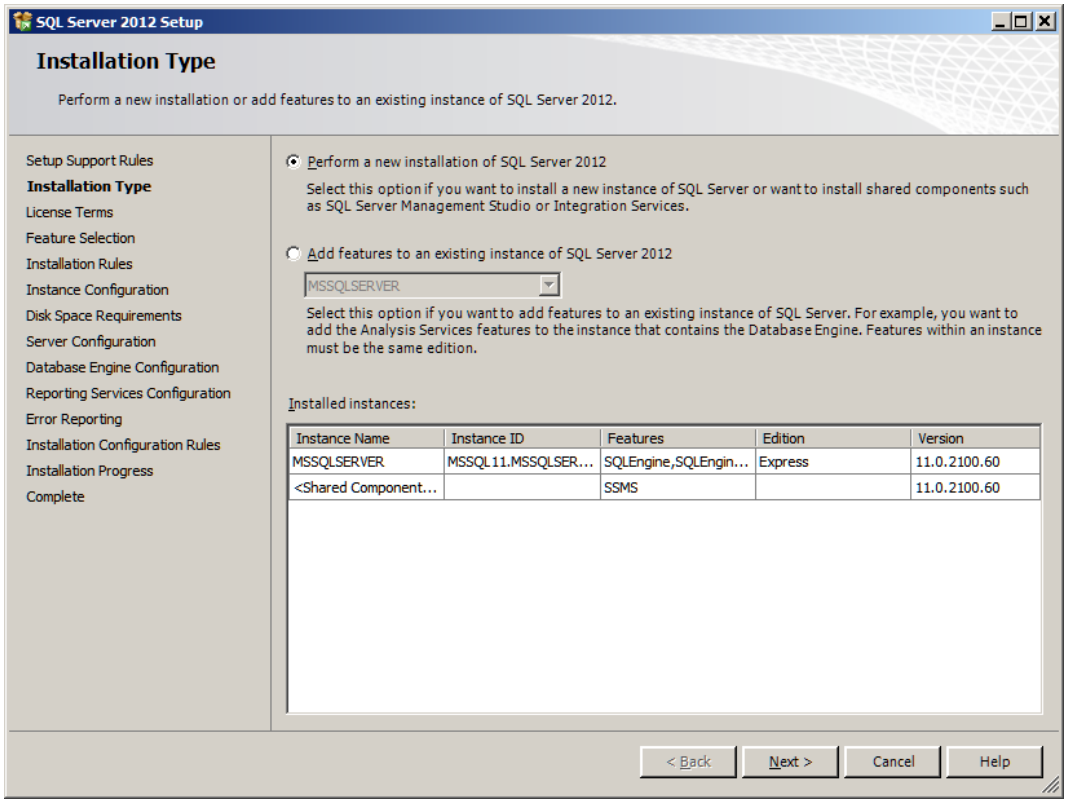
2. Run the setup .exe file The SQL Server installation center will open.



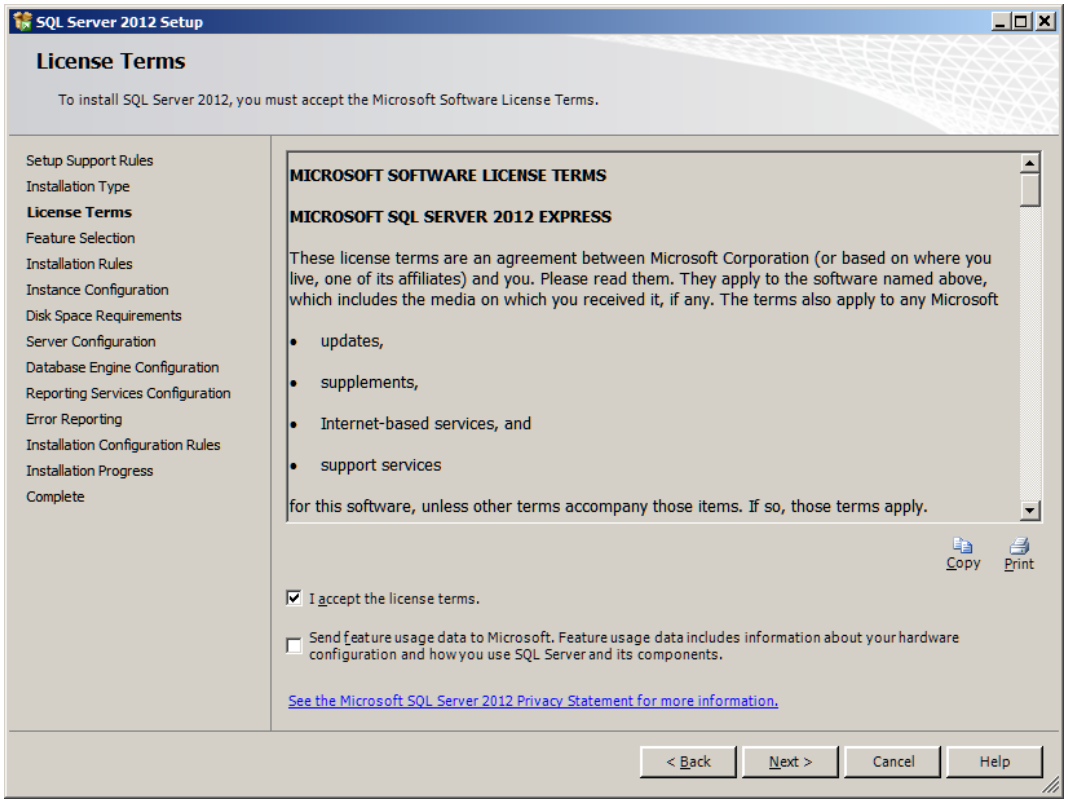
3. For a new installation select: New SQL Server stand-alone installation or add features to an existing installation.



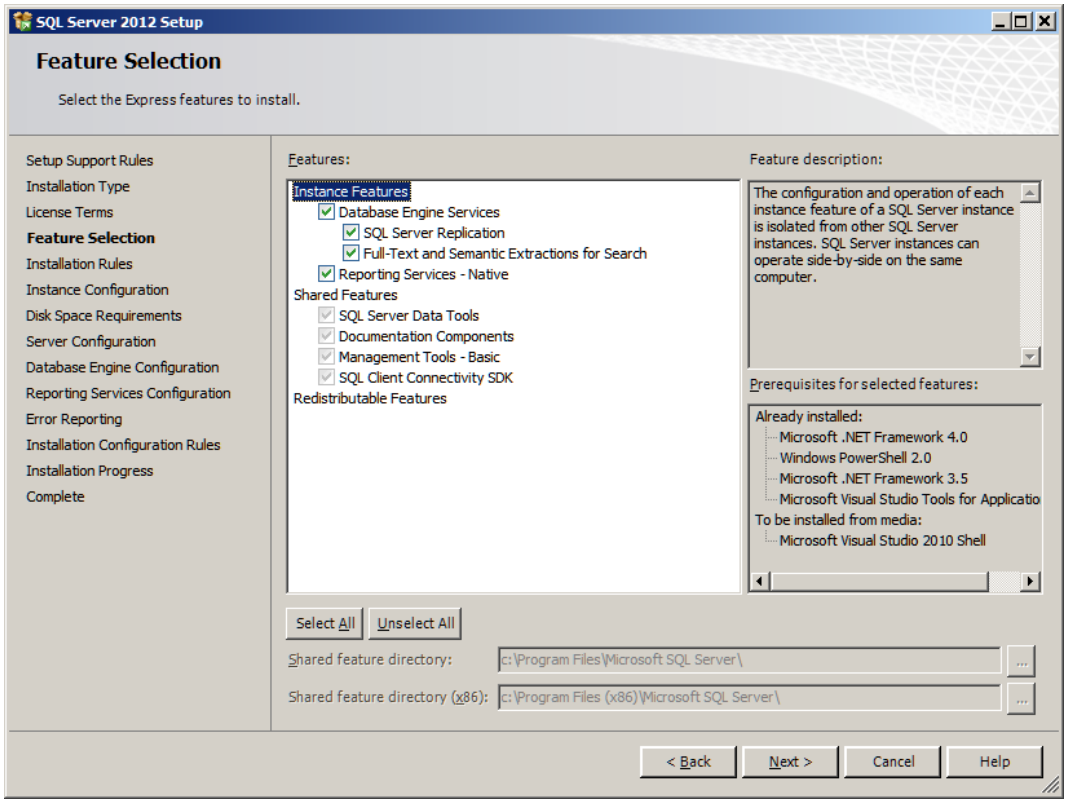
4. If your computer is connected to the internet, you might want to allow the installer to get updates.



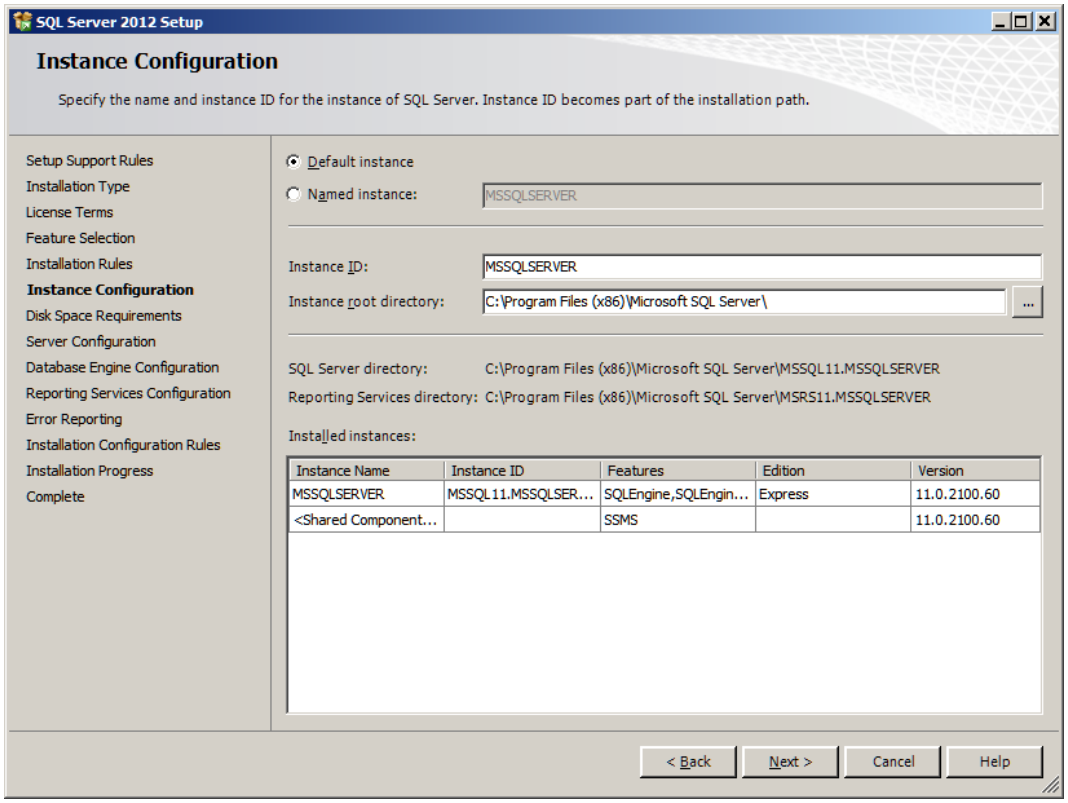
5. Select install new SQL-Server



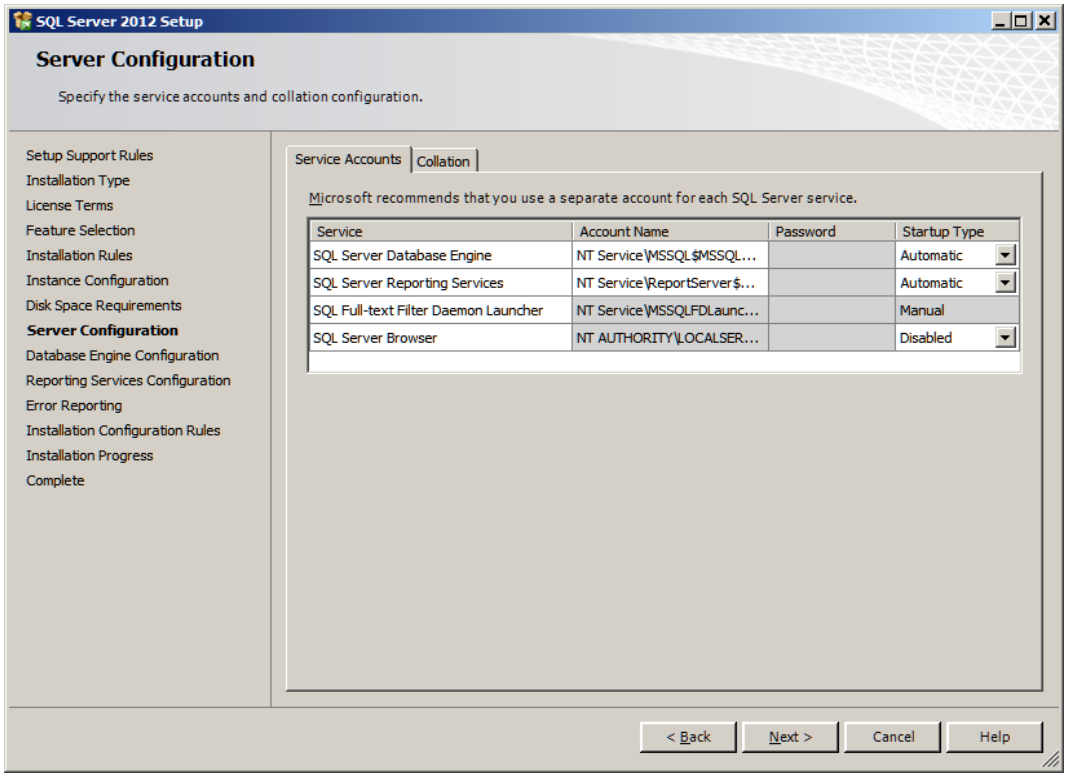
6. Accept licensing conditions and click next



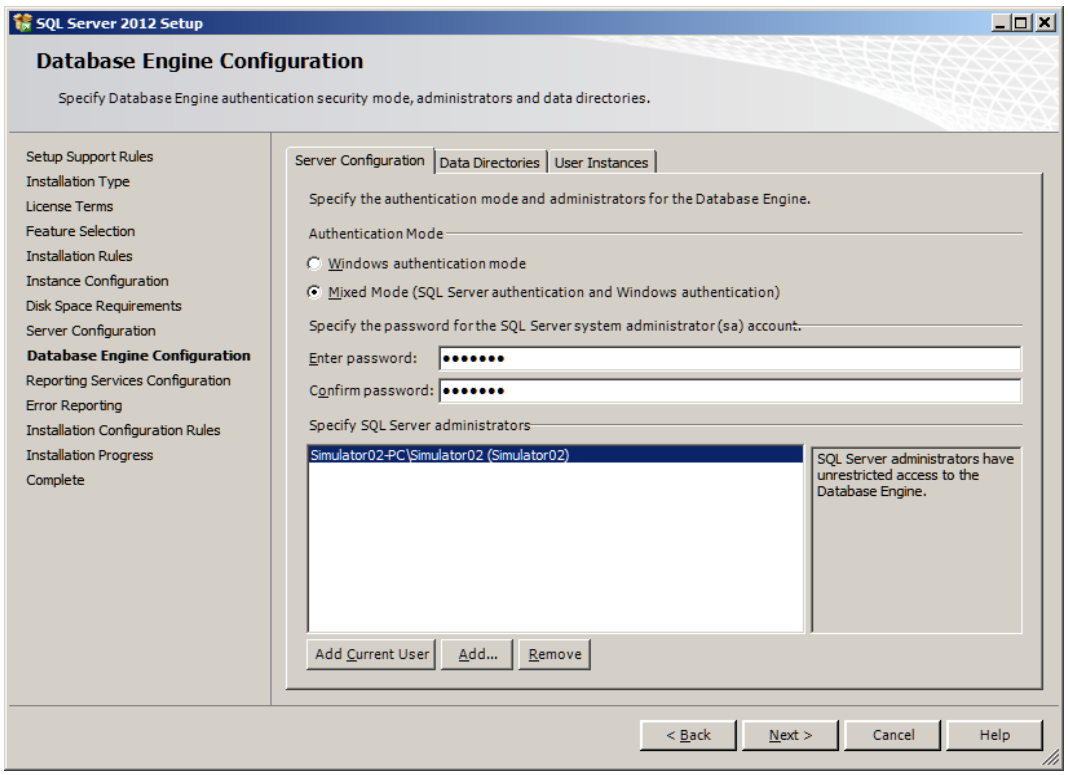
7. Select all features and click next.



8. Select Default instance. Set instance ID to MSSQLSERVER

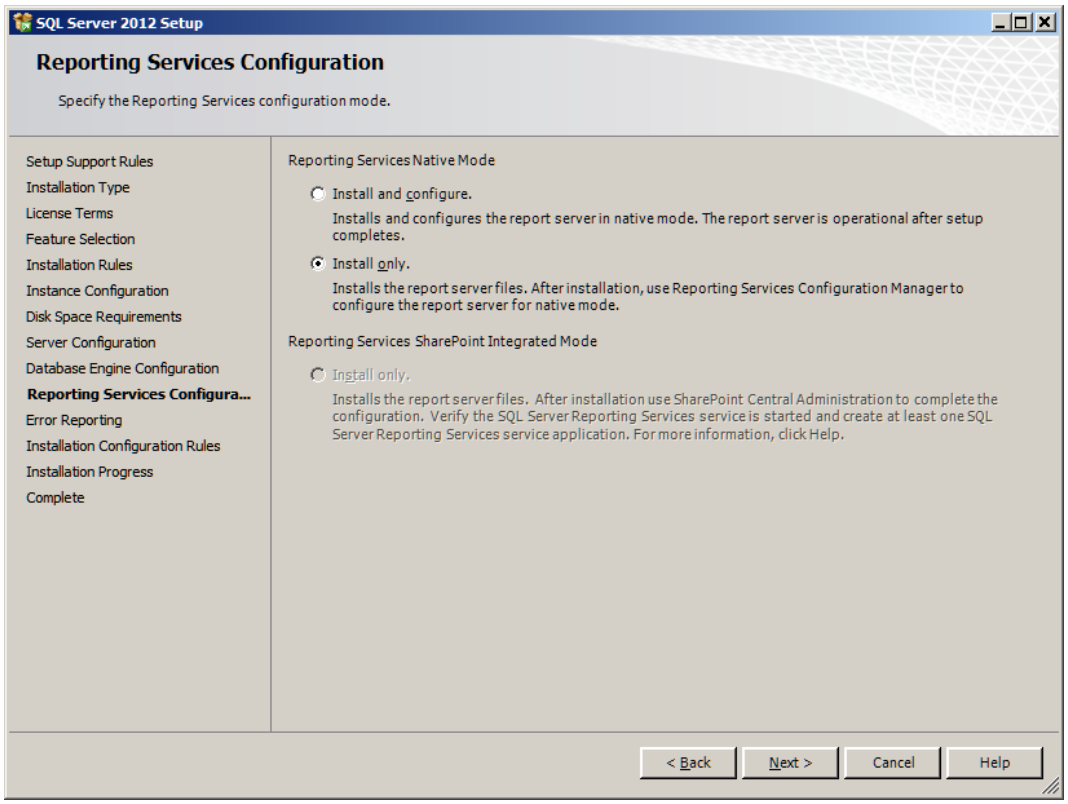


9. Use defaults and click next



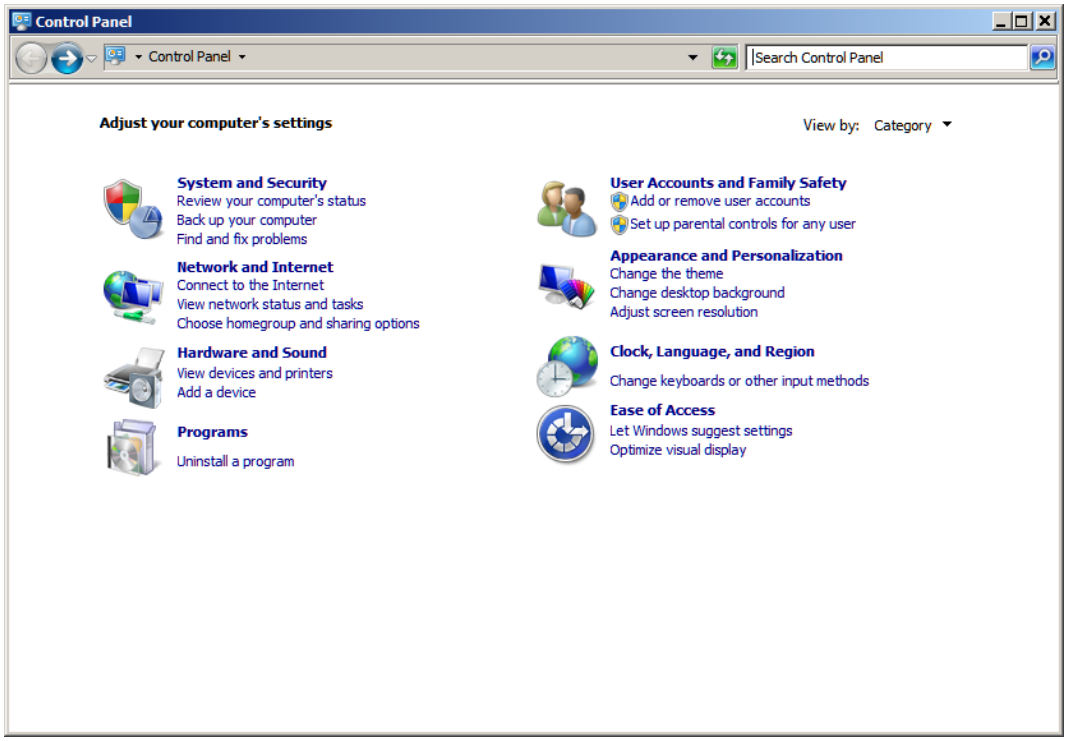
10. Set authentication mode to Mixed Mode. Depending on your security settings you might be able to let the password empty, if not you can define for example “bofpss2”. If you define a password here you will have to edit the BoF-PSS2_DB.properties –file accordingly. The simulator

installer assumes the password to be empty and the user name to be “sa” for SQL-SERVER installations. For more details see the instructions for installing the simulator 2.3
Specify the SQL Server Administrator by clicking the “Add Current User” button. The displayed name of the current user will most likely differ from the one on the picture of the manual as your computers own name will be used.

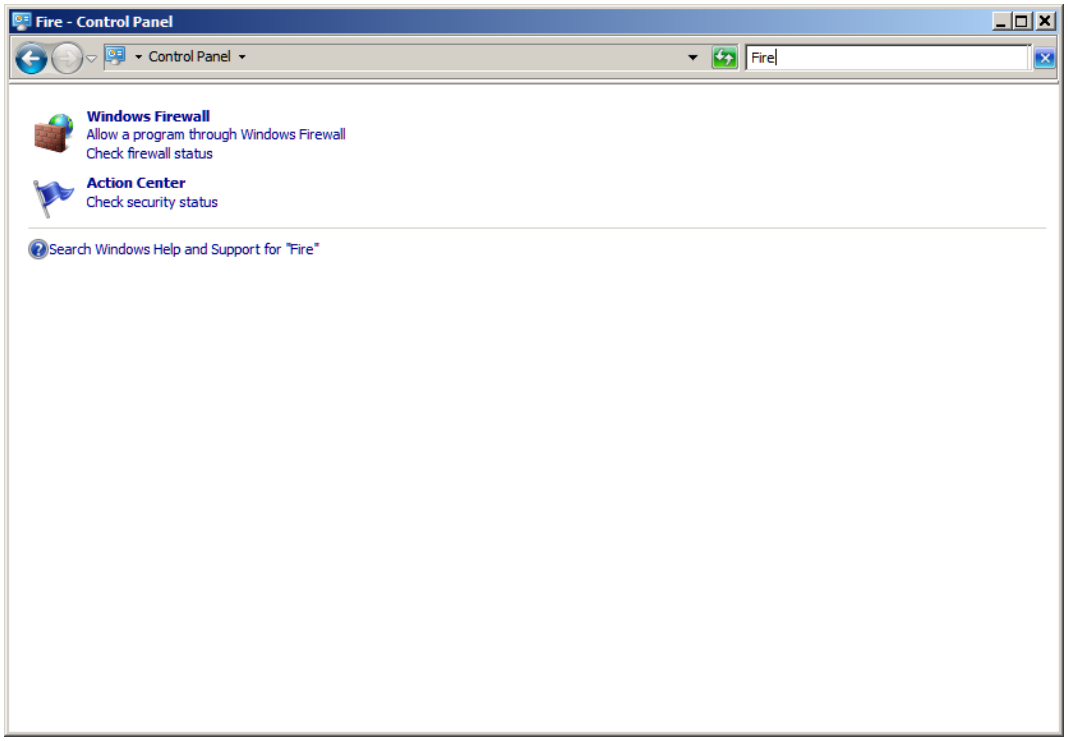


11. This guide does not cover the configuration of Reporting Services and this is why the selection install only is selected in the example. If you feel confortable in configuring the Reporting Services now, you can freely do so. Note Reporting Services are not needed for running simulations nor operating the simulator. It is a separate tool provided by Microsoft for reporting purposes.

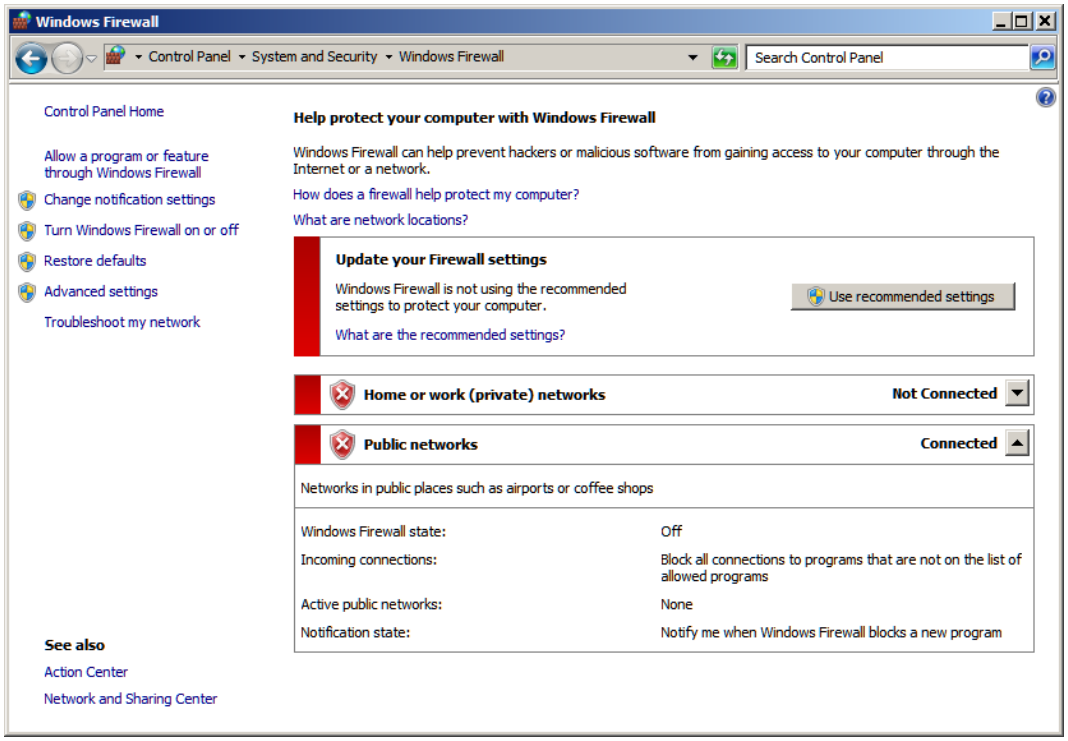
12. The installation of MS SQL-SERVER is now ready. In order to allow the simulator to connect with the SQL-SERVER you will have to define a port in to the windows Firewall. Instruction can be found from : http://windows.microsoft.com/en-US/windows7/Open-a-port-in-Windows-Firewall



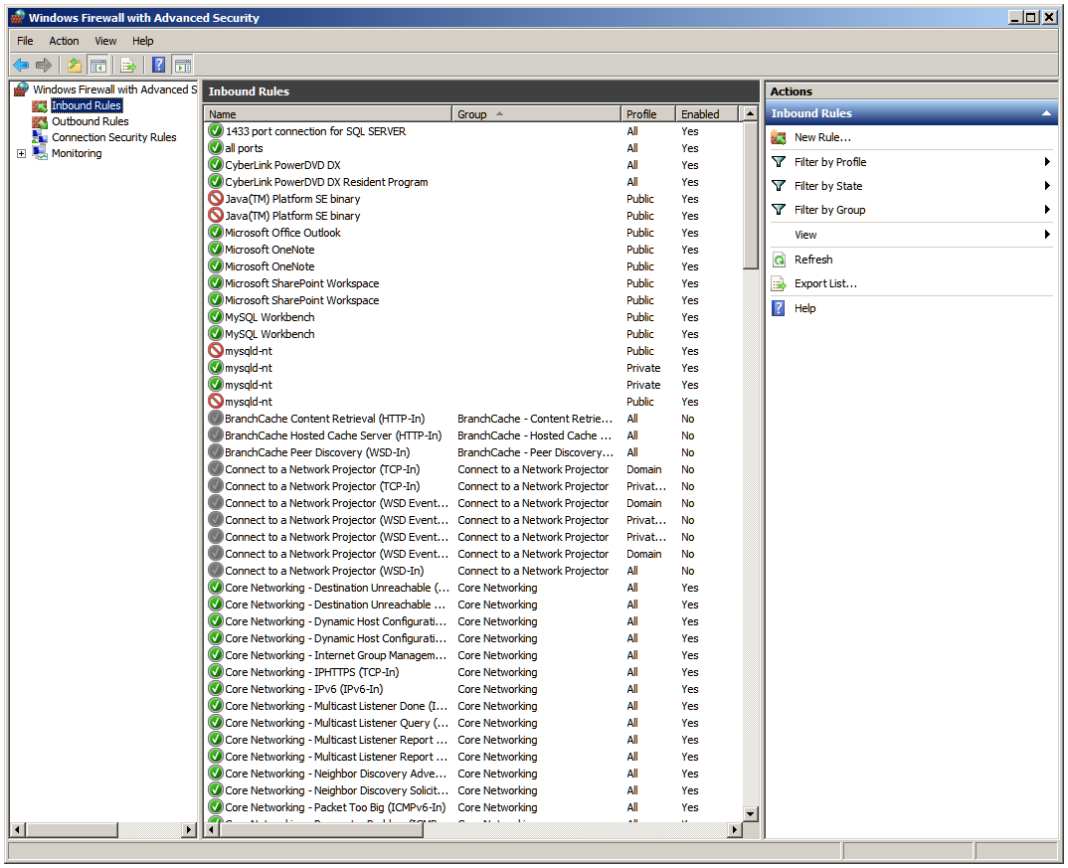
13. From the Windows Start menu select Control Panel



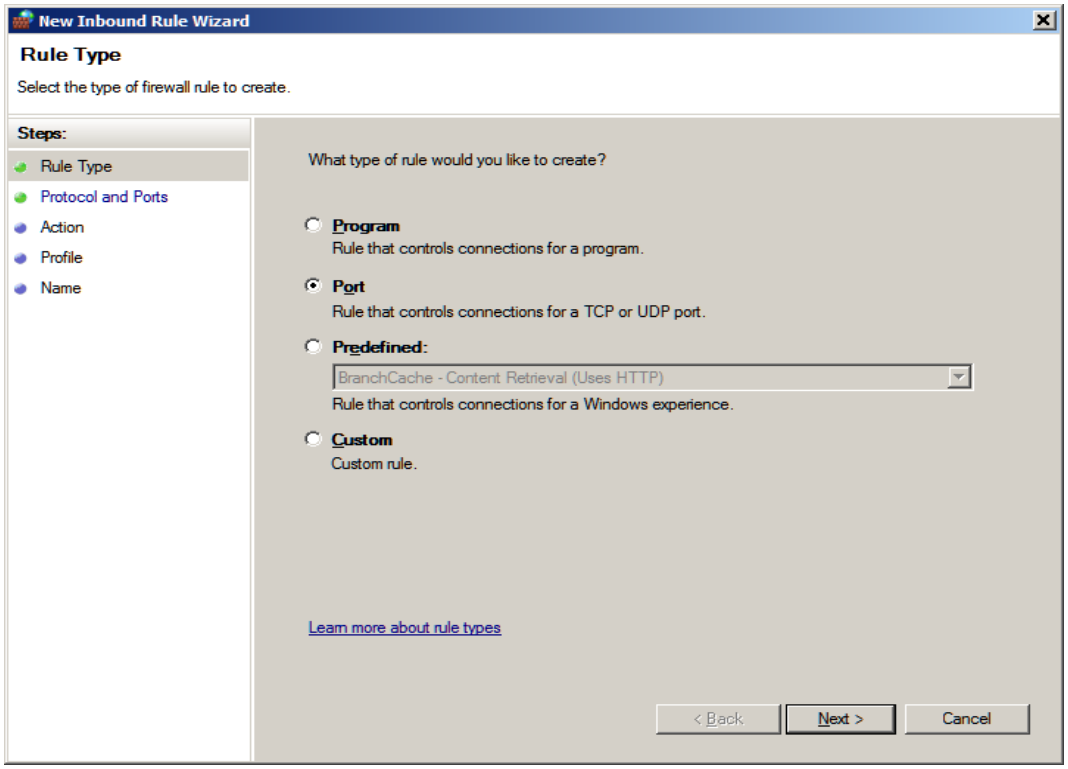
14. Write “Firewall” in to the search field and select Windows Firewall.



