



FP7 – 216693 - MULTICUBE Project

MULTI-OBJECTIVE DESIGN SPACE EXPLORATION OF MULTI-PROCESSOR SOC
ARCHITECTURES FOR EMBEDDED MULTIMEDIA APPLICATIONS

Deliverable D2.1.1: Initial Performance and Power Estimation Prototype Tool Revision [4]

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PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	
Nature of Deliverable		
R	Report	
P	Prototype	X
D	Demonstrator	
O	Other	



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Abstract: This deliverable (issued at M12) presents the results of the activity carried on from M4 to M12 in Task 2.1 (Open-source, performance and power consumption estimation framework) under the leadership of UC, with contributions from ESTECO and reviewed by POLIMI and DS2.

The main goal of this deliverable is the creation of an initial prototype tool for performance and power estimation following the Multicube specifications. The prototype tool is called Multicube-SCoPE. The current, initial version of Multicube-SCoPE is composed of SCoPE v1.1.0 and the plug-in M3P v1.0.2. The M3P is a SCoPE plug-in providing the Multicube required new features to interface the Multicube tools. Additional work has been performed in SCoPE in order to support these new features, resulting in a new SCoPE version v1.1.0. More in general, Multicube-SCoPE initial prototype provides new functionalities for automatic system model generation and configuration, and automatic metric reporting. The tool will be updated with new optimizations to reduce simulation times and new features to accurately model the Multicube use-cases, producing the final version of the prototype at M24 (D2.1.2).

This report contains:

- A summary of the structure and functionality of the initial version of Multicube-SCoPE.
- The current internet address of the web page from which the Multicube-SCoPE can be downloaded.
- A snapshot of the current Multicube-SCoPE web site content.
- Summary of improvements performed inside the SCoPE code.

The Project Coordinator

Approved by the Project Coordinator:



Date: February 12th, 2009



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1. Executive summary

The main goal of this deliverable is the creation of an initial prototype tool for performance and power estimation following the Multicube specifications. The prototype tool is called Multicube-SCoPE. The current, initial version of Multicube-SCoPE is composed of SCoPE v1.1.0 and the SCoPE plug-in called M3P v1.0.2.

The prototype tool is based on a previous tool called SCoPE. SCoPE is a tool capable of simulating SystemC systems and providing some performance and power information. However, automatic system model generation and configuration, or automatic metric reporting are completely not supported by previous SCoPE versions. Furthermore, additional features must be added to model the use-cases proposed in Multicube.

The improvements performed internally in SCoPE to support the Multicube DSE flow are mainly related to automatically obtaining system metrics and simplifying system model construction. Furthermore, in order to support the Multicube use cases, new features have been added, such as parallel multi-thread management. The additional work has been performed in SCoPE in order to support these new features, and is currently included in a new SCoPE version: v1.1.0.

M3P is the SCoPE plug-in providing the additional facilities developed to support the Multicube required new features. This plug-in provides the new services to support the Multicube requirements specified in D1.1 and D1.4.1.

The new Multicube-SCoPE framework presents the following features:

- **Automatic System Model Generation**

The open source tool provides a XML input capable of creating the system models from XML descriptions. This capability allows dynamically creating the system models, and thus, dynamically supporting any system modification that want to be explored by the Design Space Exploration (DSE) tools. As a consequence, DSE process can be completely performed without compiling the simulation model, and thus reducing the exploration time.

- **Automatic System Configuration**

The tool provides a second XML input to easily modify the system configuration in order to perform the DSE process.

- **Automatic Metric Reporting**

The tool is capable of automatically reporting a list of system metrics, following D1.1. The metrics the user wants to be reported must be indicated through a XML file at the beginning of the simulation. When a simulation finishes, a new XML file with the results is automatically created.

- **Portability**

The tool is portable across a wide range of systems. This goal is achieved by not sacrificing the efficiency of the overall exploration engine. The standard ANSI C++



programming language is used for developing the open source framework. The Standard Template Library as well as other open source libraries are used during the development process.

- **Multiple executions**

The tool has been adapted to allow multiple concurrent executions in different directories with complete independence among them. This feature allows the exploration tool to run several instances of the simulation to speed up the exploration process.

Multicube-SCoPE is distributed under the GPL license,.

The tool will be improved with new optimizations to reduce simulation times and new features to accurately model the Multicube use-cases, producing the final version of the prototype (D2.1.2).

This report is structured as follows. Section 2 presents the link to the website from which Multicube-SCoPE can be downloaded. Section 3 contains a summary of content of the website where the source code, license and documentation can be found. Section 4 presents a brief description of the main modification performed in the SCoPE tool. Finally, section 5 describes the features of the new M3P plug-in.



