

ComsolGrid – A Framework for performing large-scale Parameter Studies using Comsol Multiphysics and BOINC

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COMSOL Conference, Paris, 18th November 2010

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- **Briefly Introduction**
- **ComsolGrid**
- **Test-Cases**
- **Conclusion**

Introduction



Common style!

High effort of maintaining!

High amount of invest is needed!

Additional buildings are needed!

New infrastructure!

Not energy-efficient!

etc. pp..

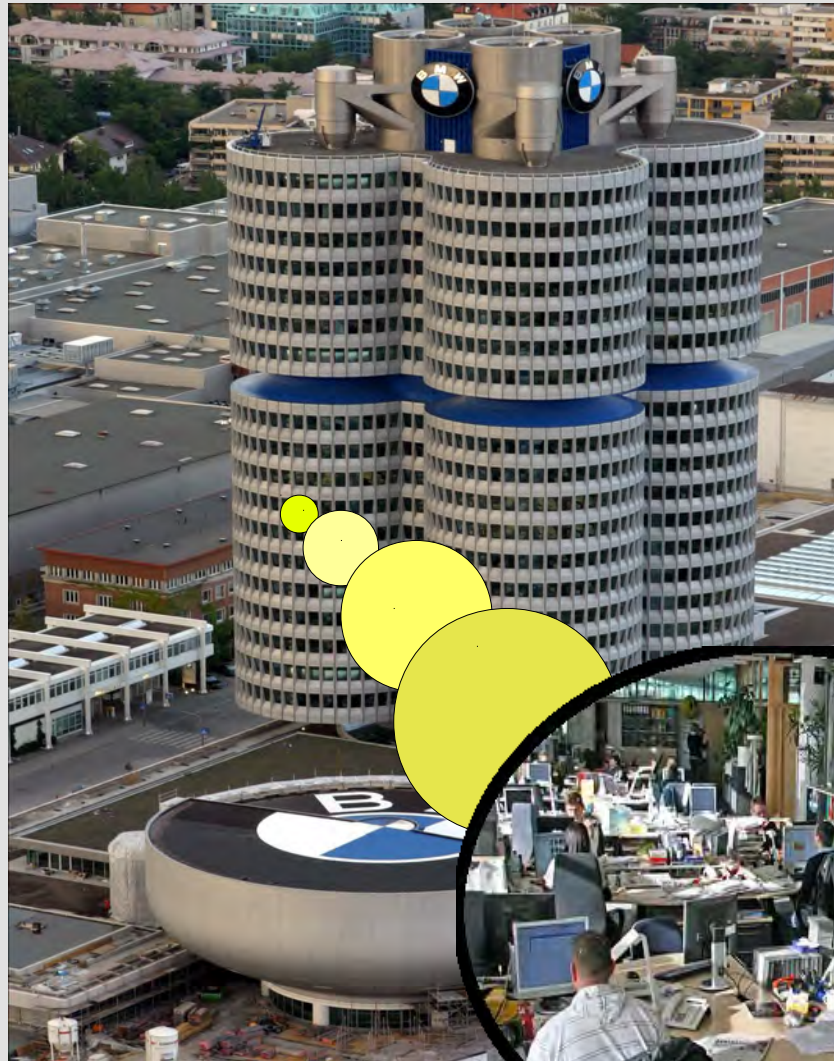
Introduction



Huge computational problems could be splitted into small valuable packages, so-called ***workunits***, e.g. ***large-scale parameter studies!***

Company members **download** these workunits, **perform the computation** and **send back** the **result**