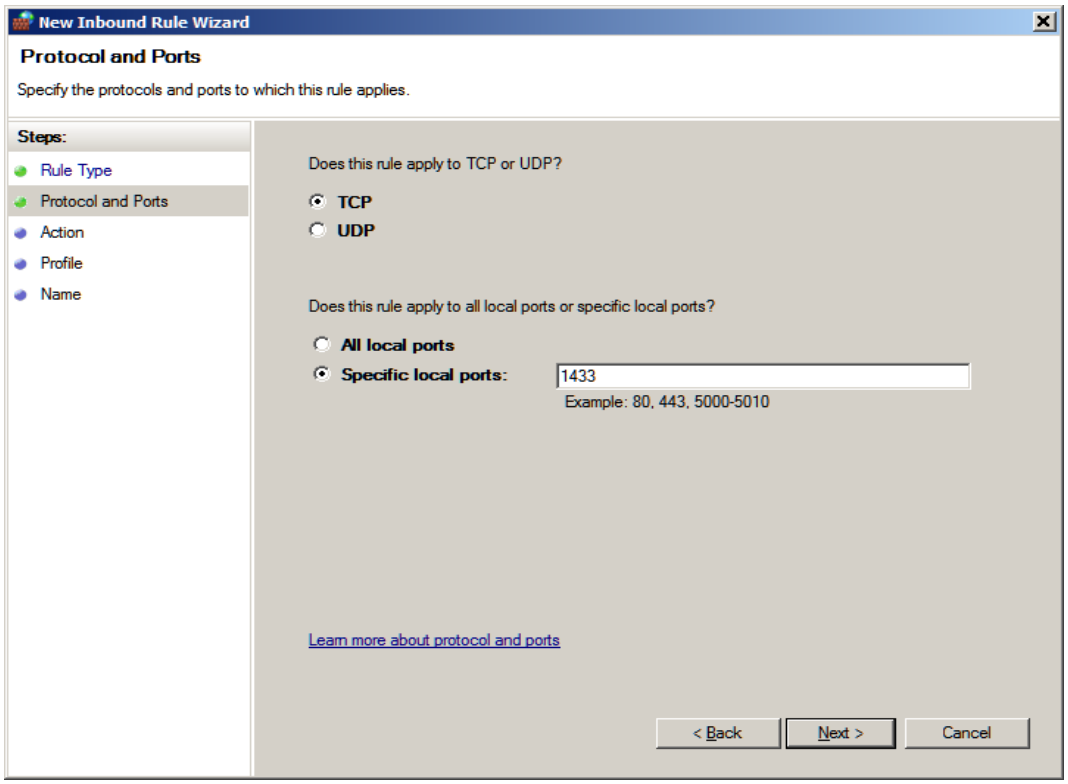
15. Select advanced settings



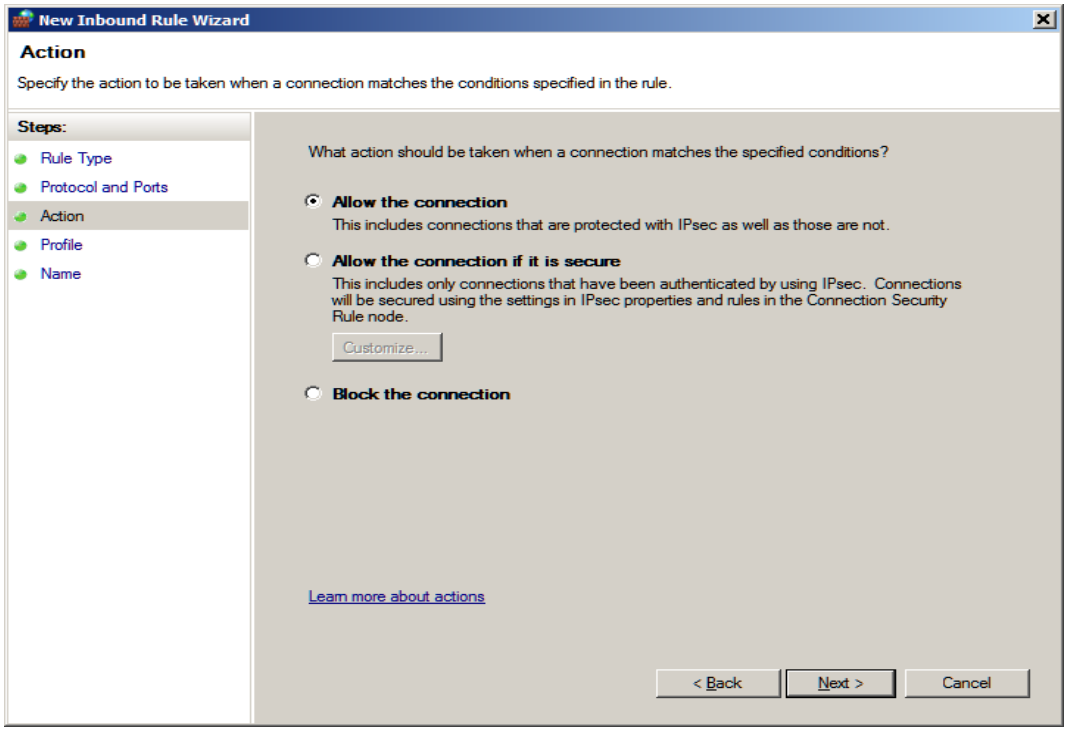
16. Select “Inbound Rules” and in the right pane “New Rule”.



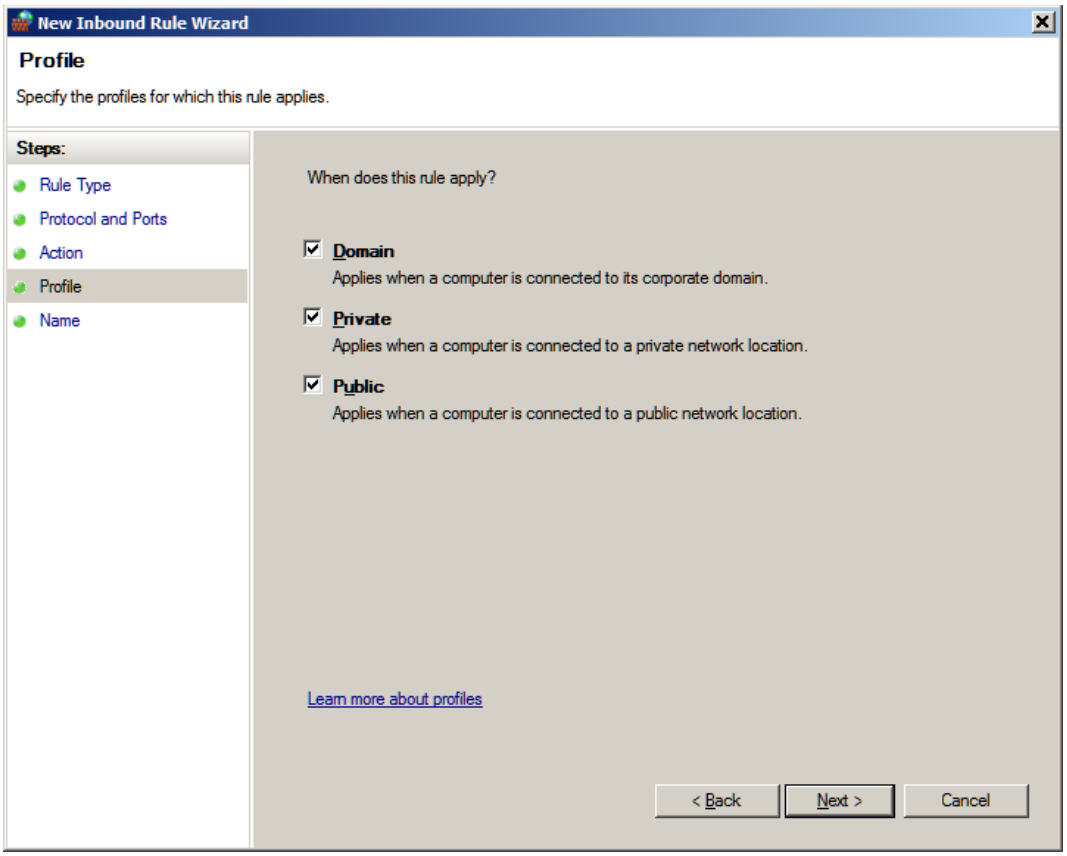
17. Select Port



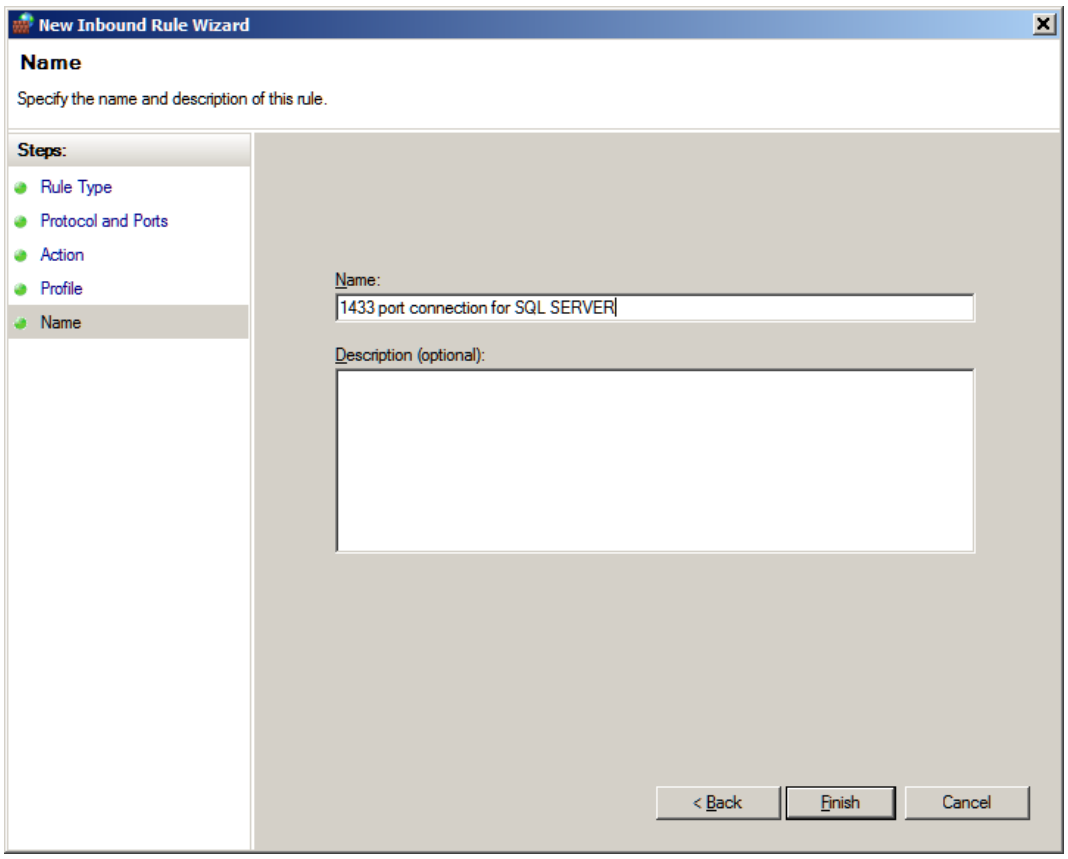
18. Select TCP and Specific local ports. Define port 1433.



19. Select Allow the connection and click next



20. Check all the boxes and click next



21. Give the connection a name. For example SQL Port 1433. Click Finish.

2.3. Installing BoF-PSS2

Here, we describe installing the BoF-PSS2 program using the installation wizard. MySQL or MariaDB needs to be installed before starting the installation. You can cancel the installation by clicking the **Cancel** button on the **Wizard** page. Clicking the **Back** button brings you back to the previous page.

Installation steps of the BoF-PSS2 simulator:

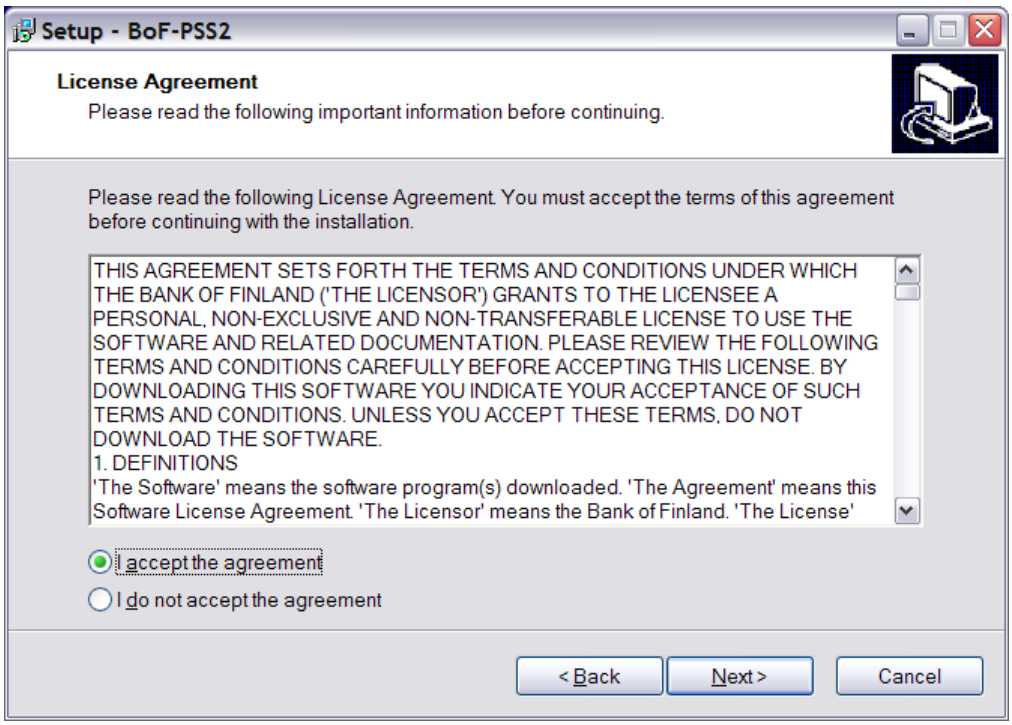
1. Download the encrypted installation file **delivery.exe** to a folder of your choosing, for example the Desktop or My Documents. Address of the download page is provided by Bank of Finland after you have ordered the simulator.

2. Double click on the .exe file you downloaded. Input the password you received from the Bank of Finland. The installation file will be extracted and stored in the same folder.

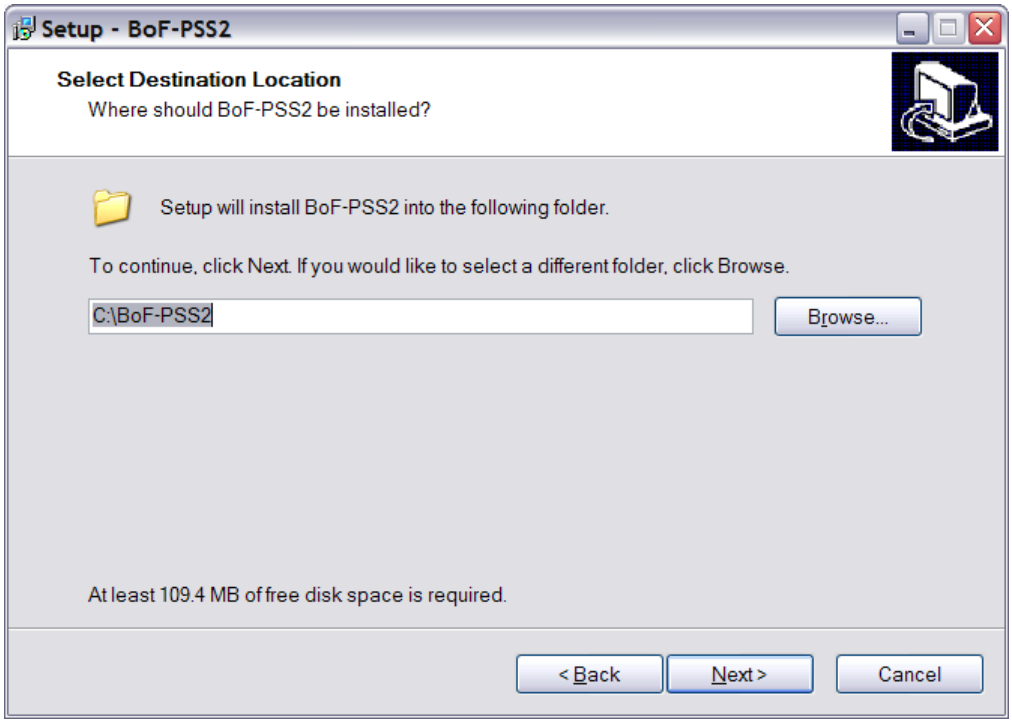
3. Double click **extracted .exe file**. The installation program starts

4. Click on the **Next** button. The license agreement appears.

5. You have to accept the license before continuing the installation. If you can't accept, the installation will be cancelled. Read the text, select **I accept the agreement** and click then on the **Next** button.

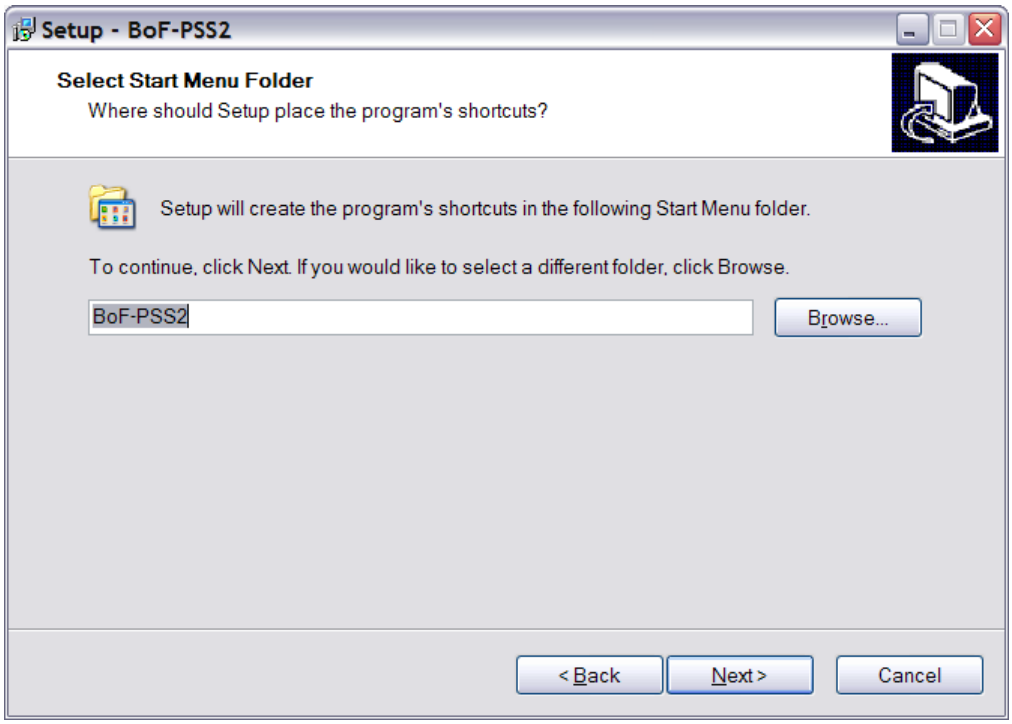


6. Select the directory where the program will be installed. It is advisable to use the default directory. Click on the **Next** button.

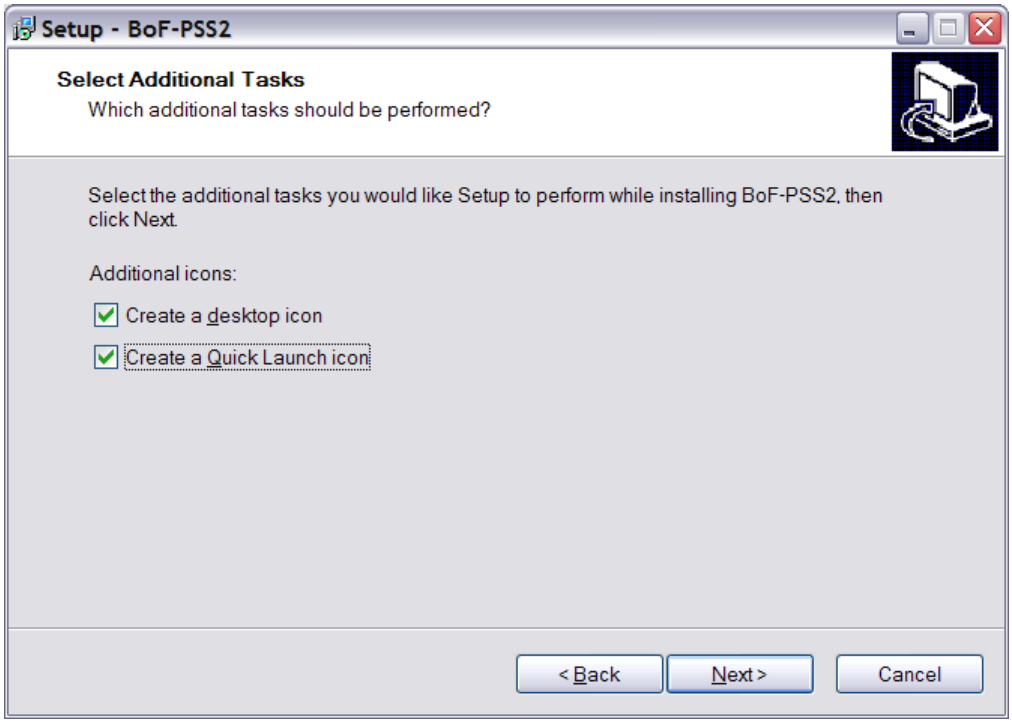


7. Don't change the default value if you want the Setup to create a folder for the simulator in the Start Menu. If you want to use an existing folder, use Browse

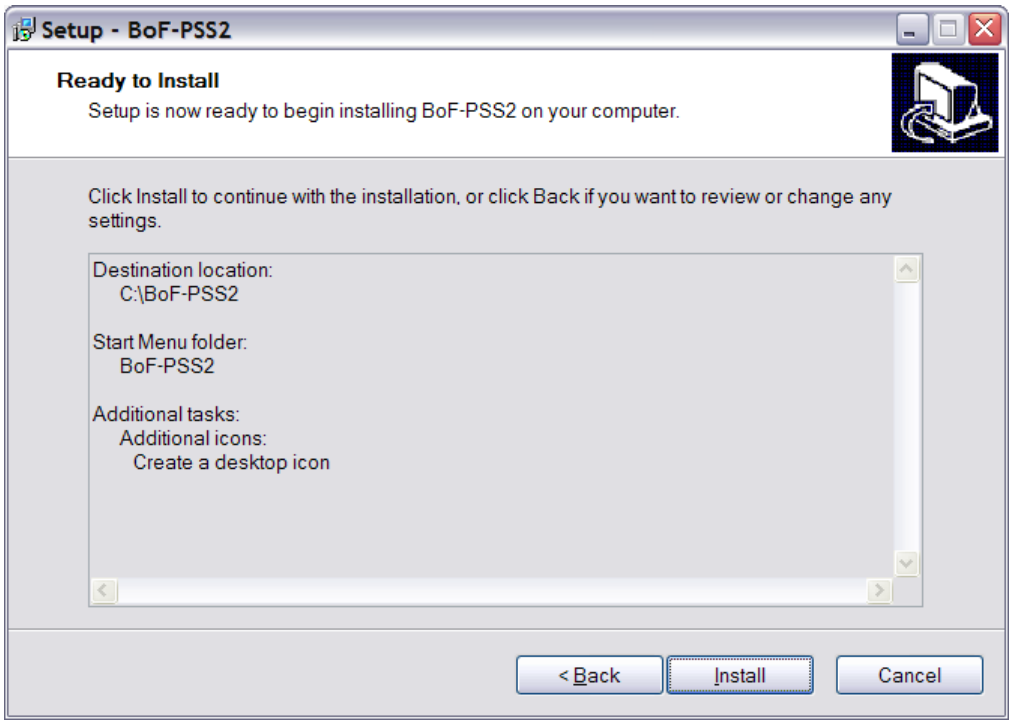
to select the Start Menu folder in which you would like the Setup to create the shortcuts for the simulator. Click the **Next** button.



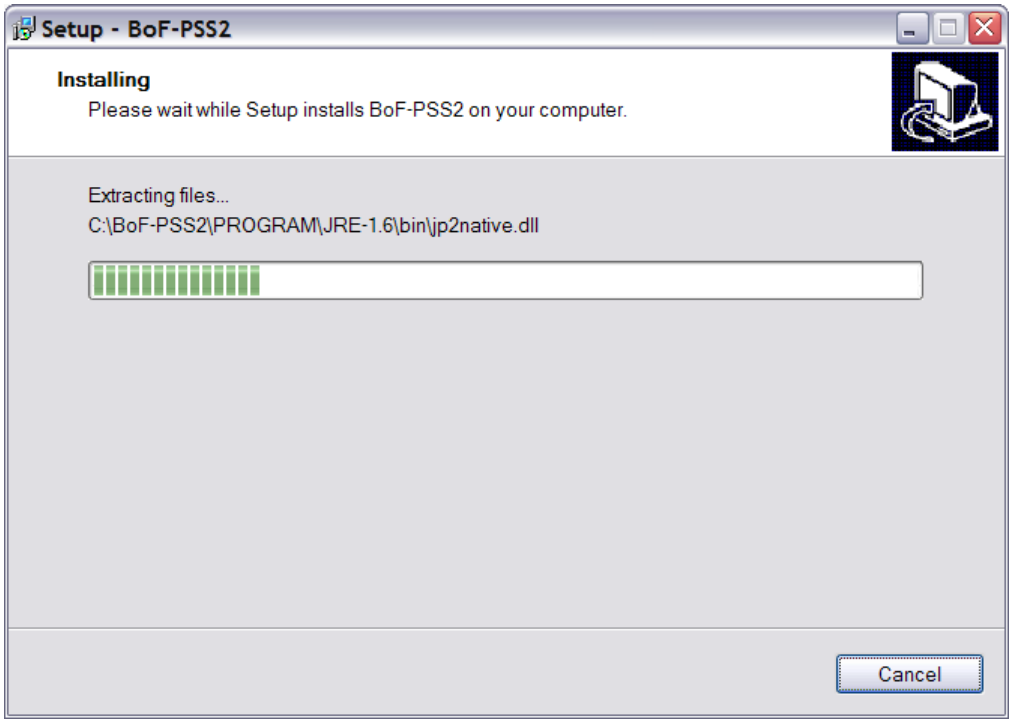
8. Select **Create a desktop icon** if you want to create a shortcut icon on your desktop. Select **Create a Quick Launch icon** and Setup creates an icon in the Quick Launch menu. Click the **Next** button and the summary of the choices appears.



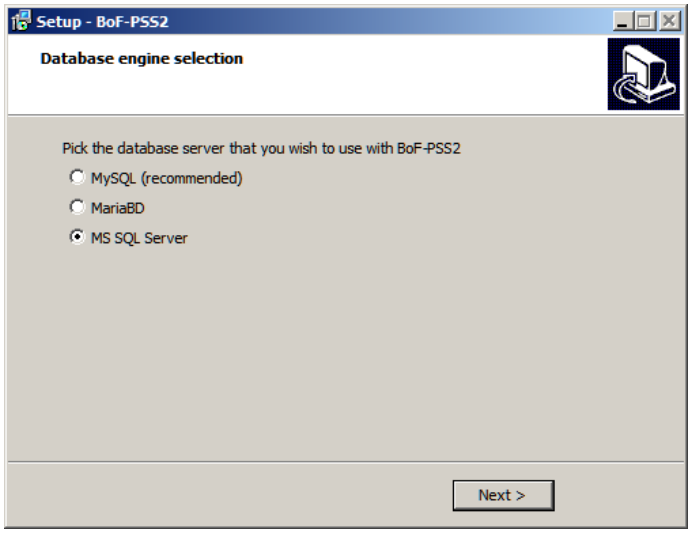
9. On this page you see all selections made on previous pages. If you want to change the selections, go back by clicking on the **Back** button. If you accept selections, click the **Install** button. The installation will start.



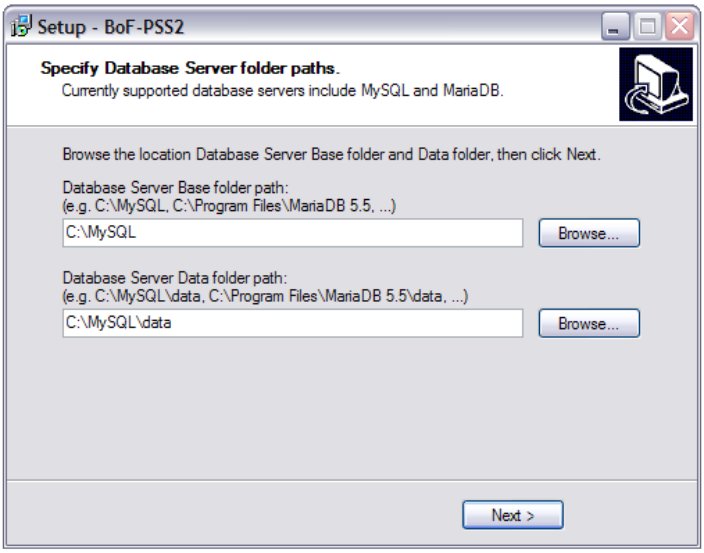
10. Wait for the files to be copied.



11. Select the database server that you wish to use with BoF-PSS2 simulator, and that you previously installed. The choice will affect the properties-file located at C:\BoF-PSS2\PROGRAM\DBConnectors\BoF-PSS2_DB.properties. The properties-file will by default specify Drizzle-connector for MySQL and MariaDB, and Microsoft JDBC4 connector for MS SQL (See also *2.8 Changing the database connector* on page 40). If you select MS SQL Server, go to step 13 after clicking **Next**. Otherwise continue to step 12.



12. In case MySQL or MariaDB was selected, BoF-PSS2 will need to know where its start-up files and databases are located. Specify the location of your database server base and data folder. If you installed to C:\MySQL\ or C:\Program Files\MySQL\ the fields should be filled automatically. Then, click **Next**. If you can't find these folders or some files inside these folders are missing, make sure that MySQL/MariaDB was installed with "Client programs" enabled in the Custom Setup screen (step 4 in MySQL/MariaDB installation steps).

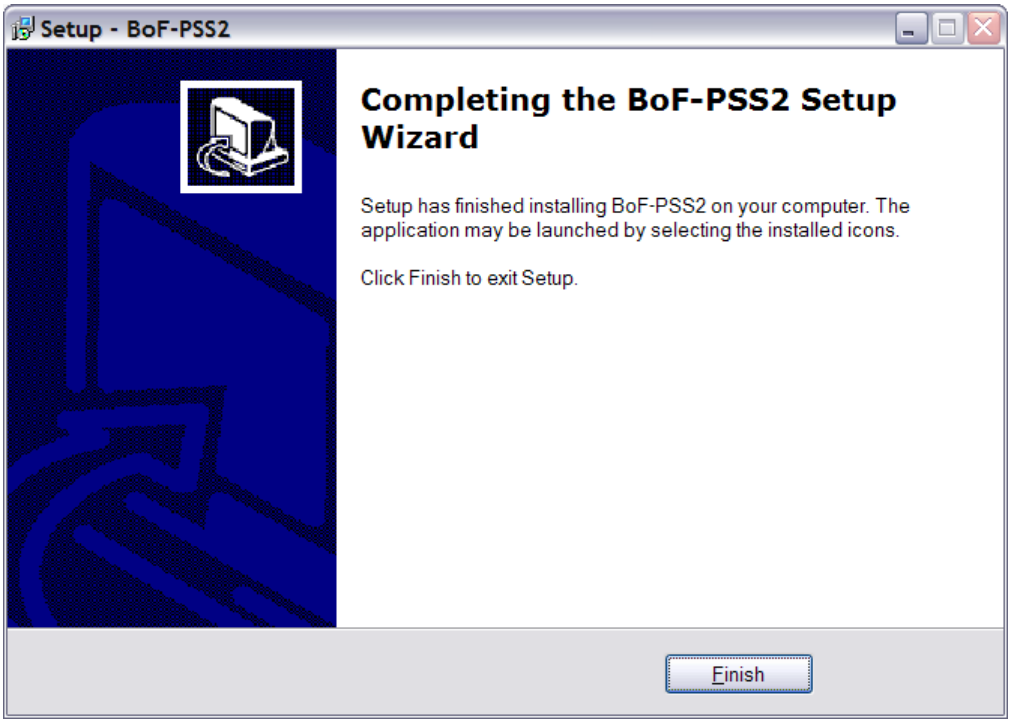


(The files affected by these path definitions are:

C:\BoF-PSS2\PROGRAM\Database.bat
C:\BoF-PSS2\PROGRAM\Database_shutdown.bat
C:\my.cnf

If you later wish to change the database server base or data folder, you can make the necessary changes to these files for example with notepad without re-installing **BoF-PSS2**. See ch 2.6)

13. Click on the **Finish** button. The **BoF-PSS2** program is now installed in your computer.



2.4. Running the simulator with Microsoft's SQL Server

If you chose to use the MS SQL-Server, you will have to install a suitable JDBC driver for MS SQL-Server. Please refer to 2.8.

2.5. Starting the BoF-PSS2 simulator

If you decided to use MS SQL-server instead of MySQL or MARIADB, you need to install a suitable JDBC Driver before running the simulator. This is because the the default Drizzle connector will not function only with MySQL and MariaDB (see 2.8).

Double click the **BoF-PSS2** short-cut icon on the desktop. If you haven't created a short-cut, start the program by selecting it from Start Menu (**BoF-PSS2**).

Three windows will be automatically opened when the simulator is started:

1. The start up.bat sequence window. This window shows information of simulator status and e.g. displays error messages if there are problems with connection to MySQL/MariaDB or in the java runtime environment. Contents of this window are written to c:\BoF-PSS\Program\log.txt
2. The MySQL monitor window opens since the MySQL server is started automatically.
3. Simulator application and user interface window itself.

When the simulator is installed, the system database (c:\BOF-PSS2\PSS2_systemdb) is not yet created. When the simulator is started, it will check if it can find the system database, if not it will create it. Later, if for a reason or an other, the simulator will not be able to find the system database, it will try to recreate it. The first session, equivalent to a situation when operating with a blank system database with no projects defined, will require that you specify a first project. The project information defines the location of databases and reports, see 3.3 for details.
After stating a name for the project, (e.g. example1) click on the file fields and the default values will appear. Save the project information by clicking on the "save project modification" button. Return to the main menu and your simulator installation is completed.

2.6. Starting and closing database server

The MySQL/MariaDB database monitor has to be up and running before launching the simulator. This simulator's startup.bat sequence automatically launches and closes MySQL/MariaDB.

If the simulator was installed with MS SQL SERVER the rows for starting databases are left out from the bat-files. MS SQL SERVER runs as a service on the background and thus will not need to be started separately unless it has been explicitly shut, when it would have to be started manually from Control Panel-> System and Security -> Administrative Tools -> Services

If you experience problems at these phase, it might be due to a missconfiguration. Normally the simulator's installation program will configure the necessary bat and cnf files autoamtically. But you might want to check this. If you installed the MySQL (or MariaDB) for example in c:/MyDB/ , the files should look like in the following examples:

the C:/my.cnf file should include the following lines:

[mysqld]

basedir = D:/ MyDB /
datadir = D:/ MyDB/data/

C:\BOF-PSS2\PROGRAM\Database.bat

```
@echo off
title MySQL
echo on
"C:\MyDB\bin\mysqld-nt" --defaults-file=c:\my.cnf --console
exit
```

C:\BOF-PSS2\PROGRAM\Database_shutdown.bat

```
echo off
"C:\MyDB\bin\mysqladmin.exe" -u root shutdown
exit
```

Starting MySQL/MariaDB independently

MySQL/MariaDB are versatile database servers. You can find information about them at www.mysql.com and mariadb.org.

MySQL databases created by the simulator can also be accessed directly for exporting or importing data or performing minor changes in the databases (e.g. delete unnecessary templates, projects or system names). Caution, however, is needed when making direct modifications. Direct usage of MySQL is described in more detail in 5.2.

2.7. Run time performance and start-up parameters

Run time performance of the simulator is largely dependent on the amount of memory available for the simulator, MySQL/MariaDB database and the operating system. In large simulations, insufficient or badly allocated memory leads to paging, where hard disk is used as an extension for main memory.

The memory allocations for simulations are controlled with two parameter files: one for the simulator and one for MySQL/MariaDB database. If you experience lengthy run times or make changes to hardware configuration of your simulator PC you might want to change these configurations to see if there is some positive impact. Remember that also too large buffer reservations may slow down processes if the memory being left for other applications is insufficient

Simulator start-up parameters

The simulator itself is a Java application and it is run in a Java virtual machine. The parameters of Java are defined in the start-up script of simulator in file C:\BoF-PSS2\PROGRAM\Start-up.bat. This file contains a code line starting the Java virtual machine and setting, inter alia, the memory limits for it.

The code line starts with command "jre-1.7\bin\java" and continues with two memory parameters: –Xms***m and –Xmx***m. Here –Xms sets the amount of memory given for the simulator applications directly at start-up and –Xmx sets the maximum amount of memory that can be given for the application. The asterisks *** represent the amount of memory in megabytes.

The memory parameters of Java virtual machine in startup.bat are automatically scaled by the installation program according to the amount of main memory in the PC or server. The code lines in different setups are by default the following:

1. "jre-1.7\bin\java –Xms64m –Xmx512m … " if the PC has 256MB or less of main memory
2. "jre-1.7\bin\java –Xms128m –Xmx512m … " if … 512MB
3. "jre-1.7\bin\java –Xms192m –Xmx1024m … " if … 768MB
4. "jre-1.7\bin\java –Xms256m –Xmx1408m … " if … 1GB or more

If the amount of memory in simulator PC is decreased after installation or the memory parameter values are too large for other reasons the simulator start-up is cancelled and error message is displayed in the start-up window saying "Could not reserve enough space for object heap". In this situation the -Xmx parameter in the file BoF-PSS2\PROGRAM\Start-up.bat must be changed to a smaller value.

