



## 216715 NEWCOM<sup>++</sup>

### DI.4.1

#### Architecture of the NEWCOM<sup>++</sup> software simulation library

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#### Abstract:

This document describes the actions that have led to the preliminary architecture of the NEWCOM<sup>++</sup> software simulation library (SSL). To obtain this result, a survey on the existing simulation tools has been carried out, jointly with the identification of the characteristics that SSL should have, to be really usable by the NEWCOM<sup>++</sup> community. The SSL, which should be integrated into the NEWCOM<sup>++</sup> portal, is composed by several components that reflect the different functionalities required by NEWCOM<sup>++</sup> researchers.

This deliverable is composed by four sections:

- the objectives and the organization of the WP is described in the Introduction;
- the answers to the questionnaire are shown and commented in Section Two;
- the guidelines for the development of the SSL are given in Section Three;
- conclusions are shown in Section Four.

The full text of the questionnaire is added in the Annex.

#### Keyword list:

Simulation and emulation tools, software library, survey.

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**LIST OF ACRONYMS**

<b>Acronym</b>	<b>Description</b>
ACML	AMD Core Math Library
ATLAS	Automatically Tuned Linear Algebra Software
AWGN	Additive White Gaussian Noise
BLAS	Basic Linear Algebra Subprograms
BSC	Binary Symmetric Channel
BSD	Berkeley Software Distribution
CDMA	Code Division Multiple Access
DCT	Discrete Cosine Transform
DFT	Discrete Fourier Transform
FAQ	Frequency Asked Questions
FFT	Fast Fourier Transform
FPGA	Field Programmable Gate Array
ISO	International Standards Organization
LAPACK	Linear Algebra PACKage
LDPC	Low Density Parity Check
MAC	Medium Access Control
MIMO	Multiple Input Multiple Output
MKL	Intel Math Kernel Library
OFDM	Orthogonal Frequency Division Multiplexing
OSI	Open Systems Interconnection
PNM	Portable Any Map
RS	Reed Solomon
SDR	Software Defined Radio
SSL	Software Simulation Library
VHDL	VHSIC Hardware Description Language

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## 1. INTRODUCTION

It is well known that the use of simulation/emulation software tools is an essential element in the analysis of complex scenarios. On the other hand, the use of simulation tools is often hindered by several factors, such as, for instance:

- cost of the simulation tool;
- necessity of long training periods;
- lack or scarcity of documentation;
- difficulty to compare results obtained with different tools.

In a large network of excellence (NoE) such as NEWCOM<sup>++</sup> [NEW+], these aspects can make the integration of the research activities very challenging. The main objective of this work package is to foster the cooperation between partners by means of the use of common research tools. This goal can be achieved by creating a “software simulation library” (SSL), in which the different simulation or emulation tools used by NEWCOM<sup>++</sup> partners can be classified, and organized and where users willing to use these simulation tool can be supported and advised. The creation of the SSL will facilitate the exchange of knowledge and experience with different simulation tools, the common definition of reference scenarios and the exchange of programmes, results and methodologies.

WPI.4 continues and extends the activity of work packages WPI.3, WPI7.1 and WPI7.2 in NEWCOM (6<sup>th</sup> FP European Network of Excellence in Wireless COMunications) [NEW]. More specifically, WPI.3 dealt with the inventory of all hardware and software resources available in NEWCOM [WPI3]. The WP also aimed at creation of a common platform for the NoE research activities. Activity of NEWCOM WPI.4 had also similarities with those carried out in WPI.7.1 and WPI.7.2 which where devoted to the identification of common reference scenarios and to the collections of the most relevant results obtained in that framework [WPI7.1, ~~WPI7.2~~].

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The main objective of WPI.4 is to build a SSL for the joint research activities of NEWCOM<sup>++</sup> members. The WP exploits the experience and skills of the members of the consortium to create a framework which can collect software modules, reference scenarios and results. The framework should also provide support to the researchers who want to use a specific simulation tool. Among the objectives of this work package there is also the proposal of reference scenarios to be used with the software library. These objectives have the final goal of fostering the cooperation between NEWCOM<sup>++</sup> partners by using common tools and by supporting the update and/or use of existing simulation tools.

This report is structured as follows:

- Section 2 contains a detailed analysis of the answers to the questionnaire. These results, which provide a first survey on the simulation/emulation tools used by NEWCOM<sup>++</sup> partners, have been used to check the availability of partners to contribute to SSL and to share own simulation modules.
- Section 3 describes the proposal of SSL which reflects the suggestions came from NEWCOM<sup>++</sup> partners. The section contains the general architecture of the SSL and provides a schematic description of the main sections.
- Section 4 contains the conclusions.

The deliverable also contains an Annex with the full text of the questionnaire.

## 2. ASSESSMENT OF THE NEWCOM++ PARTNERS' NEEDS AND EXPECTATIONS FROM THE SOFTWARE SIMULATION LIBRARY

### 2.1 Initial remarks

Before the definition of the SSL, a questionnaire was created and sent to all NEWCOM++ partners. The questionnaire was created in April 2008 and the main aspects addressed by the questionnaire were the following:

- identification of actions and tools to help the joint research activity of NEWCOM++ researchers;
- survey on the purposes of the research activity requiring simulation tools;
- survey on the simulation/emulation tools used by partners;
- identification of skills and expertise of NEWCOM++ partners with some specific simulation environment;
- survey on the availability of NEWCOM++ partners to share modules of simulation tools.

The questionnaire was distributed among the partners of NEWCOM++ at the beginning of May 2008. Institutions composed by several research groups were allowed to return separate questionnaires. 30 questionnaires were received from all the institutions of NEWCOM++. The questionnaire was composed of two parts. The first part was meant to identify actions and tools which would ease the joint use of simulation tools from different research activities. The second part was more focused on a survey on the simulation tools used by NEWCOM++ partners. More specifically, the survey included i) the purposes of the research activities which use simulation or emulation tools; ii) the kind of simulation/emulation used; iii) the identification of the skills and grade of expertise of NEWCOM++ partners with some specific simulation environments; finally, iv) the availability of NEWCOM++ partners to create and/or share existing modules of some simulation tools.

The two parts were preceded by a survey on the number of research groups working on the research different work packages (WPR1-WPR11, WPR A, WPR B, and WPR C).

**Question 1: WPRs in which your institution is involved.**

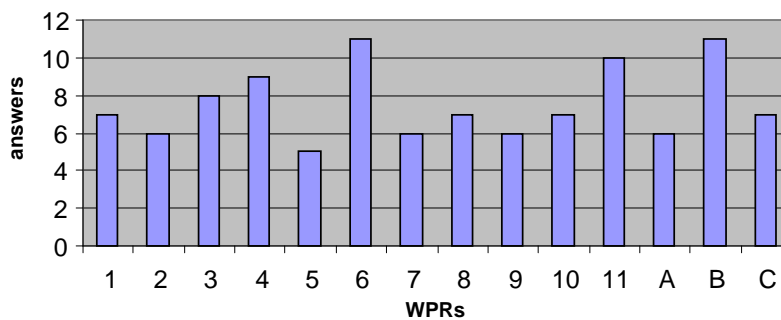


Fig. 2.1 Distribution of partners for WPRs

Numbers 1-11 in the x-axes refer to WPR1-WPR11, A,B and C refer to WPR A, WPR B and WPR C, respectively. Note that, since the questionnaire was focused on research groups rather than institutions, the numbers indicated in Fig. 2.1, are not the same as indicated in Annex 1 of NEWCOM++. The results of question 1 were used for comparison purposes with results of questions 3.1 and 3.2.

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## 2.2 Results of Part 2 of the questionnaire

### 2.2.1 Question 2.1 – Actions: rank the following proposals in order of importance for your institution (1-the most important,...)

The question aims at identification of necessary actions towards the integration of different simulation platforms used in NEWCOM++

<b>The WPI.4 should</b>
<b>Identify one or few relevant simulation platforms and create a software library.</b>
<b>Identify possible missing software modules in the software platforms used by NEWCOM++ partners and provide guidelines for their implementation.</b>
<b>Classify the different platforms used in NEWCOM++ according to their characteristics and research fields.</b>
<b>Create a section in the NEWCOM++ portal (the WPI.4 web-site) which contains information and characteristics on the different simulation tools used by NEWCOM++ partners.</b>
<b>Collect simulation results obtained by WPRs and classify them based on simulation platforms and research fields</b>
<b>Create a “simulation platform help-desk” to give information to people willing to use a given simulation tool. The help-desk gives suggestions and detailed information (how to install, how to configure,...) about the specific simulation platform, or give suggestions on the most suitable platforms to investigate a given problem.</b>
<b>(other comments)</b>

Answers to question 2.1:

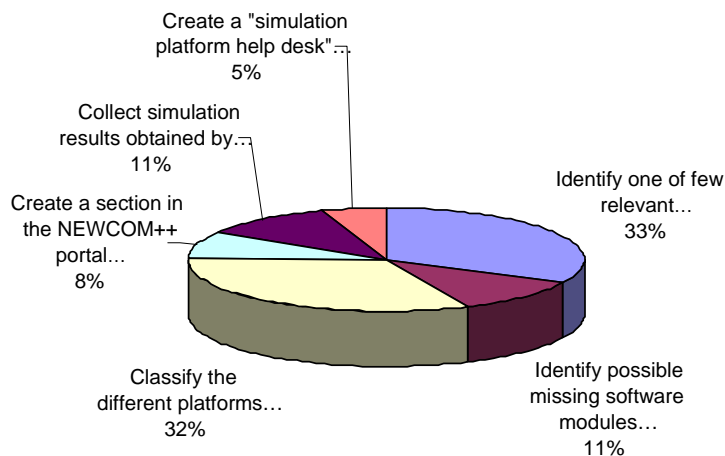


Fig. 2.2 Question 2.1 – answer ranked as the most relevant (37 answers)