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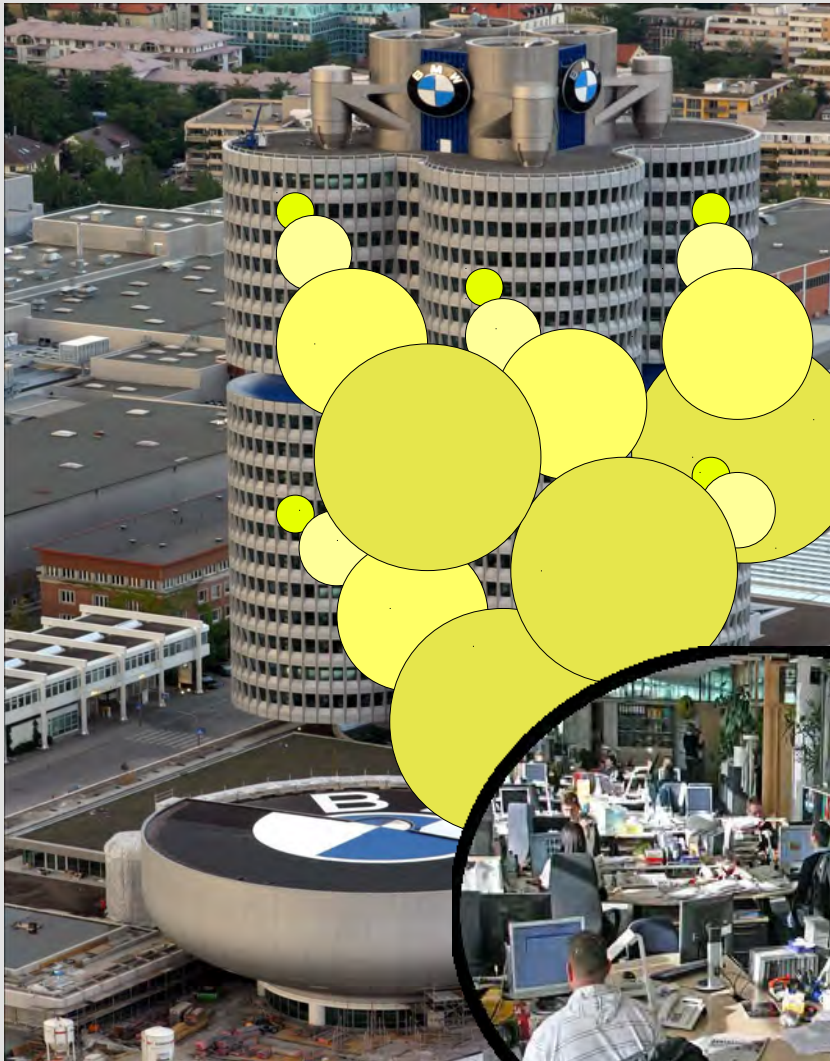
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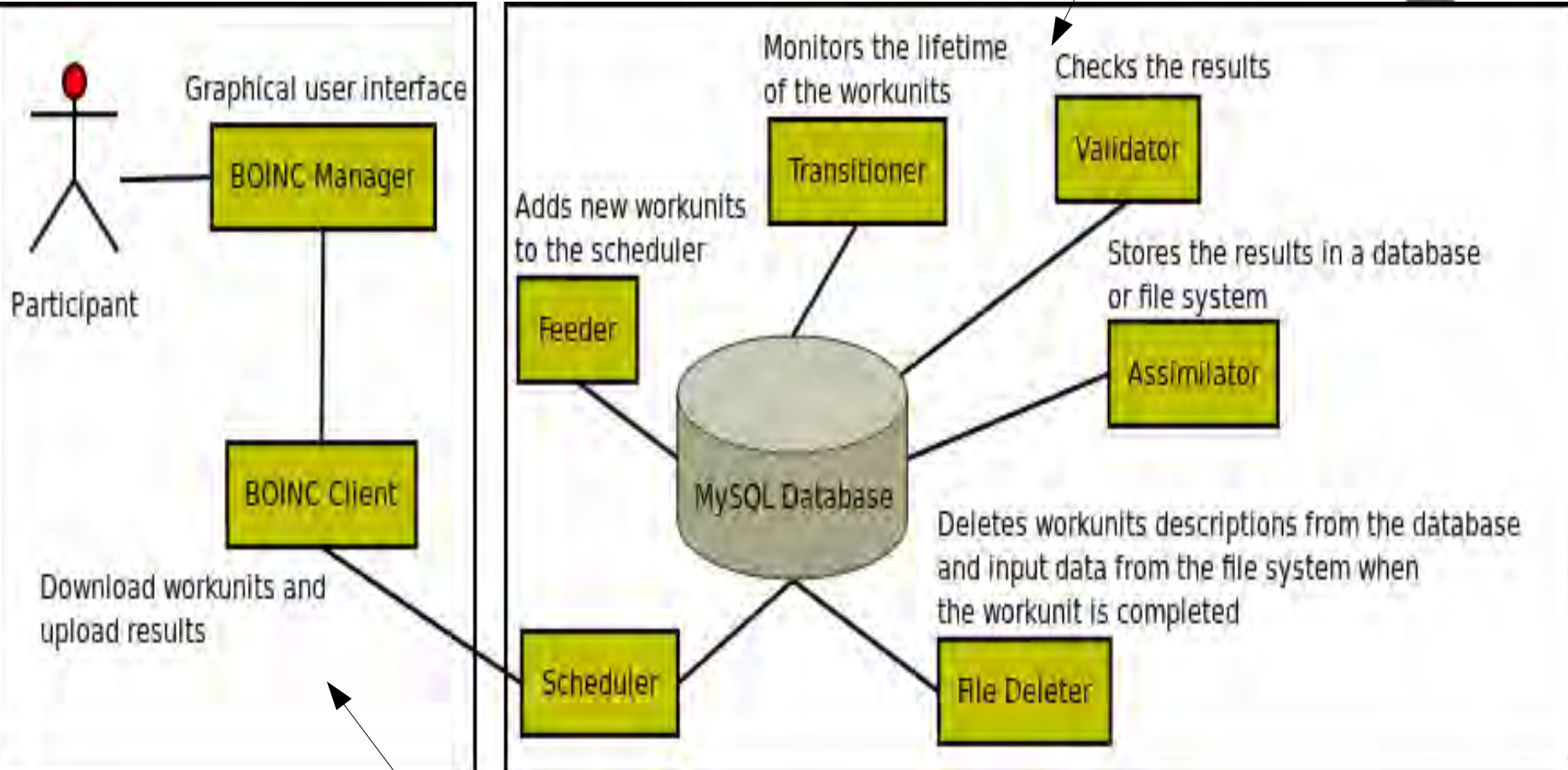
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BOINC (*Berkely Open Infrastructure for Network Computing*) is the key technology of Seti@home. It is an open-source framework for solving large-scale computational problems by means of public resource computing (PRC).