The currently used 32-bit Java Runtime Environment version 1.7 (since BoF-PSS2 v3.2.1) is capable of using a maximum of 1.7 GB of memory. This restriction is imposed by the limitations of the 32 -bit memory address space and operating system architecture. 64-bit hardware, operating systems and Java Runtime Environment allow a considerable increase, so that the limit of the maximum memory will more likely be restricted by the hardware and the amount of memory on the computer.

MySQL/MariaDB start-up parameters

Parameters for controlling MySQL/MariaDB database performance are given in configuration file c:\my.cnf. Four versions of configuration files are included with the simulator for different hardware configurations. These configuration files are

located at C:\Bof-PSS2\PROGRAM\. The installation program selects automatically one of these files to be used and copies it to my.cnf according to the amount of main memory in the PC or server. If a c:\my.cnf –file has been created already earlier, it is renamed to my_old.cnf. Selection rules are the following:

1. MySim-256M.cnf if the PC has 256MB or less of main memory
2. MySim-512M.cnf if the PC has 512MB of main memory
3. MySim-768M.cnf if the PC has 768MB of main memory
4. MySim-1G.cnf if the PC has 1GB or more of main memory

The configuration files contain following parameters.

- **Wait_timeout** is the number of seconds the database server waits for activity on a open connection before closing it. To make sure that database connection is not closed in very large and long lasting simulations this parameter is raised from default 28800 (8 hours) to 3153600 (one year in seconds).
- **Key_buffer_size** determines the cache size available for database table indexes. This is the most important buffer in MySQL/MariaDB and the value is recommended to be 25- 50% of main memory reserved for MySQL/MariaDB.
- **Join_buffer_size** determines the memory reserved for queries to multiple tables. This could have approximately 5% of all memory reserved for MySQL/MariaDB.
- **Read_buffer_size** determines memory reserved for reading tables. This is also recommended to be 5% of memory reserved for MySQL/MariaDB.
- **Sort_buffer_size** is reserved for sorting tables. Recommended size also 5%.
- **Tmp_table_size** determines the size of temporary table that can be held in memory. Recommended size 10-5% of all memory reserved for MySQL/MariaDB.
- **Myisam_sort_buffer_size** determines the memory reserved for sorting in database maintenance and defragmentation functions. Size equalling 5-10% of memory reserved for MySQL/MariaDB is adequate. Note however that this parameter does not affect the run time performance of database.
- **Table_cache** determines the number of tables that can be open simultaneously. This is set to the number of tables in one simulator project and does not need to be changed.

The values and combination of start-up parameters can be changed in the my.cnf file. The configuration files provided with the simulator are modified versions of configuration files found in the standard MySQL/MariaDB distribution. These are located in c:\mysql directory with names like my-small.cnf and my-huge.cnf, and can also be used to learn more about MySQL/MariaDB start-up commands. A

complete list of parameters and their definitions are available in the MySQL manual (chapter 5.2.3).

2.8. Changing the database connector

A JDBC driver is a software component enabling a Java application to interact with a database via the JDBC interface. The default JDBC driver used by BoF-PSS2 is Drizzle JDBC, a BSD-licensed native java JDBC driver for Drizzle and MySQL. The Drizzle database connector is located in C:\B oF-PSS2\PROGRAM\DBConnectors \DrizzleJDBC.jar.

The user may wish to use another database connector. This can be done by copying the corresponding jar-file to DBConnectors folder and editing the lines in text file C:\B oF-PSS2\PROGRAM\DBConnectors\BoF-PSS2_DB.properties.

The default connector is defined by the lines:

DBConnectorFile=DrizzleJDBC.jar
JDBC_DRIVER=org.drizzle.jdbc.DrizzleDriver
DB_URL=jdbc:drizzle://localhost/

If you are eligible to use GPL software, you can download a GPL MySQL connector from http://dev.mysql.com/downloads/connector/j/ . Similarly, if you have a commercial license for the MySQL connector you can use your licensed connector. Copy the corresponding driver file e.g. mysql-connector-java-5.1.21-bin.jar or mysql-connector-java-commercial-5.1.7-bin.jar to C:\BoF-PSS2\PROGRAM\DBConnectors. Then in BoF-PSS2_DB.properties file located in the same folder, comment the default connector lines using "#" and define the new connector according to the lines below:

If your connector file is mysql-connector-java-5.1.21-bin.jar

DBConnectorFile=mysql-connector-java-5.1.21-bin.jar
JDBC_DRIVER=com.mysql.jdbc.Driver
DB_URL=jdbc:mysql://localhost/

or if your connector file is mysql-connector-java-commercial-5.1.7-bin.jar

DBConnectorFile=mysql-connector-java-commercial-5.1.7-bin.jar
JDBC_DRIVER=com.mysql.jdbc.Driver
DB_URL=jdbc:mysql://localhost/

In practice, during the testing of the simulation we have observed no difference in using different connectors. However, the **BoF-PSS2** now includes the possibility to use any JDBC-connector. In particular DrizzleJDBC and the GPL/commercial MySQL connector are known to work with **BoF-PSS2**.

If you chose to use the MS SQL-Server, you will have to install a JDBC driver for MS SQL-Server. We recommend to use MICROSOFT JDBC DRIVER 4.0 FOR SQL SERVER. The driver can be found from Microsoft's downloading center (http://www.microsoft.com/en-us/download/details.aspx?id=11774 . The driver should be copied to c:\BOF-PSS2\PROGRAM\DBConnectors\ ). The installation program of the simulator configures the c:\BOF-PSS2\PROGRAM\DBConnectors\BoF-PSS2_DB.properties file automatically to function with this driver if the corresponding selection was made during the installation. Still it is good to check that the connection strirngs of the properties file do contain the same port, user name and passwords that you defined for the MS SQL-SERVER before.
The file should have the following rows active (not preceded by #):

DBConnectorFile=sqljdbc4.jar
JDBC_DRIVER=com.microsoft.sqlserver.jdbc.SQLServerDriver
DB_URL=jdbc:sqlserver://127.0.0.1:1433;
DB_USERNAME=sa *(depending on the defined user namewhen installing SQL-Server)*
DB_PASSWORD= *(If your securioty settings allowed you to let the password undefined, else you should define the same password)*

3 Operating the BoF-PSS2 simulator

This chapter describes **BoF-PSS2** screens and how to use them.

3.1. Short description of BoF-PSS2 simulator use

The simulation process is normally divided into distinct phases.

You begin by specifying the systems you want to simulate. This includes stating the system name, setting the open hours, and selecting the processing logics and algorithms that are used in a system, see 3.4.

Next, you import input data for the system just specified into the input database (participant names and transactions and optionally daily opening balances, intraday credit limits and bilateral balances), see 3.5.

Once you have specified the system structure and input data, you configure simulations in the **Simulation configuration** screen and cross-check data sets belonging to the simulations, see 3.9.

Simulations are executed by accessing the **Simulation execution** screen, see 3.10. You can run one or more simulations at a time.

After running the simulations, you can export reports, compare simulations, and delete or export output data, see 3.11. Reports can be saved in CSV files. These files can be further analysed and processed outside the simulator.

3.2. Main menu

When the **BoF-PSS2** program starts, the main menu appears. Select from three subsystems:

Input generation subsystem

The input generation subsystem checks the input data and stores it in the input database

Simulation execution subsystem

The simulation execution subsystem is used to configure and execute simulations

Output analysing subsystem

The output analysing subsystem facilitates output data exports, viewing of reports and output analyses.

Network analysis system

The network analysis system can be used to generate networks (graphs) from input or output transaction data and then to calculate statistics from the generated networks.

The user is directed to **Initial specifications** screen the first time the program is run in order to establish the first project. This project becomes the default project until new projects are defined. This will be prompted automatically during the first session. Read more on projects below.

3.2.1. Project

Select a project from the drop-down list on the main menu. The default project is the last selected project.

The simulator uses the definitions of the selected project until you select a new project, see 3.3. A project can be changed only from the main menu.

Projects separate the input and output data of different simulation projects (e.g. RTGS simulations from CNS simulations), allowing the same input data and the input database to be used. Generally, it is advisable to use the default directory layout.

3.2.2. Main menu buttons

The main menu provides access to sub-functions. The user must follow a logical order in the simulation process. First, load the necessary input data, then define the simulations to be executed, and finally set the results to be analysed. The process is often iterative, which leads to new input data requirements and additional simulations.

Screen / Button to open	**Purpose**
Initial specifications	You can add new projects and modify old ones
User module definitions	You can define your own modules
Import input file	You can import input data from files
Define system data	You can update or create system data
View data sets	You can view information of all data sets
Delete data sets	You can delete data sets
Export input file	You can export input data into files
Simulation	You can cross-check data sets and configure a

configuration	simulation
Simulation execution	You can execute simulations
View simulation logs	You can view simulation logs
Basic statistics reports	You can view basic statistics reports of simulations
Account comparison	You can analyse simulations at the account level by making comparisons
System comparison	You can analyse simulations at the system level by making comparisons
Delete output data	You can delete output data
Export output file	You can export output data into files
Generate networks	You can generate network data from transaction data in input or output databases.
Analyse networks	You can calculate certain statistics from the generated network files.
Generate stochastic data	Automatic generation of transaction and participant data using a generation algorithm.
Help	You can open the help
Exit program	You can stop the program by clicking the **Exit program** button

3.3. Working with projects

The **Initial specifications** screen opens, when you start the **BoF-PSS2** program for the first time.

Create a new project or modify old ones on this screen. The screen can be opened later by clicking the **Initial specifications** button on the Main menu.

Each project has its own directory that carries the project name. The project name can be up to eight characters long. Special characters should be avoided, but underline (_) is acceptable. Under this directory following sub-directories are created:

- Input database directory,
- Output database directory,
- Default directory where input files are located,
- Default directory where error lists are saved,
- Default directory where output files are saved, and
- Default directory where output reports are saved.

The location of each directory can be edited before creating the project. Default directories for other than input and output database can also be edited for existing projects.

The proposed default location of new project and all of its subfolfers can be defined by editing DefaultProjectPath variable in c:\BoF-PSS2\PROGRAM\BoF-PSS2.properties file.

You can change the default project on the **Main menu.**

The basic idea of project definitions is to separate the input and output databases for different simulation projects. Especially the output database can become very large if all simulations over a longer time are saved in the same database. The simulations will be faster when databases are kept moderate in size. It will also be easier to make back-ups, when databases are smaller.

3.3.1. Creating a new project

Projects can be created for different types of projects using different input data and creating different output data. It is easy to destroy unnecessary data when it is organised according to projects. This is especially useful when projects create large databases and file directories.

On the Initial specifications screen:

1. Click the **Create new project** radio button and type in the name of the project (up to eight characters). The program proposes input and output names and default directories. You can change them, but be careful! For example, you can name an existing database to share input data, but still keep the output databases separate.
2. Click the **Save project modification** button. The project will be saved and become vivible in the drop-down list in the **Main menu**.

   If a project folder already exists with the corresponding name, the files, including the database files, in the project folders will not be over written. Only the necessary information according to the selections will be stored in the PSS2_ systemDB.

3.3.2. Modifying an old project

On the Initial specifications screen:

1. Click the **Modify old project** radio button and choose a project from the drop-down list. Information of the selected project is shown in the fields of the screen.
2. Change the project information. Be especially careful when changing database specifications.
3. Click the **Save project modification** button.

3.3.3. Project duplicates and backups

All data which is defined or created in a simulation project is stored in the folder of this project. This makes it possible to easily backup and restore or duplicate projects.

As an example a project with name "example1" on PC 1 is considered. Its folder is located at C:\BoF-PSS\p_example1. Contents of this project can be transferred to an another computer, PC 2, including all imported data, specified systems, results from executed simulations and created reports in the following way:

1. In PC 2, which has BoF-PSS2 ready and installed, a new project is created with same name as the copied: example1. The location of this project folder is assumed to be D:\BoF-PSS\p_example1.
2. Simulator software is closed on both PC:s
3. The folder C:\BoF-PSS\p_example1 from the original PC is copied and used to replace the folder D:\ BoF-PSS\p_example1 of the newly created namesake project in the second PC.

After this the simulator can be started in PC 2 and the contents of example1-project can be used and studied further as in PC 1.

Similarly backups can be made of simulation projects. The same procedure can also be used for transferring only some parts of the projects such as input database. The overall file and directory structure of the simulator is presented in more detail in chapter 5.1.

NOTE! The major version number of the simulator in both computers has to be the same. When changes in the database structure of BoF-PSS are made, the first number in the version numbering is increased e.g. from version 1.2.0 to 2.0.0. This makes it impossible to transfer databases by simply copying the files. Also, the installed MySQL/MariaDB versions should be the same on both PC's.

3.3.4. Deleting projects

Projects that are no longer needed can be deleted to release disk space. This can be done by using the delete project feature on the Initial Specifications screen by selecting the relevant project from the old projects list and by prssing the Delete Project button at the bottom right corner.

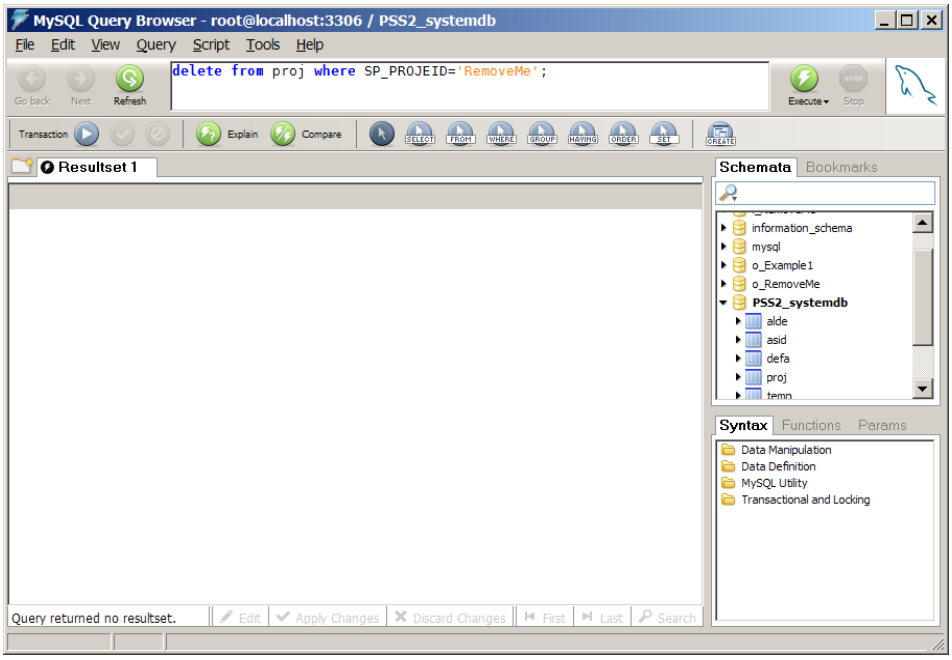
Projects can also be removed manually.Removing a project by simply deleting a project folder and all of its contents, may lead to problems. Necessary steps for deleting a project manually are described below, while instructions for direct use of MySQL are given in chapter 5.2.

Note that there is also possibility to decrease the size of existing simulator projects by deleting unnecessary input data or output results and by optimizing the database respectively. This can be done simply with the simulator user interface, see chapters 3.7 and 3.11.11.

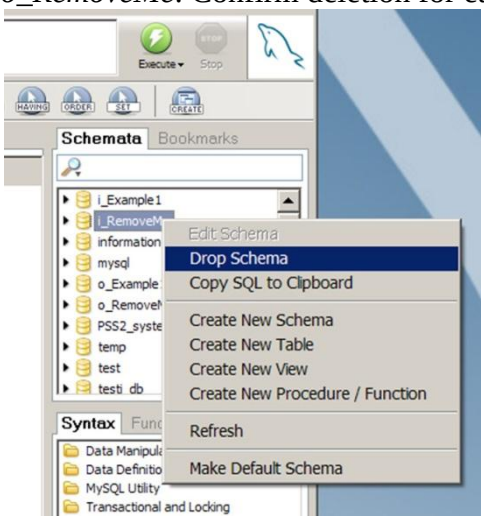
For deleting a project with name "RemoveMe" do the following steps. Note that the only project in existing BoF-PSS2 installation should not be deleted. If you need to delete the only project, create a new empty project to remain as the default project before proceding.

1. Close BoF-PSS2 and open preferred tool for directly editing MySQL database. MySQL Query browser is used in these instructions (see chapter 5.2).
2. Select PSS2_systemdb by double clicking the database name in schemata on the right.
3. Remove the line related to the project to be deleted from PROJ table. This can be done e.g. by executing a query:

delete from proj where SP_PROJEID='name_of_the_project';



4. Delete the definitions of input and output databases of the project from MySQL by right clicking the database name from schemata and selecting "Drop Schema". In this example these are Schemas *i_RemoveMe* and *o_RemoveMe*. Confirm deletion for each database.



5. After changes in database contents, the entire project folder can be deleted from the simulator folder C:\BoF-PSS\P_RemoveMe.

3.4. Setting up a payment and settlement system

Create a new system data set or modify an old system data set by accessing the System control data specification/modification screen. The screen opens by clicking the Define system data button on the Main menu. This screen is used to

define available system names and system data sets: settlement conventions and algorithms for the systems. The use of parallel system data sets for the same system facilitates simulations with the same transactions and participants, but different processing patterns or methods.

The system control data specifications contain the basic system information for each system to be simulated.

3.4.1. Creating a new system data set

On the System control data specification/modification screen:

1. Select correct **system ID** for the new system data set from drop down list. If the desired system ID is not available, click **Create new system ID** radio button and type in the system ID. It is recommended to use the name of the real system under study as the system ID.
2. Click the **Create new system data set** radio button and type in the name of the data set.
3. If you want to copy from an old system data set, click **Copy from old system data set** button. When you select a system data set from the drop-down list, information of the data set appears in the system data fields. You can change this information. Delete old algorithms and introduce new algorithms or change their parameter values.
4. System full name, system acronym and system description are optional information
5. **Opening and closing hours** are mandatory. The cross-check function is checking that the input data is within these limits. The values of open and closing hours must be between 00:00 and 24:00. If the simulated system is open over midnight, time transposition can be used. See chapter 5.7 Time transposition functionality.
6. **System type** (RTGS, CNS or DNS) is mandatory and directs which algorithms will be available in the potential algorithm window.
7. **Transfer balances to next** day can be used in multi-day simulations for transferring the end-of-day balances to become the beginning-of-day balances for the next day.
8. If the simulated system includes bilateral limits, the **bilateral limits in use** option has to be selected. After this, algorithms designed for handling bilateral limits will be available in step 11 of system definition. See 4.1.5 Algorithms for systems with bilateral limits. This selection only affects the visiblilty of the algorithms in the selection list.

9. **Intraday credit availability** requires a choice between three options. The selection '**Credits according to limit table**' requires an ICCL dataset containing the intraday credit limits to be defined. '**No credits available**' indicates that only the liquidity on accounts is available. This means that only a DBAL data set is needed. The last option '**credit available without limits**' indicates that overdrafts are freely available. This option can be used to find out the upper bound of liquidity. Note that liquidity has to be provided in some form, otherwise no transactions will settle.
10. **Handling of unsettled transactions** has four options. All unsettled transactions will be kept in a special queue for unsettled transactions until the end-of-day and the processing will be dependent on the selected option. *Transfer unsettled transactions to next day/settlement occasion* will place unsettled transactions back in the transaction queues to be settled later if possible. *Delete unsettled transactions (include in statistics)* will remove the transactions from queue but still include them in output statistics and reports. *Delete unsettled transactions (exclude from statistics)* means that the unsettled transactions will be removed from queue and also from all transaction level statistics and most system and account level statistics. They will only be included in aggregate transaction value and transaction count numbers in system and account level statistics. *Force end-of-day settlement* will result in bookings on the accounts irrespective of any credit limit violations. This can lead to negative account balances at end of day. Forced end-of-day settlement can be used to find out the minimum liquidity needed to settle all transactions at least at the ends of the day. An account violation record (AVST) will be written for every violating transaction.
11. **Select the appropriate algorithms**. Algorithms define the processing methods. Entry ENT and END end-of-day algorithms are mandatory for all systems. Select an algorithm and fill in its parameter values, when required. Add it to the attached algorithms by clicking on the **Add algorithm** button. See 4.1 Algorithms for details. Selected algorithms can be removed by selecting the corresponding row on pressing the keyboard's delete button.
12. The version 3.0.0 allows the use of time estimation algorithms (TEA). A TEA -algorithm can be associated to an algorithm and used to approximate the real duration of given algorithm run. This allows replication of precesses where settlement algorithms or processes are executed in parallel. A time estimation algorithm can be added by double clicking the field after which the system opens a new time estimation algorithm definition view. The public algorithms which are available in the general 3.0.0 version of BoF-PSS2 do not currently support time estimation, but this feature can be used in user modules. Support for TEA will likely increase in the future according to demand.
13. Click the **Save system data set** button.

3.4.2. Modifying an old system data set

You may want to change the information in an old system data set, for example, if there are errors in the first version.

1. Click **Select existing system ID** radio button and select the correct **system ID** from drop down list
2. Click the **Modify old system data set** radio button and select the name of the data set from the drop-down list. Information about the selected system data set appears in the system data fields.
3. To change information, first delete old algorithm(s) and introduce new algorithm(s) or change parameter values.
4. Click the **Save system data set** button.

3.5. Importing data

You can import data from files to the input database by accessing the Import input file screen. The screen opens by clicking on the **Import input file** button on the Main menu.
You can import participant data, daily balances data, intraday credit limits data, transaction data and bilateral credit limit data by means of this screen. System data can be defined on the System control data specification/modification screen. The input file has to be a text file, e.g. .txt or .csv. You also have to specify data and decimal separators and date and time formats.

The different input data types/data tables are coded as follows:

– **PART** contains participant and account data. This can be defined on participant level only or alternatively on combined participant and account level. In the latter case, the same participant may have multiple accounts, but for each both the participant and account ID should be specified. This feature can be used to define different omnibus accounts for clearing parties in a securities settlement system.
– **DBAL** contains the initial daily balances data of participants or accounts. It is optional, and lacking processing, starts from zero balances the first day.
– **ICCL** contains intraday credit limit changes of participants. It is also optional.
– **TRAN** contains the transactions of a given system. There can also be transactions pointing to other systems. This is done by defining the 'to-system' field for transactions. The 'from-system' field must always contain the same ID, which is defined as the system ID of the dataset.
– **BLIM** contains the bilateral limits between pairs of participants. It is optional.

– **RSRV** contains information on reservations. Reservations are used to reserve a specific amount of the available liquidity to be used to settle some specific type of transactions. Support for reservations is algorithm specific and for the moment there are no built in algorithms in the generally available version of BoF-PSS2 which support the use of reservations. Reservations data can be used in own user modules. For the availability RSRV supporting algorithms you should check with the simulator team. There can be many different reservations defined for one account.
– **SYCD** contains system control data. These data must be specified for each system. This specification is done in the System control data specification – screen, not by importing a dataset.

A **system ID** has to be defined for each imported data table. It is used when searching and configuring data that belongs to the same system. System ID is selected from a drop down list, which includes all system IDs that have been defined in the system definition window, see chapter 3.4.

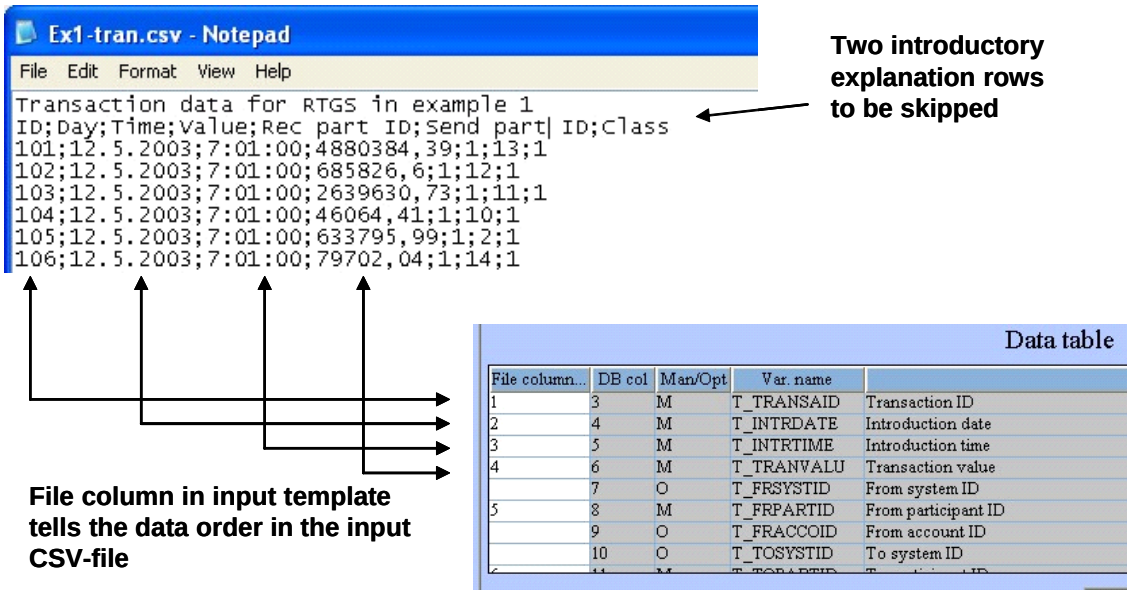
Multiple data sets can be used for running the simulations with varying input data. This is facilitated by a **data set ID** specified for each data table. The input database will thus contain parallel data sets with the same information, e.g. different data sets for intraday credits to simulate a situation with varying liquidity. There may also be different transaction flows depicting e.g. crisis situations. To manage a large number of parallel data sets effectively, it is important to create a consistent naming convention. The data set ID can be up to eight characters long.

It is important to note that the input systems only check the data content at the field level. Due to possibility of multiple parallel data sets, cross-checking can only be performed after simulations are configured and parallel data sets selected.

Templates are used for inputting data using CSV files. The templates describe the data field order in the CSV files.

The templates specify in which order to input data fields are in the input CSV-file (see example below).

Example of CSV-file and Import template relationship



When you create input data in a CSV file, consider the following:

- Make sure that the data and decimal delimiters are specified correctly.
- Values of currency can only be stated to two places after the decimal point.
- All data rows in the CSV-file should have the same number of data fields and the input template defines how these correspond to the input data base of the simulator.
- Transaction ID in TRAN tables can be numeric or alphabetical, they are sorted alphabetically. The transaction ID must be unique as it is a sorting parameter to distinguish between transactions that otherwise would occur in the same order. It is also used as a key when reporting input errors. If you use numeric values, use a sufficiently large first number (e.g. 10001) for transaction files involving ten thousand transactions to assure successful alphabetic sorting.
- When the simulation contains more than one system and interlinked transactions the TRAN data of a given system must hold all debit transactions (FROM-transactions) of that system. The simulator operates on credit transfer basis so intersystem transactions can only be made as credits to another system (i.e. all direct debit type of transactions in real systems must be converted to credit transfers in the simulator.)
- When DVP/PVP transactions are introduced a link code is needed to define the linked transaction pairs. If the system has both linked and unlinked transactions, the unlinked transactions are specified in the CSV-file with a null or blank entry i.e. an entry without data in that field (e.g. ;; or ; ; when semicolon is used as data delimiter).

3.5.1. Creating a new data set

The creating of a new data set function stores a new table in the input database. The table is defined by its given data set ID and contains data in a specified CSV file.
On the Import input file screen:

1. Select the appropriate database table type from the drop-down list (participant, transaction, daily balances, credit table or bilateral limit table).
2. The **data separator** is a mark that separates data fields from each other in the CSV file. The last selected separator is shown in the field. If you wish to change it, type in a new data separator. Any type of separator is acceptable as long as it differs from the decimal separator.
3. The last selected input decimal separator is shown in the **decimal separator** field. To change it, type in a new decimal separator. Any type of separator is acceptable as long as it differs from the data separator.
4. The last selected input date format is shown in the **date format** field. To change it, select a new one from the drop-down list. Any type of separator is acceptable. The dash does only symbol its position. See also 5.5 Date format.
5. The last selected input time format is shown in the **time format** field. To change it, select a new format from the drop-down list. Any type of separator is acceptable. The colon does only symbol its position. See also 5.6 Time format.
6. The last selected time transposition value is shown in the **time transposition** field. Transposition can be used to increase or decrease time and date values in the input data. Transposition value is given in ±hhmm –format. In import the transposition value is added to all time values (in DBAL values a whole day is added or subtracted).
   Using Time transposition can be useful if the simulated system is open over midnight, i.e., if transactions for one day in the system do not fit inside a real calendar day. For more detailed explanation see 5.7 Time transposition functionality.
7. Type in the name of the input file or select it with ‘Browse’ button.
8. Select the system ID from drop down list. Only those system names which have been defined for this project are visible. For defining system names, see chapter 3.4.
9. Click the **Create new data set** radio button and type in the name of the data set. The data set ID is the identifier for different tables of the same input data type. See 5.4 Data sets.

10. A file template describes which columns in the file correspond to particular fields in the database table. If you want to create a new template, click the **Create new template** radio button and type in the template name. Type ordinal numbers in the first column in the data table on the screen.

    Templates are stored so that if you want to use an old template, click the **Use old template** radio button and select a template from the drop-down list. The selected template is shown in the first column of the data table. Again, a consistent naming convention is helpful. Old templates can also be modified after they are selected. The changes are saved when a modified template is used.
11. Type in the **Number of rows/records to skip at the beginning** field the number of rows at the beginning of the file not to be imported (e.g. header rows).
12. Type in the **Number of rows/records to skip at the end** field the number of rows at the end of the file not to be imported (e.g. summary rows).
13. Click the **Execute import** button. Rows from the file will be imported and stored in the selected database table. You can control the number from the **Rows processed** window, as well as the **Rows with errors** window.

Items 2-6 in the above list are together referred to as the data format defaults.

3.5.2. Updating an old data set

Updating an old data set will update the given fields defined by the template in the specified data table for rows where the keys of the data table and the input CSV file match. Other rows remain untouched. Key fields cannot be updated.

On the Import input file screen:

Perform steps 1–8 as in creating a new data set in chapter 3.5.1.

9. Click the **Update old data set** radio button and select a data set from the drop-down list.

Perform steps 10–13 as in creating a new data set in 3.5.1.

12. Click the **Execute import** button.

3.5.3. Inserting data in an old data set

The inserting function provides the possibility to add rows into an existing data table defined by the data set ID. Rows without matching keys are inserted into the

selected database table. Matches are treated as errors and discarded (the database content is not changed in these situations).

On the Import input file screen:

Perform steps 1–8 as if you were creating a new data set in 3.5.1.

9. Click the **Insert in old data set** radio button and select a data set from the drop-down list.

Perform steps 10–13 as if you were creating a new data set in 3.5.1.

12. Click the **Execute import** button.

3.5.4. Stopping import

Lengthy import processing can be aborted.
In the Import input file screen:
To stop import while it is running, click the **Stop import** button. This is possible only with large files.

3.5.5. Undoing import

You may want to undo imports, for example, when a large number of errors are encountered.
In the Import input file screen:
Click the **Undo import** button. The last import will be cancelled. This possibility is only available as long as you stay on the **Import input file** screen.

3.5.6. Errors in import

On the Import input file screen:
The program checks that the data to be imported are valid. The number of faulty rows is seen in the **Rows with errors** field. Errors are listed and may be viewed by clicking the **View error report** button.

The error list file is located in the ERRORLIST directory of the project. It is named ImportInputError_date_time.csv (date in format yymmdd and time in format hhmmss), for example, ImportInputError_090407_121030.csv. Unnecessary error lists should be deleted.

In the error list the **row** refers to the row number in the input file and the **col** to the column number in the input file. The most common errors found are format errors. For date and time fields the formats used in the imported file should be the same as specified in the data format defaults. Numeric fields should be completely numeric and the decimal sign should be the same as stated in the import screen. The simulator does not support 'thousand' signs. The error 'duplicate entry' indicates that there are duplicated key information in the input file e.g. two rows with transaction data with coinciding transaction IDs. In case of coinciding keys the first data row is imported and the next ones are discarded with an error message.

Different kind of format errors and delimiter changes can arise when the input CSV file has been exported from another program, like Excel. It is advisable to check the content of exported CSV files with a software showing the true content of the CSV file e.g. Notepad. Check delimiters, date and time formats and decimal information, because there seems often to be small differences in these details if the simulator and the CSV data exporting software have not been synchronized earlier.

3.6. Viewing input data

You can view participant, daily balances, intraday credit limit, bilateral credit limit and transaction data sets with the **View data sets** screen. This screen opens by clicking the **View data sets** button on the Main menu. This is only suitable for small and moderate size data sets. For transaction data only the first 10 000 rows of data set will be shown. The **export input file** function is available to check larger data sets. MySQL database can also be accessed and even modified directly with suitable software such as MySQL Query Browser or MS Access. This possibility is described in more detail in chapter 5.25.2.

On the View data sets screen:

1. Select a data type.
2. Select a system ID.
3. Select a data set ID and data is shown on the screen.

Note! Searching transaction data may take a while if the database table is large.

3.7. Deleting input data

You can delete participant, daily balances, intraday credit limit, bilateral credit limit, transaction and system data sets using the **Delete data sets** screen. The

screen opens by clicking the **Delete data sets** button on the Main menu. The **Delete data sets** screen is also helpful in giving a view of the data sets stored in the input database.
The disk size of the input database is not decreased when data sets are deleted. For that purpose the input database needs to be optimized or defragmented after the deletion. This can be done by clicking the **optimise input database** button. For large databases this can be a lengthy process. Optimization of database will also improve the simulator performance if you have made large number of database modifications.

On the Delete data sets screen:

1. Select data type.
2. Select system ID; all data sets of the given data type and system appear on the screen.
3. Select the data sets to be deleted and click on the **Delete data sets** button.
4. If several data sets have been deleted and the disk size of simulator data needs to be decreased, click **optimise input database** button.

3.8. Export input file

You can export data from the input database to files by accessing the Export input file screen. The screen opens by clicking the **Export input file** button on the Main menu.

On the Export input file screen:

1. Select the database table type to be exported from the drop-down list.
2. Select a data set ID from the drop-down list.
3. The **data separator** is a mark that separates data fields from each other in the output CSV file. The last selected value is shown in the field. To change it type in a new data separator. Any type of separator is acceptable as long as it is different from the decimal separator.
4. The last selected decimal separator for the output CSV file is shown in the **decimal separator** field. If you want to change it, type in a new decimal separator. Any type of separator is acceptable as long as it is different from the data separator.
5. The last selected date format for the output CSV file is shown in the **date format** field. To change it, select a new one from the drop-down list. See also chapter 5.5.
6. The last selected time format for the CSV file is shown in the **time format** field. To change it, select a new one from the drop-down list. See also chapter 5.6.

7. The last selected time transposition value is shown in the **time transposition** field. The transposition value is given in ±hhmm format. In export the transposition value is **subtracted** from all time values (in DBAL values a whole day is subtracted or added). This means there is no need to change the sign of transposition value given in the input phase. For more detailed explanation see 5.7 Time transposition functionality.
8. Type in the name of the output file. The default directory is INPUT.
9. Select the **Create names of columns** field when you want the names of the columns to appear in the output file.
10. A file template describes which columns in the output file should correspond with particular fields in the database table. To create a new template, click the **Create new template** radio button and type in the name of the template. Type ordinal numbers into the first column of the data table. If you leave empty columns in the templates, these will appear as two adjacent separators in the output file.

    To use an old template, click the **Use old template** radio button and select a template from the drop-down list. The selected template is shown in the first column of the data table.
11. Type in selection criteria and select the parts of the table you want to export. Selection criteria can be written for each data field.
12. Click the **Execute export** button. Data from the selected database table will be exported to the output file. The number of rows appears in the **Rows processed** window.

To abort export while it is running, click the **Stop export** button.

The selection criteria facilitates exports of subsets of the imported input tables eg in order to edit some of the data with Excel.

3.9. Setting up simulation runs

You can create a new simulation ID, modify an old simulation ID or cross-check data sets on the **Simulation configuration** screen. The screen opens by clicking the **Simulation configuration** button on the Main menu.

3.9.1. Creating a new simulation ID

Each simulation must have a specific simulation ID of up to eight characters. Use a consistent naming convention to avoid troubles.

