FP7 – 216693 - MULTICUBE Project

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

Deliverable D3.1.1:
Initial Prototype of the Open-Source
MULTICUBE Exploration Framework

Revision [2]

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PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
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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 3.1 (Definition of the Open Source Framework for Design Space Exploration) under the leadership of POLIMI, with contributions from POLIMI, ALARI and reviewed by UC and ESTECO.

The main goal of this deliverable is the creation of an Initial Prototype of the Open-Source Exploration Framework, named *Multicube Explorer*. Multicube Explorer is a design space exploration tool for supporting platform-based design. It allows a fast optimization of parameterized system architecture towards a set of objective functions (e.g., energy, delay and area), by interacting with the Use Case simulator of the target architecture by means of the MULTICUBE XML interface defined in D1.4.1 (Definition of the Specification of the Design Flow Integration). The current version of the tool is *initial* since it contains a basic set of optimization algorithms and design of experiments modules. The tool will be extended with additional state-of-the art optimization algorithms and response surface modeling techniques to produce the final version of the prototype (D3.1.2).

This report contains:

- A summary of the structure and functionality of the initial version of the Multicube Explorer tool.

- The current internet address of the web page from which the Multicube Explorer can be downloaded.

- A snapshot of the current Multicube Explorer web site content.

The Project Coordinator

Approved by the Project Coordinator:	Date: February 10th, 2009

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I. Executive summary

This deliverable consists in the Initial Prototype of the Open-Source Exploration Framework, named Multicube Explorer. Multicube Explorer is a design space exploration tool for supporting platform-based design. It allows a fast optimization of parameterized system architecture towards a set of objective functions (e.g., energy, delay and area), by interacting with the Use Case simulator of the target architecture by means of the MULTICUBE XML interface defined in D1.4.1 (Definition of the Specification of the Design Flow Integration). The current version of the tool is initial since it contains a basic set of optimization algorithms and design of experiments modules. The tool will be extended with additional state-of-the art optimization algorithms and response surface modeling techniques to produce the final version of the prototype (D3.1.2).

The main features of Multicube Explorer consists in providing a design exploration flow covering several abstraction levels. The exploration engine is flexible and independent of the problem to be solved but it's tailored to application-specific and use-case specific design of embedded hardware platforms. The final product of the framework is a Pareto set of configurations within the design evaluation space of the given architecture.

The Multicube Explorer tool presents the following features:

- **Automatic design space exploration**
  The open source tool provides a command line interface to the exploration kernel that allows the construction of automated exploration strategies. Those strategies are implemented by means of command scripts interpreted by the tool without the need of manual intervention. This structure can easily support the batch execution of complex strategies that are less prone to human intervention, due to their execution time.

- **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.

- **Modular composition**
  One of the strength of the Multicube Explorer tool is the modularity of its components. Simulator, optimization algorithms and other design space exploration components are dynamically linked at run-time, without the need of recompiling the entire code base.

Currently, the initial version of the tool is composed by an exploration kernel that orchestrates the functional behavior of the design of experiments and optimization algorithms. The kernel module is responsible for reading in the design space definition file (in XML format, as defined D1.4.1) and accepting commands from the shell interface (or the corresponding script). It then exposes the parameters of the design space to all the modules involved in the optimization process (design of experiments and optimization algorithms) by means of a suitable core design space representation.

This report is structured as follows. Section 2 presents the link to the website from which the Multicube Explorer tool can be downloaded. Section 3 presents a summary of content of the website where the source code, license and documentation can be found.

II. Link to the website 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:

<div align="center">

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

</div>

Alternatively, the website can be reached directly with the following link:

<div align="center">

http://home.dei.polimi.it/zaccaria/multicube_explorer

</div>

The following is a snapshot of the home page:

Figure 1: Screenshot of the home page of the public website of Multicube Explorer.

III. Content of the website of the prototype

The website is composed of the following webpages:

- Home page
- Overview page
- Download page
- License page
- Documentation page
- Team page

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 Explorer Open Source Exploration Tool. It gives a brief overview of the tool goals and features and provides information on the people involved in the development.