In contrast to massive parallel computing, PRC applications are distributed onto a large number of heterogeneous client computers connected by the Internet where each computer is assigned an individual task that can be solved independently without the need of communication upon the clients.

BOINC Server

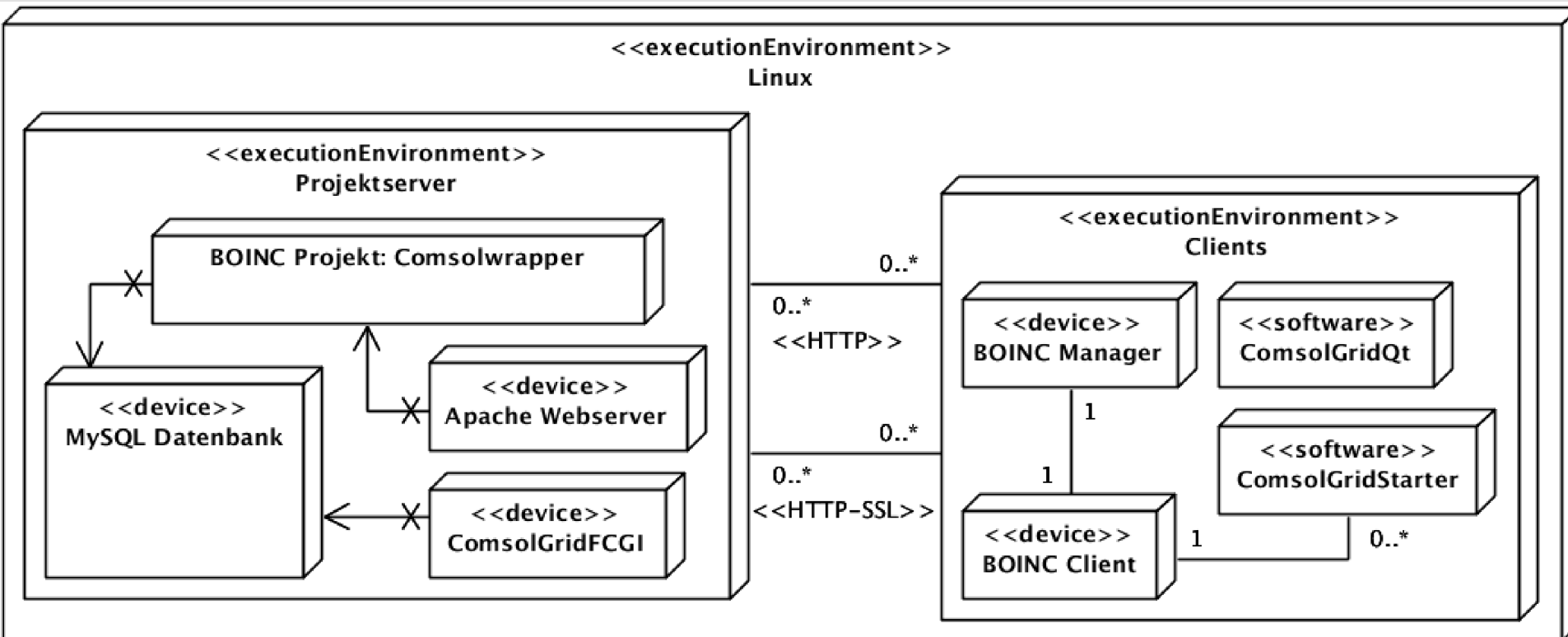


BOINC Client

- Computers, which are registered at one BOINC project
- Heterogeneous infrastructure (Linux, Mac OS X, Windows, ...)
- 32-/64-Bit, CPU, GPU, Multi-Thread