On the Simulation configuration screen:

1. Click the **Create new simulation ID** radio button and type in the simulation ID. If you want to copy from an old simulation, click the **Copy from old simulation ID** button and select a simulation ID. Information from the old simulation ID appears on the screen and can be changed.
2. Type in the name of the simulation and the description. These fields are optional.
3. Select SUB submission algorithm from the drop-down list. Parameters of the selected algorithm are shown in the **Parameters** box. Double click the box and type in the parameter values.
4. The most important task is to select the systems and their data sets to be included in the simulation. First select a system ID from the first drop-down list. Next, select data sets from the other drop-down lists. System, transaction and participant data sets are mandatory. Only systems with all mandatory data sets available can be configured, i.e. are shown in the selection window. Credit limit and daily balances data sets are optional. Add the selected values of the drop-down lists to the table by pressing the **Add/update data set** button.

   If you want to change a row in the table, select the system ID from the drop-down list, change the data sets you want and press the **Add/update data set** button.

   If you want to delete a row from the table, select it from the table and click the **Delete** button.
5. Click the **Save simulation ID** button.

3.9.2. Modifying an old simulation ID

Old simulation IDs may need to be modified, for example, in the case of errors in earlier specifications. When the simulation ID is modified, the old output data is destroyed.

On the Simulation configuration screen:

1. Click the **Modify old simulation ID** radio button and select a simulation ID from the drop-down list. Information about the selected simulation ID appears on the screen.
2. Change information.
3. Click the **Save simulation ID** button.

3.9.3. Cross-checking data sets

Cross-checking verifies that the information in selected data tables (data sets) is coherent, e.g. all accounts needed are available for booking transactions, intraday-credit changes are within transaction dates and opening hours and initial balances are within transaction days.
It is good practice to run a cross-check when a configuration is created.
During cross-check the number of errors found is shown. The progress of cross-check is displayed by telling which simulation ID, system ID and data sets are currently checked. The progress-bar window tells also, at suitable intervals, which row in the first table is under processing by showing the transaction ID or participant ID.
To stop a cross-check, press the **Stop cross-check** button.

If the cross-checking finds errors, they may be viewed by clicking the **View errors** button. The error list file is located in the ERRORLIST directory of the project. It is named SimulationConfigurationError_date_time.csv (date in format yymmdd and time in format hhmmss), for example SimulationConfigurationError_090407_121030.csv. Unnecessary error lists should be deleted.

The error list contains a reference to the incoherent input data record and information about the missing relationship data. The dataset ID and a short description will be shown for each error.
Typical cross-check errors are

- Date errors: the dates in DBAL, BLIM or ICCL tables are outside the simulation dates, i.e. dates for which transactions are specified in the TRAN table. Limits and balances should only be defined for those days which are simulated.
- Time errors: the transaction introduction times specified in the TRAN table are outside the opening hours of the simulated system, as defined in system data.
- Participant errors: there are missing participants (or typing errors) in the participant data. TRAN-PART refers to transactions with missing participants in PART data, DBAL-PART refers to missing participant data for DBAL data and ICCL-PART refers to missing participant data for ICCL data. For all participants quoted in TRAN, ICCL, BLIM and DBAL records there must be the corresponding participant in the PART data. If multiple systems or accounts are defined, the participant is checked as a combination of the system ID, participant ID and account ID.

- Erroneous system ID's in TRAN data: if the *from system id* field is explicitly defined, it should be the same as the ID of the system which this data set is attached to.

3.9.4. Creating multi system simulations

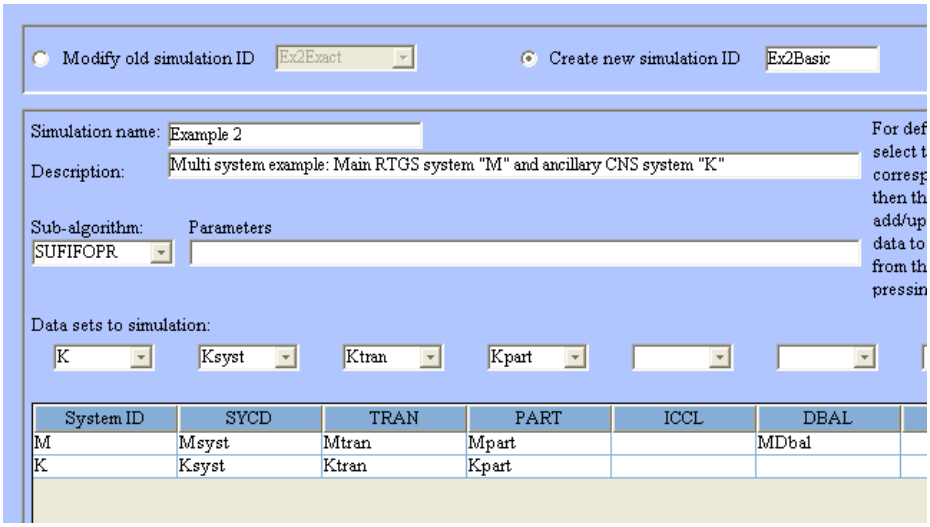
Simulations with multiple interacting systems can be created and simulated with BoF-PSS. This enables simulation and analysis of parallel systems with independent processing logics, such as network of several RTGS systems such as TARGET, combination of a RTGS system and an ancillary CNS or DNS system or a RTGS payment system together with a securities settlement system working with DVP processing.

In multi system simulations individual systems are set up independently one by one: system definition and data imports are performed for each simulated system separately. System ID field is used to collect together definitions and input data of individual systems.

For transactions between systems the receiving system name has to be defined in input data. Transactions are always included in transaction data set of that system, where the from-participant of each transaction is located. The system names used in input data (e.g. From-system and To-system in transactions) need to be the same which are used as System IDs in system definition.

The **transaction IDs must be unique simulation-wide**, i.e. the transaction data sets of the different systems cannot use same transaction IDs. Cross-check will display reused IDs as errors of the second transaction data set that uses them.
An example of multi system simulation is provided in example2 material included with the simulator (C:\BoF-PSS2\EXAMPLES). It presents a main RTGS system and an ancillary CNS using the accounts in the RTGS system as the source of liquidity. In the input data the "liquidity injections from system" and "liquidity injections from participant"-fields are defined for each participant. In the input data of this example the RTGS system is referred as "M" and the ancillary system is referred with "K". These names have to be used also as System IDs in the simulation. In multi system simulations, the cross-check is checking also coherency of multi system transactions and used System IDs.

Multi system simulations are created in **simulation configuration** screen by including all necessary systems one by one on their own rows. Screenshot from example 2 simulation configuration is shown below.



3.10. Executing simulations

You can execute simulations on the Simulation execution screen. The screen opens by clicking the **Simulation execution** button on the Main menu. Simulations can be executed as single runs or in batches consisting of many simulations.

3.10.1. Creating a new simulation batch

Simulations are executed in batches of one or more simulations. Stored simulation batch information is convenient, particularly when a large number of simulations need to be reprocessed. Output data is also defined with this screen. By creating and saving a simulation batch, the selections made in this screen can be stored for future use. Simulations can also be executed without saving the batch run information (skip steps 1 and 4 below). When exiting the window, a warning will be displayed of unsaved data. This does not refer to the output data you select to include in simulations in step 3. It will always be stored when the simulations are executed.

On the Simulation execution screen:

1. Click the **Create new simulation batch ID** radio button and type in the simulation batch ID. If you want to copy an old simulation batch ID, select the simulation batch ID from the drop-down list. Information about the selected simulation batch ID appears on the screen.
2. Select a simulation ID from the drop-down list and add it to the simulation batch table by clicking the **Add simulation ID** button. Repeat this step for all simulations you want to execute in same batch.

If you want to remove a simulation from the batch, select the simulation from the table and click the **Delete** button.

3. Select output tables to be included in the simulations. Only those statistics which are selected here are saved after the simulations. Note that all the output reports are generated based on the data saved in output tables. Selecting SYLS-table (System level statistics) and ACST (account level statistics) will be sufficient for creating system and account level reports. For time series reports, the TEST-table (transaction event statistics) must also be selected. For bilateral reports BIST- and QURE-tables (bilateral limit and queue reason statistics) are also needed. To reduce output file size, unnecessary output should be avoided, especially in large simulations.
4. Click the **Save batch** button.

3.10.2. Modifying an old simulation batch

On the Simulation execution screen:

1. Click the **Modify old simulation batch ID** radio button and select the simulation batch ID from the drop-down list. Information about the selected simulation batch ID appears on the screen.
2. Change information.
3. Click the **Save batch** button.

3.10.3. Executing and stopping simulations

Once a simulation batch has been defined, it can be executed. Single simulations can also be executed without defining a batch. For very large simulations, execution times can extend to several hours. If errors are suspected, the run should be stopped.

On the Simulation execution screen:

1. Create or modify a simulation batch or just enter the simulation ID.
2. Click the **Start** button to start the simulation execution.
3. To abort the simulation execution, click the **Stop** button. Simulation runs involving hundreds of thousands of transactions, complicated algorithms and low main memory resources may take hours.

   The progress of simulation run is shown in progress bar windows. The leftmost window shows the main type of ongoing activity: "Cross- check", "simulation" or "writing output". On the right side more detailed information is displayed.

The contents of the progress bar during cross-check are described in 3.9.3. During simulation execution the simulation ID and current date and time in the simulated environment are shown. Date and time formats in progress bar are YYYY-MM-DD hh:mm:ss.000). In the beginning of each simulation text "initializing" is shown instead of time during start-up period. While writing output the time is replaced with the name of output table being written.

For small simulations the easiest way is just to select the right simulation ID, required output tables and click on the **Start** button. The batch option is convenient when making a large number of simulations by changing for example some parameters in the input data.

3.10.4. Skip/execute cross-check

Execute cross-check is the default value. It is advisable to cross-check the data in the start of every simulation. However, a skip cross-check feature is introduced, which can be used on user's risk. This is provided to speed up very large simulations, where the cross-check is slow and when the user is sure that there are no cross-check errors in the data (i.e. the same data-sets have been cross-checked earlier).

Skip cross-check is selected by clicking on the radio button.

The risk is that there may still be a cross-check error in the data and the simulation result will be unexpected. In fatal cases (e.g. missing participant ID in PART data) the simulation will stop. In non-fatal cases (e.g. credit line for dates outside the transaction dates) the results/statistics will be incorrect and unpredictable. Other irregularities may also occur, because the cross-check has been designed to find these kinds of errors.

3.10.5. Errors in simulations

On the Simulation execution screen:

View errors arising in the simulations by clicking the **View error report** button.
The error list file is located in the error list directory of the project. It is named SimulationExecutionError_date_time.txt (date in format yymmdd and time in format hhmmss), for example, SimulationExecutionError_090407_121030.csv. Unnecessary error lists should be deleted.

3.10.6. Viewing simulations logs

You can view simulation logs by pressing **View simulation logs** button on the Main menu.

Logs of all run simulations may be viewed by accessing the **View simulation logs** screen. The log will indicate when each simulation ID was executed most recently and what output tables were selected to be stored in this execution. In the last columns of the table, you can find the number and values of settled transactions. When a given simulation ID is executed again or reused the information stored in simulation log will be overwritten.

The logs can be sorted to desired order by clicking on the column headings. An arrow indicates the sorting order (ascending or descending). By clicking on the same heading once more the sorting order will be reversed.

3.11. Analysing results

Simulation results are stored in the output database according to simulation output selections. The output can be viewed using available statistics and reporting features. All data can also be exported via CSV files for analyses in other software.

You can view basic statistics reports on the Basic statistics reports screen. The screen opens by clicking the **Basic statistics reports** button on the Main menu. You may select from six report types, see 3.11.1 System statistics reports, 3.11.2 Account statistics reports, 3.11.3 Bilateral limits statistics report, 3.11.4 System time series reports, 3.11.5 Account time series reports and 3.11.6 Bilateral limits time series report.

You can compare simulations at the system or account level. Reports are saved as CSV files and can be viewed in Excel.

System level comparisons are accessed via the System comparison analyser screen. The screen opens by clicking **System comparison** button on the Main menu. See chapters 3.11.7 Creating a new comparison view at the system level and 3.11.8 Modifying an old comparison view at the system level for further details.

Account level comparisons are accessed via the Account comparison analyser screen. The screen opens by clicking the **Account comparison** button on the Main menu. See chapters 3.11.9 Creating a new comparison view at the account level and 3.11.10 Modifying an old comparison view at the account level further details.

Delete data from output database on the Delete output data screen. The screen opens by clicking the **Delete output data** button on the Main menu. See chapter 3.11.11 Deleting data from output tables for further details.

Export data from the output database on the Export output file screen. The screen opens by clicking the **Export output file** button on the Main menu. See chapter 3.11.12 Executing export for further details.

Reports can only be produced for data tables that have been stored in the output database according to selections made in the execution phase.

3.11.1. System statistics reports

The system statistics report provides essential system level output data for the simulation.

On the Basic statistics reports screen:

1. Select a simulation from the drop-down list.
2. Type in the name of the output file.
3. Select the **System statistics report** radio button.
4. Click the **Save in csv-file** or **Save and open csv-file** button. Both actions will save the report as a CSV file; the **Save and open csv-file** will open the file in Excel.

The report contains following columns.

Col	Name	Description
1	Date	Date of simulation format (YYYYMMDD)
2	System	ID of system.
3	Tot bod balances	Sum of the balances of each account at the beginning of the day
4	AVG Cred Lim	Time weighted average of the credit limits (field Y_AVGCRLIM from SYLS)
5	Value settl	Sum of the transaction values of settled transactions during the day
6	Value unsettl	Sum of the transaction values of the unsettled transactions during the day.
7	Number settl	Count of the settled transactions
8	Number unsettl	Count of the unsettled transactions

Note that there might be some empty fields in the system statistics when the data tables required for calculations have not been saved. Note also that in multi-currency simulations the account data will be added together on system level although these might be in different currencies. The information can then only be used to check that the total turnover is technically correct.

3.11.2. Account statistics reports

The account statistics report contains the basic statistics at account level for a specified system. For multiple day simulations account statistics are presented for each day in ascending order.

In the Basic statistics reports screen:

1. Select a simulation from the drop-down list.
2. Type in the name of the output file (use a consistent naming convention).
3. Select the **Account statistics report** radio button.
4. Select a system ID from the drop-down list.
5. Click the **Save in csv-file** or **Save and open csv-file** button. Both actions will save the report as a CSV file; the **Save and open csv-file** will open the file in Excel.

The report contains following columns.

Col	Name	Description
1	date	Date of simulation format (YYYYMMDD)
3	Participant	ID of participant.
4	Account	ID of account.
5	Bod	Balance at beginning of day
6	Eod	Balance at end of day
7	Ave	Time weighted balance during the day
8	Min	Minimum balance during the day
9	Max	Maximum balance during the day
10	Average cred lim	Time weighted average of the credit limit (field A_AVGCRLIM from ACST)
11	Value settl	Sum of the transaction values of settled transactions during the day
12	Value unsettl	Sum of the transaction values of the unsettled transactions during the day.
13	Number settl	Count of the settled transactions
14	Number unsettl	Count of the unsettled transactions

3.11.3. Bilateral limits statistics report

The bilateral limits statistics report can only be created for simulations where the **bilateral limits in use** selection has been made in the system dataset. See 3.5.1. This report shows basic statistics for each day and each bilateral pair of participants or accounts. The values reported relate to that specific bilateral connection i.e. just the data between two participants.

Note! This report can become huge if the number of participants/accounts in the simulation is large.

To create the report, follow these steps in the Basic statistics reports screen:

1. Select a simulation from the drop-down list.
2. Type in the name of the output file (use a consistent naming convention).
3. Select the **Bilateral limits statistics report** radio button.
4. Select a system ID from the drop-down list.
5. Click the **Save in csv-file** or **Save and open csv-file** button. Both actions will save the report as a CSV file; the **Save and open csv-file** will open the file in Excel.

The report contains following columns.

Col	Detailed name	Description
1	Simulation date	Date of simulation format (YYYYMMDD)
2	System ID	ID of system.
3	Participant ID	ID of participant.
4	Account ID	ID of account.
5	Receiving in system	ID of receiving system
6	Receiving participant	ID of receiving participant. *MULTILIMIT indicates multilateral limit.
7	Receiving account	ID of receiving account
8	Value submitted	The bilateral volume submitted.
9	Value settled	The bilateral volume settled
10	Value unsettled	The bilateral volume unsettled
11	Value received	The bilateral volume received
12	Number submitted	The bilateral number of submitted transactions
13	Number settled	The bilateral number of settled transactions
14	Number unsettled	The bilateral number of unsettled transactions
15	Number received	The bilateral number of received transactions
16	End-of-day balance	The day's ending bilateral balance (a sending surplus is a negative balance).
17	Average limit during the day.	Average limit during the day calculated from the BLIM table
18	Minimum limit	Minimum limit during the day calculated from the BLIM table
19	Maximum limit	Maximum limit during the day calculated from the BLIM table.
20	Average balance during the day.	Average bilateral balance during the day (a sending surplus is a negative balance).
21	Minimum balance	Minimum bilateral balance during the day (a sending surplus is a negative balance).
22	Maximum balance	Maximum bilateral balance during the day (a sending surplus is a negative balance).
23	Maximum queue value	Maximum queue value during the day in this particular bilateral relationship, sender's view i.e. the largest value in queue at any time. Calculated based on TEST and QURE table. Only values of payments, which have been queued due to bilateral limits, are reported here.
24	Number of queued transactions	Number of queued transactions per day in this particular bilateral relationship, sender's view. Calculated based on TEST and QURE table. Only values of payments, which have been queued due to bilateral limits are reported here.
25	Total value of queued transactions	Total value of queued transactions per day in this particular bilateral relationship, sender's view. Only values of payments, which have been queued due to bilateral limits, are reported here.
26	Total time when limit effective	The total time during the simulation day when the bilateral limit has been effective (format hhhhmmss000, where 000 denotes milliseconds) i.e. the time during which one or more transactions have been in the bilateral

		queue in this particular bilateral relationship. Calculated based on TEST and QURE table.

All values are calculated from the sending participant's/account's side. For example, when net value of payments sent between participants B1 and B2 is 100, that is B1 has paid 100 units more to B2 than it has received payments from B2, the value of the bilateral End of day balance (column 16) on the row, that has B1 as the sending participant (column 3) and B2 as the receiving participant (column 6) is -100 and represents a sending surplus.

If receiving participant is reported as *MULTILIMIT, this means that values in that row represent the net position of the current participant/account towards all the others.

More information of using bilateral limits is presented in section 4.1.5 Algorithms for systems with bilateral limits.

3.11.4. System time series reports

The system time series report gives the opportunity to derive system-level balances and other numeric information for given points of time as time series are based on equal intervals in minutes.

On the Basic statistics reports screen:

1. Select a simulation from the drop-down list.
2. Type in the name of the output file. The default output directory is OUTPUT_REPORTS.
3. Select the **System time series report** radio button.
4. Select a system ID from the drop-down list.
5. Type in interval in minutes (1-60) into the edit box.
6. Click the **Save in csv-file** or **Save and open csv-file** button. Both actions will save the report as a CSV file; the **Save and open csv-file** will open the file in Excel.

The system time series report is calculated as the sum of the individual participant/account time series. The report contains following fields:

Col	Detailed name	Description
1	Simulation date	Date of simulation. Presented according to date format defaults
2	Beginning of period	Starting time of reported time series period
3	End of period	End time of time series period
4	Liquidity available	Aggregate value of available liquidity of all participants/accounts in the system. Recorded at the end moment of corresponding period.
5	Value submitted	Aggregate value of all transactions submitted in the system during the period

6	Value settled	Aggregate value of all transactions settled in the system during the period
7	Value in queue	Aggregate value of all transactions that were in the queue during the period. It does not matter for how long transactions stayed in the queue.
8	Number submitted	Number of all transactions submitted in the system during the period
9	Number settled	Number of all transactions settled in the system during the period
10	Number in queue	Number of all transactions that were in the queue during the period. It does not matter for how long transactions stayed in the queue.
11	Number of participants with transactions in queue	Number of participants in the system with one or more transactions in the queue during the reported period.

3.11.5. Account time series reports

The account time series report gives the possibility to derive account balances and other numeric information at given points of time as the time series are based on equal intervals (in minutes).

In the Basic statistics reports screen:

1. Select a simulation from the drop-down list.
2. Type in the name of the output file. The default directory is OUTPUT_REPORTS.
3. Select the **Account time series report** radio button.
4. Select a system ID from the drop-down list.
5. Type in interval in minutes (1-60) in the edit box.
6. Select an account ID from the drop-down list.
7. Click the **Save in csv-file** or **Save and open csv-file** button. Both actions will save the report as a CSV file; the **Save and open csv-file** will open the file in Excel.

The report contains following fields:

Col	**Detailed name**	**Description**
1	Simulation date	Date of simulation. Presented according to date format defaults
2	Beginning of period	Starting time of reported time series period
3	End of period	End time of time series period
4	Balance	Participant / account balance at the end of corresponding period.
5	Credit limit	Credit limit value of the participant / account at the end of corresponding period.
6	Liquidity available	Value of available liquidity of the participant / account at the end of corresponding period.
7	Value submitted	Aggregate value of all transactions submitted in the system during the period by this participant / account.
8	Value settled	Aggregate value of all transactions settled in the system during the period by this participant / account.
9	Value in queue	Aggregate value of all transactions of this participant that were in the queue during the period. It does not matter for how long transactions stayed in the queue.
10	Number submitted	Number of transactions submitted in the system during the period by this participant / account.
11	Number settled	Number of transactions settled in the system during the period by this participant / account.

12	Number in queue	Number of transactions of this participant that were in the queue during the period. It does not matter for how long transactions stayed in the queue.

3.11.6. Bilateral limits time series report

The bilateral limits time series report allows the user to derive statistics on the bilateral positions between a given participant and all others at given points of time as a time series. The reporting interval is given in minutes. This report will be available only for simulation IDs in which the bilateral limits in use –selection has been selected in system definition.

In the Basic statistics reports screen:

1. Select a simulation from the drop-down list.
2. Type in the name of the output file. The default directory is OUTPUT_REPORTS.
3. Select the **Bilateral limits time series report** radio button.
4. Select a system ID from the drop-down list.
5. Type in interval in minutes (1-60) in the edit box.
6. Select participant / account ID from the drop-down list. This will be the from account in the bilateral calculation reported.
7. Click the **Save in csv-file** or **Save and open csv-file** button. Both actions will save the report as a CSV file; the **Save and open csv-file** will open the file in Excel.

The report contains the bilateral limit and the current bilateral balance (end-of –time slot), the number and value of submitted and settled transactions for this pair of participants/accounts during the time slot as well as the number and value of queued transactions. Only transactions queued for the reason of bilateral limits will be reported

*MULTILIMIT as the receiving participant indicates multilateral values i.e. value calculated as a sum over all receiving participants. Queue statistics reported under *MULTILIMIT will include the transactions queued due to the multilateral limit.

Contents of this report are defined similarly as in the bilateral limits statistics report. See 3.11.3. More information of using the bilateral limits is presented in the section 4.1.5 Algorithms for systems with bilateral limits.

Note! This report can become huge if the number of participants/accounts in the simulation is large.

3.11.7. Creating a new comparison view at the system level

Comparison views provide the opportunity to compare the output of different simulations. Simulations and data fields must be defined to be compared. This function can be used for reporting the results from different simulations as columns in a common table. The percentage and absolute difference compared with the first column/simulation can also be shown. Data are saved in CSV files for further analysis. Comparable statistics include all fields, which are recorded in system statistics output table (SYLS). For detailed definitions of the individual indicators, see Description of BOF-PSS databases and files document.

On the System comparison analyser screen:

1. Select the **Create new comparison view** radio button and type the name of the comparison view. To copy from an old comparison view, select a comparison view from the drop-down list. Information of the selected comparison view is shown on the screen.
2. Type in the name of the output file. The default directory is OUTPUT_REPORTS.
3. If you want the differences from the first selected simulation to be displayed, select the **Show percentage** or **Show absolute** check-box, or both.
4. Add simulations, systems and fields to the comparison report.

Adding: Select a value from the drop-down list and add it to the table by clicking the **Add to comparison** button.

Deleting: Select the row to be deleted from the table and click the **Delete** button.

5. Click the **Save in CSV file** or **Save in CSV file and open** button. Both actions save the report as a CSV file; the **Save in CSV file and open** action also opens the report in Excel.

3.11.8. Modifying an old comparison view at the system level

On the System comparison analyser screen:

1. Select the **Modify old comparison view** radio button and select a comparison view. Information about the selected comparison view is shown on the screen.
2. Type in the name of the output file.

3. To see the differences from the first selected simulation, select the **Show percentage** or **Show absolute** check-box, or both.
4. If desired, change the comparison condition.

Adding: Select a value from the drop-down list and add it to the table by clicking the **Add to comparison** button.

Deleting: Select the row to be deleted from the table and click the **Delete** button.

5. Click the **Save in CSV file** or **Save in CSV file and open** button. Both actions will save the report to a CSV file; the **Save in CSV file and open** action also opens the file in Excel.

3.11.9. Creating a new comparison view at the account level

The account comparison view compares output data at the account level. The list of comparable statistics includes all fields, which are recorded in the account statistics output table (ACST). For detailed definitions of the individual indicators, see the Description of BOF-PSS databases and files document.

On the Account comparison analyser screen:

1. Select the **Create new comparison view** radio button and type the name of the comparison view. If you wish to copy from an old comparison view, select a comparison view from the drop-down list. Information about the selected comparison view appears on the screen.
2. Type in the name of the output file.
3. If you want to display differences with the first selected simulation, select the **Show percentage** or **Show absolute** check-box, or both.
4. Add simulations and fields to the comparison report. Select system ID from the drop-down list.

Adding: Select a value from the drop-down list and add it to the table by clicking the **Add to comparison** button.

Deleting: Select the row to be deleted from the table and click the **Delete** button.

5. Click the **Save in CSV file** or **Save in CSV file and open** button. Both actions save the report as a CSV file; the **Save in CSV file and open** action also opens the file in Excel.

3.11.10. Modifying an old comparison view at the account level

On the Account comparison analyser screen:

1. Select the **Modify old comparison view** radio button and select a comparison view. Information of the selected comparison view is shown in the screen.
2. Type the name of the output file.
3. To see the differences from the first selected simulation, select the **Show percentage** or **Show absolute** check-box, or both.
4. If desired, change the comparison condition.

Adding: Select a value from the drop-down list and add it to the table by clicking the **Add to comparison** button.

Deleting: Select the row to be deleted from the table and click the **Delete** button.

5. Click the **Save in CSV file** or **Save in CSV file and open** button. Both actions save the report as a CSV file; the **Save in CSV file and open** action also opens the file in Excel.

3.11.11. Deleting data from output tables

The output database needs cleaning up from time to time. A good practice is to delete unnecessary data as soon as possible. The disk size of the output database is not decreased when data sets are deleted. For that purpose the database needs to be optimized or defragmented after the deletion. This can be done by clicking the **optimise output database** button. For large databases this can be a lengthy process. Optimization of database will also improve the simulator performance if you have made large number of database modifications.

On the Delete output data screen:

1. To delete an entire simulation, click the **Remove entire simulation** column as selected. If you want to delete only output statistics, click the statistics tables you wish to delete and select.
2. Click the **Delete output data** button.
3. If several data sets have been deleted and the disk size of output database needs to be decreased, click **optimize output database** button.

3.11.12. Executing export

Output data can be exported in CSV files using templates and selection criteria.

On the Export output file screen:

1. Select a simulation ID from the drop-down list.
2. Select a database table from the drop-down list.
3. Select data format defaults.
4. Type in the name of the output file if you want to change it. The default is the simulation id dash output table e.g. "Sim8-TEST" for the TEST-table of simulation Sim8.
5. A file template describes which columns in the file correspond to particular fields in the database table. To create a new template, click the **Create new template** radio button and type in the name of the template. Type the order of the data columns in the output file into the first column of the data table using numbers starting from one.

If you want to use an old template, click the **Use old template** radio button and select a template from the drop-down list. The selected template is shown in the first column of the data table. Ready-made templates for all output database tables are included in the simulator for exporting all data fields. The names of these templates are the table name followed by -ALL e.g. TEST-ALL.

6. Type in the optional selection criteria.
7. Click the **Execute export** button. Data from the selected database table will be exported to the output file.

On the Export output file screen:

To abort export while it is running, click the **Stop export** button.

3.12. Network analysis

Since version 3.3.0 the simulator is equipped with an improved network analysis toolkit, which is based on the Java Universal Network/Graph Framework.

With the new toolkit, network analysis can be easily and instantly applied to the transaction data imported into the simulator (TRAN table) or the transaction data of a simulation (TEST table). It is also possible to analyse a network generated by other means, as long as the data format is qualitatively equivalent to transaction

data and can be imported into the TRAN or TEST table by the import functionality of the simulator or by other means e.g. direct use of SQL commands.

The network analysis toolkit can be used to create visualization of a network and to calculate generally used network indicators

3.12.1. Data selection

Follow these steps to select the data used for network visualization and network statistics. At this point the data should be present either as a TRAN table in in the input database or TEST table in the output database.

Input data table / Output data table:

Select the 'input data table' or 'output data table'. Select your SystemID and DatasetID or SimulationID. When the latter is selected, the simulator automatically fetches the data to 'Begin date','End date','Begin time' and 'End time' boxes**.** This can take a moment depending on the size of your data.

(If the dates and times will not appear, make sure that the data is in the correct format.)

'Begin date','End date','Begin time' and 'End time':

These **dates** and **times** affect the time window used in the visualization, and only the date affects the **date** window used in network statistics calculation.

Dates and times should be entered in the same format as they appear in the database tables **TRAN**/**TEST**. For dates this format is **yyyymmdd**. For times the default format is **hhmmss000000**, where 000000 denotes microseconds. There is some flexibility with the time format, less so with the date format.

SQL filter

It also possible to restrict the network to transactions according to any logical combination of other fields in the TRAN/TEST table. The restriction will apply to both network visualization and network statistics. Standard SQL syntax is supported.

Examples of conditions that can be entered into SQL filter:

input data:
T_TRANVALU>1e6
T_TOPARTID='Bank1' OR T_FRPARTID='Bank1'
T_TRANCLAS=1.2

output data:

E_TRANVALU>1e6
E_TOPARTID='Bank1' OR E_FRPARTID='Bank1'
E_SETTSTAT=0

3.12.2. Network Visualization

Edge width (Gross value/net value/count) and Edge type (Directed/Undirected)

For the 'Directed' edge type the edges are arrows, for the 'Undirected' the edges are line segments.

Gross value: (Directed) One edge is aggregated transaction volume in one-direction, and the width of the edge is proportional to the volume. (Undirected) The edge is the sum of aggregated volume in both directions.

Net value: (Directed) One edge is bilaterally netted transaction volume between two nodes, direction given by the direction of the net flow. (Undirected) Same as directed but without the direction.

Vertex size

Gross throughput: The radius of each vertex is proportional to the sum of absolute values of transaction in and out of the vertex.

Connections: The radius of each vertex is proportional to the number of connections to other vertices.

Betweennes/Pagerank: The radius of a vertex is proportional to the centrality of the vertex as defined by the indicator.

Vertex layout

Four different automatic layouts of vertices are supported. Circle layout arranges the vertices around a circle in alphabetic or numeric order. Three other layouts arrange the nodes based on the links between them. See the JUNG 2.0.1. API for more information about different layouts:
http://jung.sourceforge.net/site/apidocs/edu/uci/ics/jung/algorithms/layout/package-summary.html

Edge size normalization constant and Vertex size normalization constant

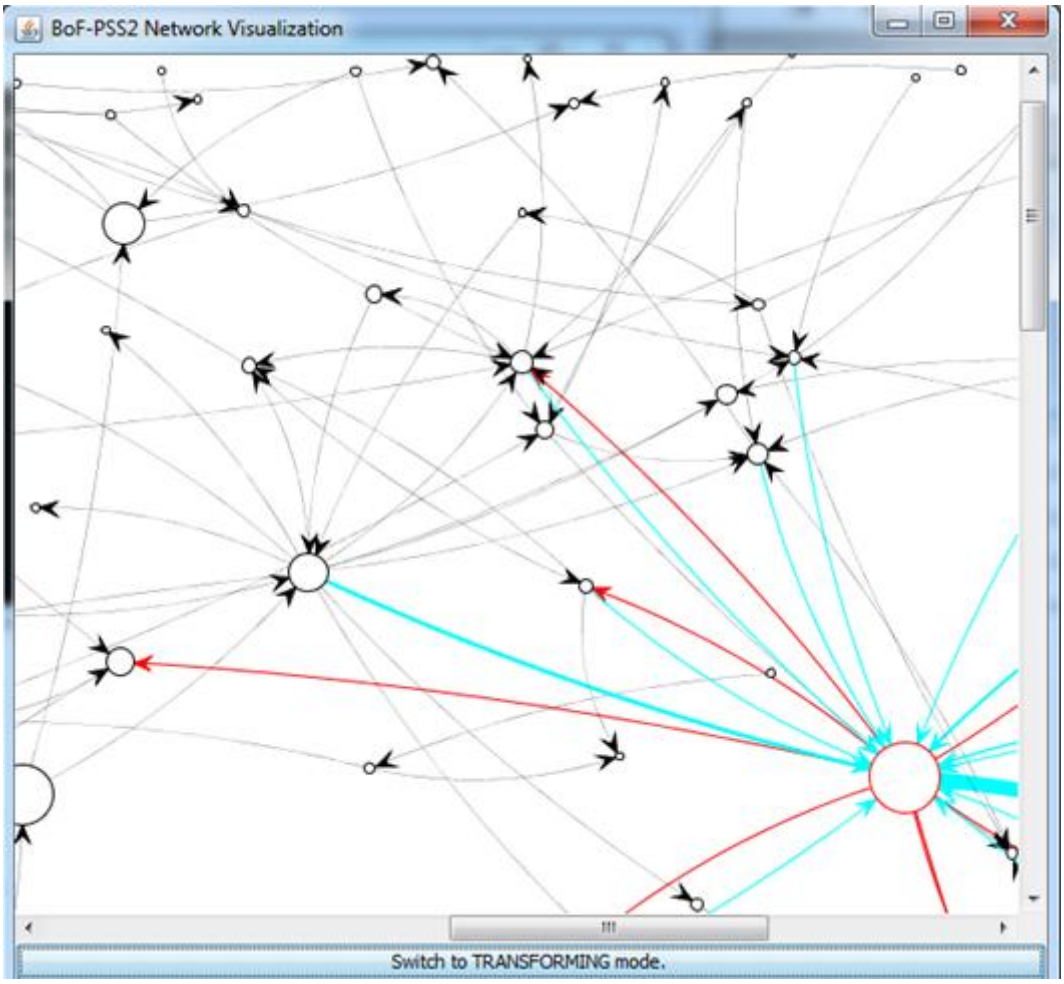
These optional constants can be used to scale up or down the width of edges or size of vertices to please the eye, or in order to visualize different networks or the same network at different times using equivalent scales so that the visual differences can be directly compared.

For example, if the vertex size is according to throughput, the vertex size normalization constant is a vertex throughput, for which the vertex size would be

about 1 cm on the screen. Increasing the number will shrink the vertices. Decreasing the number will increase the vertices. Same idea applies to the edge width normalization constant.

Vertex labels

Tick the box to include vertex labels.



In the "picking" mode the arrows are colored according to the direction of the arrow with respect to the picked node(s). Use the "Switch to PICKING/TRANSFORMING" mode button to change between the "picking" and "transforming" mode.

3.12.3. Network Statistics

Choose the ‘Aggregation period’, ‘Direction of analysis’, ‘Edge weights’ and a set of indicators according to your taste. Select the output-xlsx-file and click Generate Statistics. You can follow the progress of calculation in the status console. After done, click ‘Open in Excel’ to view the statistics. (If Excel does not start, make sure that you have Excel installed and that the path that follows “SET PATH” in Start-up.bat in BoF-PSS2\PROGRAM folder is pointing to correct folder in your Excel installation, and that there is a file called Excel.EXE in there.)