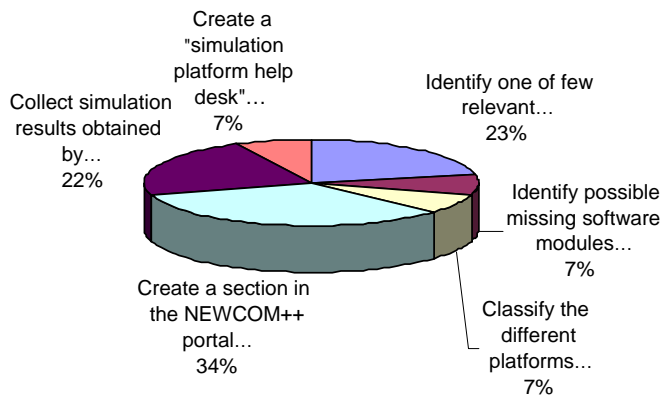


Fig. 2.3 Question 2.1 – answer ranked as the second most relevant (27 answers)

Fig. 2.2 and Fig. 2.3 show that NEWCOM++ partners prefer to have an instrument for classifying the different simulation tools rather than identify possible missing software modules. This answer is probably due to the awareness that the identification of missing software modules is a very time consuming operation and, for this reason, should be limited to very few simulation tools. Another interesting aspect is that a significant percentage of researchers (33% as first choice) propose to focus only on one or two simulation platforms and create a more complete framework for these tools.

Eliminato: Fig. 2.2

Eliminato: Fig. 2.3

2.2.2 Question 2.2 – WPI.4 web-site (internal to the NEWCOM++ portal)

The question is related to the creation of a WPI.4 web-site (internal to NEWCOM++ portal).

Question
A. Do you think the implementation of the WPI.4 web-site would be useful to provide information on the different simulation tools used in NEWCOM++?
B. Do you think NEWCOM++ people would use the WPI.4 web-site?
C. Would you contribute to create the web-site?
D. Would you contribute to update the web-site?

Answers:

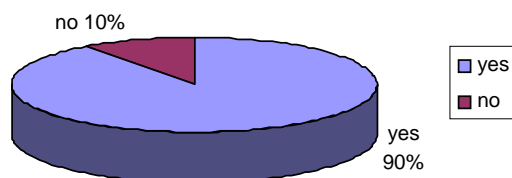


Fig. 2.4 Answers to question A of 2.2 (30 answers)

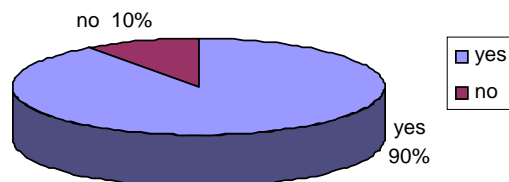


Fig. 2.5 Answers to question B of 2.2 (30 answers)

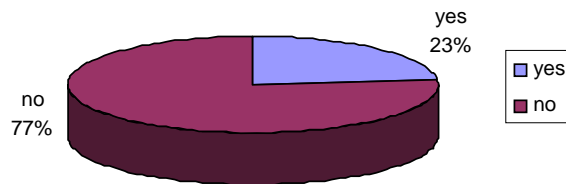


Fig. 2.6 Answers to question C of 2.2 (30 answers)

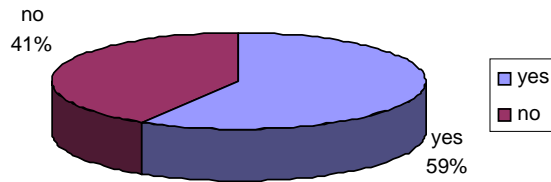


Fig. 2.7 Answers to question D of 2.2 (29 answers)

Answers to questions A and B indicate people in NEWCOM++ believe (93%) that a WPI.4 web-site (internal to NEWCOM++ portal) can be useful for people using simulation tools. Obviously, due to the limited man-power allocated to the WP, only a minority of partners can give a contribution to the realization (question C) and update (question D) of the web-site. However, the percentage of researchers willing to update the web-site is larger than 50%.

2.2.3 Question 2.3 - Contributions

The question is related to the contents the Web-site discussed in Question 2.2 should have..

Question
A. Which information should the WPI.4 web-site contain?
B. Are you available to contribute to the web-site? (if yes, please, indicate for which platform you can contribute)
C. Are you available to contribute to the “simulation platform help-desk”? (if yes, please, indicate for which platform you can contribute)

Answers:

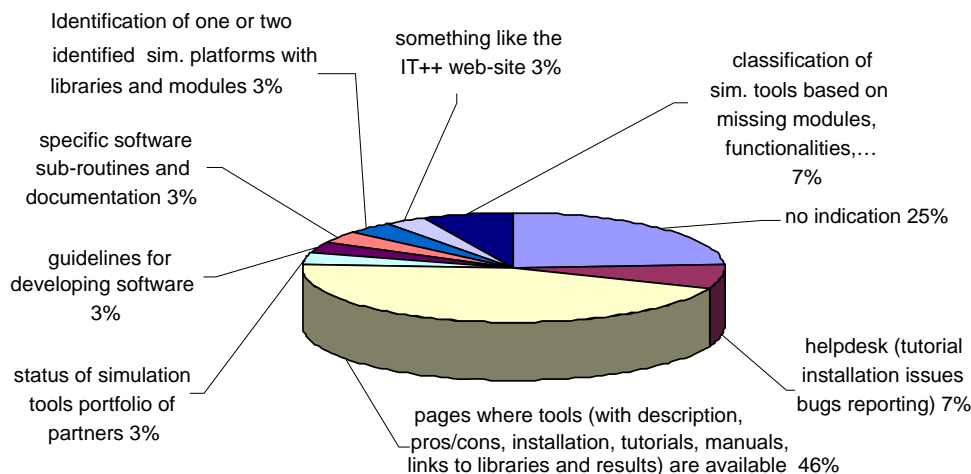


Fig. 2.8 Answers to question A of 2.3 - Information to be contained in the WPI.4 web- site (29 answers)

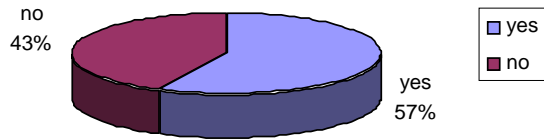


Fig. 2.9 Answers to question B of 2.3 (21 answers)

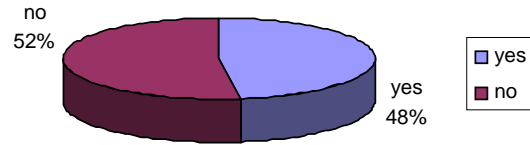


Fig. 2.10 Answers to question C of 2.3 (23 answers)

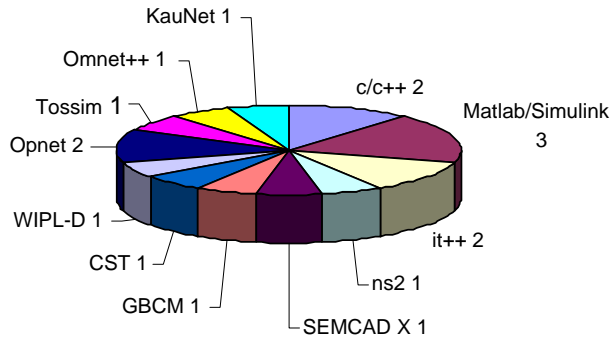


Fig. 2.11 Contribution to WPL4 web-site, answers to questions B and C

Answers to question 2.3 indicate that the majority of people supports the idea to have pages dedicated to each simulation tool used in NEWCOM++ with indication of installation guidelines, pros/cons, existence of manuals, tutorials, etc.. Fig. 2.10 also indicates that 50% answerers can support the creation of a “simulation help desk” to support users willing to adopt a given simulation tools. Finally, Fig. 2.11, shows the platforms for which people can contribute for web-site and/or simulation help-desk.

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Eliminato: Fig. 2.11

### 2.3 Results on Part 3 of the questionnaire

#### 2.3.1 Question 3.1 – WPRs in which your Institution is using (or you have planned to use) simulation tools

The question aims at evaluating the number of simulations tools used in each WPR.

Answers:

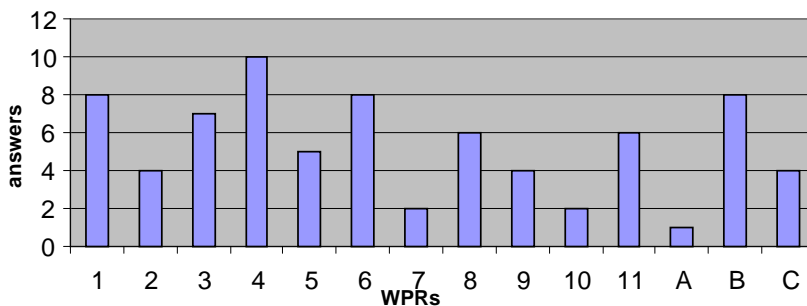


Fig. 2.12 Simulations tools used in each WPR

Numbers 1-11 in the x-axes refer to WPR1-WPR11, A, B and C refer to WPRA, WPRB and WPRC, respectively. In all the WPRs, NEWCOM<sup>++</sup> partners make use of simulators. The number of simulation tools ranges from 1 (WPRA) to 10 (WPR4) with an average number of 5.2.