Implementation of 3 main components:

- ComsolGridFCGI ← Interface for maintainer of simulations
- ComsolGridQt ← Uses ComsolGridFCGI to create parameter-studies
- ComsolGridStarter ← Handler for COMSOL Multiphysics (Start, Stop, Pause, Abort)-of simulations



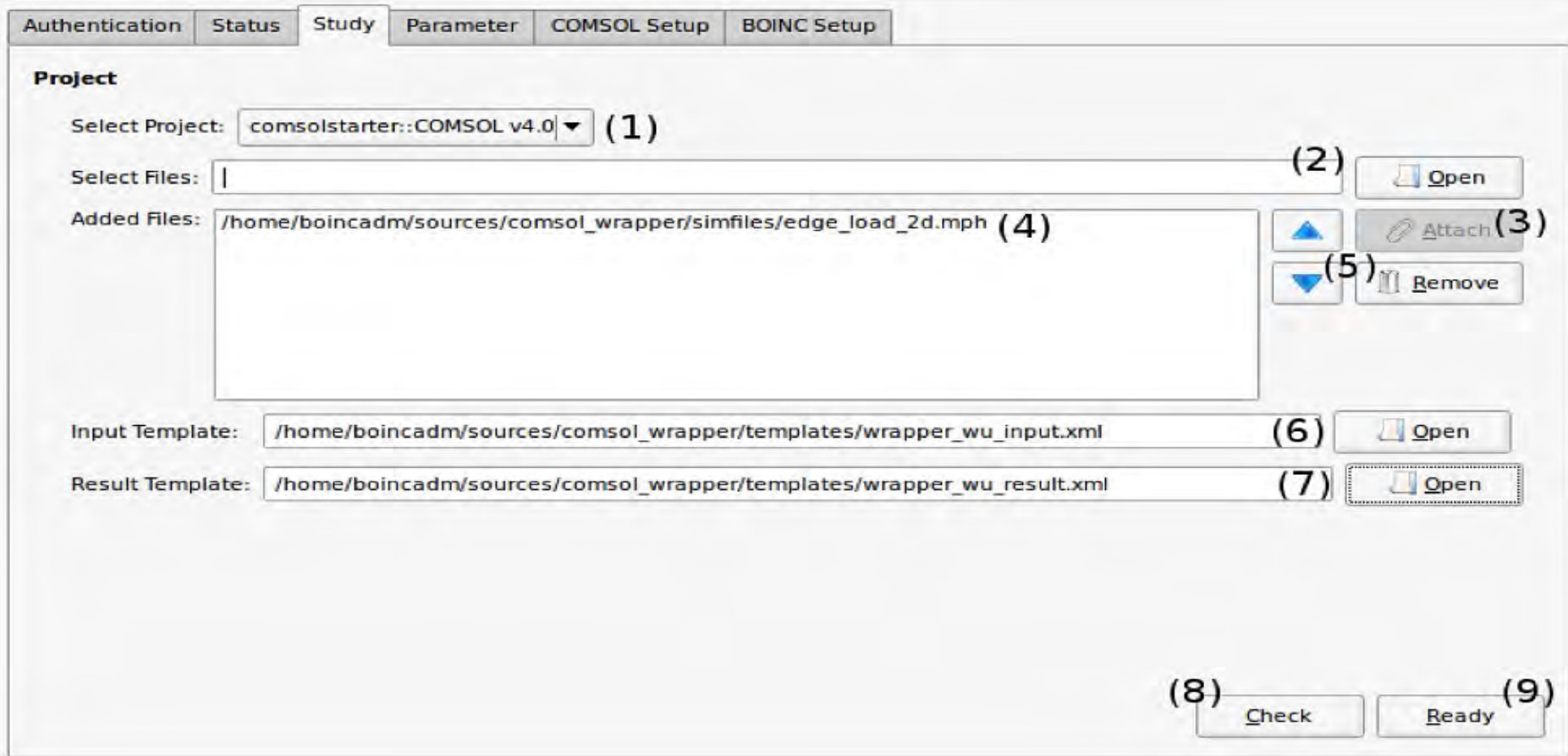
Roles:

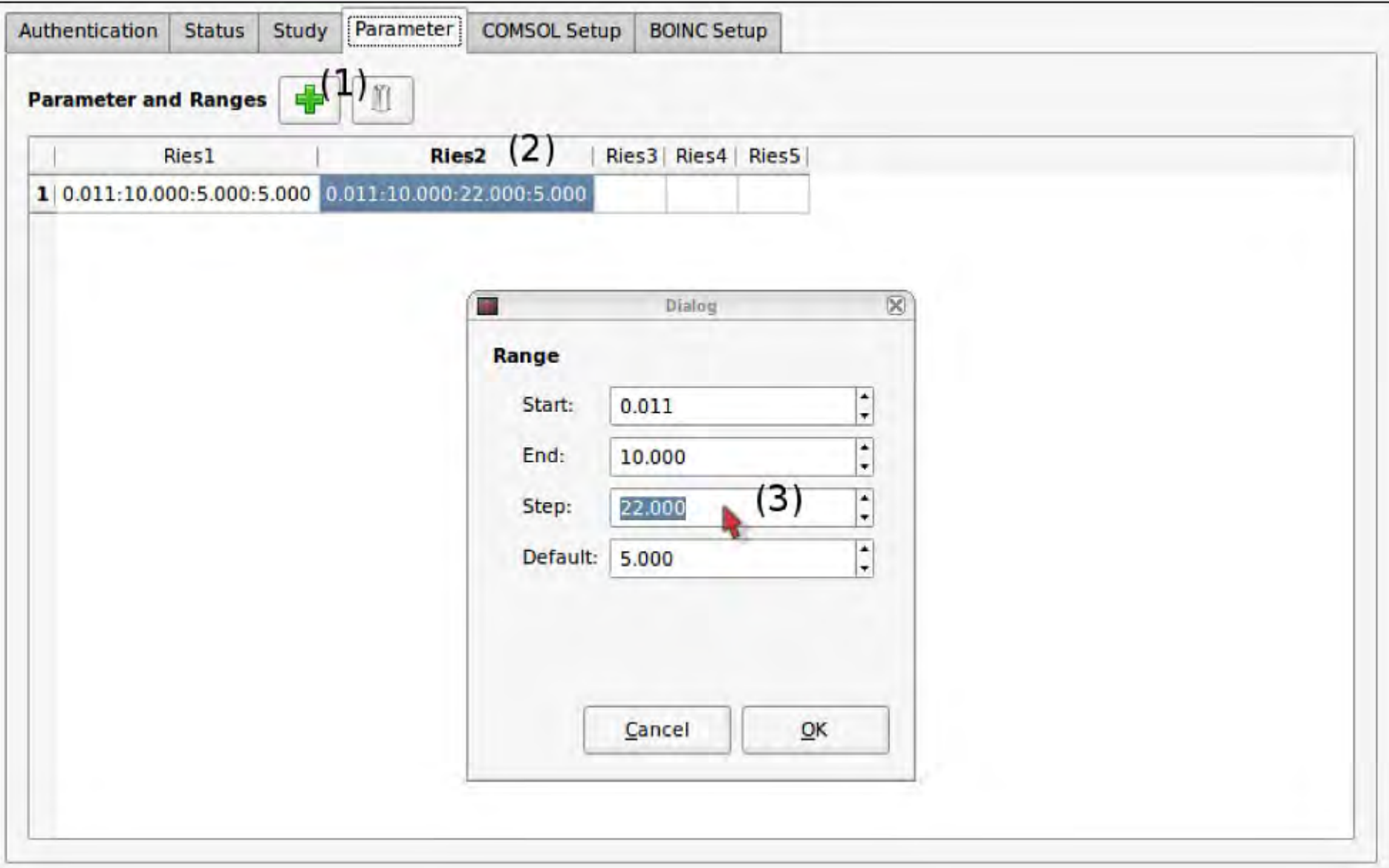
```
1 CREATE TABLE `comsolwrapper`.`comsolgrid_roles` (  
2   `id` INT NOT NULL AUTO_INCREMENT PRIMARY KEY ,  
3   `userid` INT NOT NULL ,  
4   `appid` INT NOT NULL ,  
5   `role` INT( 5 ) NOT NULL ,  
6   `description` VARCHAR( 254 ) NOT NULL  
7 ) ENGINE = MYISAM ;
```

- (1) Administrator ← Open for some definitions... :-)
- (2) Developer ← Developer can add new scientific applications
- (3) Scientist ← Persons of this role can add new simulations and add new parameter values of one simulation
- (4) Tester ← testing purposes, should be removed in productive releases

A graphical user interface to create new parameter studies.

Small and focused on use.