Multicube Explorer

Multicube Explorer is a design space exploration tool for supporting platform-based design. It allows a fast optimization of parameterized system architecture towards a set of objective functions (e.g., energy, delay and area), by interacting with a system-level simulator. Multicube Explorer provides a set of innovative sampling and optimization techniques to help finding the best objective-function trade-offs. It also provides an open XML interface for supporting new platforms/architectures.
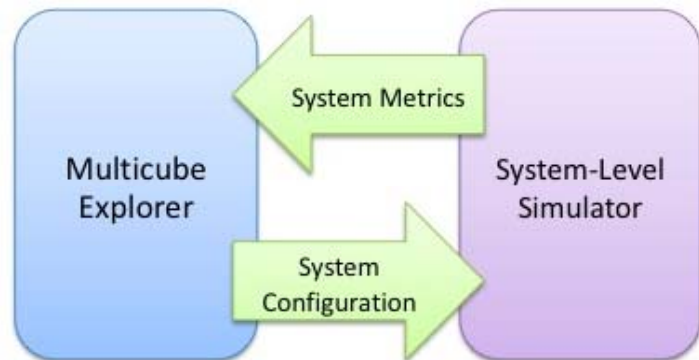
Funded by FP7 project:

Project coordinator: Cristina Silvano
Team Leader: Vittorio Zaccaria
**Development Team:** Gianluca Palermo, Giovanni Mariani

III.2. Overview page

This page gives an overview of the tool structure and composition by hightlighting the functionality and features offered to the user. It also highlights the interfaces with the use case simulators.

Overview of Multicube Explorer

Multicube explorer is an interactive program that lets the designer explore a design space of configurations for a parameterized architecture for which an executable model (use case simulator) exists. Multicube explorer is an advanced multi-objective optimization framework which is entirely command-line/script driven and can be retargeted to any configurable platform by writing a suitable XML design space definition file and providing a configurable simulator.
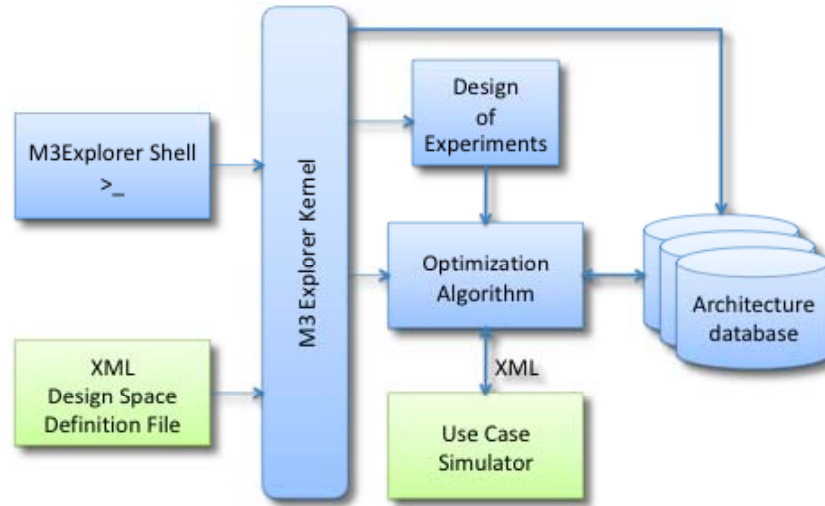
Goals of Multicube Explorer

The overall goal of the open source design space exploration framework aims at providing a retargetable tool to drive the designer towards near-optimal solutions to the architectural exploration problem, with the given multiple constraints.

The final product of the framework is a Pareto curve of configurations within the design evaluation space of the given architecture.

Automatic design space exploration

One of the goals of the open source tool is to provide a command line interface to the exploration kernel that allows the construction of automated exploration strategies. Those strategies are implemented by means of command scripts interpreted by the tool without the need of manual intervention. This structure can easily support the batch execution of complex strategies that are less prone to human intervention, due to their execution time.

Portability

Another goal of the open source tool is to be portable across a wide range of systems. This goal will be achieved by not sacrificing the efficiency of the overall exploration engine. The

standard ANSI C++ programming language will be used for developing the open source framework. The Standard Template Library as well as other open source libraries will be used during the development process.

Modular composition

One of the strength of the open-source tool is the modularity of its components. Simulator, optimization algorithms and other design space exploration components are dynamically linked at run-time, without the need of recompiling the entire code base. This will be supported by well-defined interfaces between the drivers supporting the simulation and the optimization algorithm. This will strongly enable the introduction of new modules for both academic and industrial purposes. Given the modular decomposition, a single optimization algorithm can used for every use case simulator. Moreover, a single use case architecture can be optimized with a wide range of optimization algorithms.