### 2.3.2 Question 3.2 – WPRs in which your Institution is using (or you have planned to use ) emulators<sup>1</sup>

The question aims at evaluating the number of emulators used in each WPR.

Answers:

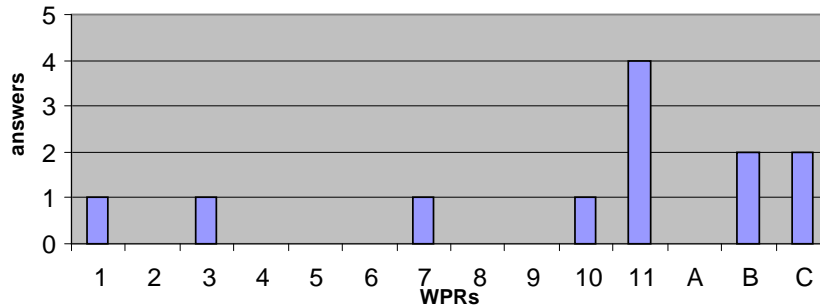


Fig. 2.13 Emulators used in each WPR

Numbers 1-11 in the x-axes refer to WPR1-WPR11, A, B and C refer to WPRA, WPRB and WPRC, respectively. The comparison between figures 2.12 and 2.13 reveals that, as expected, the use of emulators in NEWCOM<sup>++</sup> is limited to some WPR (WPR11 in particular).

### 2.3.3 Question 3.3 – Simulation's layers

The question aims at collecting information on which layers (according to ISO-OSI definition) are commonly investigated in NEWCOM<sup>++</sup> with the use of simulators/emulators.

*Question: NEWCOM<sup>++</sup> addresses several topics in wireless communications, simulation tools are commonly used to investigate some aspects of the OSI layers. Please, indicate which layers are you considering with your simulation tools and which purposes*

Layers/	Put a cross on the layers of interest (multiple crosses are allowed)	Purposes of the analysis (link level analysis, channel modelling,...)
Physical		
Data link		
Network		
Transport		
Application		
X-layer (indicate the layers)		

<sup>1</sup> An **emulator** duplicates (provides an **emulation** of) the functions of one system using a different system, so that the second system behaves like (and appears to be) the first system. Emulators can be **software** as well as **hardware**.

Answers:

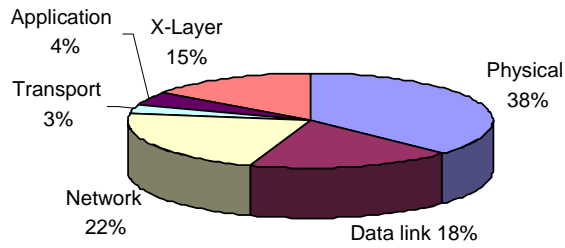


Fig. 2.14 Layers (OSI model) considered by NEWCOM++ partners (67 answers)

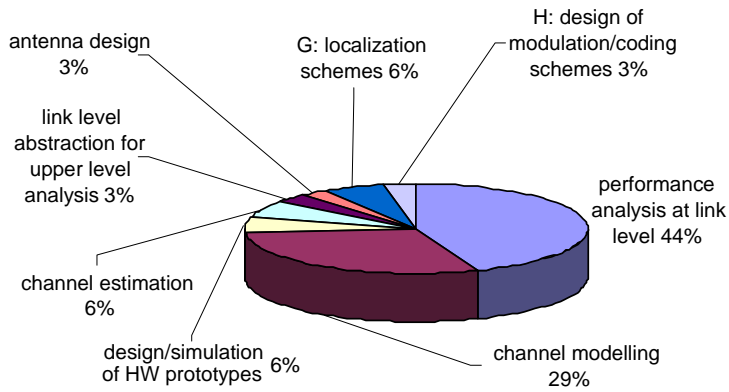


Fig. 2.15 PHY layer – purposes of the simulation analysis

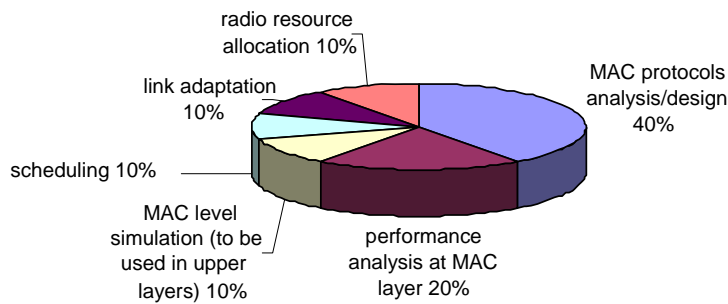


Fig. 2.16 MAC layer – purposes of the simulation analysis

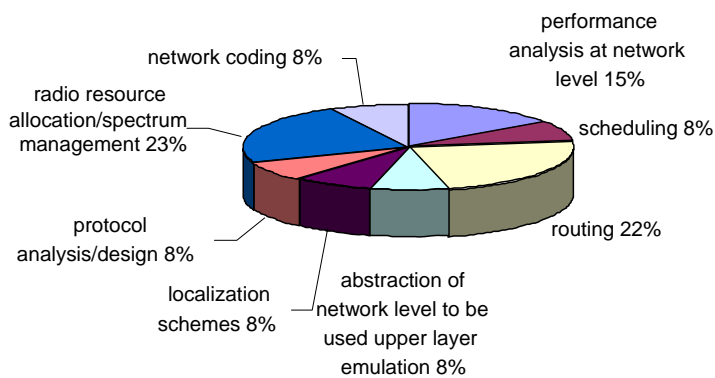


Fig. 2.17 NET layer – purposes of the simulation analysis

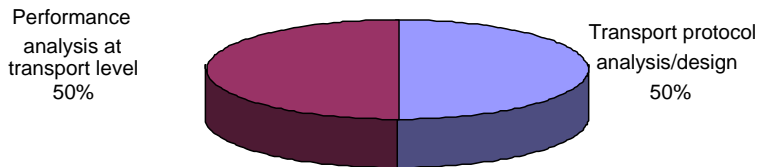


Fig. 2.18 TRANSPORT layer – purposes of the simulation analysis.

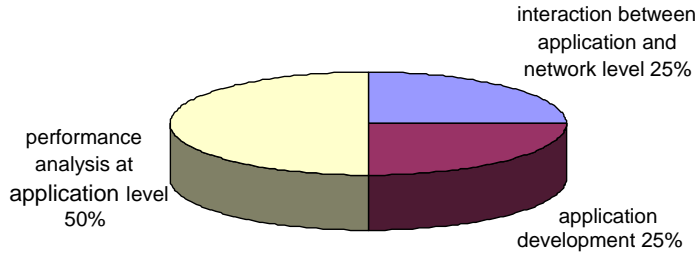


Fig. 2.19 APPLICATION layer – purposes of the simulation analysis

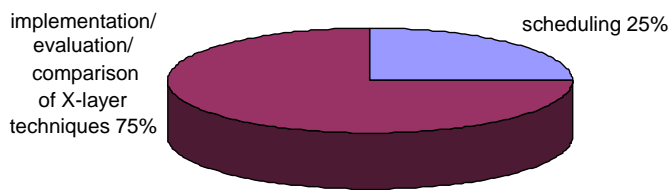


Fig. 2.20 cross-layer – purposes of the simulation analysis

As expected the analysis of PHY layer plays the major role but also NETWORK and DATA LINK are significant. Cross-layer techniques (which require the analysis of different layers) represent 15% of all the research activity requiring simulators/emulators. A more detailed analysis on the specific research fields for the different layers can be found in Figs. 2.15-2.20.

**2.3.4 Question 3.4 - Simulation platforms**

The question aims at collecting information on the kinds of simulation platforms used in the NoE.

Question: Please, indicate which kind of simulation/emulation platforms do you use in NEWCOM++.