The screenshot shows the 'Parameter and Ranges' section of the ComsolGridQt software. The interface includes a menu bar with 'Authentication', 'Status', 'Study', 'Parameter', 'COMSOL Setup', and 'BOINC Setup'. Below the menu bar, there is a 'Parameter and Ranges' section with a green plus icon and a trash icon, both labeled with '(1)'. A table below shows parameter ranges for 'Ries1', 'Ries2 (2)', 'Ries3', 'Ries4', and 'Ries5'. The 'Ries2 (2)' column is highlighted, and its range is '0.011:10.000:22.000:5.000'. A dialog box titled 'Dialog' is open, showing the 'Range' settings for 'Ries2 (2)'. The 'Step' field is highlighted with a red arrow and labeled with '(3)', showing the value '22.000'. The 'Start' field is '0.011', the 'End' field is '10.000', and the 'Default' field is '5.000'. The dialog box has 'Cancel' and 'OK' buttons.

	Ries1	Ries2 (2)	Ries3	Ries4	Ries5
1	0.011:10.000:5.000:5.000	0.011:10.000:22.000:5.000			

Dialog

Range

Start: 0.011

End: 10.000

Step: 22.000 (3)

Default: 5.000

Cancel OK

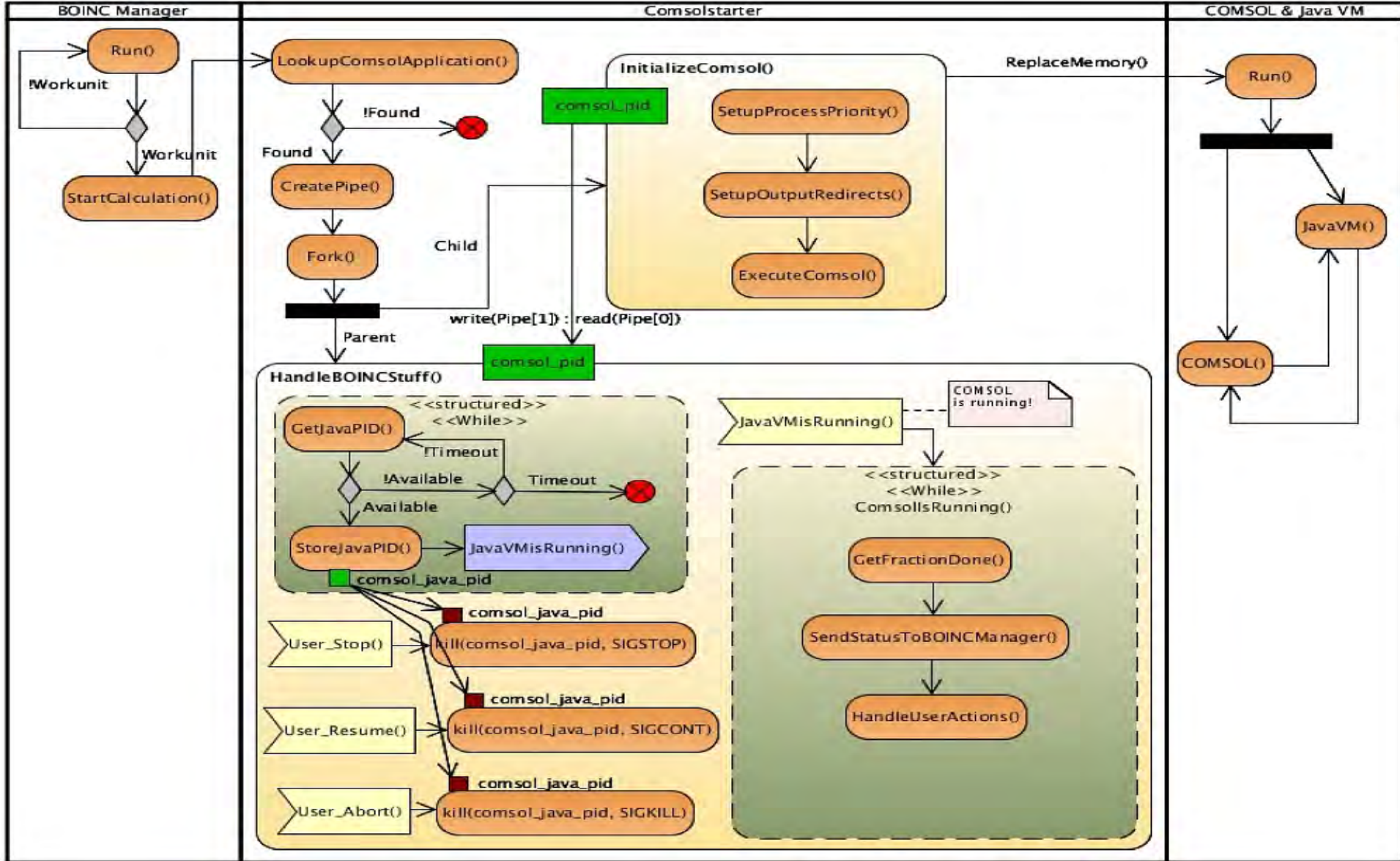
BOINC Manager displays the progress in percent of each calculation.