Aggregation Period (Day/Week/Month/Year)

Choose how frequently the statistical indicators are calculated.

Direction of Analysis (Inward/Outward/Undirected)

These settings can be used to adjust the network to which the indicators are applied. Unless you absolutely know what you are doing, it is recommended to used the standard 'Outward' direction.

Inward: Changes the direction of each arrow in the graph before calculating the statistics.

Outward (recommended): Calculates the indicators using standard directed graph.

Undirected: Calculates the indicators using undirected graph.

Edge weights (None/Gross value/Net value)

These settings can be used to adjust the weights of the network to which the indicators are applied much the same way as the 'Edge width'can be chosen in the visualization. Additionally, there is possibility to choose weight 'None', which neglects any counts and volumes of transactions and is only concerned with relations between the vertices. Indicators marked with * are affected by the weights.

Indicators:

The toolbox supports a number of network indicators that are part of JUNG 2.0.1. and a couple of additional indicators 'Connectivity','Eccentricity' and 'Reciprocity'. Following is a short description of each indicator. Technical details of indicators can be found in network literature and: http://jung.sourceforge.net/site/apidocs/edu/uci/ics/jung/algorithms/scoring/package-summary.html

Barycenter (G): Inverse of sum of distances to other nodes.

Closeness(G): Inverse of average distance to other nodes.

Betweenness(G): How many shortest paths go through this node. If a shortest path is not unique, the score is divided by the corresponding factor. For example, if there are three shortest paths from A to F (say A->B->E, A->C->E and A->D->E) and one unique shortest path from G to H: G->B->H, then node B gets score 1.3333333=0.3333333+1 .

Connectivity(L): Number of links divided by number of other nodes.

Clustering coefficient(G): Tells if the neighbours of this node tend to link with each other.

Eccentricity(G): Distance to farthest node.

Eigenvector(G): Eigenvector centrality. (Pagerank with parameter 0)

In-degree/inflow*(L): Number of links or value (in the weighted case) that come to this node. (Does not work for undirected networks.)

Out-degree/outflow*(L): Number of links or value (in the weighted case) that leaves this node. (Does not work for undirected networks.)

Neighbors/throughput*(L): Number of neighbours connected to through directed or undirected vertices. If same neighbour is connected both through in-edge and out-edge, it is counted only once. In the weighted case this is the summed value to this node plus the summed value from this node.

Reciprocity(L): How large proportion of this node's neighbours are linked via both incoming and outgoing links.

HITS*(G): Assigns two scores, a Hub score and an Authority score to each vertex based on whether they are good 'hubs' or 'authorities'. Takes in a parameter between 0 and 1 similar to Pagerank (see below).

Pagerank*(G): PageRank is an eigenvector-based algorithm. The score for a given vertex may be thought of as the fraction of time spent 'visiting' that vertex (measured over all time) in a random walk over the vertices (following outgoing edges from each vertex). PageRank modifies this random walk by adding to the model a probability (specified to empty field next to Pagerank) of jumping to any vertex. If alpha is 0, this is equivalent to the eigenvector centrality algorithm; if alpha is 1, all vertices will receive the same score, the inverse of the number of vertices in the network. Thus, alpha acts as a sort of score smoothing parameter.

3.12.4. Generate stochastic data

The simulator supports automatic generation of transaction and participant data. Logic for data generation can be implemented as algorithms with algorithm type DGA (Data generation algorithm). Own DGA algorithms can be included through user module definition screen. In version 2.4.0, however, no such built in DGA algorithm is yet included.

3.13. Operating the simulator via command-line

The **command-line interface (CLI)** of the simulator can be used to configure and run simulations without starting the graphical user interface. It is useful when large number of similar tasks needs to be performed. Example of such situation

could be repetition of a certain simulation for hundreds of times with different data sets. With the CLI it is also possible to use the BoF-PSS2 via other software, which is creating the simulated data or commanding the execution.

CLI is designed to cover the most frequently used repetitive tasks. The graphical user interface is still used in tasks which are considered to be typically one off actions. Examples of these are creation of new projects, setting the data format defaults, definition of new templates and also definition of system data set contents. The operations supported by the CLI are **importing datasets, configuration of simulations**, **executing simulations** and **exporting results**.

In the command mode the simulator software is divided in two parts. First, there is server software, which is the actual simulator executing the given commands similarly as in the graphical mode. This server is displayed as a console window. The server is started by executing the Start-up-SERVER.bat file located in C:\BoF-PSS2\PROGRAM. The server must be running before any commands to the simulator can be given with the script language. The server is closed by executing the C:\BoF-PSS2\PROGRAM\PSS2_server_shutdown.bat file.

Second part is the client program, C:\BoF-PSS2\PROGRAM\BoF-PSS2.bat, which is called in the command prompt with the actual script command given in the argument. It passes on the individual command parameters to the server and collects the feedback of the commands submitted.

There are three general options for using the command interface:

a. Giving the individual commands directly in command prompt of the operating system, i.e. opening up the command prompt and executing the command.
b. Using a program which forms the script commands and submits them to the operating system to be executed in command prompt.
c. Writing a text file with a batch of sequential commands to be executed. The launch of the execution is done again via the command prompt. The text file can be created with Notepad, Excel or any other suitable program.

You can, and probably have to use the graphical and command-line user interfaces in turns. Those tasks which are not repetitive are often easier to do using the graphical interface and those that have to be repeated several time with small changes in the parameters can be efficiently and rapidly executed using the command-line interface. **Using both interfaces simultaneously is however impossible.**

For detailed instructions and description of the CLI, see the separate document **BoF-PSS2 Command-Line Interface User Manual**.

4 Algorithms and user modules

4.1. Algorithms

"Algorithms" is a common term applied to the simulator's special settlement functions such as splitting and netting. Common algorithms are provided as part of the software, and users can also develop their own algorithm modules. The interface for BoF-PSS2 algorithms and user-defined modules is the same.

The available algorithms are divided into the following main groups:

- Submission algorithms (SUB) fetch the next transaction to be submitted for processing.
- The system event handler algorithms (SEH) can be used to bypass the default event handling logics related to events (end of day, introduction of new transaction, limit changes, Transaction expiry, …) occurring during a simulation.
- Entry algorithms (ENT) make the initial processing of each transaction.
- Settlement algorithms (SET) call specified subalgorithms to settle queued transactions. The SET algorithms self do not contain any logic to release payments.
- End-of-day algorithms (END) process the final steps during a day or settlement cycle.
- Time estimation algorithms (TEA) are used to estimate the real time used for specific process. For example, a TEA algorithm can be used to induce a more realistic delay due to the processing of a settlement algorithm. TEA is also needed to simulate parallel processing of algorithms. To be able to use a TEA-algorithm, the parent algorithm must support TEA estimation.

The submission algorithm is only available at the simulation level. For every simulation, a submission algorithm must be selected. Its task is to determine which transaction is the next to be processed from all pending transactions in all systems. All other algorithms are specified at system level. The submission algorithm can be thought of as the process in which the bank decides, which is the next transaction to submit for processing to any of the systems in the simulation. This is the algorithm to modify if new behavioural patterns for banks are introduced.

The other main algorithms are assigned on system level. For example, an RTGS and net-settlement system can use different entry-algorithms in the same simulation. For every system, the entry (ENT) and end-of-day (END) algorithms

must be specified. The system event handler and settlement algorithm are optional.

The following sub-algorithms can be used with ENT entry algorithms:

- Splitting algorithms (SPL) split a large transaction into sub-transactions according to specific rules.
- Injection algorithms (INJ) transfer liquidity between ancillary and main systems.

The following sub-algorithms can be used with SET settlement algorithms:

- Queue release algorithms (QUE) check and fetch individual transactions for possible settlement from the waiting queue in the order defined in the algorithm. They are useful for settling previously queued transactions once an account or participant has received more liquidity.
- Splitting algorithms (SPL) split transactions into smaller sub-transactions.
- Injection algorithms (INJ) transfer liquidity between ancillary and main systems.
- Bilateral off-setting (BOS) checks and fetches transactions that can be bilaterally off-set from the waiting queues.
- Partial netting algorithms (PNS) seek to settle a group of the queued transactions.
- Multilateral netting algorithms (MNS) attempt to settle all queued transactions in one netting event.

For special cases following separate algorithm categories are available:

- Queue release algorithm for secondary queue (QU2) is used in special case of receipt reactive gross settlement.
- In simulations with bilateral limits own algorithms are used. See section 4.1.5 for more details. For example, the bilaterally queued payments are released by QUB-algorithms.
- Partial net settlement or bilateral offsetting of bilaterally queued payments is handled by BBS-algorithms in simulations with bilateral limits.

For each payment and settlement system, there can only be one specific sub-algorithm defined of each category in the current ENT and SET algorithms. This means that the main algorithms will use the same splitting and injection algorithms, if these are defined. The order in which the sub-algorithms are set in the simulator control data specifications is important because **sub-algorithms are called from the main algorithms in the order they were set**.

The specific algorithms are attached to the specified payment and settlement systems on the **System control data specification/modification** screen. The required parameter values are given at the same time as a parameter string. The basic controls are made for the parameters, but it is essential that users are cautious when introducing parameters. Any user-defined modules must be introduced to the system by stating the initial specifications on the **User module definition** screen. Thereafter, it is possible invoke them on the **System control data specification/modification** screen in the same way as originally provided modules and algorithms.

The time estimation algorithms (TEA) are tied to other algorithms and thus defined slightly differently (see chapter 3.3.1 step 12). They provide function to calculate an estimate to the time that would have been used in the real world by a specific algorithm.

The algorithms provided with the simulator are shortly described in the table below. More detailed definitions of the processing logics can be found in separate document, Algorithm descriptions and user module development guide. Descriptions of typical combinations of algorithms depending on the system type can be found in the next chapters. Most of the sub-algorithms are used both for RTGS and CNS systems while DNS systems have a very limited number of specific sub-algorithms.

Type	Name	Parameters	Description
SUB	SUFIFOPR	None	Fetches the next transaction or system event (among all systems) according to simulation time, priority and transaction id.
ENT	ENBASIC1	None	Performs the basic entry processes on a specified transaction.If the sending participant has no transaction in queue, the algorithm checks the possibilities for booking according to available liquidity (balance + available intraday credit), splits the transaction according to defined splitting algorithm when needed and passes the transaction or its parts for booking or into the waiting queue. ENBASIC1 does not support: Bilateral limits, multilateral limits and reservations are not taken into account.
ENT	ENFORURG	Priority (0-9)	Settles normal transactions according to normal rules i.e. as ENBASIC1 but settles highly urgent payments immediately irrespectively of liquidity constraints on the sending account. When the liquidity constraint is violated a violation entry is written to the AVST-table. The priority code is defining which level of transactions should be treated as highly urgent e.g. a parameter value of 7 indicates that

Type	Name	Parameters	Description
			transactions with a priority value equal to 7 or higher will be treated as highly urgent payments. Algorithm is only available in RTGS and CNS systems.
ENT	ENTDUAL1	Limit (0-9) Priority(0-9) Open (hhmmss) Close (hhmmss)	Entry algorithm for RTGS system with secondary receipt reactive queue. (See ch. 4.2.14.2.1 for more details). Performs the basic entry process for transactions with equal or higher priority than Limit-parameter and forced immediate settlement regardless of all limits for transactions with higher or equal priority than the Priority-parameter. Transactions with smaller priority than Limit-parameter are placed in secondary queue QU2. Open hours for QU2 are defined with parameters Open and Close.
BNT	ENBILIM1	Priority code (0-9)	Performs the basic entry processes in simulation with bilateral limits in use. See ch. 4.1.5. For each transaction checks the possibilities for booking and passes the transaction or its parts for booking or into the waiting queue. Transactions with a higher priority than the defined will be treated as urgent payments and will be processed irrespectively of bilateral limits, but the bilateral limit balances will still be updated. The other transactions will be checked against the bilateral limits and will only be booked if they pass both the bilateral limit requirement and the overall liquidity/debit cap requirement. Supports Credit cap limits starting from version 3.1.0
END	ENDRTGS1	None	Basic end of day algorithm of RTGS process. Executes the settlement algorithm and specified subalgorithms for one final time and performs end of day procedures for transactions remaining in queues. The settlement algorithm is called for each remaining participant separately passing the participant as parameter.
END	ENDCNS01	None	End of day/settlement cycle for CNS system type.
END	ENDDNS01	time1, … , time40	End of day/settlement cycle for DNS system type. Time, when the algorithm is executed is defined with the parameters. At least one time has to be given, while maximum number of separate settlement runs is 40.
BND	ENDRBIL1	code, starting time	End of day algorithm for systems with bilateral limits. The code parameter defines what should be done with the remaining bilaterally queued transactions (1 = delete, 2 = process as normal payments) and the time parameter defines when the release code is applied.
SET	SEBASIC1	None	Calls specified subalgorithms to settle queued payments. It is invoked each time a new transaction is put into queues or liquidity has

Type	Name	Parameters	Description
			been transferred to an account with queued transactions.
SET	SETDUAL1	None	Used in simulations with secondary receipt reactive queue (See ch. 4.2.1 for more details) to call sub algorithms for settling payments in queues. It is invoked each time a new transaction is put into queues or liquidity has been transferred to an account with queued transactions. For the normal primary RTGS-queue all normal sub algorithms are available. QU2 algorithm is used to release payments from the secondary queue.
BET	SEBILIM1	Priority code (0-9)	Calls specified subalgorithms to settle queued payments. It is invoked each time a new transaction is put into queues or liquidity has been transferred to an account with queued transactions. It invokes specified sub-algorithms. Urgent transactions, higher than the specified priority, will be processed without regarding bilateral limits, while the other transactions should fulfil limit requirements. Only bilateral offsetting algorithms for bilateral queues (BBS) are used for settling transactions in bilateral queues. All other algorithms are available for "normal" transactions.
QUE	QUFIFOPR	None	Releases individual transactions from waiting queues upon arrival of additional liquidity in priority and FIFO order.The exact behavior depends on the calling algorithm. QUFIFOPR performs FIFO on the set of transactions it receives as parameter. The defaullt event handler calls it account by account, which means that it acts as an account wise FIFO algorithm.
QUE	QUUSEDEF	None	Releases transactions from waiting queues upon arrival of additional liquidity in the order defined by user defined fields 1and 2. (T_USERCOD1...2) in ascending order and the first code has the highest priority. This facilitates free definition of queue order by moving the right data to the user code fields e.g. the size of transactions. Note that the User code fields are of type VARCHAR(12) in order to carry all kind of data and thereby sorted in alphabetic ascending order, which means that numeric values need to be same length in order to be sorted correctly.
QUE	QUUSEDBP	None	Releases transactions from waiting queues upon arrival of additional liquidity in the order defined by user defined fields 1and 2 by using the bypass option. (T_USERCOD1...2) in ascending order and the first code has the highest priority. This facilitates free definition of queue order by moving the right data to the user code fields e.g. the size of transactions.

Type	Name	Parameters	Description
			Note that the User code fields are of type VARCHAR(12) in order to carry all kind of data and thereby sorted in alphabetic ascending order, which means that numeric values need to be same length in order to be sorted correctly. In the bypass case transactions are processed in priority and FIFO order with the exception that if a transaction higher up in the queue cannot be settled, it is bypassed and payments lower in the queue are tested for settlement (in priority or FIFO order) until no more settlable transactions can be found.
QU2	QURRFIPR	EOD ("gross" or "return") NewPriority (0-9, optional)	Releases transactions from secondary queue in priority FIFO order in receipt reactive gross settlement simulations. EOD parameter defines the processing logic of secondary queue payments at the end of each period: *gross* means transactions are moved into primary RTGS queue, *return* means transactions are discarded (i.e. returned to original sender). In the former case transactions are given a new uniform priority if NewPriority has a value. Otherwise they retain their original priority. (See ch. 4.2.1 for more details)
QUB	QBFIFOPR	None	Releases transactions from bilateral waiting queues, when bilateral limits are increased and upon arrival of transactions from the counterparty in priority and FIFO order. Supports Credit cap limits starting from version 3.1.0
QUB	QBBYPAFI	None	Releases transactions from bilateral waiting queues, when bilateral limits are increased and upon arrival of transactions from the counterparty in priority and FIFO order with the exception that if a transaction higher up in the queue cannot be settled, it is bypassed and payments lower in the queue are tested for settlement (in priority or FIFO order) until no more settlable transactions can be found. Supports Credit cap limits starting from version 3.1.0
QUB	QBUSEDEF	None	Releases transactions from bilateral waiting queues, when bilateral limits are increased and upon arrival of transactions from the counterparty in the order defined by user defined fields 1and 2. (T_USERCOD1...2) in ascending order and the first code has the highest priority. This facilitates free definition of queue order by moving the right data to the user code fields e.g. the size of transactions. Note that the User code fields are of type VARCHAR(12) in order to carry all kind of data and thereby sorted in alphabetic ascending order, which means that numeric values need to be same length in order to be sorted correctly. Supports Credit cap limits starting from version

Type	Name	Parameters	Description
			3.1.0
QUB	QBUSEDBP	None	Releases transactions from bilateral waiting queues, when bilateral limits are increased and upon arrival of transactions from the counterparty in the order defined by user defined fields 1and 2 by using the bypass option. (T_USERCOD1...2) in ascending order and the first code has the highest priority. This facilitates free definition of queue order by moving the right data to the user code fields e.g. the size of transactions. Note that the User code fields are of type VARCHAR(12) in order to carry all kind of data and thereby sorted in alphabetic ascending order, which means that numeric values need to be same length in order to be sorted correctly. In the bypass case transactions are processed in priority and FIFO order with the exception that if a transaction higher up in the queue cannot be settled, it is bypassed and payments lower in the queue are tested for settlement (in priority or FIFO order) until no more settlable transactions can be found. Supports Credit cap limits starting from version 3.1.0
SPL	SPMVALU1	Max. transaction value, positive amount with two decimals	Splits transactions into sub-transactions according to specified maximum transaction value. For example, if a max value of 500 is specified, a transaction of 1,350 is split into sub-transactions of 500, 500 and 350, with 350 the last to be processed.
SPL	SPAVLIQ1	None	Splits transactions using available liquidity. For example, when 450 units are available on the account, a transaction of 1,350 is split into 450 and 900 of which the 450 is directly processed and 900 remains in the waiting queue.
INJ	INVALUE1	Positive value with two decimals	Injects liquidity to a participant/account when required in given amounts defined with the parameter value. The source of liquidity and permission to perform injections are defined by using the "Liquidity injections from system" and "Liquidity injections from participant" fields in PART data. When excess liquidity becomes available, the injected liquidity is released and returned to the source participant/account again in payments with the same value defined in the parameter. Typically liquidity injections can be used between a main and ancillary payment system.
INJ	INPERCE1	Positive percentage (format 100.00)	Injects an amount that corresponds to a given percentage of the credit limit available in the ancillary system.
INJ	INJEXACT	None	Injects exactly the required value of liquidity from the account defined in PART data. Returns are also performed with exact amounts: either according to what has been injected or how much liquidity is available to return.

Type	Name	Parameters	Description
BOS	BOBASIC1	None	Performs bilateral off-setting of waiting queues in FIFO and priority order and using available liquidity. The algorithm is performed after each transaction queue entry and liquidity change, so caution is needed with large transaction volumes. Because of the bilateral processing, the priority FIFO rule can become bypassed on system level in bilateral off-setting.
BOS	BOUSEDEF	None	Performs bilateral off-setting of waiting queues using available liquidity in the order defined by user defined fields 1and 2. (T_USERCOD1...2) in ascending order and the first code has the highest priority. This facilitates free definition of queue order by moving the right data to the user code fields e.g. the size of transactions. Note that the User code fields are of type VARCHAR(12) in order to carry all kind of data and thereby sorted in alphabetic ascending order, which means that numeric values need to be same length in order to be sorted correctly. The algorithm is performed after each transaction queue entry and liquidity change, so caution is needed with large transaction volumes. Because of the bilateral processing, the priority FIFO rule can become bypassed on system level in bilateral off-setting.
BBS	BBFIFOPC	None	Performs partial bilateral net offsetting of bilaterally queued transactions in FIFO and priority order by including transactions that can be settled within the available bilateral limit. The algorithm removes transactions one-by-one in priority and time order (starts by removing the most recent submitted transactions with the lowest priority) for each participant pair. The solution must fulfil the bilateral limit criteria and the overall balance limitations. The algorithm is performed after each transaction queue entry, liquidity transfer and overall credit and bilateral limit change, so caution is needed with large transaction volumes. Supports Credit cap limits starting from version 3.1.0
BBS	BBDEQUEC	None	Performs partial bilateral net offsetting of bilaterally queued transactions in user-defined order (ascending user-defined field 1 and 2) by including transactions that can be settled within the available bilateral limit. The algorithm removes transactions one-by-one in (starts by removing the last based on user defined field 2 first and then field 1) for each participant pair. The solution must fulfil the bilateral limit criteria and the overall balance limitations. The algorithm is performed after each transaction queue entry, liquidity transfer and overall credit and bilateral limit change, so caution is needed

Type	Name	Parameters	Description
			with large transaction volumes. Supports Credit cap limits starting from version 3.1.0
BBS	BBFIFOPI	Minutes interval (1-60);starting- time (hhmmss)	Performs partial net offsetting of bilaterally queued transactions in FIFO and priority order at given time intervals during the day (in minutes). A starting-time may be defined (the default starting time is when the system is opened) The algorithm removes transactions one-by-one for participants unable to settle to see if a partial settlement is possible. Supports Credit cap limits starting from version 3.1.0
BBS	BBDEQUEI	Minutes interval (1-60);starting-time (hhmmss)	Performs partial net offsetting of bilaterally queued transactions in user-defined order at given time intervals during the day (in minutes). A starting-time can be defined (the default staring-time is when the system is opened). The algorithm removes transactions one-by-one for participants unable to settle to see if a partial settlement is possible. Supports Credit cap limits starting from version 3.1.0
BBS	BBFIFOPT	Time;time;time;…;time (max 12, 24 h HH:MM format	Performs partial net offsetting of bilaterally queued transactions in FIFO and priority order at the specified times during the day. The algorithm removes transactions one-by-one for participants unable to settle to see if a partial settlement is possible. Supports Credit cap limits starting from version 3.1.0
BBS	BBDEQUET	Time;time;time;…;time (max 12, 24 h HH:MM format	Performs partial net offsetting of bilaterally queued transactions in user-defined order at the specified times during the day. The algorithm removes transactions one-by-one for participants unable to settle to see if a partial settlement is possible. Supports Credit cap limits starting from version 3.1.0
PNS	PNFIFOPC	None	Performs partial multilateral net settlement of queued transactions in FIFO and priority order by including transactions that can be settled with available liquidity (the algorithm removes transactions one-by-one for participants unable to settle to see if a partial settlement is possible). The algorithm is performed after each transaction queue entry, so caution is needed with large transaction volumes.
PNS	PNDEQUEC	None	Performs partial multilateral net settlement of queued transactions in defined order (ascending user-defined field one and two and transaction ID in the TRAN data) by including transactions that can be settled with available liquidity (the algorithm removes transactions one-by-one for participants unable to settle to see if a partial settlement is possible). The algorithm is performed after each transaction queue entry, so caution is needed with large transaction volumes.
PNS	PNFIFOPI	Minutes interval (1-60); Starting time (hhmmss)	Performs partial net settlement of queued transactions at a given time interval during the

Type	Name	Parameters	Description
			day (in minutes) in FIFO and priority order by including transactions that can be settled with available liquidity (the algorithm removes transactions one-by-one for participants unable to settle to see if a partial settlement is possible). The starting-time parameter defines when the first netting occasion occurs.
PNS	PNDEQUEI	Minutes interval (1-60); Starting time (hhmmss)	Performs partial multilateral net settlement of queued transactions at the given time interval during the day (in minutes) in defined order (ascending user-defined field one and two and transaction identifier in the TRAN data) by including transactions that can be settled with available liquidity (the algorithm removes transactions one-by-one for participants unable to settle to see if a partial settlement is possible). The starting-time parameter defines when the first netting occasion occurs.
PNS	PNFIFOPT	Time;time;time;…;time (max 40 , 24 h HH:MM format)	Performs partial net settlement of queued transactions at given times in FIFO and priority order by including transactions that are possible to settle with available liquidity (the algorithm removes transactions one-by-one for participants unable to settle to see if a partial settlement is possible).
PNS	PNFIFOPD	None	Performs partial net settlement of queued transactions at given occasions in FIFO and priority order by including transactions that are possible to settle with available liquidity (the algorithm removes transactions one-by-one for participants unable to settle to see if a partial settlement is possible).
PNS	PNDEQUED	None	Performs partial multilateral net settlement in DNS systems based on ascending order of user defined fields one and two and the transaction identifier. The algorithm removes transactions one-by-one for participants unable to settle to see if a partial settlement is possible.
PNS	PNDEQUET	Time;time;time;…;time (max 40, 24 h HH:MM format	Performs partial net settlement of queued transactions at defined occasions in defined order (ascending user-defined field one and two and transaction identifier) by including transactions that can be settled with available liquidity (the algorithm removes transactions one-by-one for participants unable to settle to see if a partial settlement is possible).
MNS	MNSETTLC	None	Performs total net settlement of all queued transactions when sufficient liquidity is available. Total net settlement implies that settlement is only performed in cases where all queues can be emptied (partial multilateral settlement not accepted). The algorithm is performed after each transaction queue entry, so caution is needed with large transaction volumes.
MNS	MNSETTLD	None	Performs total net settlement of all queued

Type	Name	Parameters	Description
			transactions in deferred net settlement systems (DNS) when sufficient liquidity is available.
MNS	MNSETTLI	Minutes interval (1-60); Starting time (hhmmss)	Performs total net settlement of all queued transactions when sufficient liquidity is available at the given time interval during the day (in minutes). The starting-time parameter defines when the first netting occasion occurs.
MNS	MNSETTLT	Time;time;time;…;time (max 40, 24 h hhmmss format	Performs total net settlement of all queued transactions when sufficient liquidity is available at the defined times.

4.1.1. Algorithms for RTGS systems

Real-time Gross Settlement (RTGS) systems process transactions one-by-one in a real-time environment using central bank accounts. Each transaction is booked, queued or discarded as defined by the algorithms set for the system. The release of queued transactions is determined using various settlement algorithms. The user specifies the processing patterns by selecting algorithms and assigning necessary parameters.

The main algorithms available for RTGS systems are the ENT algorithms ENBASIC1 and ENFORURG, the END algorithm ENDRTGS1 and the SET algorithm SEBASIC1. ENT and END algorithms should be chosen for all normal RTGS simulations. If a system with a queuing facility is simulated, the SEBASIC1 algorithm should also be selected.

The ENFORURG algorithm enables settlement of highly urgent payments irrespectively of the liquidity constraints. When the balance restriction is violated an account violation statistics entry is written in the AVST-table. The priority parameter defines the urgency level of transaction that will be settled immediately as highly urgent payments. The other transactions are regarded as normal transactions, which follow the general rules for settlement. This makes it possible to find out what the efficient liquidity need (lower bound) would be, if highly urgent payments were settled at once and less urgent payments were settled eg by the end of the day.

RTGS systems may incorporate payment-splitting and liquidity-injection sub-algorithms. These are invoked by the ENT algorithm if they have been specified.

When a queuing facility is included, the SEBASIC1 algorithm invokes the specified sub-algorithms in the order specified on the define system data screen to settle queued transactions. SEBASIC1 will also invoke payment-splitting and liquidity-injection when these have been specified.

Currently, the ENT and SET algorithms can only invoke a single sub-algorithm of the same type (SPL, INJ, QUE, BOS, PNS or MNS), e.g. there can only be one splitting algorithm in use for a given system. In principle, custom user modules with the possibility of handling multiple sub-algorithms can be

developed to overcome this limitation. The different algorithm classes can be seen to have partially overlapping functions, particularly related to queue arrangements. This is because gridlock resolution algorithms such as PNS and MNS are independent from QUE algorithms in the way they order the transactions in the queues before processing. As an example it is possible to create a system with QUE algorithm releasing individual transactions with priority FIFO logic and PNS algorithm which follows user defined queue order in selecting the transactions to be settled e.g. smallest first.

The table below shows examples of possible RTGS configurations using the main and sub-algorithms. In all cases the basic submission algorithm, SUFIFOPR, is used to submit payments in order based on time (earliest first), priority of the transaction (descending order, i.e. highest priority first) and the transaction ID (ascending order). When transactions in the simulation compete for the same time slot, then the transaction with the highest priority is chosen. If there are still several competing transactions, then the transaction ID order becomes the determining factor. This means that in multisystem simulations the transactions in the system containing the smallest transaction IDs will be executed first when time and priority are the same.

Some examples of possible logical algorithm combinations in RTGS systems:

RTGS description	Main alg.	Sub-alg.	Comments
1. No queuing facility available, transactions without liquidity remain unsettled	ENBASIC1 ENDRTGS1		Can be used with "credit without limits" to find the "upper bound" and "lower bound" of liquidity.
2. FIFO queuing	ENBASIC1 ENDRTGS1 SEBASIC1	QUFIFOPR	Transactions are queued when liquidity is insufficient for settlement; they are released in FIFO and priority order as liquidity becomes available from incoming payments or extended credits.
3. Bypass FIFO queuing	ENBASIC1 ENDRTGS1 SEBASIC1	QUBYPAFI	Same as 2, except that the FIFO order is bypassed to settle payments lower in the queue for which sufficient liquidity is available.
4. FIFO queuing and bilateral offsetting	ENBASIC1 ENDRTGS1 SEBASIC1	QUFIFOPR BOBASIC1	Transactions are queued in FIFO order and settled also with bilateral offsetting when sufficient liquidity is available. Note: Bilateral offsetting can cause bypasses in strict system level priority FIFO order of transactions.
5. FIFO queuing, bilateral offsetting and full multilateral netting at a given interval	ENBASIC1 ENDRTGS1 SEBASIC1	QUFIFOPR BOBASIC1 MNSETTLI	As in 4, plus full multilateral netting is attempted at a given interval (e.g. every 10 minutes).
6. Queuing and splitting according to maximum value	ENBASIC1 ENDRTGS1 SEBASIC1	QUFIFOPR SPMVALU1	As in 2, but large transactions are split into smaller ones to better circulate liquidity.
7. Queuing and splitting according to available liquidity	ENBASIC1 ENDRTGS1 SEBASIC1	QUFIFOPR SPAVLIQ1	As in 2, but all unsettlable transactions are split based on available liquidity. This algorithm gives the benchmark for maximal liquidity employment (difficult to implement in practice).

The desired RTGS system structure is defined by combining the various available standard algorithms or user-developed modules. In most cases, the SEBASIC1 will be invoked in addition to the mandatory ENDRTGS1 and ENBASIC1 or ENFORURG. A queue release algorithm, e.g. QUFIFOPR, is also often used in RTGS simulations because most RTGS systems contain queuing possibilities.

Only those algorithms that are strictly necessary to describe the desired processing logic should be included in system definition. Before performing large

scale simulations it is wise to validate the created model by testing the process with simple examples with only few transactions so that the correct outcome for the input can be verified from the output.

Note that there is no checking logic in the simulator to assess whether the selected algorithm combination is rational. The user is responsible for selecting appropriate algorithms among those applicable for RTGS simulations.

4.1.2. Algorithms for CNS systems

Continuous Net Settlement (CNS) systems are private systems that process transactions one-by-one in a real-time environment. Transactions are booked on private settlement accounts during the day. In most cases, these are settled with central bank accounts at the end of the day and possibly more often. From the simulator's standpoint, RTGS and CNS systems are quite similar. However, CNS systems offer the possibility for intraday liquidity swaps with an RTGS system and the end-of-day settlement in an RTGS system.

Processing (booking, queuing and discarding) of transactions takes place as in an RTGS system. The user specifies the processing patterns by selecting algorithms and assigning necessary parameters. The algorithms available for CNS systems are also the same as for RTGS systems.

When CNS systems are simulated separately (not as part of a multisystem environment with a main RTGS system), the initial liquidity needed for the processing can be introduced as:

- initial balances representing liquidity reservations made on RTGS accounts,
- credit limits representing the credit risk of the private settlement bank or the system itself, and
- liquidity transactions made from the special account of the settlement bank.

When the CNS system operates based on credit risks, the simulator calculates the open positions for each participant.

The table below shows examples of possible CNS configurations using the various main and sub-algorithms. In all cases, the submission algorithm, SUFIFOPR, submits payments in time, priority and transaction ID order. If there are transactions in single or several systems competing for the same time slot, then the transaction with the highest priority is chosen. If there are still several competing transactions, then the transaction ID order becomes the determining factor. All systems are treated equally, so the priorities used in different systems should be on the same scale if submission order is critical. Because transaction ID's must be unique simulation-wide, you should use smaller IDs for "more important" systems, as these IDs will be the final determining factor.

Some examples of possible logical algorithm combinations in CNS systems:

CNS description	Main alg.	Sub-alg.	Comments
1. No queuing facility available, transactions without liquidity will remain unsettled	ENBASIC1 ENDCNS01		Can be used with "credit without limits" to find the "upper bound" and "lower bound" of liquidity.
2. FIFO queuing	ENBASIC1 ENDCNS01 SEBASIC1	QUFIFOPR	Transactions are queued when liquidity is insufficient for settlement; they are released in FIFO and priority order as liquidity becomes available from incoming payments or extended credits.
3. Bypass FIFO queuing	ENBASIC1 ENDCNS01 SEBASIC1	QUBYPAFI	Same as 2, except that the FIFO order is bypassed to settle payments lower in the queue for which enough liquidity is available.
4. FIFO queuing and bilateral offsetting	ENBASIC1 ENDCNS01 SEBASIC1	QUFIFOPR BOBASIC1	Transactions are queued in FIFO order and settled also with bilateral offsetting when sufficient liquidity is available Note: Bilateral offsetting can cause bypasses in strict system level priority FIFO order of transactions.
5. FIFO queuing, bilateral offsetting and full multilateral netting at given intervals	ENBASIC1 ENDCNS01 SEBASIC1	QUFIFOPR BOBASIC1 MNSETTLI	As in 4, plus full multilateral netting is attempted at a given interval (e.g. every 10 minutes).
6. FIFO queuing and splitting according to maximum value	ENBASIC1 ENDCNS01 SEBASIC1	QUFIFOPR SPMVALU1	As in 2, but large transactions are split into smaller ones to better circulate liquidity.
7. FIFO queuing and splitting accord available liquidity	ENBASIC1 ENDCNS01 SEBASIC1	QUFIFOPR SPAVLIQ1	As in 2, but all unsettlable transactions are split based on available liquidity. This algorithm gives the benchmark for maximal liquidity employment (difficult to implement in practice).
8. FIFO queuing with liquidity injections	ENBASIC1 ENDCNS01 SEBASIC1	QUFIFOPR INVALUE1	Transactions are queued and liquidity swaps are executed in both directions with an RTGS system, when liquidity is needed or superfluous.

Define the desired CNS system structure by combining the available algorithms and user-developed modules. In most case, SEBASIC1 is also invoked along with

the mandatory ENBASIC1 (or ENFORURG) and ENDCNS01. A queue release algorithm (e.g. QUFIFOPR) is also used in most CNS simulations because most CNS systems contain a queuing facility.

When simulations involve a CNS system interacting with an RTGS system, it is important to provide in PART data the correct account information for end-of-day settlement and possible intraday liquidity swaps. For each account in CNS system having possibility of liquidity swaps, the source system and source account of liquidity must be defined. Similarly account on which the end of day settlement is performed has to be defined for each CNS account with this feature. The ENDCNS01 algorithm performs the end-of-day settlement bookings. These may violate the liquidity restrictions in the RTGS system, so the user can select an option that writes violations to an output table. One way of avoiding violations is to use debit caps and reservations to keep the positions within acceptable limits. If there is a partly or complete net settlement during or at the end of the settlement cycle, the type of net settlement algorithm should be specified.

Only those algorithms that are strictly necessary to describe the desired processing logic should be included in system definition. Before performing large scale simulations it is wise to validate the created model by testing the process with simple examples with only few transactions so that the correct outcome for the input can be verified from the output.