Simulation Tool	Programming language	Supported OS: Windows, Linux, Unix, other	Commercial, open source, freeware	Purposes of the analysis	General comments

Answers:

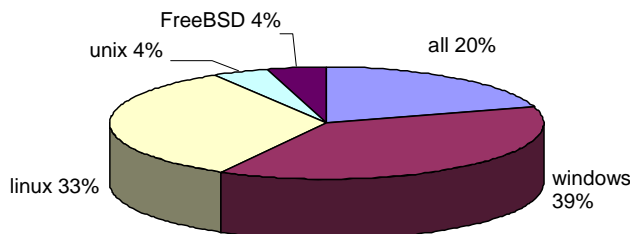


Fig. 2.21 Supported OS (69 answers)

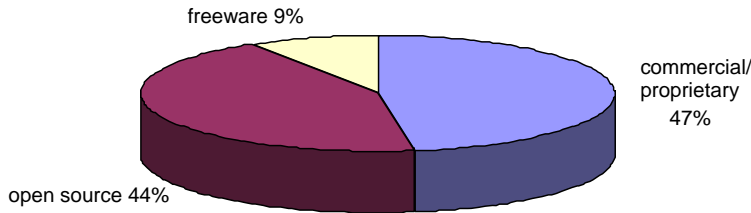


Fig. 2.22 Kind of platform (57 answers)

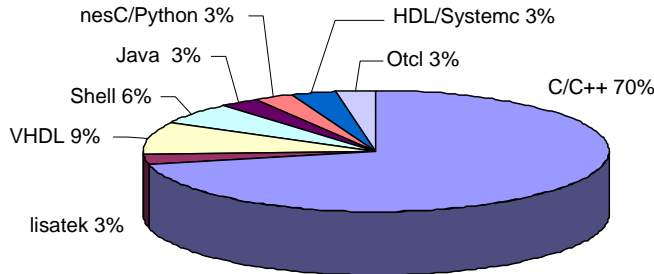


Fig. 2.23 Programming languages (35 answers)

As expected, Fig. 2.21, shows that 92% of the platforms supported by simulation tools is Windows/Linux. Only a small fraction requires Unix (4%) and FreeBSD (4%). Fig. 2.22 shows that although commercial/proprietary software represent 47% of all simulation tools used, open source platforms are quite common in NEWCOM++ (44%). As far as program languages are concerned, Fig. 2.23 shows that, as expected, c/c++ is the leading language with about 70%. The remaining 30% is spread around other 7 languages. Note that VHDL is, jointly with Verilog, the world wide reference language for field-programmable gate arrays (FPGA) and application-specific integrated circuits.

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Eliminato: Fig. 2.23

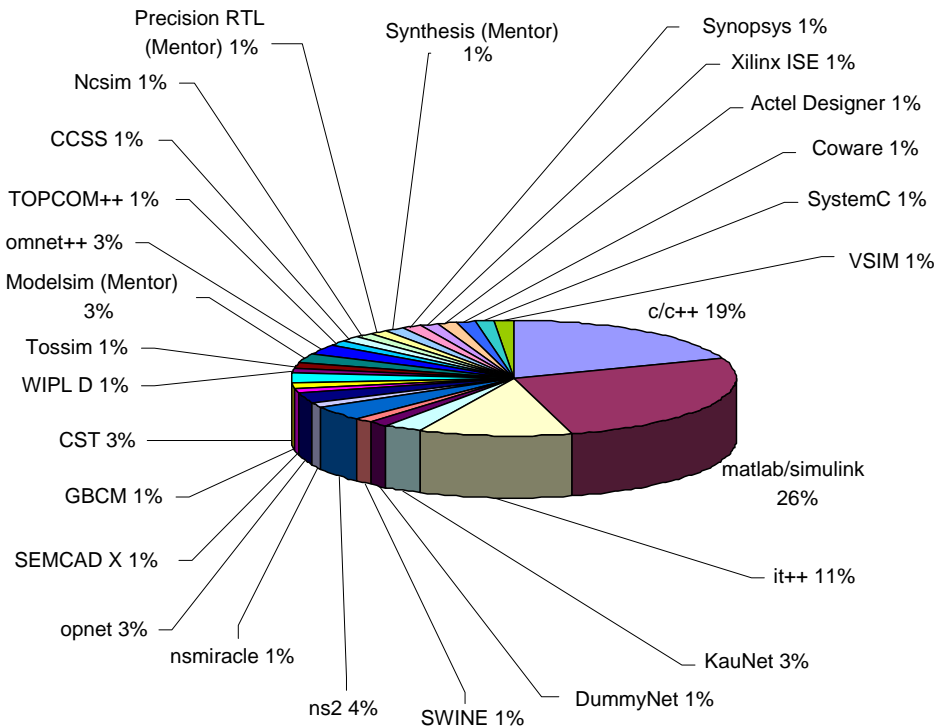
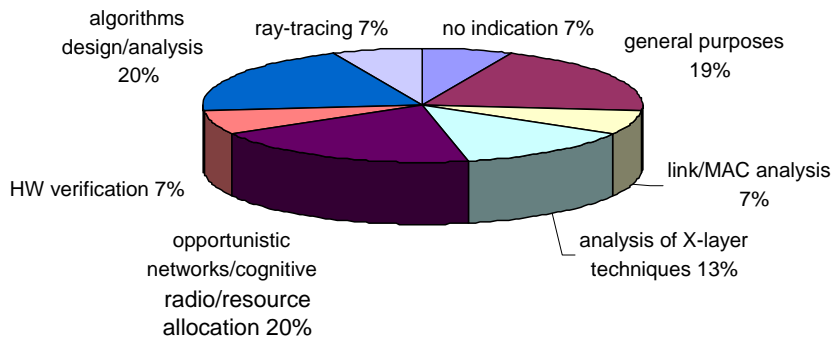
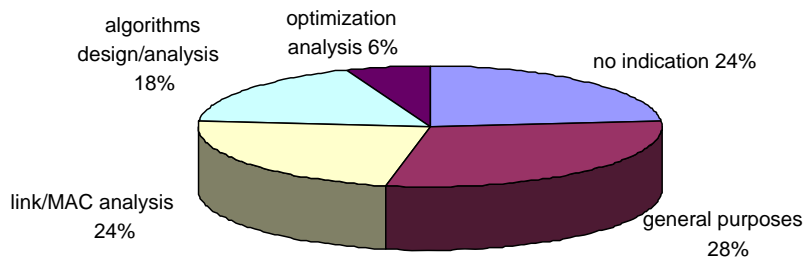


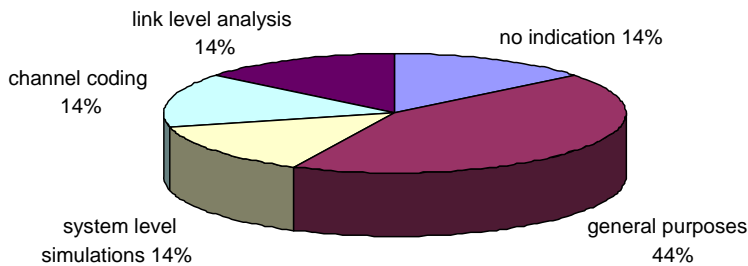
Fig. 2.24 Simulation tools (72 answers)



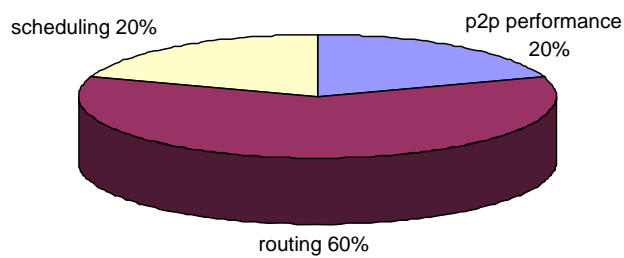
**Fig. 2.25 Purposes of the simulation tools: C/C++ (14 answers)**



**Fig. 2.26 Purposes of the simulation tools: matlab/simulink (19 answers)**



**Fig. 2.27 Purposes of the simulation tools: it++ (8 answers)**



**Fig. 2.28 Purposes of the simulation tools: ns2 (3 answers)**

**Tab. 2.1 Purposes of the other (all except c/c++, matlab/simulink, it++, ns2) simulation tools.**

Simulation Tool	Purposes
KauNet	transport Protocol analysis
DummyNet	No indication
SWINE	No indication
nsmiracle	No indication
opnet	MAC protocols design/analysis
SEMCAD X	FDTD solver
GBCM	channel modelling
CST	antenna characterization, propagation analysis
WIPL D	antenna characterization
Tossim	protocol analysis, software debugging
Modelsim (Mentor)	HW verification
omnet++	network simulation, protocol design/analysis
TOPCOM++	link level analysis
CCSS	link level analysis
Ncsim	IP design
Precision RTL (Mentor)	FPGA design
Synthesis (Mentor)	FPGA design
Synopsys	CMOS design/synthesis
Xilinx ISE	FPGA design
Actel Designer	FPGA design
Coware	ASIP developement
SystemC	PHY level analysis
VSIM	HW simulatiom

Fig. 2.24 provides a survey on the specific simulation tools used. matlab/simulink-based tools are used in 26% of the simulators, whereas home-made software tools written in C/C++ represent 19%. Interestingly, 11% of tools are based on it++ platform, whereas 44% of the tools use 24 different platforms. Among these, 4% of tools are based on ns2 platform. Fig. Fig. 2.25, to Fig. 2.28, show the purposes of the analysis for the first four platforms: c/c++, matlab/simulink, it++ and ns2. As expected, while the fields of investigation of c/c++, matlab/simulink and it++ platforms are very general, ns2 is basically used for upper layers analysis. Finally, Tab. 2.1, shows the main purposes of analysis for the remaining 23 platforms.