COMSOL Multiphysics creates a log file of the performing process. This value is shown in the BOINC Manager.

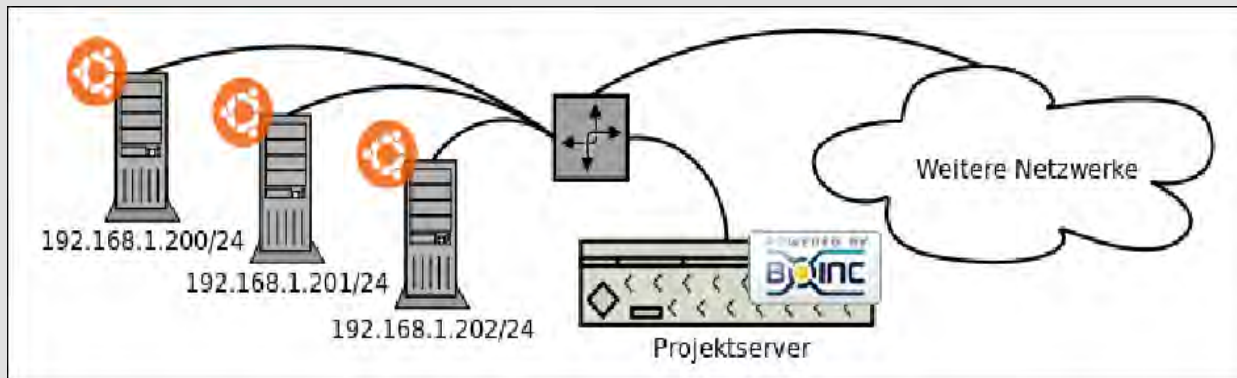
```
1 COMSOL Batch (64-bit)
2
3 Version: COMSOL 3.5 a (COMSOL 3.5.0.603)
4
5 Patent pending.
6 Copyright (c) 1998-2008 by COMSOL AB.
7 All rights reserved.
8
9
10 Starting batch job.
11
12 Solve Problem
13 Current Progress: 0 %
14 Updating extended mesh
15 Current Progress: 0 %
16 ...
17
18 Matrix factorization
19 Current Progress: 1 %
20 20 2.0858 0.36232 36 9 36 2 1 0
21 21 2.4402 0.36232 37 9 37 2 1 0
22 ...
```

Project	Application	Name	Elapsed	Progress	To completion	Report deadline	Status
comsolwrapper	COMSOL v4.0 Wrapper (prototype) 0.10	wu_comsol_1_nodelete_1	00:06:28	75.000%	00:02:07	Wed 28 Jul 2010 16:24:...	Running
comsolwrapper	COMSOL v4.0 Wrapper (prototype) 0.10	wu_comsol_6_nodelete_2	00:03:03	38.000%	00:04:45	Wed 28 Jul 2010 16:24:...	Waiting to run
comsolwrapper	COMSOL v4.0 Wrapper (prototype) 0.10	wu_comsol_5_nodelete_1	00:03:03	100.000%	---	Wed 28 Jul 2010 16:24:...	Waiting to run
comsolwrapper	COMSOL v4.0 Wrapper (prototype) 0.10	wu_comsol_5_nodelete_0	00:03:03	25.000%	00:06:59	Wed 28 Jul 2010 16:24:...	Waiting to run
comsolwrapper	COMSOL v4.0 Wrapper (prototype) 0.10	wu_comsol_4_nodelete_1	00:03:03	25.000%	00:06:59	Wed 28 Jul 2010 16:24:...	Waiting to run
comsolwrapper	COMSOL v4.0 Wrapper (prototype) 0.10	wu_comsol_4_nodelete_0	00:03:03	100.000%	---	Wed 28 Jul 2010 16:24:...	Waiting to run
comsolwrapper	COMSOL v4.0 Wrapper (prototype) 0.10	wu_comsol_3_nodelete_1	00:03:03	25.000%	00:06:59	Wed 28 Jul 2010 16:24:...	Waiting to run
comsolwrapper	COMSOL v4.0 Wrapper (prototype) 0.10	wu_comsol_3_nodelete_0	00:03:03	50.000%	00:03:10	Wed 28 Jul 2010 16:24:...	Waiting to run
comsolwrapper	COMSOL v4.0 Wrapper (prototype) 0.10	wu_comsol_2_nodelete_1	---	0.000%	00:07:04	Wed 28 Jul 2010 16:24:...	Ready to start
comsolwrapper	COMSOL v4.0 Wrapper (prototype) 0.10	wu_comsol_2_nodelete_0	---	0.000%	00:07:04	Wed 28 Jul 2010 16:24:...	Ready to start