Note that there is no checking logic in the simulator to assess whether the selected algorithm combination is rational. The user is responsible for selecting appropriate algorithms among those applicable for CNS simulations.

4.1.3. Algorithms in DNS systems

Deferred Net Settlement (DNS) systems settle transactions in batches at given settlement occasions. Participants hold settlement accounts. Although the DNS system uses batch settlement, the simulator process resembles the RTGS and CNS processes to the extent that each transaction is processed in real-time according to its submission time and is queued until the next settlement occasion. This approach makes it possible to track the accumulation of credit risks when the transactions are processed by participant and delivered as final to end customers. The DNS processing also reports the queuing time.

Transactions are booked in DNS systems when sufficient liquidity is available, i.e. the settlement accounts have a positive value or the debit cap (credit limit) for the accounts has not been exceeded. Otherwise, transactions are transferred to the next settlement occasion or discarded. No queue release algorithms should be assigned for DNS systems as this makes the system work in continuous mode. DNS systems use time-of-netting algorithms (PNS or MNS).

The user specifies the processing patterns by selecting algorithms and assigning necessary parameters.

When DNS systems are simulated separately (not as a part of a multisystem environment with a main RTGS system), the initial liquidity needed for the processing can be introduced as initial balances or credit caps for each participant. “Credit without limits” assigns open-ended credit caps.

DNS systems use the same entry algorithm ENBASIC1 as other systems, but have a special END algorithm ENDDNS01 for defining the end-of-day occasion and any intraday settlement cycles. DNS systems use very few sub-algorithms. A set of deferred PNS algorithms (PNFIFOPD and PNEQUED) and a deferred MNS algorithm (MNSETTLD) are available. These are performed at the end of each specified settlement cycle. Payments can also be split according to value.

The table below shows examples of possible DNS configurations using the different main and sub-algorithms. The submission algorithm, SUFIFOPR, submits payments in time, priority and transaction ID order. If there are transactions in single or several systems competing for the same time slot, then the transaction with the highest priority is chosen. If there are still several competing transactions, then the transaction ID order becomes the determining factor. All systems are treated equally, so the priorities used in different systems should be on the same scale if submission order is critical. Because transaction ID's must be unique simulation-wide, you should use smaller IDs for "more important" systems, as these IDs will be the final determining factor.

Examples of algorithm combinations in DNS systems:

DNS description	Main alg.	Sub-alg.	Comments
1. Full multilateral netting at given occasions	ENBASIC1 ENDDNS01	MNSETTLD	Transactions are netted with full ("all or nothing") multilateral netting at end of the settlement cycle.
2. Partial netting at given occasions	ENBASIC1 ENDDNS01	PNFIFOPD	Transactions are settled in FIFO order within the given debit caps/liquidity using partial net settlement.

Define the desired DNS system structure by combining the available algorithms or user-developed modules. These are basically net settlement algorithms in DNS systems. DNS systems can also include splitting and injection features. Queue release algorithms should not be invoked.

Typical simulations regarding DNS are dividing the process into more settlement cycles and checking the effects on liquidity and speed. This is preferably done by dividing the transaction input data in separate slots e.g. by using the export input data by selecting the time slots according to settlement cycles. Each settlement cycle can then be run separately resulting in complete statistics for each cycle.

In simulations where a DNS system is cooperating with an RTGS system it is important to provide the correct account information for end-of-day settlement and possible intraday liquidity swaps. The ENDDNS01 algorithm will perform the end-of-day settlement bookings. Note that these may violate the liquidity restrictions in the RTGS system. Violations are written to AVST output table, if this output form is selected in simulation configuration phase.

Note that there is no checking logic in the simulator to assess whether the selected algorithm combination is rational. The user is responsible for selecting appropriate algorithms among those applicable for DNS simulations.

4.1.4. Algorithms in DVP/PVP processing systems

In delivery-versus-payment and payment-versus-payment (DVP/PVP) processing, two transactions defined by the T_LINKCODE and T_LINKSYST are linked together. Booking of linked transactions can only be done when both legs are settlable. DVP/PVP transactions can be processed in separate dedicated DVP/PVP systems or among normal one-legged transactions in traditional systems. DVP/PVP transactions can also have their "legs" in different systems as defined by the T_LINKSYST field. See also chapter 4.2.2 Group codes for DVP linking multiple transactions.

Note that you always need to include a QUE-algorithm for DVP-processing, because even if introduced at the same time the first transaction leg has always to wait in queue for the submission of the other transaction leg even if it might be the next transaction to be processed.

DVP/PVP limits the use of the available netting algorithms. Available settlement algorithms function only on a single-system level and cannot be used for linked transactions between different systems (e.g. netting can only be done within one system at a time). There are also limitations for the algorithms applied within one system. The user can design own user modules with complex DVP-algorithms to overcome these limitations.

For DVP/PVP within the same system, full multilateral settlement is available. Partial net settlement algorithms are provided in such form that when a leg is unsettlable, the other leg is also discarded. Otherwise, DVP/PVP functions like PNS algorithms for normal one-legged transactions. However, the "optimality" of such algorithm for DVP/PVP transactions has not been verified and the results can be inconsistent (caution is needed; it is more a generalization of the algorithm possibilities).

Splitting and bilateral offsetting is not possible for DVP/PVP transactions as this would be difficult to introduce for the other leg. If defined, splitting and offsetting are only performed for normal one-legged transactions.

Examples of algorithm combinations in DVP/PVP processing in a single system:

DVP/PVP processing	Main alg.	Sub-alg.	Comments
1. Straight-forward RTGS processing	ENBASIC1 ENDRTGS1 SEBASIC1	QUEFIFOPR	Transactions are settled in FIFO order when sufficient liquidity available.
2. DNS based on full multilateral netting	ENBASIC1 ENDDNS01	MNSETTLD	Transactions are netted with full ("all or nothing") multilateral netting at given occasions.
3. CNS system with queuing and partial netting at given intervals	ENBASIC1 ENDDNS01 SEBASIC1	QUEFIFOPR MNSETTLI	Transactions are queued and settled in FIFO order and multilateral netting is performed at given time intervals.

DVP/PVP transactions can be defined for all types of systems (RTGS, CNS and DNS). These can be defined for processing within one system or as intersystem transactions.

Note that there is no checking logic in the simulator to assess whether the selected algorithm combination is rational. The user is responsible for selecting appropriate algorithms for the system type (RTGS, CNS or DNS).

4.1.5. Algorithms for systems with bilateral limits

Bilateral limits can be used to describe debit caps, credit caps (since version 3.1.0) and similar participant level bilateral or multilateral restrictions for payment clearing and settlement. The functioning of these limits is described below first in bilateral level. Definition of multilateral level is explained separately at the end.

If a bilateral limit (debit cap) is set from participant *A* to participant *B*, the cumulative net value of payments settled between these participants – called bilateral balance – must remain within the given limit. The debit cap defines the smallest allowed value for this bilateral balance. A 'sending surplus' (i.e. when A has sent a greater value of payments to B than it has received) is equivalent to a negative value of the bilateral balance. Thus a negative limit value defines a situation, where a higher value of payments is allowed to be sent to a given participant than is received. The opposite case, a positive bilateral limit, means that participant *A* requires that a certain value of payments has arrived from participant *B* before it settles any outgoing payments to B.The constraint can be formulated the following way for any given moment *T*:

$$bilateral\ balance(T) = S_{BA}(T) - S_{AB}(T) \geq debit\ cap(T)$$

where $S_{XY}(t)$ denotes the cumulative value of settled payments from participant *X* toward participant *Y* starting from beginning of day until the time *t*.

A bilateral credit cap defines similarly the upper limit for the bilateral balance between A and B. Thus if A sets a credit cap against B, the incoming payments from B to A are blocked if they lead to an increase of A's bilateral balance over the given credit cap. The constraint takes the following form:

$$bilateral\ balance(T) = S_{BA}(T) - S_{AB}(T) \leq credit\ cap(T)$$

The calculation of bilateral balance starts from zero from the beginning of each simulated day, or from the moment when first bilateral limit is defined to the given pair of participants. Thus bilateral positions are followed only for those participant pairs where some constraints are also in place. No balances are transferred to next day in multiday simulations.

Bilateral limits can be viewed from two perspectives depending on the type of system under study:

- In liquidity based systems (typically RTGS) the limits are defined by the sender of payments. Here the sender can restrict the value of outgoing payments in order to save liquidity. Limit can be set individually for each bilateral pair of participants or multilaterally to limit the total net value of liquidity flowing out from a given participant.
- In credit based systems (typically CNS), the participant receiving payments is actually setting the limits. These can be viewed as restrictions for each sender's ability to send payments towards the receiver -limits for the credit exposure the receiver is accepting. In this case, for example, credit limit granted from participant A to B has to be implemented in the simulator as bilateral debit cap limit in the opposite direction, from B to A. This way it is correctly limiting the payments sent from B to A.

All bilateral limitsare set within the BLIM input table. The limits do not need to be symmetric, i.e., limit from *A* to *B* does not need to be same as from *B* to *A*. Bilateral limits are only in force for those participant pairs for which they are explicitly specified. Debit caps are defined by setting a value to the L_NEWVALUE field and credit caps are defined by setting a value in the L_DBCVALUE field of the BLIM data table. either one or both values can be set with one row of input data file. In such simulator projects, which are created with older version than 3.1.0, such debit and credit cap values, which have same participants and same time label, are necessary to be imported in one and same row of data file. For more details see Descriptions of Databases and files.

Specified bilateral limits are valid until the simulation ends or the limit is changed. Individual bilateral limits can be altered during the day and also completely removed by placing a special value (0.99) in the input.

If a new value of bilateral limit is defined, which causes the already existing bilateral balance to be infeasible, the limit change will still take place. The new limit will block all payments, which would cause the situation to become still worse. Thus violated debit cap does not prevent inflow of payments even if bilateral position would remain below the defined limit still after the payment is received. Similarly violated credit cap position does not prevent outgoing payments.

In addition to bilateral limits, also multilateral intraday limits can be defined in BLIM table by stating the receiving participant as *MULTILIMIT. This means that net value of payments sent and received between specified participant/account and all others has to remain within the given multilimit. The difference between multilimit functionality and normal intraday credit limit is that ICCL restriction can be affected by beginning of day balance of the participant while multilimit only records and limits the total change of balance during the day. Values for multilimit are given similarly as other bilateral limits i.e. negative value indicates that sending surplus is allowed. Another way to describe the difference is to note that ICCL data can be used to define actual liquidity for participants, while BLIM data only defines limitations for the flow of existing liquidity. Thus such simulation would not be able to settle any payments regardless of the BLIM values, where only bilateral limits would be defined but no liquidity would be given with DBAL or ICCL data or by granting of unlimited credit in the system setup.

The bilateral limits can be applied to one part of the transaction flow. This is carried out by giving a high priority for those transactions, which need to be settled regardless of bilateral limits. All transactions that pass the bilateral limit control have also to pass the general liquidity availability control i.e. general credit limits may not be violated. High priority transactions, and those which have no bilateral limits affecting them, are processed normally by the simulator. When bilateral limits are violated because of high priority payments, change in the limit value or forced settlement on payments (e.g. at the end of day) record is written to account violation statistics.

Simulated systems with bilateral limits require their own bilateral algorithms. These are filtered to be visible in the **system control data specification window** when **bilateral limits in use** is selected. Bilateral algorithms are available for RTGS and CNS systems. The behavioural rules related to bilateral limits are algorithm specific and thus the exact specific behavioural details for each algorithm must be checked from the algorithm specific descriptions. One example

of such rules is the special treatment of high priority payments. Some examples of bilateral processing alternatives and algorithm combinations are given below.

Description of setup	Main alg.	Sub-alg.	Comments
1. Straight-forward RTGS processing with bilateral limits. Bilateral limits given in BLIM dataset.	ENBILIM ENDRBIL1 SEBILIM1	QBFIFOPR	Transactions are settled in FIFO order when sufficient liquidity is available. Besides normal tests for available liquidity, transactions have to pass bilateral limit tests.
2. CNS-processing with user defined queue order and bilateral limits. High priority transactions bypass bilateral checks.	ENBILIM(5) ENDRBIL1 SEBILIM1	QBUSEDEF	Transactions are settled in user defined order (i.e. ascending by user defined input fields 1 and 2). Transactions with high priority (i.e. smaller than given parameter 5) are settled whenever liquidity is sufficient. Others have to also pass the bilateral limit tests. Note: same algorithms apply in CNS as in RTGS.

4.2. Algorithms for special cases

This chapter contains descriptions of different sets of algorithms that have been developed for special cases. Often the settlement convention in question requires a special set of algorithms to be selected, and these algorithms will probably not function as intended in other combinations. A given set of algorithms need to be used as described and if used in other combination great caution is needed.

Following special algorithm sets are described here:
- receipt-reactive RTGS in chapter 4.2.1
- DVP linking of multiple transactions i.e. Group code algorithms in chapter 4.2.2

4.2.1. Receipt-reactive RTGS

The general idea of the receipt-reactive RTGS convention is that the participants can divert some part of the outgoing payment flow to a secondary queue. Using a predetermined time period (e.g. one minute, one hour) to cumulate the amount of incoming funds, this secondary queue releases payments whose amounts aggregate up to, but do not exceed, this total amount of incoming funds. Figure 1 contains a visual presentation of the dynamics in the receipt reactive model for two time periods.

This settlement convention is a type of liquidity management convention that functions independently from a participant's total liquidity balance. The secondary receipt-reactive queue complements the higher priority RTGS payment flow so that a participant's total liquidity balance never goes down under the starting balance because of the receipt-reactive queue's handling of its lower priority payments.

The receipt reactive model requires a set of three special algorithms: entry algorithm ENT/ENTDUAL1, settlement algorithm SET/SETDUAL1 and queue release algorithm for secondary queues QU2/QURRFIPR. A time period parameter is introduced in the first of the user-defined fields in the participant table (PART). This predetermines the amount of time during which incoming funds will be cumulated for the purpose of allowing payment release from the receipt-reactive queue. Note that there need to be a time period value for each participant using this feature. If this value is zero or there is no period value given, transactions for such participant stay in the secondary queue until it is closed.

The processing steps in the receipt reactive model can be described as follows

- in the entry phase the transactions can be divided into three streams:
  - immediately forced settlement of payments with highly urgent priority (i.e. settled even if these violate all limits),
  - normal transactions for RTGS processing including the normal primary queue and
  - low priority payments for the secondary queue during the open hours of the secondary queue
- in the settlement phase all normal RTGS algorithms can be called and in addition a QU2 algorithm for releasing transactions from the secondary queue
- in the queue release phase of the secondary queue the transactions which fit the positive net balance of that given period will be settled in priority and FIFO order,. The period in minutes can be defined separately for each participant. At the end of the period the remaining transactions in the secondary queue of that period can be moved up to the RTGS queue with their original priority or by giving them a new uniform priority or alternatively they can be discarded.

The entry algorithm ENTDUAL1 takes four parameters:

- Limit (0-9), which defines the value of priority required for entering the normal RTGS process. Transactions with a lower priority than the limit value are placed into the secondary queue.
- Priority (0-9) defines the minimum value of priority for highly urgent payments. Transactions with equal or higher priority are settled immediately even if they would violate any limit.
- Open (hhmmss) defines when the secondary queue is opened. All transactions entered before this point in time are treated as normal RTGS transactions.
- Close (hhmmss) defines when the secondary queue is closed. All transactions entered after this point in time are treated as normal RTGS transactions.

The SET algorithm SETDUAL1 takes no parameters, but can include a set of the normal RTGS sub-algorithms such as QUBYPAFI (see for example SEBASIC1). In addition, one QU2 algorithm can be specified for releasing transactions from the secondary queue.

The QU2 queue releasing algorithm, QURRFIPR, releases transactions from the secondary queue based on the period information provided in the P_USERCOD1 field of the PART table and it employs the following parameters:

- EOD ("gross" or "return"), which defines if unsettled secondary queue transactions are moved to the RTGS queue – the "gross" case – or if unsettled transactions are discarded i.e. returned to sender – the "return" case.
- NewPriority (0:9) is optional. It defines the value of priority given to the transactions moved via "gross" to the normal RTGS queue. If the parameter has not any value, transactions are moved with their original priorities.

The period parameter in the PART-table has an important function as it defines how the open hours of the secondary queue can be divided into sub-periods. The format for this parameter is hh:mm, for example 01:30. If incorrect format is used, period of 60 minutes is assumed and an error message is shown in the console. Within each sub-period the net received balance starts from zero and is calculated such that outgoing payments released by the secondary receipt-reactive queue are netted against all incoming payments. This net received balance must always be greater than or equal to zero. Payments sent via the normal RTGS process by certain participant do not affect the processing of payments in the secondary queue of this particular participant: only amount of funds received and payments sent from the secondary queue are relevant. For example if the period is defined to be 30 minutes, a participant can settle as many secondary queue transactions in FIFO order up to the aggregate amount of surplus received during the given 30 minute interval. This is not an end-of-period settlement, but payments can be released from the receipt-reactive queue all time during the period so long as the net received balance is non-negative. After the end of the period in our example 30 minutes, the net received balance is set to zero and the process begins again.

When the secondary queue closes by the end of the period, the EOD process will determine how unsettled transactions are treated. When value of EOD parameter is "gross", the transactions from secondary queue are moved to primary queue with the NewPriority value and parameter value "return" will discard the transactions. For example if OPEN is defined as 10:15:00, CLOSE as 15:30:00 and the period as 30 minutes, the receipt-reactive calculation periods will be 10:15-10:44:59, 10:45:00-11:14:59,…,15:15:00-15:30:00.

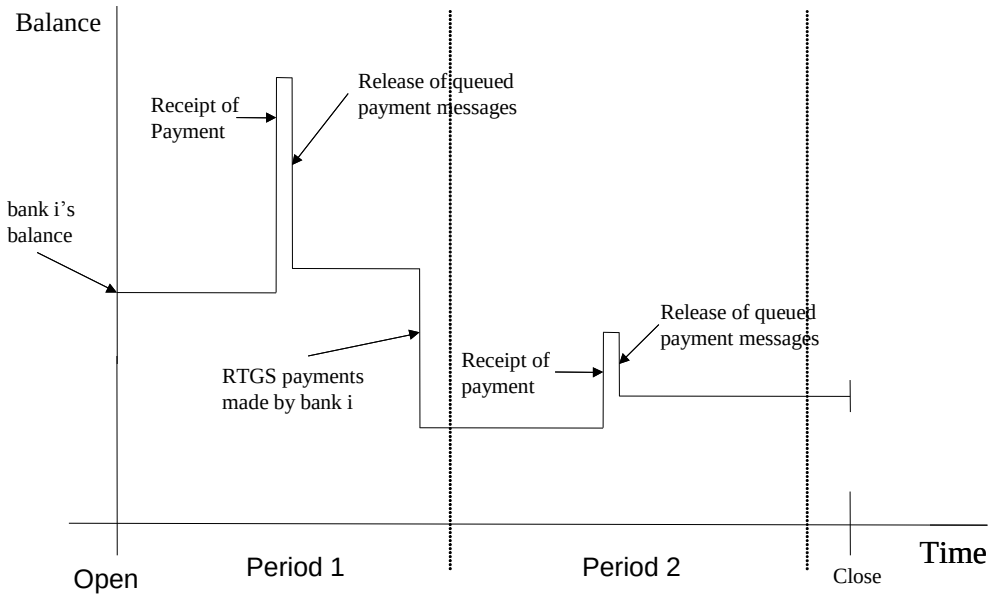


Figure 1 Dynamics of participant balance under receipt-reactive settlement

4.2.2. Group codes for DVP linking multiple transactions

Normal link codes are used to connect exactly two transactions together for DVP or PVP type of conditional settlement. Group code algorithms generalise this setup and allow arbitrary many transactions to be tied together in a group, where none of the transactions in the group is settled unless all the transactions in that group can be settled simultaneously.

Group codes for transactions are imported in the first user defined field of transaction data. For each group the number of transactions in that specific group is also required. This is imported also in transaction data, in second user defined field of each transaction with a group code.

Group code algorithms were created as user modules and are included in the simulator as normal algorithm modules. For linking transactions in a group efficiently together they maintain their own data structure. This data structure is used by all group code algorithms and thus it is stored in the simulator engine, in first of the user object data handles reserved for user module data. Because of this, other user modules which utilise the user defined fields 1 or 2 of transaction data or the userObjectData1 handle in the engine should not be used together with group code algorithms to avoid data conflicts. User ObjectData handles are described in more detail in the algorithm descriptions and user module development guide document.

Following algorithms are included in the group code modules:

Type	Name	Parameters	Description
SUB	GCSUB	None	Performs normal submission algorithms tasks in priority FIFO order and in addition creates the data structure linking grouped transactions together and includes all transactions with group code in it.
ENT	GCENT1	None	Performs the basic entry processes of a specified transaction. Group codes are taken into account when direct settlement of transactions at the entry is tried.
QUE	GCQUBF1	None	Performs queue release continuously in bypass FIFO-logic taking into account the group codes.
PNS	GCQUBFI2	Interval (0-60) Starting time (hhmmss, optional) maxRound	This user module is implemented as PNS algorithm but it acts like a QUE algorithm: it releases from queue only individual transactions or groups tied together with one group code. Algorithm is executed for the first time at moment given with the optional second parameter or at beginning of day and after that at intervals given with the first parameter. Processing of the queue is performed in bypass FIFO mode: queue is ordered in Priority FIFO order, but if the first transaction cannot be settled, next one is tried and so on. When a settlable transaction is found, the search loop is continued instead of restarting from the first transaction. If settlable transactions are found during one loop, new round is started. During one execution of the algorithm the whole queue is worked through at most as many times as indicated with the third parameter maxRound.
PNS or MNS	GCPNST	Time;time;time;…;time (max 40 , 24 h HH:MM format)	This algorithm is not yet included in version 2.4.0 delivery. Performs batch runs on designated moments to settle a group of the queued payments with group codes. Implementation of this algorithm will be provided, where total value of transactions to be included in the group of settled transactions is maximized. Algorithm can be implemented as MNS so that it can be used together with PNS-queue release presented above.

SET algorithms and END algorithm from the normal RTGS algorithms should be used together with GC-modules. Other sub algorithms should not be mixed with GC-algorithms since these do not follow the conditions for settlement stated in the group codes.

4.3. System event handler algorithms (SEH)

This is a special type of algorithms that are used to adjust the basic rules of a simulated system. Rules here mean the way a system reacts to specific events occurring during a simulation. Each payment system can have its own set of rules according to which it reacts to different events occurring in a settlement process.

The events recognized by the simulator's default event handler are the following:
- Introduction of a new transaction
- Bilateral limit change
- Intraday Credit limit change
- Receipt reactive period start
- Receipt reactive period end
- Reaching the from time of a payment (PROCTYPE)
- Expiry of till time (PROCTYP2)
-End of day

The event handler contains also some common routines like the booking routine. Thus it contains the logics that follow "booking events".

The SEH algorithm is optional and if one is defined it will override the default behaviour.

Algorithms may also introduce new types of events, which will require new processing logics which can be introduced using SEH algorithms.

4.4. Time estimation algorithms (TEA)

Time estimation algorithms are used to estimate the time, a specific process or algorithm would have used in the real world. To do so, the time estimation algorithms can use variables such as the amount of transactions, amount of iterations, used CPU time and lot of other possible variables related to a specific process for which time estimation is required.

The variables and parameters according to which a TEA -algorithm can calculate a time estimate will only depend on the properties and the implementation of the algorithm. Also the calling parent algorithm must be able to provide the required dynamic parameters to the TEA-algorithm. The parameters used to estimate time usage are the following:

- Dynamic parameters are the parameters the parent algorithm will provide to the TEA-algorithm. Dynamic parameter values are defined during simulation runs.

- Fixed parameters are defined in the system definition before the simulation, and they are coefficients of the estimation function.

To be able to attach a time estimation algorithm to a parent algorithm, all the dynamic parameters of the TEA-algorithm must be supported by the parent algorithm. The parent algorithm can support more dynamic parameters than the TEA-algorithm.

The following time estimation algorithmis are provided:

Type	Name	Parameters	Description
TEA	TEALGO1	Dynamic parameters: **x** = transaction count in the parent algorithm **y** = account (participant) count in the parent algorithm (e.g. in netting solution) **z** = actually used CPU time in milliseconds (varies, set relevant coefficients as 0 for environment independent results) Fixed parameters: a9, a8, a7, a6, a5, a4, a3, a2, a1, a0, b1	Time estimation function: $b1\ (a0 + a1\ x + a2\ y + a3\ z + a4\ x^2 + a5\ y^2 + a6\ z^2 + a7\ x\ y + a8\ y\ z + a9\ x\ z)$

New TEA algorithms can be introduced as user modules similarly as any other algorithms.

4.5. User module interface

Adding user modules gives you the possibility to create your own settlement algorithms and processing conventions. See **User module development guide** for details. The easiest way to develop user modules is by copying relevant parts from an existing algorithm and inserting the desired modifications. You can add your own user modules by accessing the **User module definition** screen. The screen opens by clicking the **User module definitions** button on the Main menu.

4.5.1. Adding a user module

Before you can add a user module to the simulator, you first have to compile it from the Java code file (.java) with a Java compiler to a class file (.class). You can accomplish this with Sun's javac. The simulator's main JAR-file BoF-PSS2.jar must be in included class path while compiling. For detailed instructions, see the document *BoF-PSS2 Algorithm Descriptions And User Module Development Guide*.

On the User module definition screen:

1. Type in the name of the user module (max. 8 characters).
2. Click the **Browse** button and select the Java class file of the module.
3. Select a user module type from the drop-down list.
4. Select the system types this algorithm is available for (RTGS, CNS, DNS).
5. If the module can accept parameters in the system data definition stage, you have to define the parameter names and types. Type in the name of the in the edit box, and select a checking rule from the drop-down list. Add the parameter and the checking rule for the user module by pressing the **Add parameter** button. Repeat the procedure for each parameter required.

   If you want to delete a parameter from the user module, select it from the table and click the **Delete parameter** button.
6. Click the **Save definition** button. The algorithm should now be selectable in the system data definition screen.

5 Data content and databases

5.1. File directory structure

The simulator has a file directory structure that is partly built by the setup program and partly by the application based on users' project specifications.

The **setup program creates** the following directories:

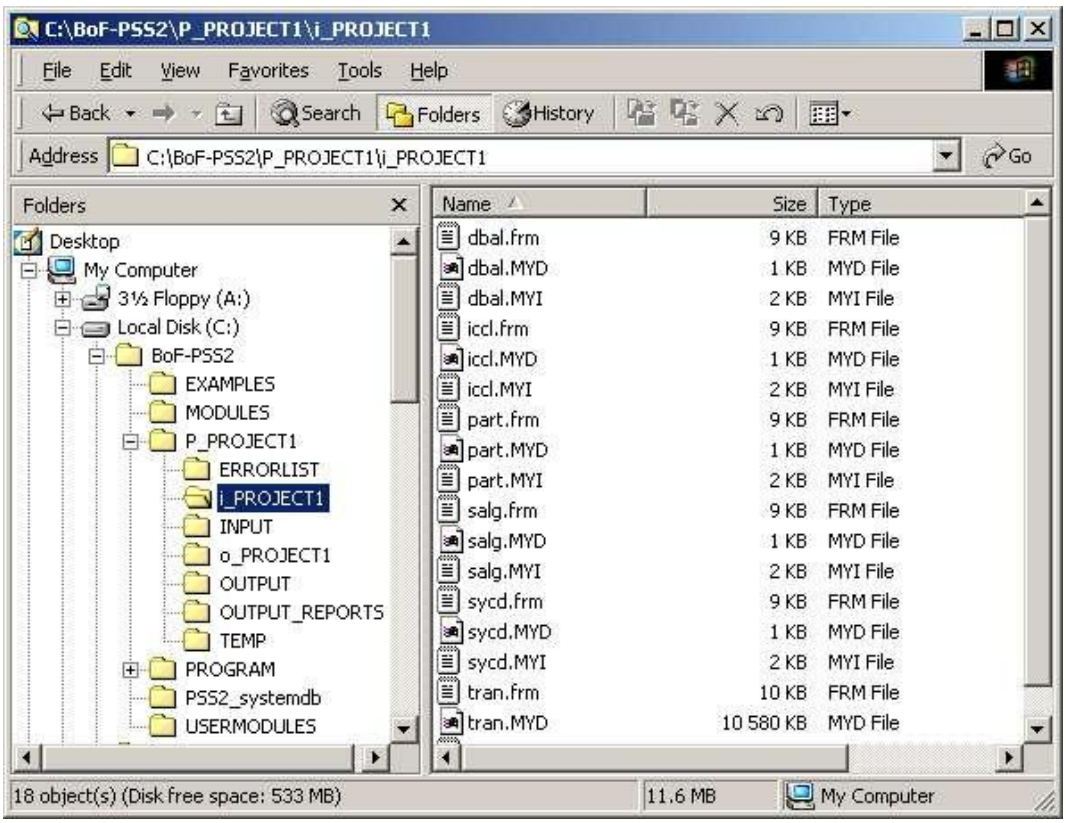
- MODULES (contains built-in modules' / algorithms' code files),
- PROGRAM (contains sub-directory JRE-1.7 for Java Run Environment, necessary script files and the simulator proper BoF-PSS2.jar),
- USERMODULES (for user defined modules), and
- EXAMPLES (The file ex#_description.txt contains information about the specific simulation example).

The **application creates** the directory PSS2_systemdb (for the system database) when the first project is defined. It also creates a directory in the BoF-PSS2 directory for each project using its name preceded by P_ and the following sub-directories:

- i_projectname (for the input database)
- o_projectname (for the output database)
- ERRORLIST (for error lists)
- INPUT (for input files)
- OUTPUT (for output files)
- OUTPUT_REPORTS (for output reports)
- NETWORKS (for generated networks)
- NETWORK_REPORTS (for network analysis results)
- TEMP for temporary storage (all files in TEMP can be destroyed when the simulator is not in use)

If you are going to make a large number of simulations analysing different aspects, it can be good to organise them in separate projects

Here is an example of a directory structure.



5.2. About MySQL

MySQL is a popular and efficient open source database product with good documentation and a good reputation. Information about MySQL can be found on MySQL AB's website www.mysql.com. An online reference manual is available and it can also be downloaded from the MySQL site. Advanced simulator users can make their own database retrieval procedures directly to the databases as SQL queries. Also Java and C++ connectors are available, as well as a general ODBC connector that can be used with e.g. MS Access or Visual Basic.

There are free and easy to use tools available with graphical user interface for browsing and monitoring the MySQL database structure and viewing data contents of the tables with simple queries. These tools can also be used to make small manual editions or deletions in the database that can be helpful in advanced use of the simulator. Examples of such operations include deletions of unnecessary templates, user modules or projects. Because user friendly tools are available for this, no special user interfaces have been included in the simulator.

Below two practical tools for direct use of MySQL database are presented: MySQL Query browser (5.2.1) and MyODBC (5.2.2). Under separate topic (5.2.3) there are instructions how these tools can be utilized.

The MySQL database of the simulator cannot be directly used while the simulator is running. This is because all relevant tables are locked to ensure data integrity during simulations. Thus it is necessary to close the simulator and start the MySQL server before direct access is possible. The latter can be done by executing the database.bat script provided with the simulator (C:\BoF-PSS2\PROGRAM\Database.bat).

5.2.1. MySQL Query Browser

MySQL Query Browser is a free visual tool, which can be used to browse the structure of a MySQL database and its data contents, and build and execute SQL queries. Queries can also be generated graphically and contents of the databases can be modified manually if necessary.

Information of the product and download sites can be found from MySQL pages:

http://dev.mysql.com/downloads/gui-tools/5.0.html

Query browser video tutorials are recommended as a quick start reference. For example the Edit queries –tutorial shows how to make manual changes in table contents, which can be necessary as simulator database maintenance work. Instructions for these are given in chapter 5.2.3.

In order to use Query browser with simulator databases following things need to be taken into account:

- Direct access of database is impossible when simulator is running.
- Closing the simulator closes also MySQL server, which needs to be started by executing the C:\BoF-PSS2\PROGRAM\Database.bat
- In the start-up window of Query Browser, use
    - "localhost" as server host value
    - 3306 as port value
    - "root" as user name
    - Or other settings according your own hardware setup (contact your local IT personnel if proposed settings don't work)

Query browser can be used to build and execute SQL queries e.g. to export data from simulator databases into files. Below some example queries are given.

Exporting MySQL tables are executed by the **SELECT INTO OUTFILE** command.

For example, to export a MySQL table **to a CSV file**:

```
SELECT * INTO OUTFILE 'c/temp/partfile.csv' FIELDS TERMINATED
BY ';' FROM PART WHERE P_DATSETID='ds1';
```

Similarly, a query can be built in Query Browser and the result set can be exported with menu functions after right clicking the result set.

5.2.2. MyODBC interface

MyODBC driver is a standard interface, which enables connections to MySQL database from most database and analysis software working on Microsoft Windows platform and using large data sets. Examples of applications that can be connected are Access and SAS.

Information of the connector and download sites can be found on MySQL pages:
http://www.mysql.com/products/connector/

After installing the MyODBC, new data sources are defined from Windows control panel / Administrative tools / Data sources. Own data source name needs to be defined for each database, which is to be accessed from the third party software.

Special instructions related to use of MS Access with MyODBC are found also in MySQL reference manual:
http://dev.mysql.com/doc/refman/5.0/en/connector-odbc-examples-tools-with-access.html

5.2.3. Direct modifications of simulator database

All features that a simulator user might want to have are not included in the simulators graphical user interface. Some of these tasks can be performed by directly accessing the MySQL database. These are mainly deletions of instances that can be created in the simulator but not removed if they turn out to be useless such as user modules or import templates. Below are listed some possible maintenance tasks and how to perform them with Query Browser tool. For assistance with Query browser see 5.2.1 or tutorials provided by MySQL.

Caution is always needed when direct modifications are made in the database. Backup copies and use of graphical tool, such as MySQL Query Browser, which shows visually the changes and allows undoing are recommended.

Task	How to do in Query Browser	Notes
Delete unused import or output **templates**	- Open system database and TEMP table - Click "edit" from bottom toolbar - Right click the row with the template to be deleted. First column contains the template names. - Select "delete row" from the menu - Click "Apply changes" from bottom toolbar	Example of Query browser view is shown below. Table contains also the built in ALL- and EMPTY-templates
Delete **user modules**	- Open system db and ALDE table - Select and delete the line with name of the unused module in the first column as was explained above.	User modules are in the end of the table. Don't delete the references to built in algorithms.
Delete an unnecessary **project**	- Open System database and PROJ table. - Select and delete the line with name of the unnecessary project in the first column as was explained above. -The project folder has to be deleted manually.	Do not delete project that was active when simulator was last time running. If this is done, SD_PROJEID field in DEFA-table of system database has to be also manually altered before simulator can start again.

5.3. Databases

The simulator uses MySQL databases located on the workstation. There are three types of databases: system database, input database and output database. The simulator has a common system database, which is created during the first session with the program. The program creates the directory PSS2_systemdb in the installation directory. Input and output databases are created automatically for each project defined by the user.

C:\BoF-PSS2 is the default directory for the simulator, see Figure 1.

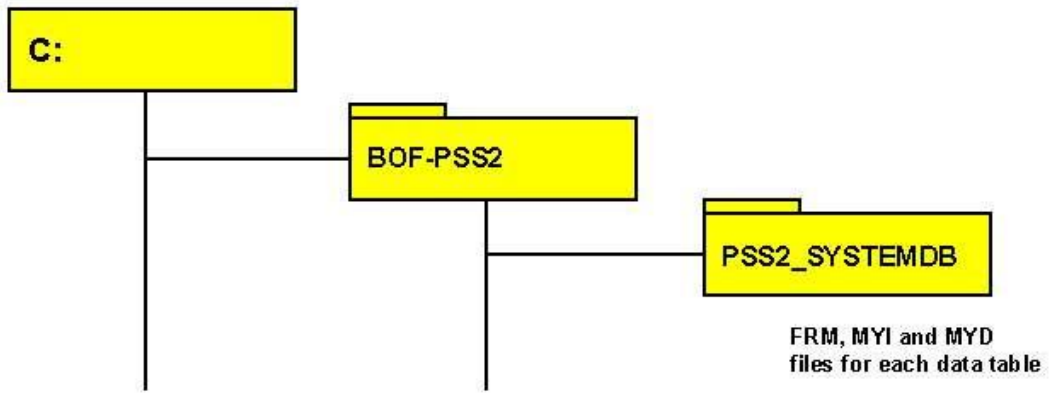


Figure 1.