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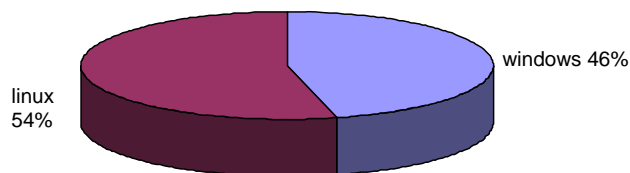
Eliminato: Tab 2.1

**2.3.5 Question 3.5 - Tools for Software Defined Radio**

The question aims at collecting information on the kinds of platforms used for software defined radio (SDR) in NEWCOM++

Tool	Programming language	Supported OS: Windows, Linux, Unix, other	Commercial, open source, freeware	Purposes of the analysis	General comments

Answers:



**Fig. 2.29 Supported OS (13 answers)**

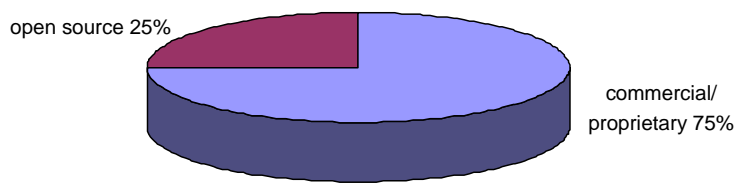


Fig. 2.30 Kind of platform (8 answers)

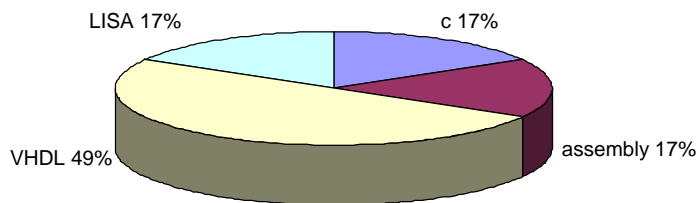


Fig. 2.31 Programming languages (6 answers)

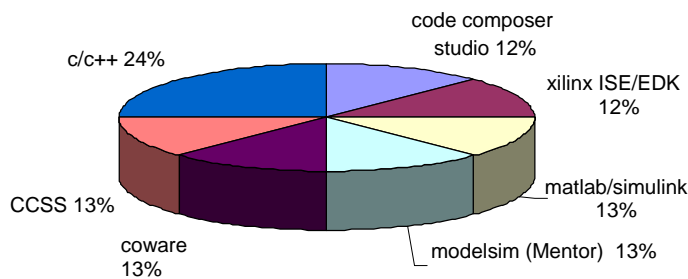


Fig. 2.32 SDR tools (8 answers)

Tab. 2.2 Purposes of the SDR tools

Simulation Tool	Purposes
code composer studio	Baseband processing
xilinx ISE/EDK	Prototyps
matlab/simulink	Debugging, algorithm analysis/design
modelsim (Mentor)	HW simulation
cowaare	HW simulation
CCSS	HW simulation
c/c++	emulation

Fig. 2.29 indicates that about 50% of the platforms used for SDR use Windows as OS, the remaining use Linux, whereas the majority of the platforms are commercial/proprietary (75%). Fig. 2.31 shows that VHDL is the major program language for SDR (49% followed by LISA (17%), C (17% and Assembly (17%). 24% and 13% of the tools for SDR is home-made software written c/c++ and matlab/simulink, other relevant tools are cowaare (13%), CCSS (13%), modelsim (13%), code composer studio (12%), xilinx ISE/EDX (12%). Main purposes of the analysis on SDR are illustrated in Tab. 2.2.

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Eliminato: Tab. 2.2



### 2.3.7 Question 3.7 - Advantages/disadvantages

NEWCOM++ researchers are asked to indicate pros and cons of the simulation/emulation platforms they use.

*Question: Could you indicate some advantages (i.e.: easy to use, flexible,...) and disadvantages (i.e.: expensive, requires a long period of training, ...) of the simulation platform you are using?*

*Answers:*

**Tab. 2.3 List of advantages/disadvantages**

Tool	Advantages	Disadvantages
c/c++	Fast, development environments, low cost, flexible	development time, careful management of computer resources (RAM...CPU), need for detailed documentation, difficult debugging, limited data visualization, limited libraries
ns2	open source/freeware, several modules available, commonly used	not easy to use, poor accuracy wireless channel models, bugs, documentation
omnet++	open source/freeware, several modules available, fast, interaction with it++	very modular but wireless modules are not reliable, installation is not easy, difficult to install
topcom++	fast (implemented in C++)	not freeware, slow
matlab	user friendly, fast learning curve, large number of build-in functions, easy management of matrices/vectors, debugging capability	Commercial, not customisable, expensive
Xilinx ISE	Easy to use	limited support code
NCSim/synopsys	reliability/management of complex design	long training period
opnet	user friendly, complete sim platform, oriented to simulation of networks, graphic interfaces	Expensive, complex parameterization, not adequate for low levels
Java	Flexible/portable, possibility to write GUIs	no specific support for wireless channels, no powerful enough to write emulator
DummyNet	Simple set-up, use of real end-application and transport protocols	no dynamic control, no functionality for wireless channel, only IP level emulation, only available on FeeBSD
KauNet	simple set up, use of real end-application and transport protocols, fine control of errors and delay, flexible, open source	no functionality for wireless channel, no support for high level scenarios with mobile users, only IP level emulation, only available on FeeBSD, smaller user base
it++	easy to use, libraries available, open source, multi-platform, fast, good community support, flexible	few source coding tools, modest documentation, no command line interface, no plotting functionality, steeper learning curve
SEMCAD X	Reliable, simple user interface	high computer memory is required, whole body of libraries is expensive
GBCM	realistic channel models	no ray tracing (only statistical results)
CST	very reliable, simple user interface	high computer memory requirements
WIPL D	very reliable	not user friendly
Tossim	user friendly, flexible	requires application developed in nesC/TinyOS, only applicable to WSN
ModelSim	accurate results at gate level	Low level verification tool
SystemC	support hardware primitives, open source	Slow
VSIM	support with SystemC modules	Expensive, slow

Tab. 2.3 indicates main advantages and disadvantages of the simulation/platforms used by NEWCOM++ researchers.

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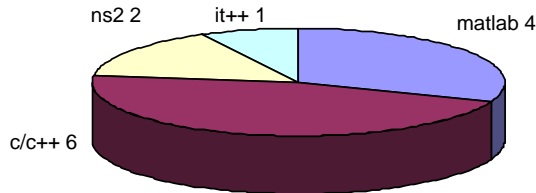
**2.3.8 Question 3.8 - Software Modules**

The question aims at collecting information on which software modules researchers wish to make available in NEWCOM++.

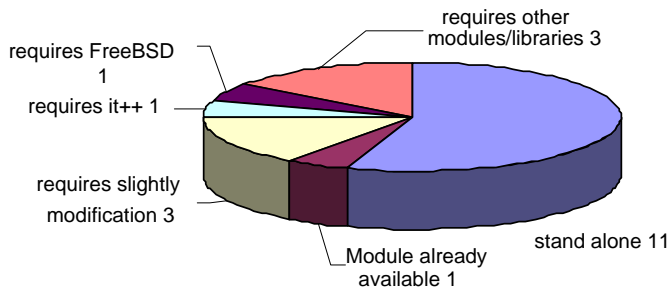
*Question: Will you make available simulation modules in NEWCOM++?*

Platform (C, C++, ns-2,...)	Description of the module	Is a stand alone module? Does the module need to be modified to be integrated by other partners? (provide some details)	WPR (or WPRs) of reference

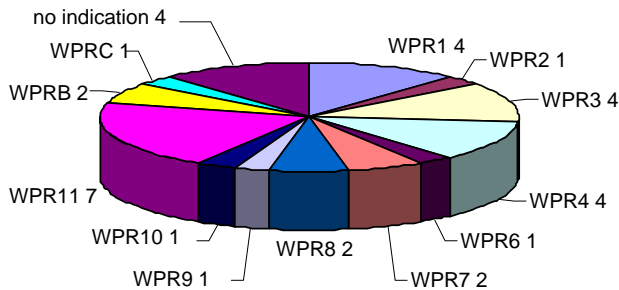
Answers:



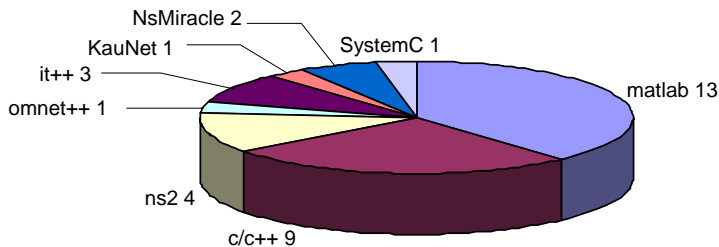
**Fig. 2.35 Software modules made available**



**Fig. 2.36 Requirements for the software modules that are made available**



**Fig. 2.37 Software modules per WPR**



**Fig. 2.38 Platforms of the modules.**

Fig. 2.35 shows the number and the platforms of software modules to be made available within NEWCOM++ community. Note that questionnaires were distributed at the beginning of the joint activities of the NoE, this number is expected to increase significantly in the next months. Fig. 2.36 indicate the requirements of these software modules to be used by any people. About 50% are stand alone modules but the others require additional modules, a specific OS, and slight modifications of the software. Fig. 2.37 shows the modules distributed among WPRs. Finally, Fig. 2.28 shows the platforms of the modules. As expected the majority of these modules are based on matlab/simulink and c/c++.

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Eliminato: Fig. 2.36

Eliminato: Fig. 2.37

Eliminato: Fig. 2.28

**2.3.9 Question 3.9 - Development of simulation modules**

NEWCOM++ researchers are asked about their availability in implementing new modules for the own platforms in NEWCOM++.

Question: Are you going to implement new simulation modules in NEWCOM++?