II. Link to the webpage of the prototype

The public website of the Initial Prototype of the Open-Source MULTICUBE Exploration Framework can be reached by following the appropriate link on the MULTICUBE official website under the open-source tools page:

http://www.multicube.eu/open_source.html

Alternatively, the initial prototype of the Open-Source *MULTICUBE-SCoPE* can be reached directly with the following link:

<http://www.teisa.unican.es/gim/en/scope/multicube.html>

The following figure is a snapshot of the home page:

Multicube-SCoPE

Welcome to the **Multicube-SCoPE** project website! This project has been developed by GIM-TEISA department at the University of Cantabria (GIM-TEISA-UC) and funded by the FP7 EU Project MULTICUBE. This FP7 EU project aims at the development of a design exploration flow covering several abstraction levels based on the application of several *multiobjective design space exploration* techniques by means of a multi-objective exploration engine and multilevel simulation tools to achieve automatic architectural (hardware) and run-time (software) optimizations of MPSoCs.

Multicube-SCoPE is an evolution of SCoPE oriented to **Design Space Exploration (DSE)**. Multicube-SCoPE is a fast system performance analyzer capable of supporting dynamically configurable XML system descriptions. Multicube-SCoPE automatically provides the system metrics required to drive the DSE process. Multicube-SCoPE is the result of combining two elements: the new **SCoPE** version (v1.1.0) and the **M3P** plugin for SCoPE.

M3P is an *open source* plug-in developed by the GIM-TEISA-UC to integrate SCoPE within the MULTICUBE project design flow. It is the extension of the **SCoPE System-level Simulator** which allows the simulation tool to communicate with a *multicube Explorer* performing the DSE using the XML interface defined within the MULTICUBE project to exchange system configuration and system metrics data.


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Figure 1: Screenshot of the home page of the public website of Multicube-SCoPE

III. Website content

The website is composed of the following web pages:

- Home
- Source
- Installation
- Developers

The following sections describe in detail the content of each page with a small summary highlighted in *italic*.



III.1. Home page

This page is the welcome page for the Multicube-SCoPE Open Source Tool. It gives a brief overview of the tool goals and features and provides information on the people involved in the development.

The *home page* introduces Multicube-SCoPE tool. This tool represents the extension of the previous tool SCoPE for Design Space Exploration. Multicube-SCoPE is a combination of the new SCoPE version (v1.1.1) and the M3P plug-in.

Then, the web introduces the MP3 plug-in and how it fits within the MULTICUBE exploration framework as the piece of software that enables the SCoPE system level simulation communicate with the design space simulation tool following the XML interface definition established by the MULTICUBE project to exchange system configuration and metrics results. The following figure shows the MULTICUBE design space exploration and simulation framework highlighting the M3P and SCoPE pair as the core of this deliverable.

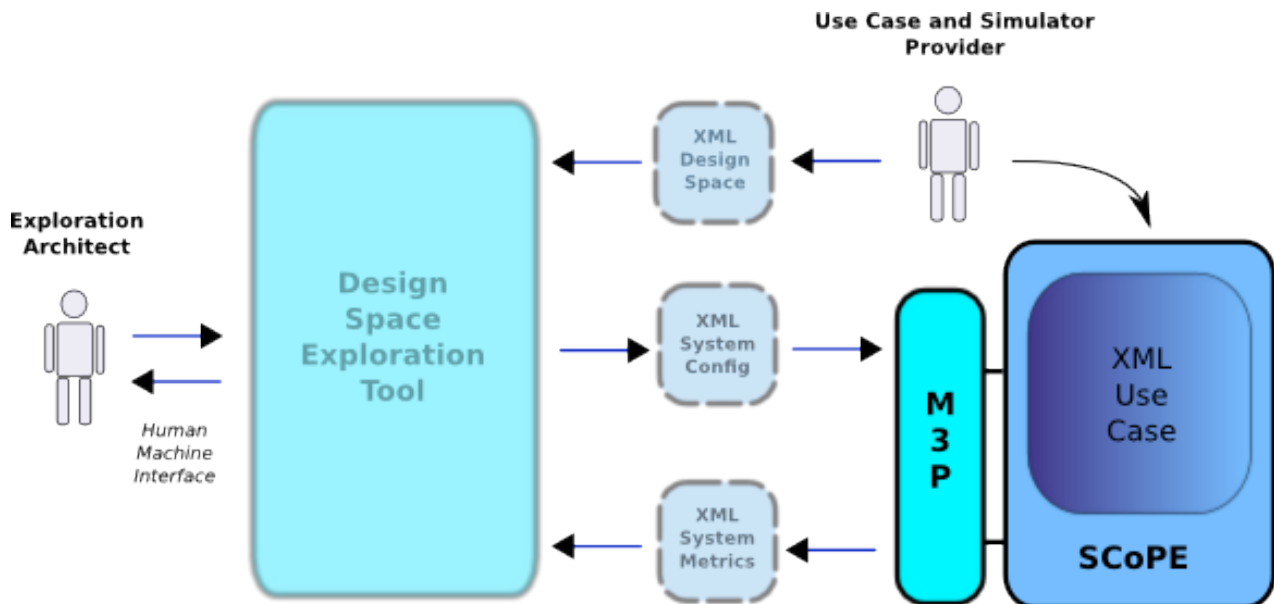


Figure 2: Screenshot of the home page of the public website of Multicube-SCoPE Simulator.