In MySQL, each database has three separate files for each database table. They contain:

– data dictionary information (.FRM files)
– index information (.MYI files), and
– data files (.MYD files).

Input and output databases reside in the project directories. The project directory by default is identical with the project name. The input and output databases by default are located in different subdirectories of the project directory and identified by the prefix "i_" for input databases and "o_" for output databases, followed by the project name. These directories are created by the initial specification view together with the .FRM, .MYI and .MYD files for each database table, see Figure 2.

Only one input and output database can be specified for each project at any given point in time. However, especially if the input database is shared by different projects, e.g. the same input data is used both for a liquidity requirement and a systemic risk simulation project, the user can specify other directory names. Here, caution is needed to ensure database integrity. In some cases, it may be convenient to store large databases on a network drive.

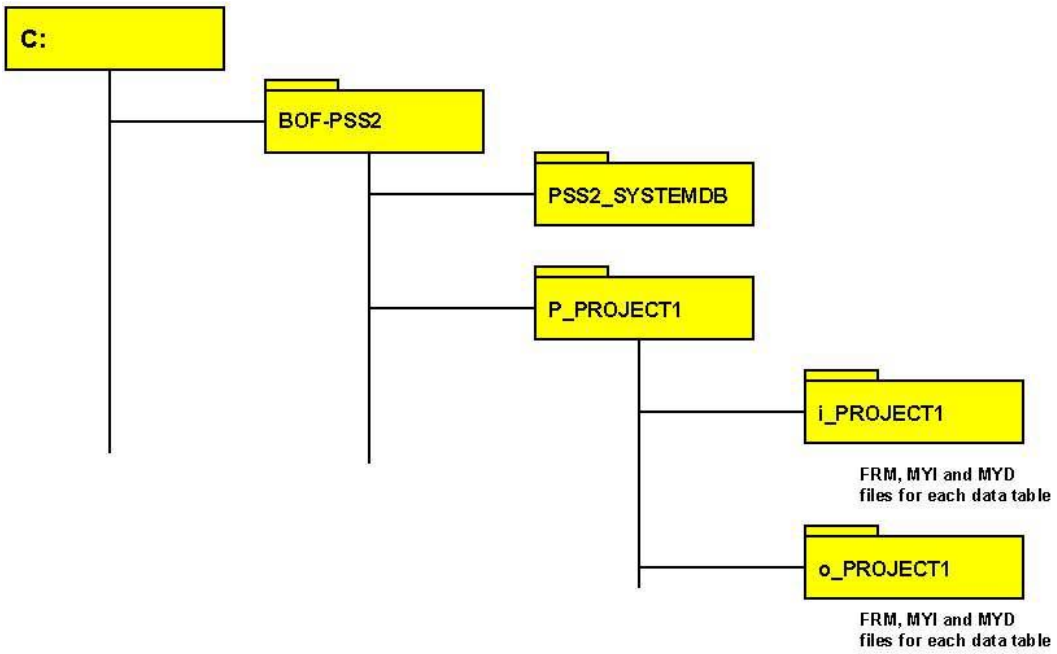
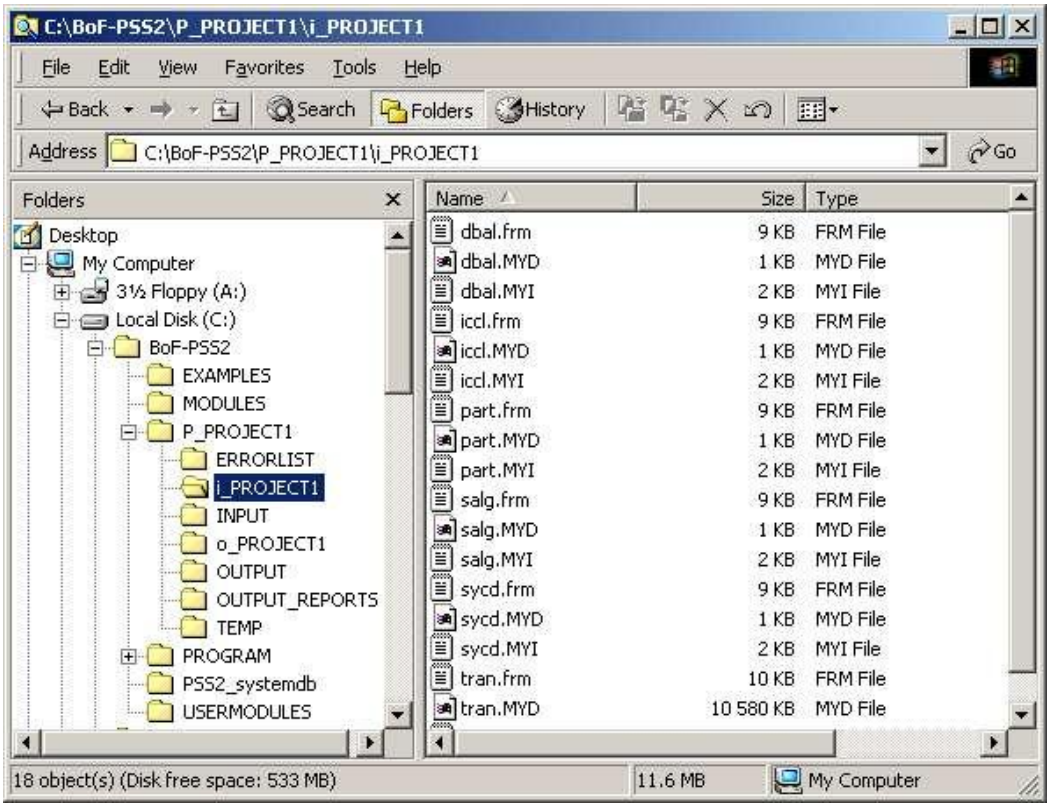


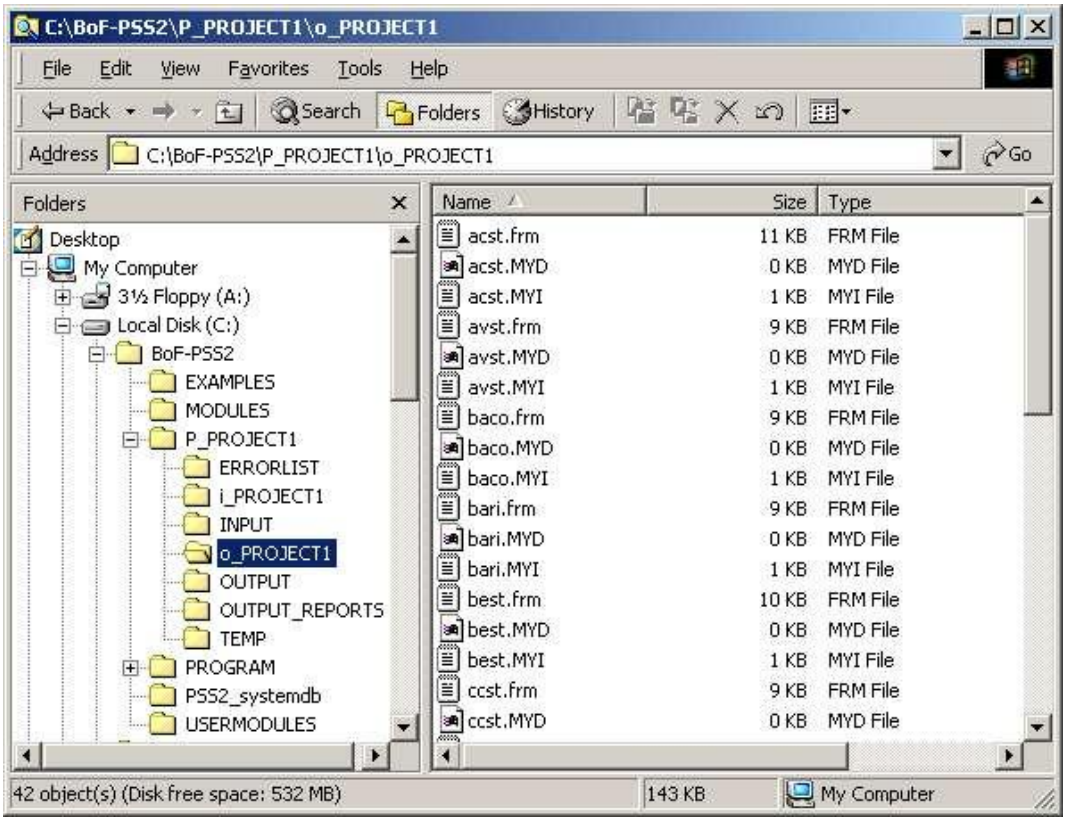
Figure 2.

5.3.1. Database structure

An example of the input database structure is shown below. In the right window, FRM, MYI and MYD table files appear.



Here is an example of the output database structure.



5.3.2. Database tables

INPUT DATABASE

SYCD System control data

Contains system control data for a specific system, for example system ID, name, type, and open hours.

PART Participant data

Contains participant data for a given system. Participants can be distinguished at two levels. The participant ID can be 11 characters long and can contain, e.g. a SWIFT BIC address. The account ID can be 34 characters long and can contain an IBAN. Both fields can also be used for other identifiers, e.g. in securities settlement systems, the account ID could be the ISIN code. The participant ID is mandatory. The account ID can be omitted, in which case it appears as empty (i.e. contains the value "").

DBAL Daily balances data

Contains daily opening balances for the participants in the PART table.

ICCL Intraday credit limits data
Contains information of original values and changes in intraday credit limits for participants specified in the PART table.

TRAN Transaction data
Contains transaction data sets for participants set in the PART table related to one system (or many systems when multiple systems are simulated).

BLIM Bilateral limits data
Contains information of the original value and changes of bilateral limit values for given pairs of participants or accounts specified in PART table. BLIM table can also be used to define multilateral limits i.e. limits for transactions between one participant and all the others in simulated system.

RSRV Reservations table
This table is included in database of version 2.4 for future use. Yet no functionalities are implemented, which would use this table.

SALG System algorithms
This table contains the algorithm definitions for the different systems.

OUTPUT DATABASE

SYLS System level statistics
Contains system level statistics of simulation runs.

ACST Account level statistics
Contains the general statistics per participant or account for a given day.

TEST Transaction event statistics
Contains the general statistics for actual transaction events for specific simulation runs.

NEST Netting event statistics
Contains information of netting events in specific simulation runs. This is an algorithm specific feature and will depend on the algorithm. The algorithm must support this function to enable the recording of this statistic.

AVST Account violation statistics
Contains information of account violations in simulation runs.

BEST Booking event statistics
Contains information of bookings in simulation runs.

UNST Unsettled transactions statistics
Contains information about transactions that remained unsettled in simulations.

SUST Submitted transactions statistics
Can be used to follow a user-made submission algorithm output (it, however, duplicates transaction statistics).

QUST Queued transactions statistics
Contains general information of queued transactions of specified simulation runs.

QURE Queue reason statistics
Contains information about the reason why individual transactions were placed in the queue. Changes in the queuing reasons are also reported.

BIST Bilateral limits statistics
Contains end of day bilateral balances for each bilaterally limited pair of participants or accounts defined in BLIM input data. The end of day bilateral balance is recoded only for pairs that have a bilateral limit defined in the BLIM dataset used in the simulation. Balances for multilateral limits are not recorded.

CTST Comment transactions statistics
Contains event information on commented transactions of specified simulation runs.

CCST Comment intraday credit statistics
Contains information of changes on commented intraday credit limits of specified simulation runs.

BACO Basic comparison view
Contains template data of the comparison analysis report.

A description of the detailed content of the database tables can be found in the separate document 'Descriptions of BoF-PSS2 Databases and Files', which can be found on the website of the simulator.

5.3.3. Database table repairs

If the Simulator and MySQL are closed by the user while the software is writing into some database table, the database can become corrupted. Typically this can happen if the simulator seems to be stuck and the user closes it with "end task" in Windows task manager.

As a result of corrupted database table the simulator won't start and in the start up window, e.g. following error message can be presented "*Can't open file: 'tablename.MYI'. <errno:144>*"

This can be fixed by repair table command using e.g. MySQL Query Browser or in command-line console if the previous is not available. For console view, run C:\BoF-PSS\Program\Database.bat and after that C:\mysql\bin\mysql.exe. This will start the database server and console view.

Assuming that input database table "TRAN" is corrupted in project "example1", following commands are required.
use i_example1; (+ Enter)
repair table tran; (+ Enter)
For more details see MySQL manual.

5.4. Data sets

One input database can store many data sets for each type of input data. The different data sets are stored in the same physical database table and are distinguished by their data set ID. The user defines the data set ID separately for each data table; it has no internal database relation with any other data set ID of other database tables.

In the simulation execution phase, the user defines which specific data sets are to be used in a specific simulation as described in the Figure 3. These are cross-checked to see that the information is coherent, e.g. all accounts or participants can be found for the transactions, and all systems are specified the account or participant to which the transaction data refer.

To manage a large number of parallel data sets, a consistent naming convention is a good idea.

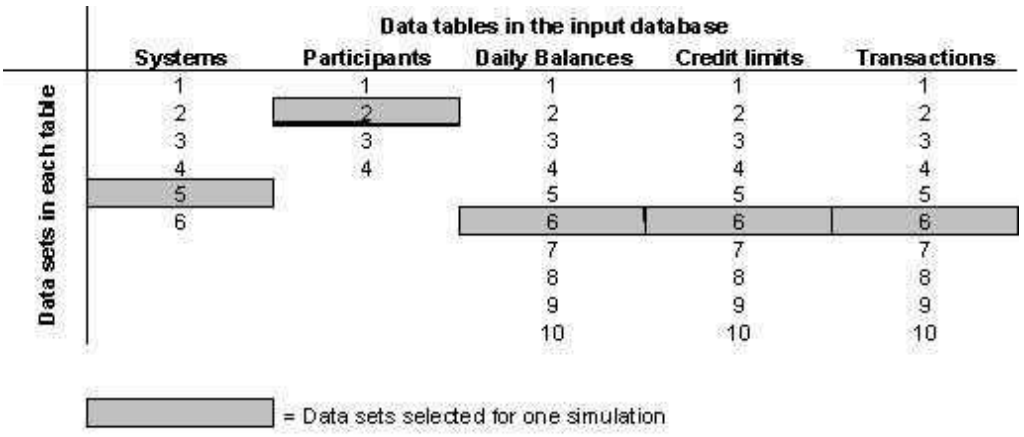


Figure 3.

5.5. Date format

You can select any of the following date formats:

yyyymmdd	ddmmyyyy	mmddyyyy
yyyy-mm-dd	dd-mm-yyyy	mm-dd-yyyy
yyyy-m-d	d-m-yyyy	m-d-yyyy
yymmdd	ddmmyy	mmddyy
yy-mm-dd	dd-mm-yy	mm-dd-yy
yy-m-d	d-m-yy	m-d-yy

Where d = day, m = month and y = year, a single d and m means that days and months are stated with one or two digits.

The dash (-) separator only signifies the position of the separator in the input file. The actual separator can be any character, e.g. the dd-mm-yyyy format will correctly interpret May 15, 2003, no matter if it is written as 15-03-2003, 15.03.2003 or 15/03/2003. In export files, the separator will always be a dash (-).

When using dates where the year is defined by two digits, the simulator parses them so that 20 years from today are in the future and 80 years before now in the past. For example in the year 2009 digits 09-29 would refer to the years 2009-2029 and digits 30-08 to the years 1930-2008.

The internal data format in the input database is YYYYMMDD.

5.6. Time format

You can select from the following time formats:

hhmmss.ssssss	hh:mm:ss.ssssss
hhmmss.sss	hh:mm:ss.sss
hhmmss.ss	hh:mm:ss.ss
hhmmss.s	hh:mm:ss.s
Hhmmss	hh:mm:ss
Hhmm	hh:mm

Where h = hour, m=minute and s = second. The maximum accuracy (resolution) is 1/1000000 second.

Hours are given according to the 24-hour system.

The separator colon (:) only signifies the position of the separator in the input file. The separator can be any character. In output files, the separator is always a colon, when specified.

5.7. Time transposition functionality

A number of systems apply a processing day stretching over midnight. Most often processing for the next value day is started on the evening of the previous day. Currently in the simulator opening and closing hours of systems must be within same calendar day i.e. between 00:00 and 24:00. To circumvent this limitation transposition of time values can be performed in order to get the input data to match the simulator's 24 hour calendar day based timing.

Time transposition functionality can also be used for aligning systems working in different time zones or data collected from different time zones into one (multi system) simulation. In such case the original time labels of simultaneous transactions from different time zones would be divergent. Caution is needed in export and reporting of results of multi time zone simulations. Most secure solution would be to use the results only in simulated "mean time".

The **time transposition** feature performs specified time/date conversions for the data automatically. All information in the simulator and its databases will function in a 24hrs framework (simulation time), but the input data and the output data will be converted from/to actual timing. To have a clear terminology "**simulation time/data**" refers to the time in databases always within the 24 hours of a given day and "**actual day/time**" refers to the input data and output report data, which can stretch over to two consecutive days, but is always in total within 24 hours.

Time transposition value is inserted in the data format default window during import or export of data. It has the format ±hhmm, and can take values form +23:59 to -23.59. A positive value will increase the time information in all input time and date values. A negative value will decrease all time values respectively. For example a value of +0400 means that a transaction with actual values (CSV-file with transactions data) of time 22:10 and day 20.2.2004 becomes 021000000 (hhmmss000) on 20040221 (YYYYMMDD) in the TRAN table in the input database. A negative value will convert the timing in the same way but to an earlier occasion.

Time transposition field in data format defaults functions in the same way as others (decimal and data separators, date format etc), i.e. a selected value is in force on all screens until it is changed. The default value for time/day conversion is +00:00.

Time transposition is applied to all imported time and date fields. These include for example TRAN-, ICCL- and BLIM-data. **Processing of DBAL-values** differs from the other input data. For DBAL data any positive value in time transposition means that all introduction days are moved to be one day later while any negative value has no effect on DBAL days. This is because any positive value is assumed to move the start of the simulations to the next day.

All reports will use the actual time/date format.

Note: Any algorithm parameters with time values have to be given in simulation time. Time transposition is not applied on these. Also selection rules in export must be done based on simulation time (see 5.9).

Note: The time transposition is just an input/output feature which will just convert the information during import, export or report creation.

5.8. File template

A file template describes which columns in the CSV file correspond to particular fields in the database table. For example, if you want to import a CSV file with participant data to the PART table and the CSV file's first column contains participant ID and the second column the name of the participant, you define in the import template "1" in the first row (P_PARTICID) and "2" in the third row (P_FULLNAME). The other rows stay empty, if these are the only fields to import.

Templates are saved in the TEMP (template) table in the SYSTEM database. The input data tables PART (participant), DBAL (daily balances), ICCL (intraday credit limits) and TRAN (transaction) have all their own templates.

Ready-made templates are provided in the simulator for all output database tables for exporting all data fields. The names of these templates are the table name followed by –ALL e.g. TEST-ALL.

Templates are updated when you change the information in them. If you want to remove templates, you have to modify the MySQL database directly. For instructions see 5.2.35.2.3.

5.9. Selection criteria

Selection criteria can be used for exporting a given part of an input or export data table.

You can type selection limitations in rows corresponding to the variables/fields in the database table.

If selection criteria are assigned to several variables, each assignment limits the search, i.e. it operates on an ".AND." basis (e.g. in transaction data table a selection T-TRANVALUE 10000 and T-FRPARTID=ABCBANK selects those transactions over 10,000 in value and sent by ABCBANK).

If multiple criteria are given to the same variable, these are separated by a semicolon (;). The equal (=) function always operates on an ".OR." basis (e.g. T-FRSYSTID =POPS;=PMJ selects transactions from POPS or PMJ systems.) Similarly, T-TRANVALUE >10000;=10000 exports the transactions equal or above 10,000 in value. The larger than (>) and smaller than (<) signs also delimit the selection to values between these values.

5.10. About using Microsoft Excel with the simulator

Microsoft Excel is a handy tool for editing simulator data, analysing simulation output and creating reports and graphs.

The following facts are worth noting if you plan to use Excel with the **BoF-PSS2** simulator:

- Old Excel versions have a limit of 65,536 rows per worksheet. Excel 2007 can handle 1,048,576 rows.
- Excel may produce additional rows and columns when saving a table as CSV file (all rows and columns that have been active in the table during Excel calculations will be saved in the CSV file, even though they are empty at the time of saving).
- Large values may be distorted (less accuracy).

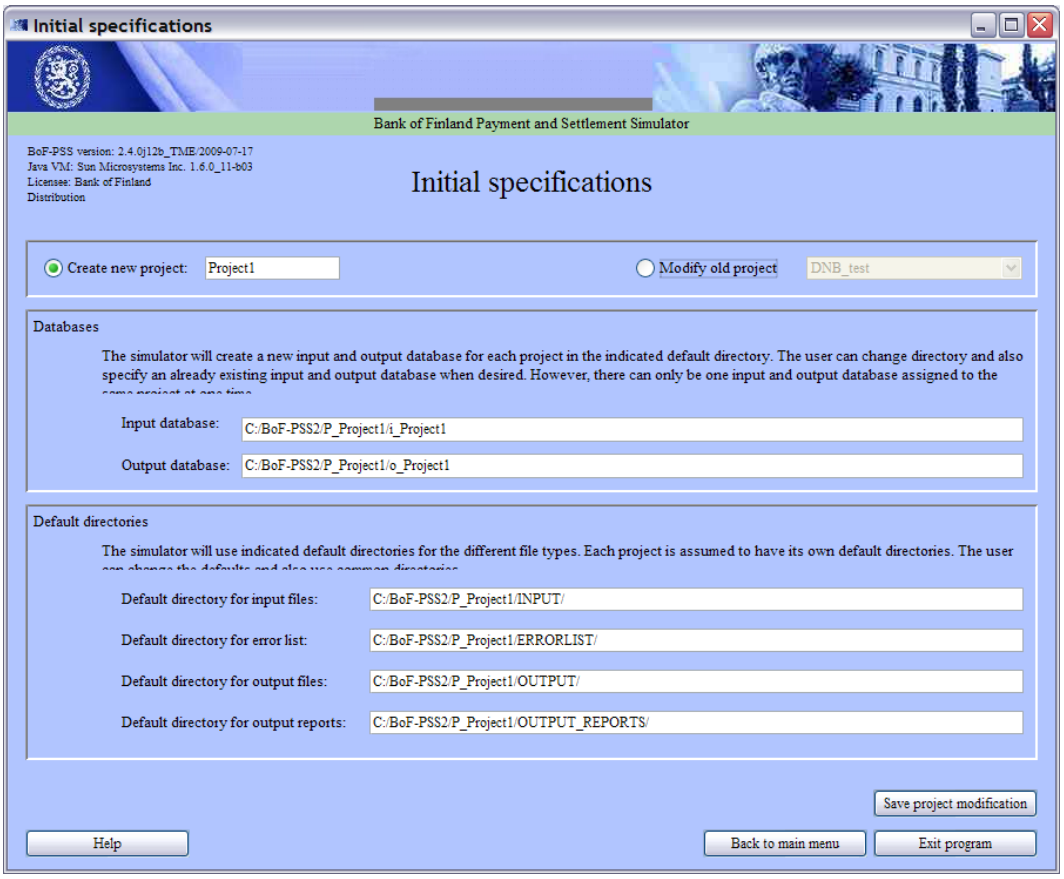
– Check that delimiters (decimal and data separators) and presentation formats (date and time) are identical with simulator specifications.
– The actual content of CSV files stored by Excel can be checked with Notepad or some other text editor.

The output reports and output CSV-files have not been edited. The idea is that everyone can edit them according to own desires using Excel or other reporting tools. When some reports are used frequently it is a good idea to read the output CSV-files into a predefined Excel table.

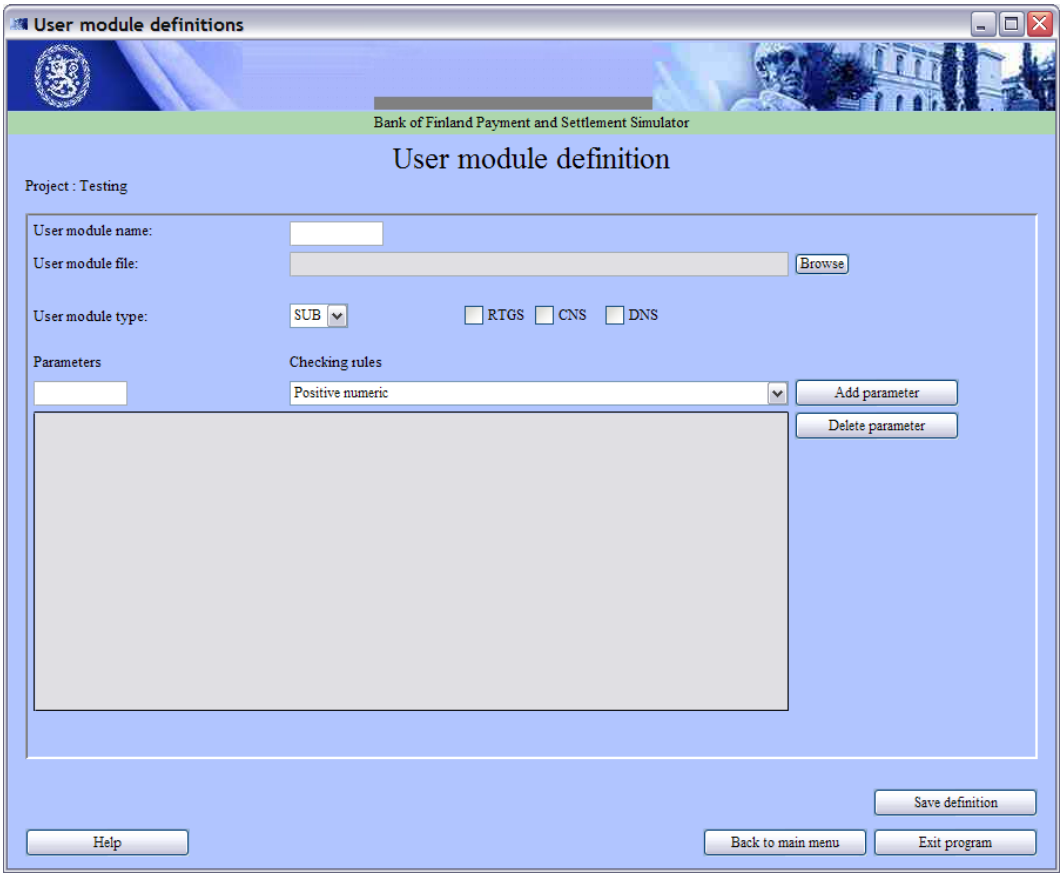
6 Application screens

6.1. Main menu

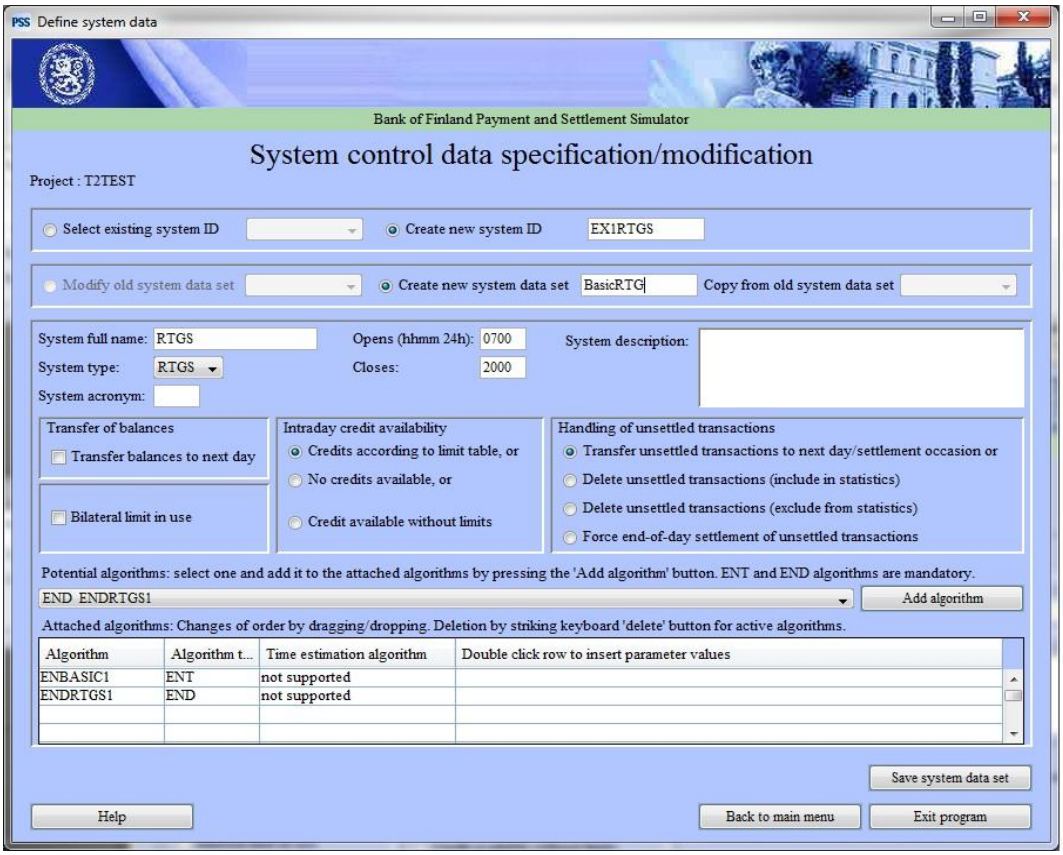
6.2. Initial specifications



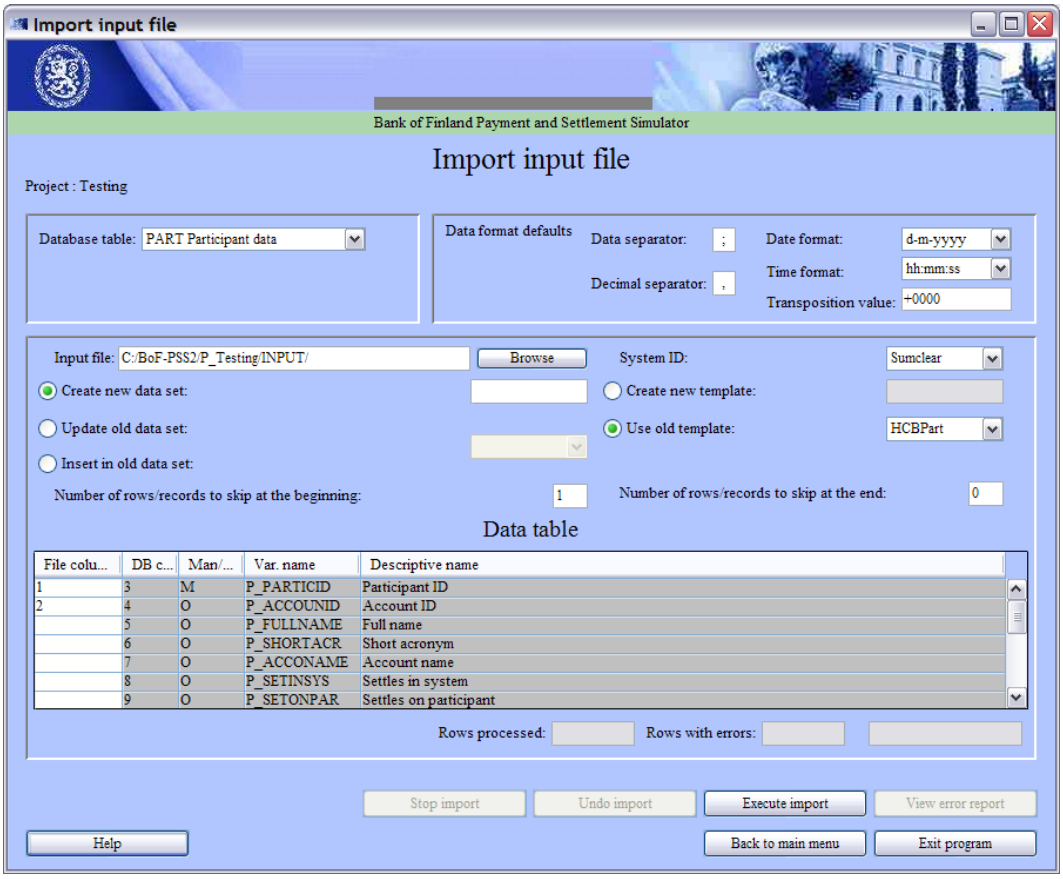
6.3. User module definition



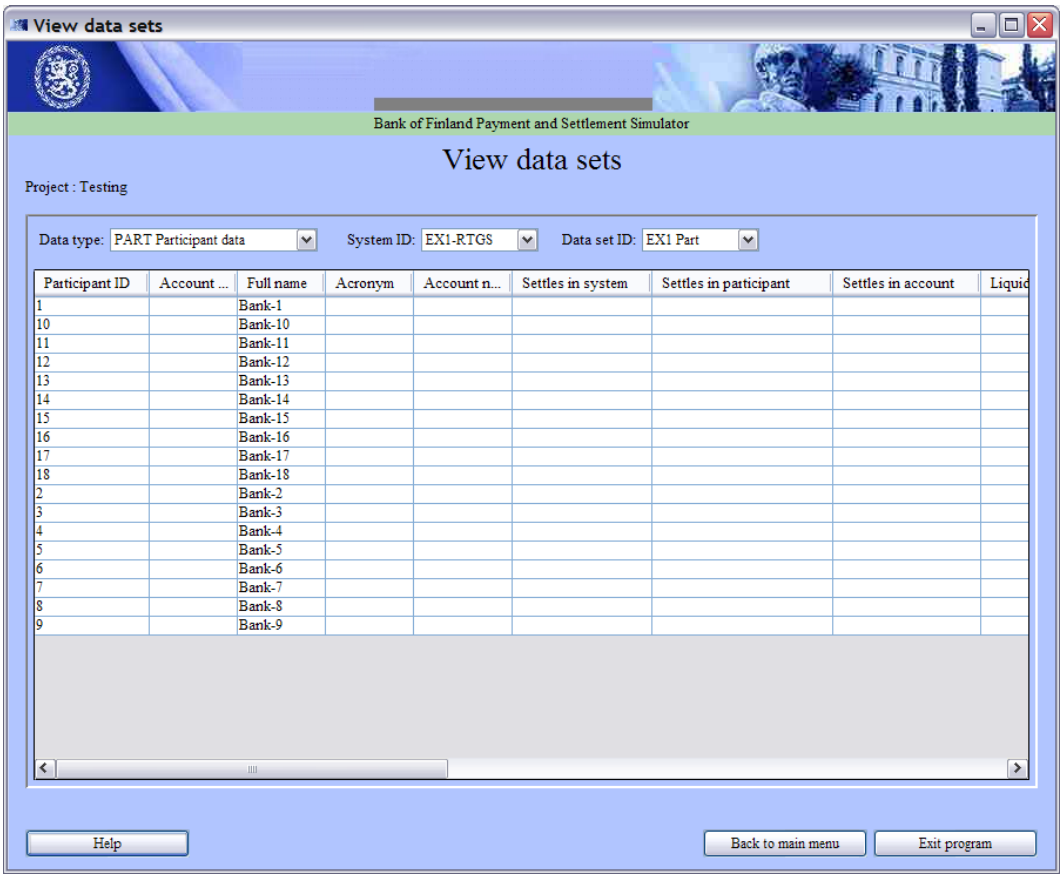
6.4. System control data specification/modification