Tool (C, ns-2,MathLab...)	Description of the module	WPR (or WPRs) of reference

Answers:

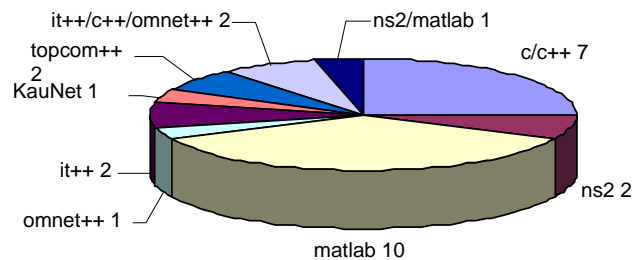


Fig. 2.39 Platforms of the software modules

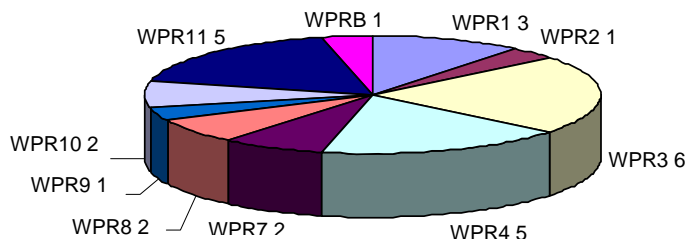


Fig. 2.40 Software modules per WPR

Tab. 2.4 List of modules per WPR.

WPR	Purposes of the module
WPR1	indoor propagation, channel estimation, channel modelling
WPR2	transceiver design
WPR3	resource allocation, channel modelling, modulation and coding, signal processing, random number generators using SFMT, PHY level for IEEE 802.16, adaptive modulation and coding (AMC)
WPR4	modulation and coding, equalization, receiver architecture, random number generators using SFMT
WPR5	
WPR6	
WPR7	tool for robust packet segmentation, robust header decoding
WPR8	Scheduling
WPR9	Scheduling

WPR	Purposes of the module
WPR10	
WPR11	routing, mobility modelling, support for opportunistic networking
WPRA	
WPRB	positioning estimation
WPRC	

Fig. 2.39 indicates the reference platforms of the new modules. Fig. 2.40 shows the distribution among WPRs. Tab. 2.4 provides an indication on the research purposes of the new modules.

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Eliminato: Tab. 2.4

**2.3.10 Question 3.10- Contributions to simulation tools**

NEWCOM++ researchers are asked to indicate their availability (if any) to contribute to some simulation platform.

Question: Can you provide contribution to any simulation tool?

Simulation Platform	Documentation (reference documentation of modules, tutorial examples, installation/configuration manuals,...)	Bug-fixes, usability and portability improvements

Answers:

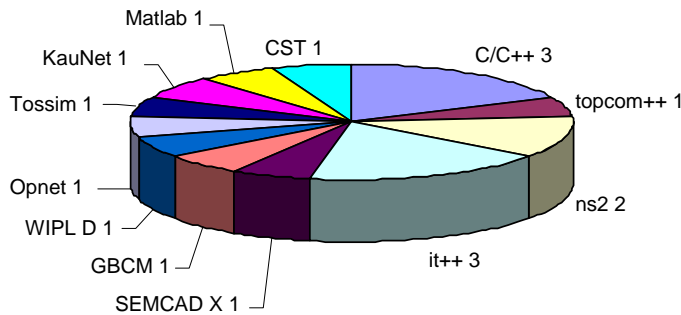


Fig. 2.41 Number of contributions to simulation tools

Tab. 2.5 List of contributions.

Tools	Contribution
C/C++	documentation of own modules, tutorials, installation/configuration,
topcom++	general documentation
ns2	tutorials
it++	general documentation, bug-fixes, usability and portability improvements, tutorials, examples
SEMCAD X	brief description
GBCM	general documentation
WIPL D	tutorials, installation/configuration, examples, brief description
Opnet	brief description
Tossim	general documentation, installation/configuration
KauNet	general documentation, bug-fixes, usability and portability improvements,
matlab	tutorials, examples
CST	brief documentation

Fig. 2.41 shows NEWCOM researchers are available to give a contribution for 12 different platforms. In particular it++ (jointly with c/c++) with 3 indications of availability is the more cited platform. Tab.

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2.5 shows the list of possible contributions. Researchers willing to contribute to It++ platform can give a contribution on general documentation, usability and portability, provision of tutorials and examples.

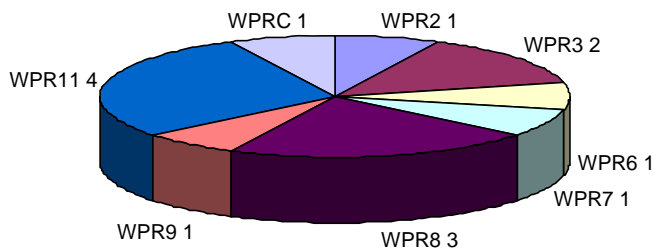
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**2.3.11 Question 3.11- Shared simulation tools**

NEWCOM++ researchers are asked to indicate if they are sharing (or available to do) the own simulation platform (or modules) to other NEWCOM++ partners.

*Question: Have you planned to share with other partners the simulation platform you are using?*

WPR	Software tool/module	Will new modules be implemented? (Describe them)	Other partners	Aim of the analysis
WPR.1				
WPR.2				
WPR.3				
...				



**Fig. 2.42 Shared simulation tools per WPR**

Fig. 2.42 shows the distribution of shared platforms/modules per WPR. 8 out of 14 WPRs have already identified platforms to be shared. Finally, Tab. 2.7, which is organized per WPR, indicates the software tools to be shared, the two partners involved, and the purposes of the analysis.

**Tab. 2.6. List of tools/modules/partners/aim of analysis per WPR.**

<b>WPR</b>	<b>software tool</b>	<b>new modules</b>	<b>partners</b>	<b>aim of the analysis</b>
WPR1				
WPR2	matlab	transceiver design with partial CSI		Impact of partial CSI on the transceiver design
WPR3	matlab, c++	channel models, channel encoder/decoders	Bilkent-NKUA/IASA, CNIT-UCL	analysis of adaptive modulation and coding (AMC)
WPR4				
WPR5				
WPR6	one but no indication			
WPR7	it++	joint source/channel coding/decoding	CNRS-FTW	improve reliability with transmissions over wireless channels
WPR8	matlab, c/c++	scheduling algorithms, new traffic model, Wimax platform	CNIT-NKUA/IASA	scheduling
WPR9	c/c++	new scheduling algorithms		scheduling
WPR10				
WPR11	ns2, KauNet	mobility module, opportunistic networking	CNIT-CNRS, CNIT-CNRS, KaU-CNRS	routing algorithms, study of information dissemination, E2E performance evaluation
WPRA				
WPRB				
WPRC	one but no indication		CEA-LETI-CNRS	NoC platform, develop partial FPGA reconfiguration

### 3. ARCHITECTURE OF THE NEWCOM<sup>++</sup> SOFTWARE SIMULATION LIBRARY

#### 3.1 General architecture

The results of the questionnaire ‘Recognition on NEWCOM<sup>++</sup> Simulation Tools’ allow us the identification of the main elements which set up the SSL. Results of question 2.1 indicate that NEWCOM<sup>++</sup> community support the idea of having a web-site where information on the existing simulation tools can be easily available. It is worth noting that the classification of the platforms is made necessary by the large number (24) of different simulators used in NEWCOM<sup>++</sup> (see also answer to Question 3.4 - Fig. 2.24). The information on the simulation platforms should comprise the classification of the platforms, the collection of manuals, the creation of FAQs, installation guides and examples of application. Furthermore, the idea to focus on one or two specific simulation platforms and provide them additional information is also supported by several NEWCOM<sup>++</sup> researchers. Owing to the limited effort, we have decided to focus on a single platform. IT<sup>++</sup> has been chosen to be the reference platform. The choice of this platform has been motivated by the following considerations: i) it<sup>++</sup> is used by about 11% of NEWCOM<sup>++</sup> researchers (which makes it the third platform after matlab-based and c/c++-based simulators); ii) several researchers of NEWCOM<sup>++</sup> have a large experience with this platform (see answer to Question 3.6) and are willing to contribute (see answer to Question 3.10); iii) this activity can take advantage from the activity carried out by WL3 of NEWCOM, which was focused on it<sup>++</sup>.

The previous guidelines have been elaborated to create a first version of the SSL architecture for the SSL. A graphical illustration of the SSL in terms of block diagrams is shown below.