In addition to the introductory information stated above, the home page also emphasizes the funding and objectives of the FP7 EU MULTICUBE project to give a proper context and credits to the Multicube-SCoPE tool introduction.

III.2. Download page

This page provides the link to download the elements that compose the initial prototype of the Multicube-SCoPE open-source performance and power estimation tool for DSE.

The source page briefly describes all the source code developed in this deliverable and gives the instructions to download the Multicube-SCoPE components: SCoPE and M3P. A pack with all the Multicube-SCoPE components can be downloaded from the web page.

Furthermore, links for downloading the Multicube-SCoPE components separately are also reported. The M3P plug-in sources and documentation can be downloaded directly from this web page.

A link to the SCoPE website is provided together. At the official SCoPE web page can also be found the documentation required to understand how to use the tool. This documentation includes the user manual and the developer API reference manual.



Figure 3: Screenshot of the download page of the public website of Multicube-SCoPE Simulator.

The download page includes a link to an auto-installation script which allows the user to automatically install and configure the M3P plug-in and example together with the SCoPE tool thus avoiding the somewhat painful installation and configuration steps that must be followed if performing manually the whole installation process with each piece of software.

The downloadable packages also include an application example based on a MPEG4 codec developed by IMEC, a partner of the MULTICUBE project, adapted to be run and simulated within the M3P + SCoPE framework. This element can be found in the private area of the Multicube web site.



Latest stable release of M3P:

February 09th, 2009 - Release 1.0.2



III.3. Installation page

This page shows how to install the Multicube-SCoPE tool.

This page provides the instructions to configure and install all the elements needed to successfully use the Multicube-SCoPE tool. The page starts by indicating all the system requirements that must be checked out before trying the main configuration and installation steps. The GNU C/C++ tool chain, bison and flex analyzers and SystemC library are the system prerequisites.

After checking out that all the building tools and helpers are there, the first step of the configuration and installation process is to build SCoPE. It is a more or less trivial task after getting the proper sources that are available within the restricted area of the MULTICUBE project web site, setting some shell system variables and executing the command `make library`. More information can be found at the SCoPE web site:

<http://www.teisa.unican.es/scope>

Finally for the configuration and installation of the M3P plug-in and MPEG4 codec example the auto installation script should be used. Alternatively the installation page gives the steps to manually build the M3P library and MPEG4 example from the source code files that can be downloaded from the links provided in the source page.

home source installation developers

Multicube-SCoPE: The installation

In order to make **Multicube-SCoPE**, you have to check out the following list of *System Requirements*, pointing out the tools you need to do the job:

- GNU C/C++ toolchain: gcc/g++ (v4.x), make
- Bison and flex tools (as required by SCoPE)
- zlib-devel library

Of course, you'll have also to get a working installation of the *SCoPE system-level simulator* and the *SystemC 2.2 library* which is used by SCoPE to specify the system to simulate. You can download the latest stable release of SystemC library from the Open SystemC Initiative (OSCI) website. The required SCoPE latest stable release, which is version 1.1.0 (February 2009), must be downloaded from [SCoPE web page](#).

To get all the components working from scratch you must follow these steps:

1. Build SystemC
2. Build SCoPE
3. Build M3P
4. Build and run the adapted IMEC example

To do the first step you must read the SystemC documentation. Basically you must download and uncompress the package and then you must execute the sequence of commands: `configure`, `make` and `make install`. For building SCoPE you must follow these instructions:

1. Set the environment variables
 - `export SYSTEMC=[systemc installation path]`
 - `export SCOPE_HOME=[scope installation path]`
 - `export SCOPE_XML_PLUGIN=[scope-xml-plugin installation path]`
2. Uncompress the package and enter the SCoPE directory
3. Execute: `make libraries`

Figure 4: Screenshot of the installation page of the public website of Multicube-SCoPE Simulator.



III.4. Team page

This page shows some information about the development team.

This page shows some information about the development team and their relationship with the GIM-TEISA department at the University of Cantabria and a mention to the funding from FP7 EU project.