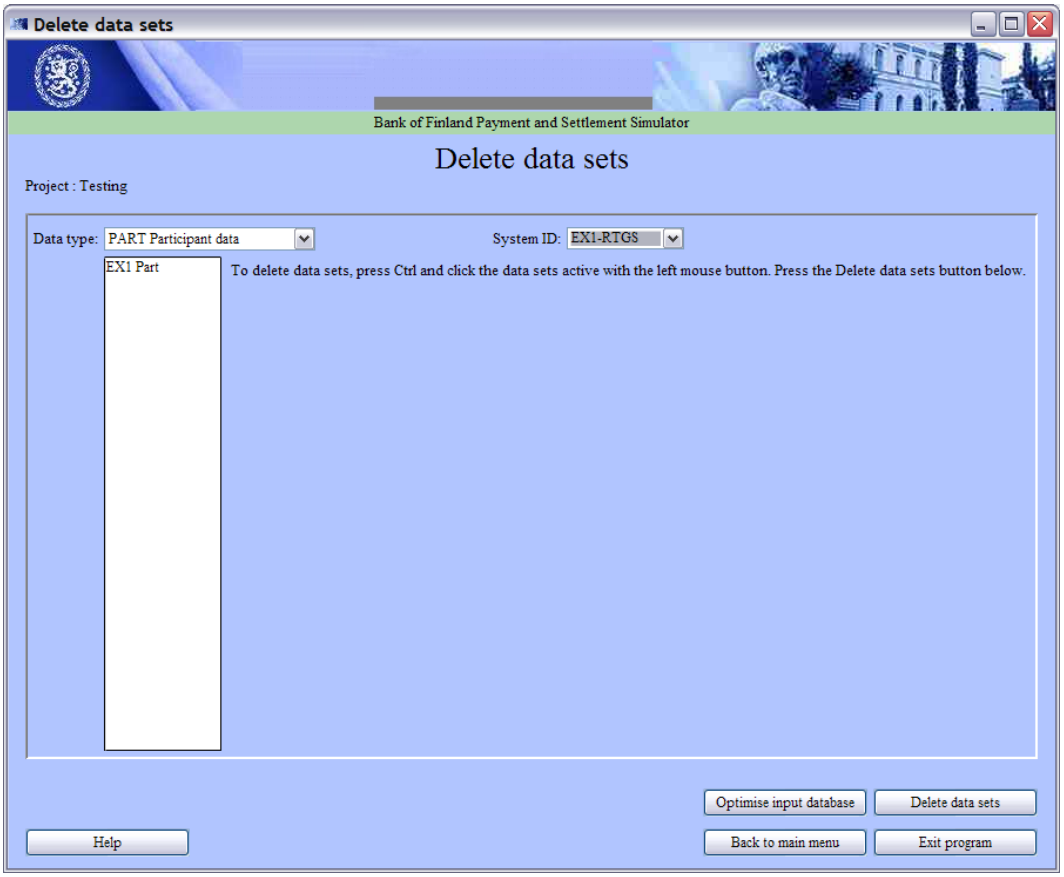
6.5. Import input file



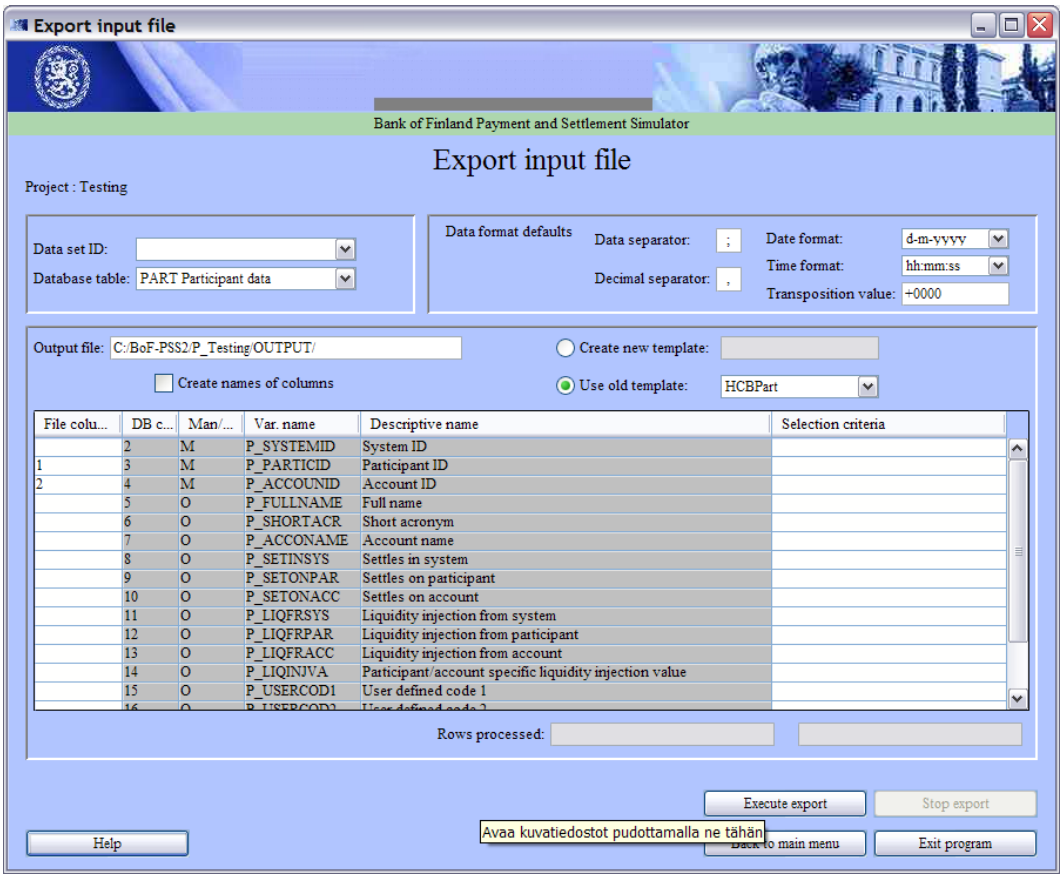
6.6. View data sets



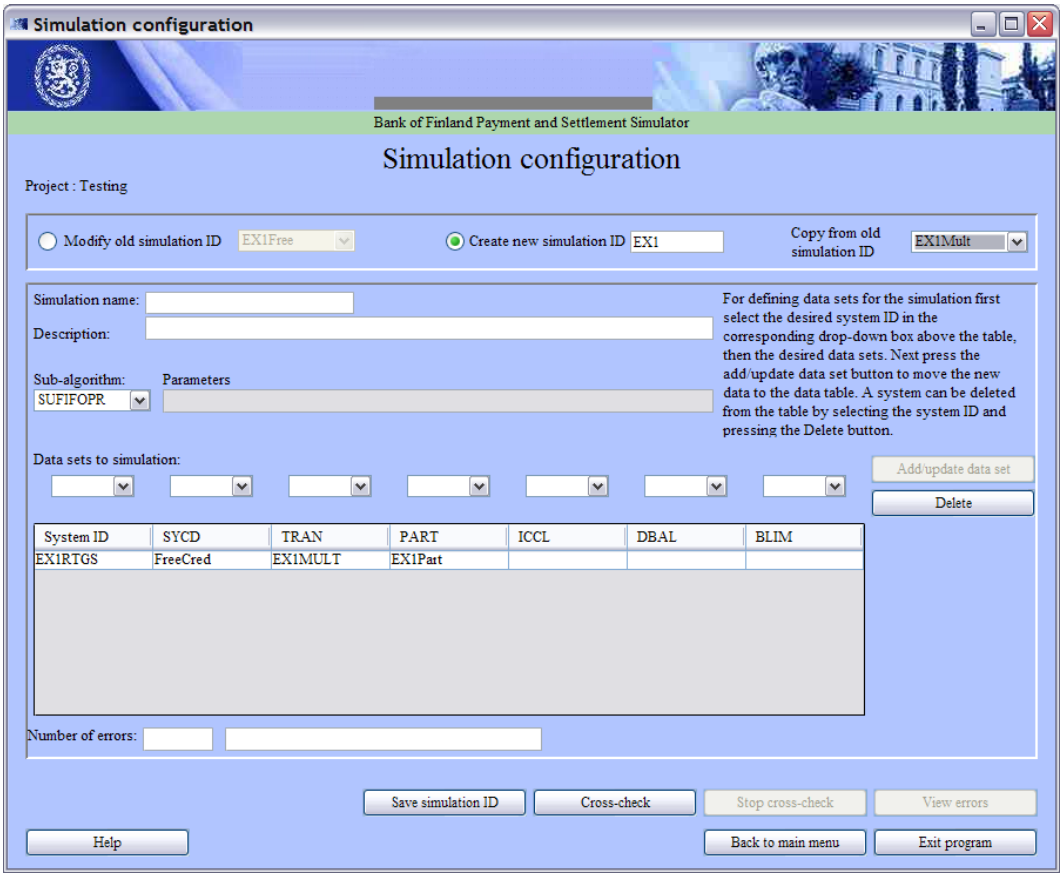
6.7. Delete data sets



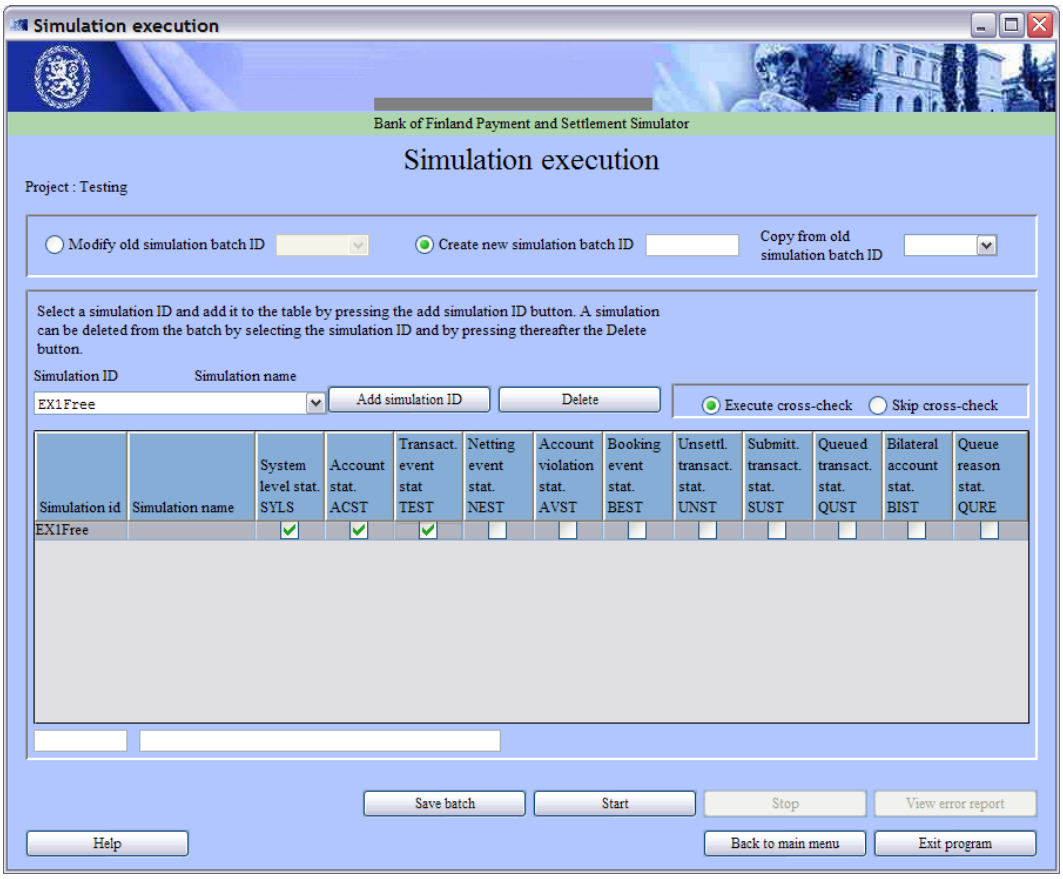
6.8. Export input file



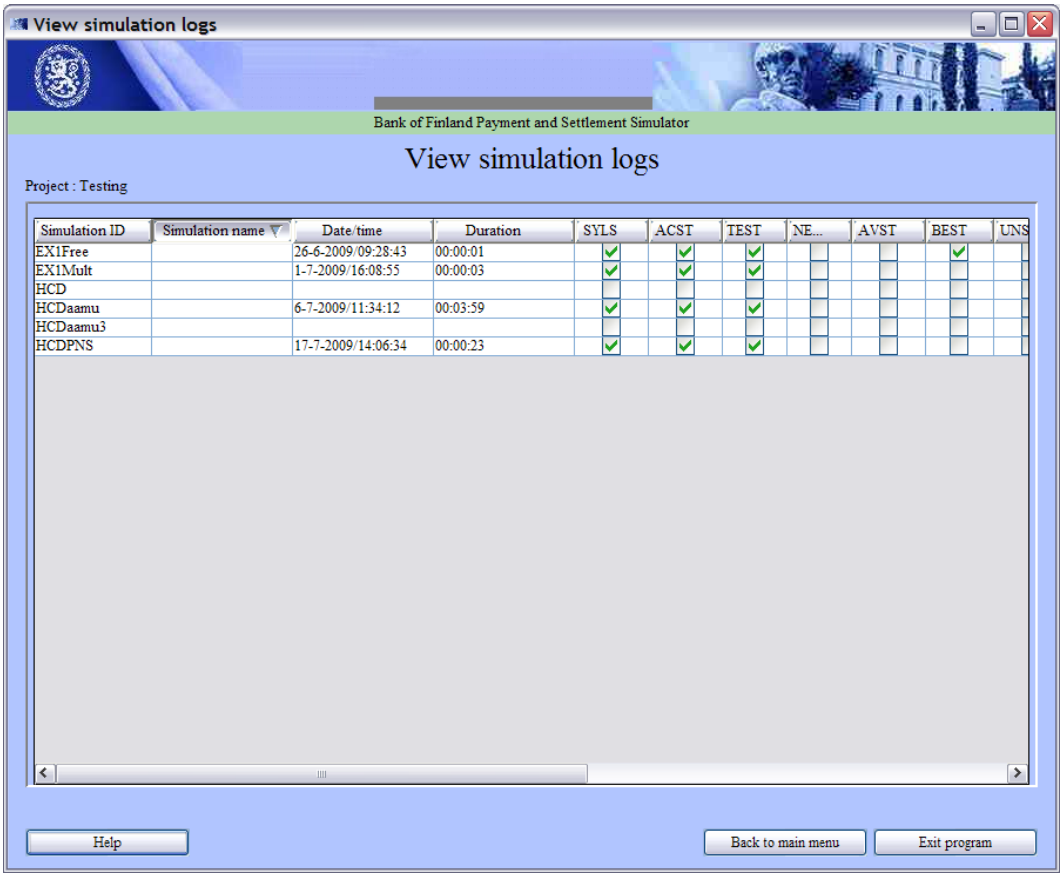
6.9. Simulation configuration



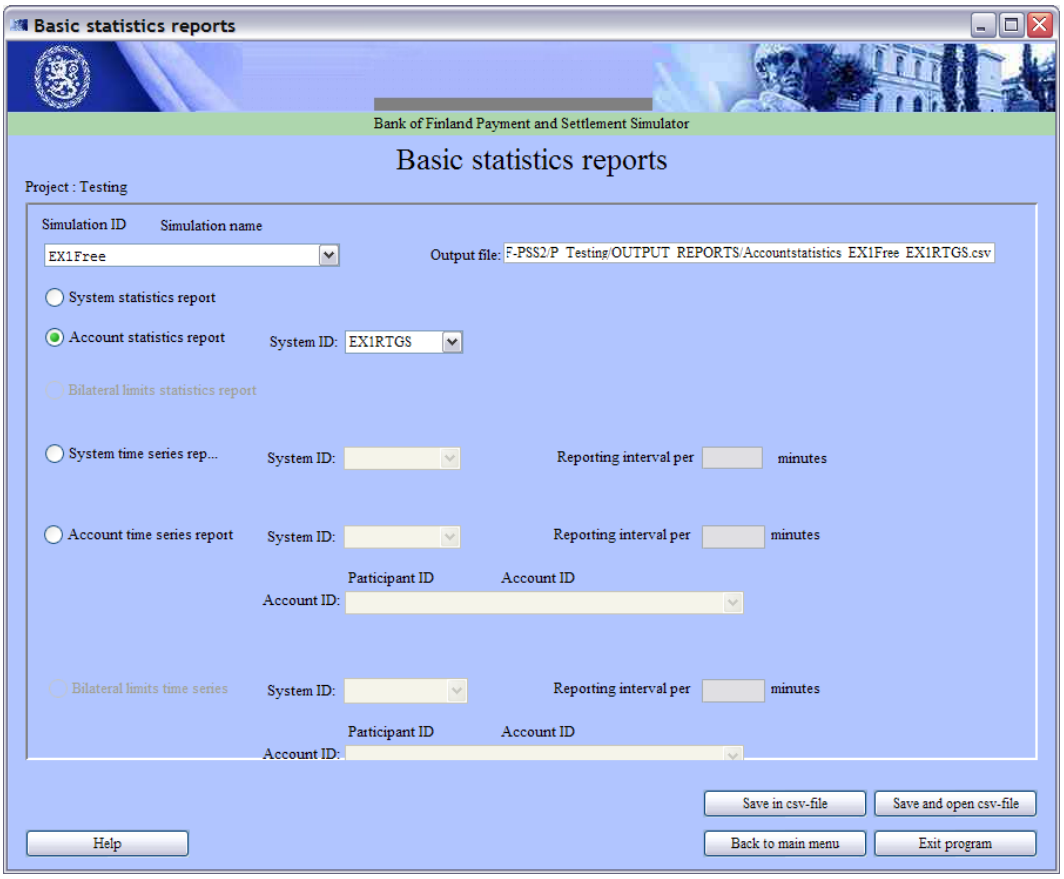
6.10. Simulation execution



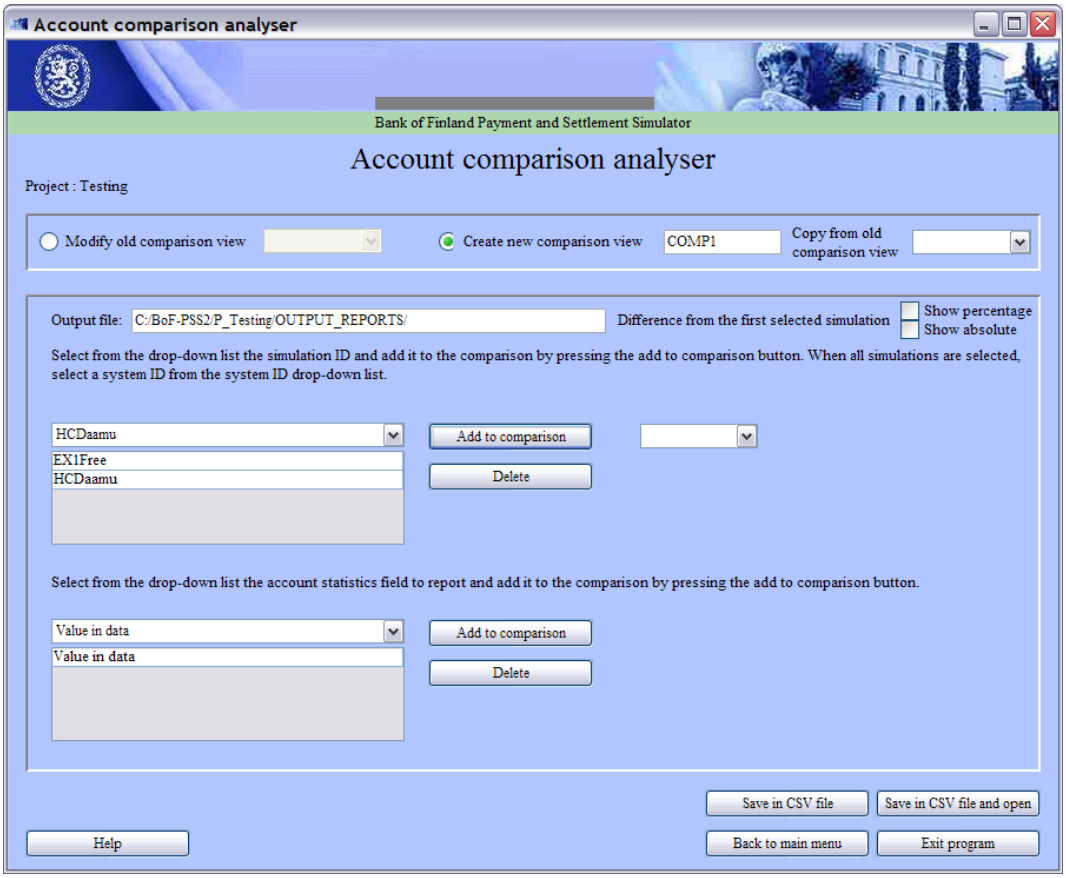
6.11. View simulation logs



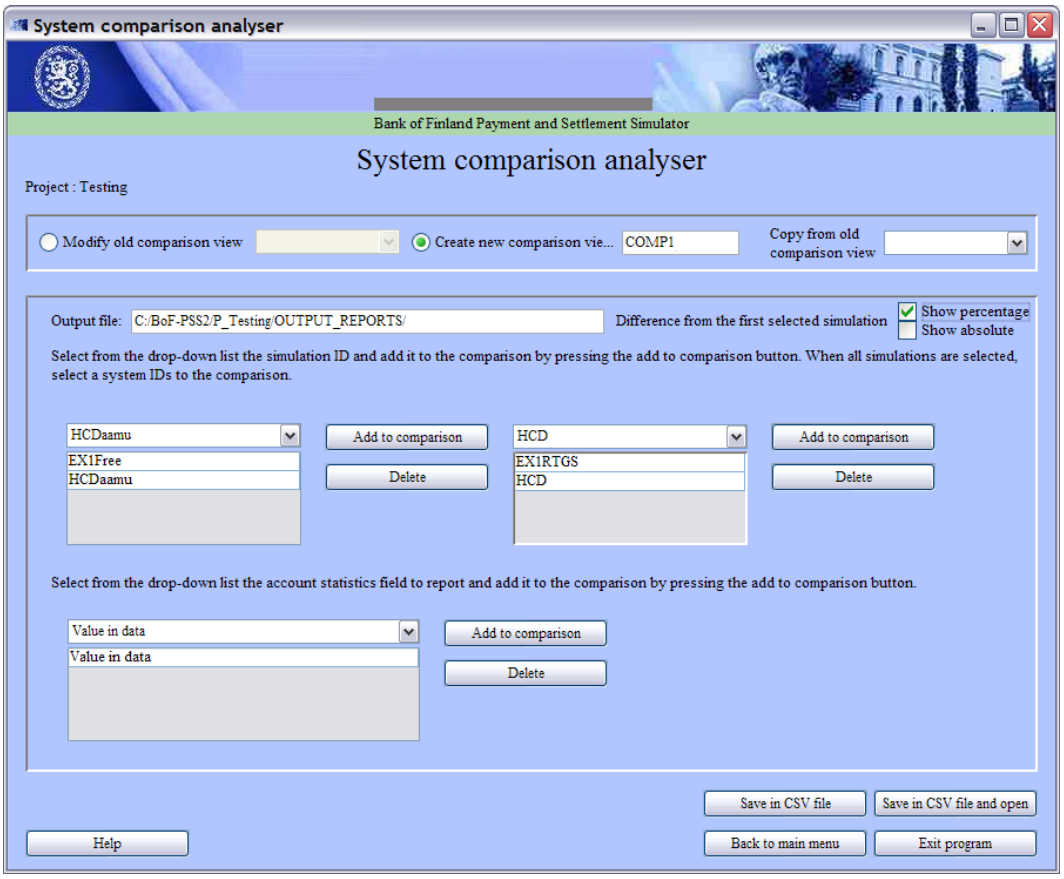
6.12. Basic statistics reports



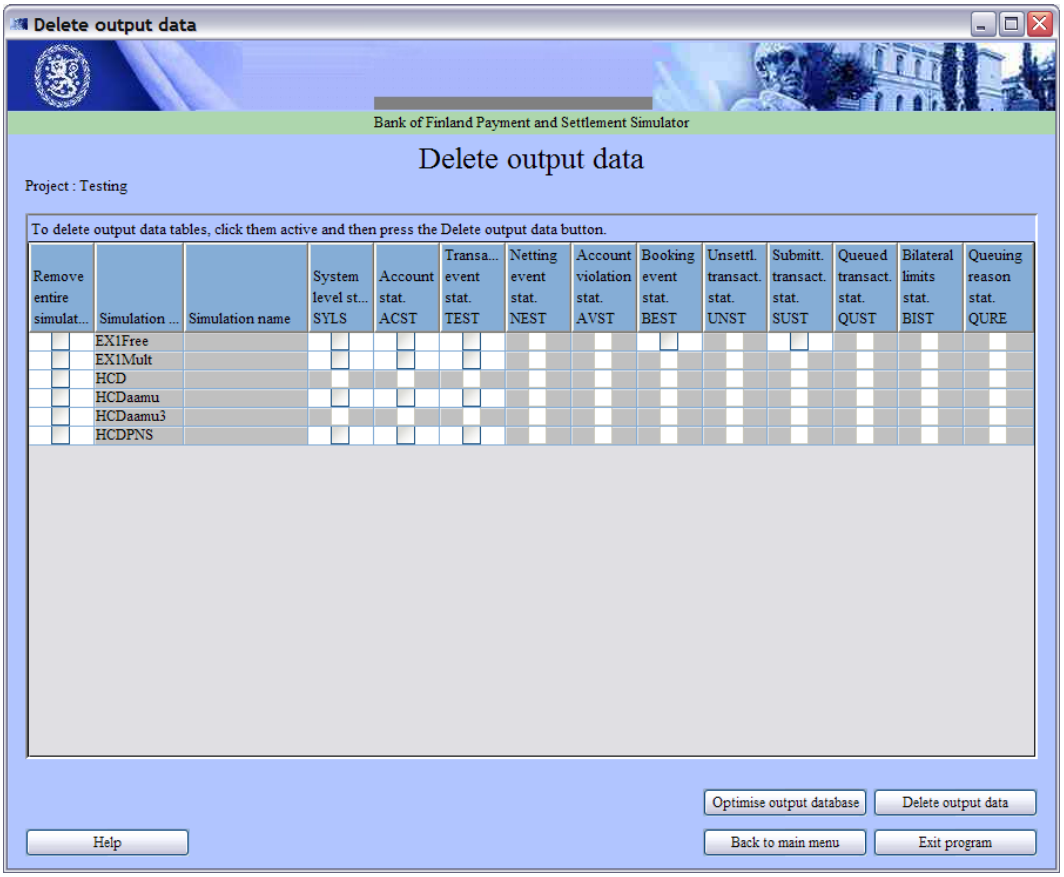
6.13. Account comparison



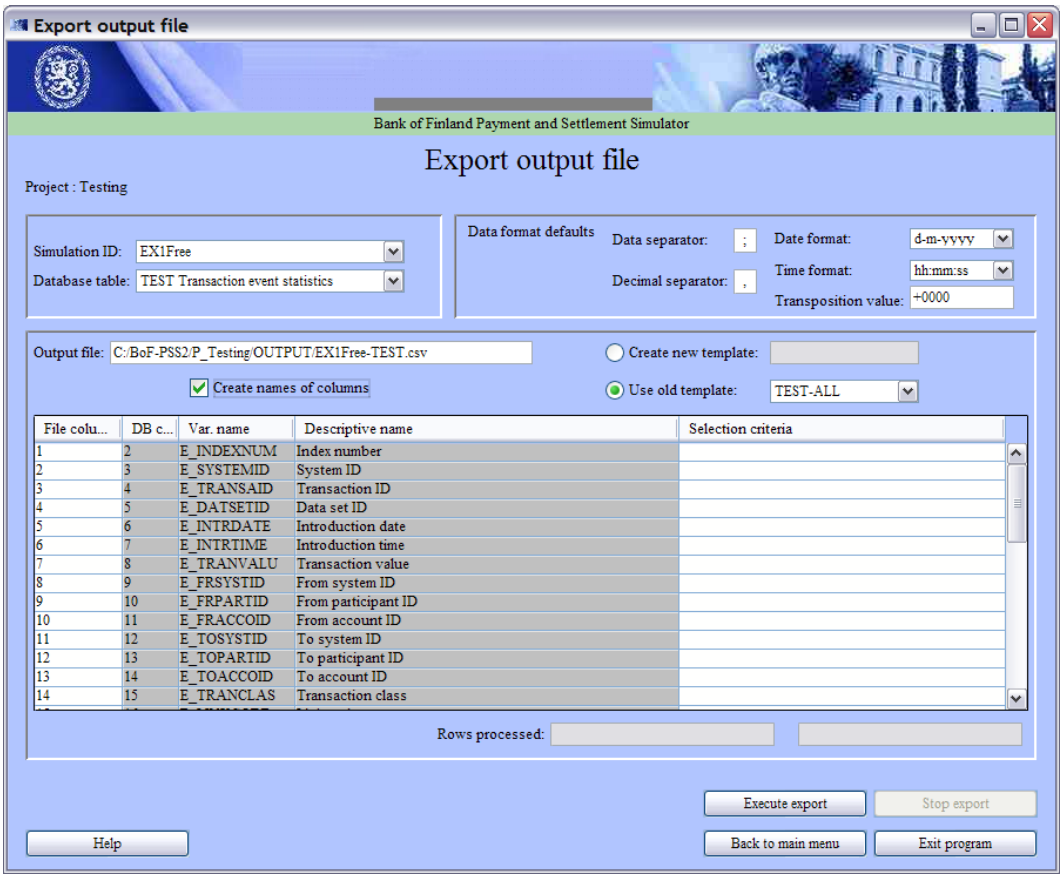
6.14. System comparison



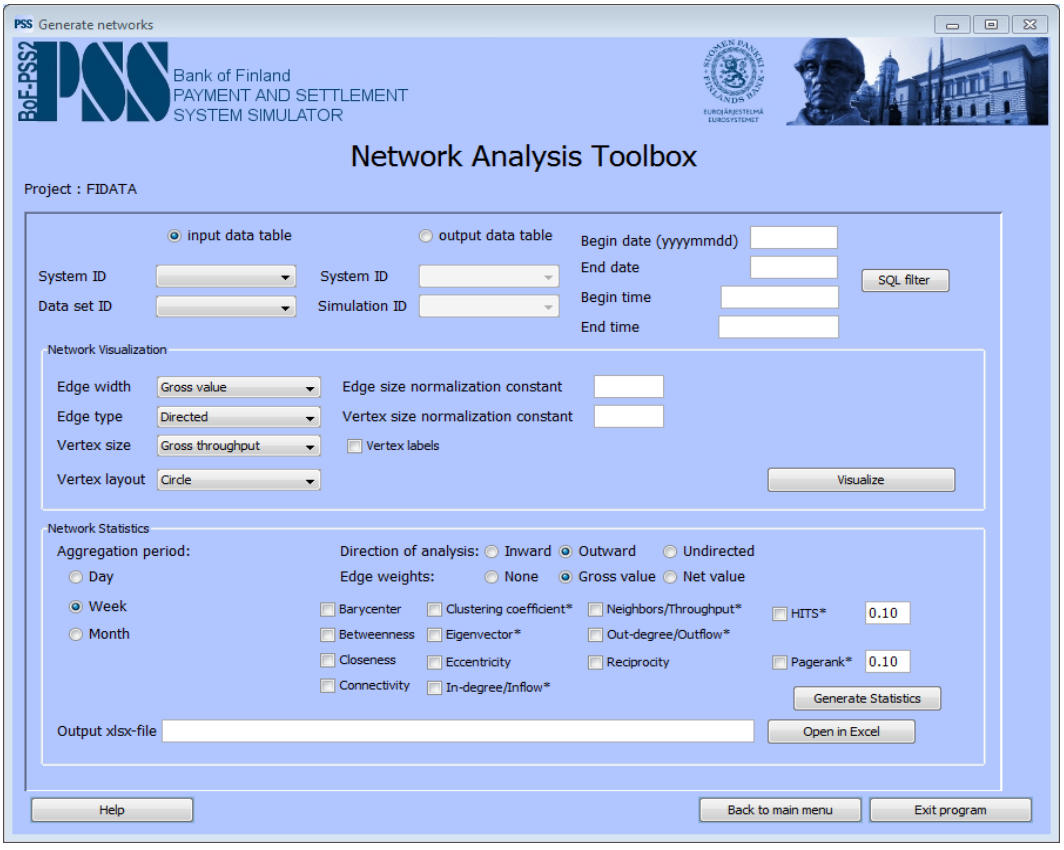
6.15. Delete output data



6.16. Export output file



6.17. Network Analysis Toolbox



7 Technical documentation

The following documents on **BoF-PSS2** are available via the internet-site http://www.bof.fi/sc/bof-pss:

- This user manual
- Simulator presentation and basic information
- Database and file descriptions
- BoF-PSS2 Command-Line Interface User Manual
- Algorithm descriptions and user module development guide
- Example data sets for different system setups and some correct output for these
- Step-by-step tutorial presenting the example 1
- Javadoc documentation of the simulator application

Source codes for the available algorithms.

8 Troubleshooting guide

This chapter is designed to help users to find and eliminate problems when employing the simulator.

It is a list of frequently encountered problems by the users. This list will be updated based on user experiences. Please send you experiences to the email address:

bof-pss@bof.fi

The updated guide will be posted on the web-site: www.bof.fi/sc/bof-pss and will be distributed with any new version of the simulator. If you have used your version already for some time, it might be good to check for the updated trouble shooting guide on the internet.

No data sets to configure in the simulation configuration screen

You must Define system data in the Input Generation Subsystem before the configuration screen can offer you data sets for the systems to simulate.

No settled transactions although simulations was run successfully

The system could be lacking liquidity. Check that you have granted enough liquidity via initial balances or intraday credit limits (tables of free usage).

The liquidity could also be lacking due to date and/or time errors. Check via View data sets that the date and time data for transactions, initial balances and intraday credit limits are correct. Check also that the open hours of the system is correctly specified (hhmm in 24 hour format) in the Define system data screen. Be especially cautious if you have been using Excel for editing the data, because Excel is often changing the date and time formats when writing to CSV files. Check for instance with Notepad that the formats are in the correct format in the input CSV files.

No transactions found and simulation terminated/done immediately

The simulator and MySQL perform well with most regional settings. However, with some special regional settings control characters seem to be converted and thereby corrupted. Please, try using some common regional setting alternative (e.g. English UK or USA). Regional settings are changed in the control panel section of Windows.

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Developers/Contributors at Bank of Finland

The BoF-PSS2 simulator is the second payment and settlement simulator built by the Bank of Finland. The first one was originally developed for internal use only, but it expanded well outside the Finnish borders. The new version has been built based on experience gathered from the first, but designed for international and independent usage and includes more features than its predecessor did. BoF-PSS2 also has a technical design that is more efficient for large simulations. Acknowledgement is also given to the persons from the Bank of Finland who were involved in the first version, because without the first version there would not have been a second one.

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tester of user interfaces and simulations of BoF-PSS2

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Kasperi Korpinen
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project manager for the BoF-PSS2 project
designer/developer of the BoF-PSS2 simulator
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Designer / developer of the BoF-PSS2 simulator for the version 2.4.0
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testing and distribution of BoF-PSS2

Kimmo Soramäki
designer/developer/programmer of the BoF-PSS1 simulator

Kirsti Tanila
tester and user of BoF-PSS1 simulator

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designer / developer of the BoF-PSS2 simulator for the version 3.2.0
co-author of the reference manual and other user documents

Petri Uusitalo
distribution design and organisation

Developers at MSG Software Oy

The development of the BoF-PSS2 simulator was contracted to MSG Software Oy based on the specifications developed by the Bank of Finland. MSG personnel will also support the software and develop new parts and features.

Maritta Halonen
user interface design
co-author of reference manual and data dictionary
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Project manager, developer

Timo Koistinen
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developer output reports

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system design
technical and algorithm documents

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project manager
system/user interface design
testing
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specifications and design
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alpha and beta testing

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