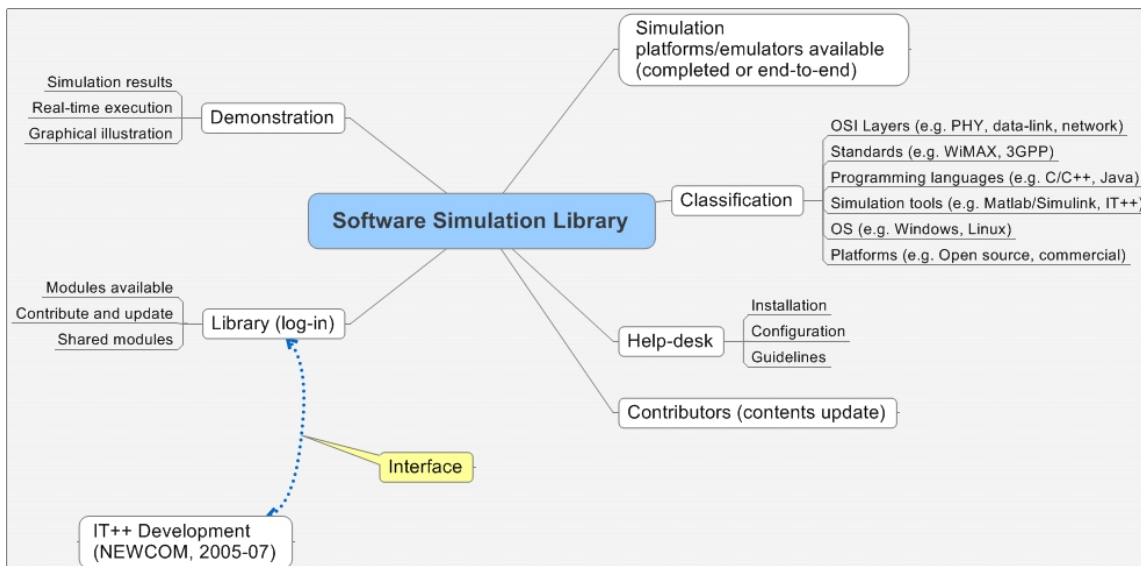


Fig. 3.1 Graphical illustration of the software simulation library

Let us note that the “Software Simulation Library” in Fig. 3.1 is not a separate architectural building block, but the core of the presented architecture, which consists of seven main blocks. More specifically:

- *Simulation platforms/emulators available*: These are end-to-end simulators/emulators already developed by NEWCOM ++ partners.
- *Classification*: The available simulators are classified with respect to: (i) the OSI layers they correspond to, (ii) their application on particular standards, (iii) the programming language,

- (iv) the simulation tools that have been used, (v) the operational system (OS), in which they have been developed; and (vi) the type of platform, under which they have been executed.
- *Help-desk*: The help-desk provides support to the simulation library development with typical responsibilities, such as installation, configuration process, and other guidelines.
- *Contributors*: This is a list of persons who contribute to the simulation library, and who are responsible for the contents update.
- *Library (Log-in)*: After appropriate authentication, users can contribute and update the simulation library development. They can also provide some shared modules to the other users. An interface with the IT<sup>++</sup> simulation library could be useful in terms of general structure for the contents development.
- *Demonstration*: Simulation results can be depicted by the available simulators. Users are also able to run an executable file in real-time simulation.
- *IT<sup>++</sup> Development (NEWCOM, 2005-07)*: It is a link to the IT<sup>++</sup> simulation library developed in NEWCOM and its short description.

The simulation tools may have links in different blocks under ‘Classification’. For instance, consider a tool X, which addresses PHY layer issues, is written in C++ and runs on Windows system. Then, it will have three links in ‘Classification’ block.

The ‘Software simulation library’ can have two entities; (i) One for external use; and (ii) One for internal use. That is, a public web site for non-NEWCOM<sup>++</sup> members and contents, such as ‘Simulation platforms available’, ‘Demonstration’, ‘Help-desk’, etc. On the other hand, the ‘internal’ web site requires appropriate authentication. It can be used by NEWCOM<sup>++</sup> partners to develop, upload and update contents, such as ‘Library’ and ‘IT<sup>++</sup> Development’ interface blocks.

In following, each corresponding block is described in more detail.

### 3.2 Simulation platforms/emulators available (completed or end-to-end)

The available end-to-end simulation platforms/emulators that have been developed throughout the project phase are listed here. Small description of these simulation platforms/emulators can be included. This is useful for both external and internal users (i.e. non-NEWCOM<sup>++</sup> and NEWCOM<sup>++</sup> members, respectively) to have an overall picture of what NEWCOM<sup>++</sup> has archived so far.

### 3.3 Classification

The different simulators been developed are classified in this part. The classification includes:

- *OSI layers*: The available simulators correspond to different OSI layers, e.g. physical layer, data-link layer, network, etc.
- *Standards*: There can be simulators that correspond to different standards (e.g. WiMAX, 3GPP, etc).
- *Programming languages*: The different simulators are based on programming languages, such as C/C++, Java, etc.
- *Simulation tools*: There are different simulation tools used for simulation development, such as matlab/simulink, IT<sup>++</sup>, etc.
- *OS*: Simulation development is done under different OS, such as Windows, Linux, etc.

- *Platforms*: Simulators are build using different platforms, such as Open source, commercial, etc.

### 3.4 Help-desk

To support the simulation library development, a help-desk is required to provide the users with useful information, such as installation, configuration process and other guidelines (e.g. manuals). Users may submit questions to the help-desk for additional support by email.

### 3.5 Contributors (contents update)

A list of contributors is provided in this part. Contributors are responsible for the contents update of the web-site/simulation library.

### 3.6 Library (log-in)

In this part, users after logging-in can contribute to the simulation modules development, update their contents, and provide modules to be shared with other users. An interface with the IT<sup>++</sup> simulation library can be useful for the contents development.

In particular, it has been identified, that this interface should enable the following actions:

#### 3.6.1 Accessing source code

The source code of any of the IT<sup>++</sup> library classes or functions can be accessed in two ways: (i) by downloading the whole IT<sup>++</sup> package, or (ii) by the Subversion (SVN) repository of the project at the SourceForge <http://itpp.svn.sourceforge.net/viewvc/itpp/>

There are usual subdirectories named *branches*, *tags* and *trunk* in the *itpp* directory at the SVN repository. The *itpp\_external* project includes companion mathematical libraries (FFTW, BLAS, CBLAS and LAPACK). The *trunk* is the location where the main development cycle goes on. *Branches* and *tags* are used for parallel development and maintenance of stable releases, e.g. *itpp-4-0* branch is used for maintaining the latest stable releases.

The Newcom Software Library can provide graphical access to the required branch of the IT<sup>++</sup> development tree and allow retrieving required modules or functions. One has to stress that a single source file (‘.cpp’ and the corresponding header ‘.h’ file) may include many classes and functions, e.g. all classes related to the communication channels (BSC, AWGN, multipath fading, etc.) are included in the *channel.cpp* file.

#### 3.6.2 Contributing modules to the IT<sup>++</sup>

The IT<sup>++</sup> is developed by the community of contributors from all around the world under the [GNU General Public License](#) (GPL) license and everybody can share its own code in order to provide new features or improve existing ones. The provided modules should include documentation with Doxygen comments in include (‘.h’) files. Source (‘.cpp’) files should be documented according to a common standard for well documented C++ code. Details of the documentation rules are provided at the IT<sup>++</sup> web page <http://itpp.sourceforge.net>.

Additionally, the IT<sup>++</sup> uses conventions regarding e.g. functionality, naming (classes, variables, files) and in smaller degree interface, which should be followed. The authors also should provide simple testing programs and data vectors, which should allow testing their modules after compilation of the library.

The IT<sup>++</sup> is free source code project, however it is administered, which means that contributors do not have administrative rights and cannot add or change project's source code. Each contributor must submit its module at the project's web page, and it will be later added to the projects by one of its administrators or developers.

The Newcom Software Library can redirect to this page or provide its own interface to it.

### 3.7 Demonstration

In this part, a demonstration of the available simulators can be shown, e.g. depicting available simulation results. A user can run an executable file in real-time simulation, and get a graphical illustration of the simulation output procedure.

### 3.8 IT<sup>++</sup> Development (NEWCOM, 2005-07)

A short description of the IT<sup>++</sup> simulation library during the first phase of NEWCOM is provided below.

IT<sup>++</sup> is a library of mathematical, signal processing and communication algorithms and data structures written in the C++. Many of the IT<sup>++</sup> features are provided by the means of classes, which depend on each other, also using the inheritance mechanism. The IT<sup>++</sup> has been designed and developed to provide help in the simulation of communication systems and for supporting research in the area of communications.

The IT<sup>++</sup> library was originally developed in the former department of Information Theory at the [Chalmers University of Technology](#) in Sweden, however after a few years it has developed a life of its' own. Right now the IT<sup>++</sup> is a free source code project developed by the community of contributors from all around the world under the [GNU General Public License](#) (GPL) license. The development of the IT<sup>++</sup> was supported by the NEWCOM project during years 2005-2007. The main web page of the project is hosted at the [SourceForge](#): <http://itpp.sourceforge.net>, also the [Subversion](#) (SVN) repository of the project is stored at the SourceForge: <http://itpp.svn.sourceforge.net/viewvc/itpp/>. The main web page includes the newest information about the project, help and complete documentation (which is also provided in the packages with the source code).

The IT<sup>++</sup> has been successfully compiled and run on many systems and architectures including wide variety of Linux systems, Sun Solaris, Microsoft Windows and Mac OS X. The kernel of the library consists of generic vector and matrix classes, and a set of accompanying routines. Such a kernel makes IT<sup>++</sup> similar to matlab or [GNU Octave](#). There are more similarities between IT<sup>++</sup> and matlab/Octave, e.g. in the function interfaces and naming conventions. The IT<sup>++</sup> makes an extensive use of existing open-source or commercial libraries for increased functionality, speed and accuracy. Use of the IT<sup>++</sup> without those libraries is possible, but will result in reduced functionality. In particular, [BLAS](#), [LAPACK](#) and [FFTW](#) libraries can be used. Some optimized platform-specific libraries can be used as well, i.e.:

- [ATLAS](#) (*Automatically Tuned Linear Algebra Software*) – includes optimized BLAS and a limited set of LAPACK routines;
- [MKL](#) (*Intel Math Kernel Library*) - includes all required BLAS, LAPACK and FFT routines and is provided by Intel for its processors. The MKL for the Linux is provided for free;
- [ACML](#) (*AMD Core Math Library*) - includes BLAS, LAPACK and FFT routines and is provided for free by AMD for its processors.