Architecture of the tool

The tool is basically composed by an exploration kernel which orchestrates the functional behavior of the design of experiments and optimization algorithms.
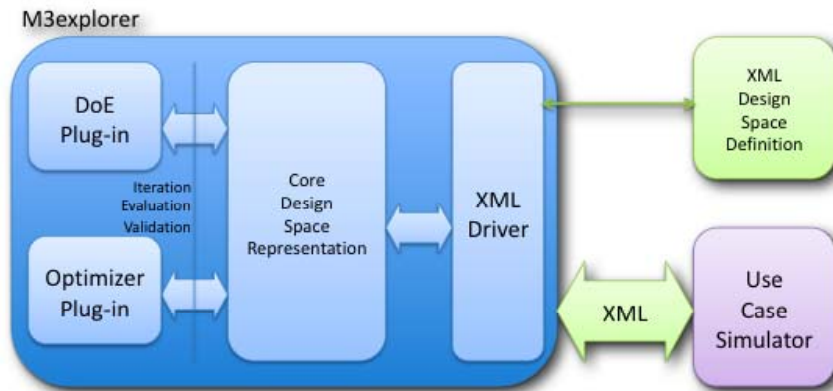
The kernel module is responsible for reading in the design space definition file (in XML format) and accepting commands from the shell interface (or the corresponding script). It then exposes the parameters of the design space to all the modules involved in the optimization process (DoE, Optimization Algorithms) by means of a core design space representation.

The core design space representation provides a set of abstract operations that are mapped on the specific use case under analysis. The abstract operations are represented by iterators over the feasible design space, among which we can find:
• Full search iterators.
• Random search iterators, (global and neighborhood).
• Factorial iterators (two-level, two-level + center point).

The core design space representation provides also services for validating architectural choices at the optimizer level and evaluating the associated objective functions. The objective functions are defined as a subset of the use case system level metrics and can be manipulated by the user by interacting with M3explorer.

Interaction with the simulator

The design space exploration is performed by using the simulation abstraction layer exported by the XML driver to the optimizer plug-ins. In principle, the optimizer instantiates a set of architectural configurations by means of the design space iterators, and passes the

corresponding representation to the XML driver which will execute the simulator. Information about simulator runs will be displayed directly on the M3explorer shell.
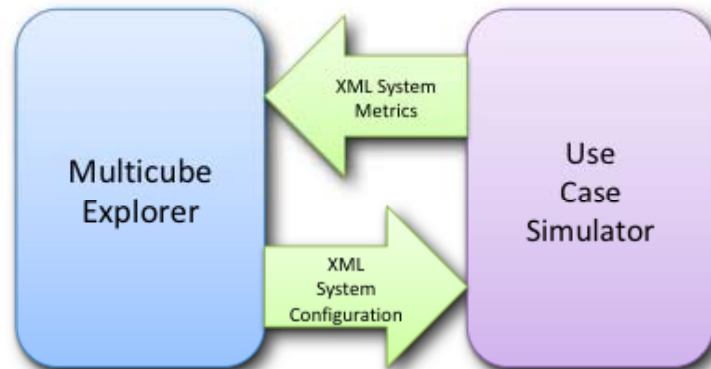
M3Explorer creates a specific directory to execute each instance of the simulator. In this directory, a valid system parameters file is created before starting the simulator. A system metrics file is expected to be obtained as the output of the simulator execution.

III.3. Source code download page

This page provides the link to download the initial prototype of the Multicube Explorer open-source exploration framework. It also provides information about the pre-requisite programs to be installed before compiling and running Multicube Explorer.

Latest stable release:
December 23rd, 2008 - Release 0.5 - [multicube_release_0_5.tar.gz]

For any bug report, please write to Vittorio Zaccaria: zaccaria@elet.polimi.it

Prerequisite programs and libraries:

1. GCC g++ 4.0.1 or higher
2. Libxml2
3. Bison/YACC parser generator
4. Flex/Lex lexical analyzer

Supported platforms:

III.4. License page

This page shows the open-source licensing terms associated with Multicube Explorer.

Multicube explorer is open-source and it is released under the BSD license:

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III.5. Documentation page

This page links to the current documentation of the open-source exploration tool. It is composed by a user manual (in pdf format) and an on-line HTML developer documentation that has been created with doxygen.

User Manual
Multicube Explorer, User Manual version 0.5

API documentation for developers:
Multicube Explorer, API Documentation version 0.5

III.6. Team page

This page shows some information about the development team.