ComsolGrid



- COMSOL Multiphysics Version 4.0a shared with *Network File System* (NFS) Protocol
- Test clients are in the same subnet
- 32-/64-Bit COMSOL versios is used
- Ubuntu Linux 10.4 (LTS)



- **Validator** checks the results
- **Assimilator** stores the results in a database of file system

```
1 BOINC is ENABLED
2
3 DAEMON pid status ... commandline
4 1 12846 running ... feeler -d 2
5 2 12848 running ... transitioner -d 2
6 3 12850 running ... file_deleter -d 2
7 4 12852 running ... comsol_bitwise_validator -mod 2 1 -d 2 -app comsolstarter
8 5 12854 running ... comsol_copydir_assimilate -d 2 -app comsolstarter
9 6 12856 running ... db_purge -d 2 -min_age_days 7 -gzip
10
11 TASK ... period next run ... commandline
12 1 ... 5 min NOW ... db_dump -d 2 -dump_spec ../db_dump_spec.xml
13 2 ... 5 min NOW ... run_in_ops ./update_uotd.php
14 3 ... 5 min NOW ... run_in_ops ./update_forum_activities.php
15 4 ... 5 min NOW ... update_stats -update_users -update_hosts
16 5 ... 5 min NOW ... run_in_ops ./update_profile_pages.php
17 6 ... 1 days NOW ... run_in_ops ./team_import.php
18 7 ... 1 days NOW ... run_in_ops ./notify.php
```

Test Case

Name of the simulation model *falling_sand.mph*

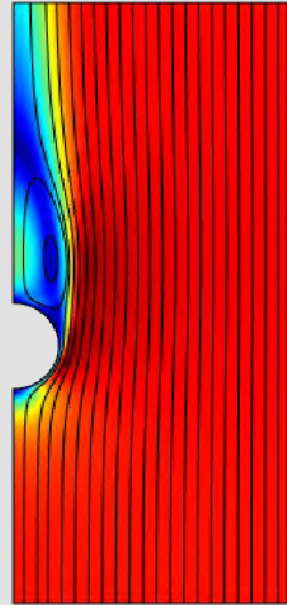
- (1) **objWidth**, width of the model (default: 0,006m)
- (2) **objHeight**, height of the model (default: 0,014m)

Variations of Parameter (1) & Parameter (2):

	Start	Stop	Step	Default
(1)	0.001	0.015	0.0005	0.006
(2)	0.001	0.025	0.001	0.014

→ 54 Simulations!

→ 108 Workunits!



Name	Expression	Value	Description
rho_water	1000[kg/m^3]	1000 kg/m³	Density, water
mu_water	1.51e-3[Pa*s]	0.00151 Pa*s	Dynamic viscosity, water
r_grain	1[mm]	0.001 m	Radius, grain
V_grain	4/3*pi*r_grain^3	4.189E-9 m³	Grain volume
rho_grain	2900[kg/m^3]	2900 kg/m³	Grain density
m_grain	V_grain*rho_grain	1.215E-5 kg	Grain mass
F_g	m_grain*g_const	1.191E-4 N	Gravitational force on grain
objWidth	6e-3	0.006	ComsolGrid Parameter 1
objHeight	14e-3	0.014	ComsolGrid Parameter 2

Test Case

108 results

'Over' results

'Success' results

'Client error' results

Server state	# results
Inactive	0
Unsent	0
Unsent (in work seq)	0
In Progress	0
Over	108

Outcome	# results
Init	0
Success	82
Couldn't send	0
Client error	5
No reply	0
Didn't need	21
Validate error	0
Client detached	0

Validate state	# results
Initial	48
Valid	27
Invalid	4
Skipped	3
Inconclusive	0
Too late	0

Client state	# results
Downloading	0
Downloaded	0
Compute error	2
Uploading	0
Uploaded	0
Aborted	3

File Delete state	# results
Initial	63
Ready to delete	19
Deleted	0
Delete Error	0
Total files deleted	19

Rate of Success: 95%

5% are misconfigured client machines, not a problem of ComsolGrid!

- It works!
- We use available and maintained infrastructures!
- BOINC is open-source, for free, and you can modify it!
- ComsolGrid is an cheap way the install your own high-performance cluster!

Thanks,

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