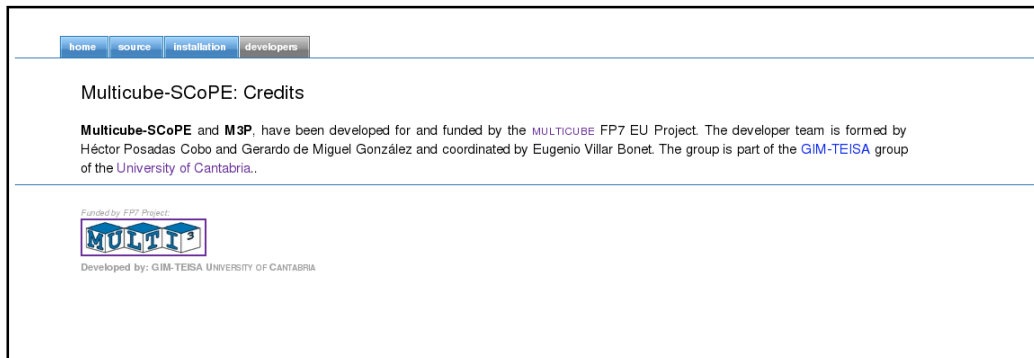


Figure 4: Screenshot of the credits page of the public website of Multicube-SCoPE Simulator



IV. Improvements to SCoPE internals

SCoPE is a SystemC library capable of performing timed simulations of embedded systems composed of SW components running over TLM HW platform models. In addition SCoPE obtain some default metrics about system performance and power consumption of these SW components. The goal of SCoPE is to provide the designer with a fast and sufficiently accurate emulation of the system behavior for functionality verification and constraints checking.

However, Multicube project presents a different approach. In the project the goal is to check the system performance when modifying the platform. Multiple platform configurations for the same system are proposed and the performance estimations obtained are used to select the best possibilities. This new approach implies two new challenges to be resolved:

- Platform to be simulated cannot be a SystemC description. A SystemC description is a fixed C code describing the system components, and its interconnections. That code is compiled together with all the simulation executable, and thus cannot be dynamically modified. As a consequence, modifying the system components, as the type of bus, or the number of processors, require a complete recoding and compiling process.
- When simulating several times the same system, parts of the simulation can remain unchanged. Reusing information, the modeling of these parts can be improved, optimizing simulation speed.

Furthermore, the Multicube Use Cases require modeling elements not supported by the original SCoPE infrastructure.

To solve these limitations, the original SCoPE had to be improved. This extension has been included in the new SCoPE version, called v1.1.0

The main modifications performed in the SCoPE internal code are:

- Simplification of the platform model building process. Functions for connecting the system components, create the memory maps and loading SW tasks has been simplified in order to allow dynamic, automatic system model construction.
- Extensions of the system components default management. The HW system components that can be used to build the system inherits from a basic set of components. To support all the metrics required these basic components has been extended. The extended components support power features and are able of saving information about system communications and timing information. This information can be used to obtain the system metrics.
- Support for multi-thread parallelism. Previous versions of SCoPE allow modeling parallel execution of processes in multiprocessor systems. However, threads of the same process cannot be executed in parallel even when there are empty processors in the system. The multimedia example requires this level of concurrency, so the SCoPE internal mechanisms have been modified to support it.
- SCoPE operation has been fixed to guarantee concurrent execution of different simulations in order to optimize the use of the host infrastructure.



V. M3P characteristics

M3P is a plug-in for SCoPE which adapts SCoPE to be used for a Design Space Exploration process. Its initial version is centered on modifying the original SCoPE interfaces in order to comply with the Multicube requirements. The initial M3P features are focused on automatic system model building, automatic system configuration and automatic metric reporting.

- **Automatic System Model Building:** In order to allow a complete exploration of the design space, the M3P allows the complete building of the system model dynamically. The system architecture and characteristics are described in an XML file. From this XML file, M3P manages the SCoPE resources to build the system model. To allow the exploration, M3P support incomplete system descriptions. Thus the system is built depending on the configuration options. As a consequence the modeling technique is really flexible, allowing not only to explore the optimal characteristics of the system components, but also to analyze the whole system architecture.
- **Automatic system configuration:** M3P is prepared to accept the XML System Configuration files specified in the Multicube D1.1 and D1.4.1 documents. This capability allows M3P to consider automatically the different system configurations selected from the DSE tools to be analyzed.
- **Metric reporting:** M3P is prepared to get the output metrics required for the system exploration and automatically provide them to the DSE tools. M3P is capable of reading the XML Design Space Definition files specified within the Multicube project to know the metrics that must be reported. Furthermore, it automatically generates an XML output file with the metric results conforming with the Multicube specification.

These three capabilities guarantee the correct integration of Multicube-SCoPE into a complete DSE framework if the DSE tools follow the Multicube specifications for tool integration. It has been checked with modeFRONTIER and Multicube Explorer.