The main programming features of the IT<sup>++</sup> include templated array and stack container classes, input and file argument parser and timing functions and classes. The IT<sup>++</sup> provides wide variety of mathematical functions and data types including templated vector and matrix classes and binary and

Galois data types. The IT<sup>++</sup> includes statistics classes and functions, matrix decomposition (e.g. eigenvalue, Cholesky, LU, Schur, SVD, and QR) functions, generators of random numbers and functions allowing among other things solving linear system of equations, integration of 1-dimensional functions and unconditional nonlinear optimization (Quasi-Newton search).

The IT<sup>++</sup> provides filter and windowing functions and their classes both in the time and in the frequency domain, FFT, DFT, DCT and Hadamard transforms and other signal processing features. The IT<sup>++</sup> includes wide variety of communication tools, like modulators (also for the OFDM, CDMA and MIMO systems), pulse shaping filters, channel models (BSC, AWGN and multipath fading channel models), interleavers and extensive library of the error correction codes (Hamming, extended Golay, CRC, BCH, RS, convolutional codes, turbo codes and LDPC codes).

The IT<sup>++</sup> includes also some classes for the protocol simulation, audio coding, speech processing and reading and saving images in the PNM format.

#### 4. CONCLUSIONS

This first WPI4 report has addressed the current assessment of needs and expectations of the NEWCOM<sup>++</sup> software simulation library, a web-platform which will allow to classify and organize the simulation and emulation tools used by NEWCOM<sup>++</sup> partners. The SSL will give the possibility to all users (both involved and not involved in NEWCOM<sup>++</sup>) willing to use simulation/emulation tools to find the comprehensive support and to be advised on using these tools.

The answers collected from the distributed questionnaires are presented in the graphical form in this report. The collected information has become the basis for determining the architecture of created WPI4 web-site, a practical realization of the SSL concept, and has defined its seven main blocks, which will be considered in the design phase. Inter alia, the simulation platforms or emulators already developed by NEWCOM<sup>++</sup> partners will be available and logically classified with respect to various criteria. The rich-in-content help-desk will provide sufficient support to the simulation library development. Moreover, it must be stressed, that simulation results can be depicted by the available simulators and the users will be able to run an executable file in real-time simulation. The created software simulation library, that will be also associated with the NEWCOM project achievements, conduces to the assurance of continuity of the idea of fostering the cooperation between partners by the means of the use of common research tools.

Once again let us recall and stress, that the creation of the SSL will facilitate the exchange of knowledge and experience with different simulation tools, the common definition of reference scenarios and the exchange of programmes, results and methodologies. To reach this target specified in Technical Annex, the great emphasis will be devoted to the concept of x-layer simulation and possible interactions between simulators and emulators.

**ANNEX: TEXT OF THE QUESTIONNAIRE****1. General information**

<b>Institution</b>	
<b>Responsible (name and email)</b>	
<b>Contact person for the liaison with WPI.4 (name and email)</b>	

**WPRs in which your institution is involved.**

WPR.1	WPR.2	WPR.3	WPR.4	WPR.5	WPR.6	WPR.7
WPR.8	WPR.9	WPR.10	WPR.11	WPR.A	WPR.B	WPR.C

(put a cross on the WPRs)

## 2. WPI.4 and NEWCOM<sup>++</sup> people

Indicate the main actions you believe are necessary to use and possibly integrate the different simulation platforms used in NEWCOM<sup>++</sup>

**2.1 Actions: rank the following proposals in order of importance for your institution (1-the most important,...)**

The WPI.4 should	Rank	Comment (optional)
Identify one or few relevant simulation platforms and create a software library.		
Identify possible missing software modules in the software platforms used by NEWCOM <sup>++</sup> partners and provide guidelines for their implementation.		
Classify the different platforms used in NEWCOM <sup>++</sup> according to their characteristics and research fields.		
Create a section in the NEWCOM <sup>++</sup> portal (the WPI.4 web-site) which contains information and characteristics on the different simulation tools used by NEWCOM <sup>++</sup> partners.		
Collect simulation results obtained by WPRs and classify them based on simulation platforms and research fields		
Create a “simulation platform help-desk” to give information to people willing to use a given simulation tool. The help-desk gives suggestions and detailed information (how to install, how to configure,...) about the specific simulation platform, or give suggestions on the most suitable platforms to investigate a given problem.		
(other comments)		

### 2.2 WPI.4 web-site (internal to the NEWCOM<sup>++</sup> portal)

Question	YES	NO
Do you think the implementation of the WPI.4 web-site would be useful to provide information on the different simulation tools used in NEWCOM <sup>++</sup> ?		
Do you think NEWCOM <sup>++</sup> people would use the WPI.4 web-site?		
Would you contribute to create the web-site?		
Would you contribute to update the web-site?		

**2.3 Contributions**

<b>Question</b>	<b>Answer</b>
<b>Which information should the WPI.4 web-site contain?</b>	
<b>Are you available to contribute to the web-site?</b>	(if yes, please, indicate for which platform you can contribute)
<b>Are you available to contribute to the “simulation platform help-desk”?</b>	(if yes, please, indicate for which platform you can contribute)

### 3. Recognition on NEWCOM++ simulation tools

#### 3.1 WPRs in which your Institution is using (or you have planned to use ) simulation tools

WPR.1	WPR.2	WPR.3	WPR.4	WPR.5	WPR.6	WPR.7
WPR.8	WPR.9	WPR.10	WPR.11	WPR.A	WPR.B	WPR.C

(put a cross below each WP)

#### 3.2 WPRs in which your Institution is using (or you have planned to use ) emulators <sup>2</sup>

WPR.1	WPR.2	WPR.3	WPR.4	WPR.5	WPR.6	WPR.7
WPR.8	WPR.9	WPR.10	WPR.11	WPR.A	WPR.B	WPR.C

(put a cross below each WP)

#### 3.3 Simulation's layers

NEWCOM++ addresses several topics in wireless communications, simulation tools are commonly used to investigate some aspects of the OSI layers. Please, indicate which layers are you considering with your simulation tools and which purposes

Layers/	Put a cross on the layers of interest (multiple crosses are allowed)	Purposes of the analysis (link level analysis, channel modelling,...)
Physical		
Data link		
Network		
Transport		
Application		
X-layer (indicate the layers)		

#### General comments (optional)

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<sup>2</sup> An **emulator** duplicates (provides an **emulation** of) the functions of one system using a different system, so that the second system behaves like (and appears to be) the first system. Emulators can be **software** as well as **hardware**.

### 3.4 Simulation platforms

Please, indicate which kind of simulation/emulation platforms do you use in NEWCOM<sup>++</sup>.

Simulation Tool	Programming language	Supported OS: Windows, Linux, Unix, other	Commercial, open source, freeware	Purposes of the analysis	General comments

(add lines if you need)

#### General comments (optional)

### 3.5 Tools for Software Defined Radio

Tool	Programming language	Supported OS: Windows, Linux, Unix, other	Commercial, open source, freeware	Purposes of the analysis	General comments

#### General comments (optional)

### 3.6 Experience

Can you rank the experience of your group with these platforms?

- 1: no experience
- 2: sometimes used
- 3: frequently used
- 4: expert

Tool	TOSSIM	OPNET	OPNET <sup>++</sup>	Ns-2	others	others
Experience 1:4						

Tool	C	C <sup>++</sup>	Java	Matlab	others	others
Experience 1:4						

In the case you indicate 4 (expert) in one of the boxes, please indicate also the contact person (name, email)

**General comments (optional)**

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**3.7 Advantages/disadvantages**

Could you indicate some advantages (i.e.: easy to use, flexible,...) and disadvantages (i.e.: expensive, requires a long period of training,...) of the simulation platform you are using?

Simulation platform	Advantages	Disadvantages

**3.8 Software Modules**

Will you make available simulation modules in NEWCOM<sup>++</sup>?

Platform (C, C++, ns-2,...)	Description of the module	Is a stand alone module? Does the module need to be modified to be integrated by other partners? (provide some details)	WPR (or WPRs) of reference
(add boxes if you need)			

**General comments (optional)**

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**3.9 Development of simulation modules**

Are you going to implement new simulation modules in NEWCOM<sup>++</sup>?

Tool (C, ns-2, MathLab...)	Description of the module	WPR (or WPRs) of reference
(add boxes if you need)		

**General comments (optional)**

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**3.10 Contributions to simulation tools**

Can you provide contribution to any simulation tool?

Simulation Platform	Documentation (reference documentation of modules, tutorial examples, installation/configuration manuals,...)	Bug-fixes, usability and portability improvements

**General comments (optional)**

--

**3.11 Shared simulation tools**

Have you planned to share with other partners the simulation platform you are using?

WPR	Software tool/module	Will new modules be implemented? (Describe them)	Other partners	Aim of the analysis
WPR.1				
WPR.2				
WPR.3				
WPR.4				
WPR.5				
WPR.6				
WPR.7				
WPR.8				
WPR.9				
WPR.10				
WPR.11				
WPR.A				
WPR.B				
WPR.C				

**General comments (optional)**

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