

MULTICUBE



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MULTICUBE

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

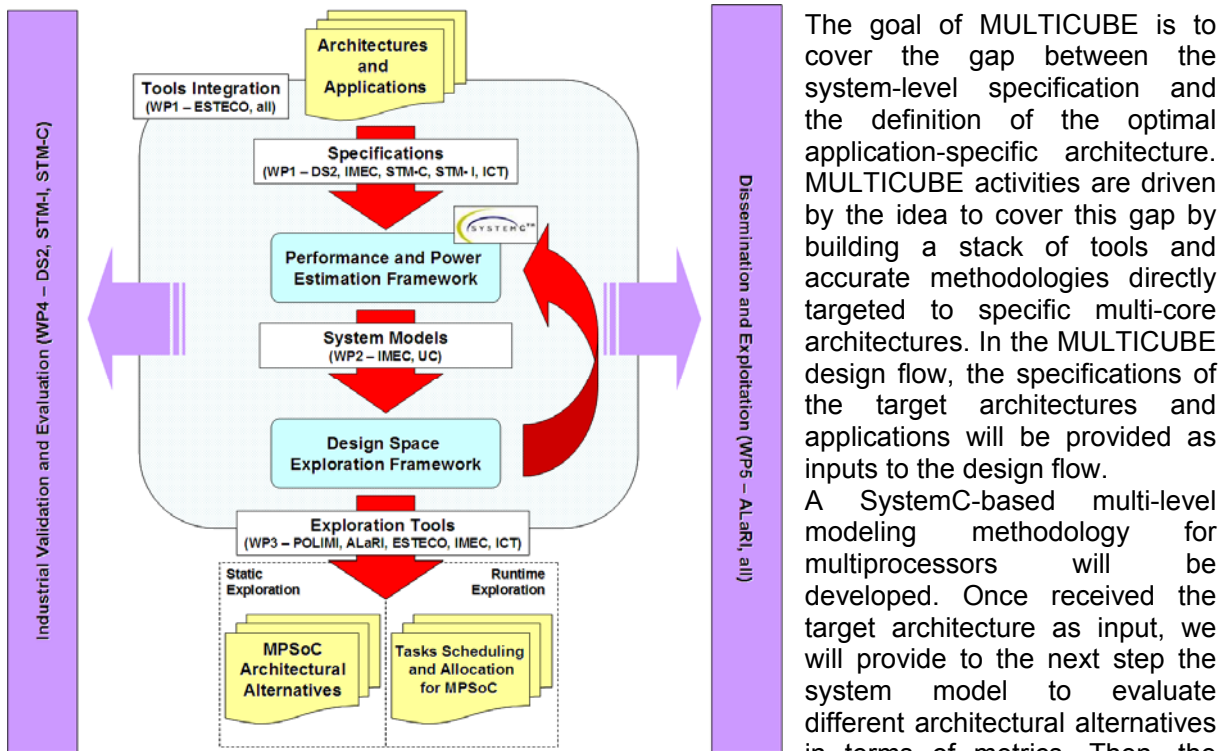
Many point tools exist to optimize particular aspects of embedded systems. However, an overall design space exploration framework is needed to combine all the decisions into a global search space, and a common interface to the optimization and evaluation tools. The MULTICUBE project focuses on the definition of an automatic multi-objective Design Space Exploration (DSE) framework to be used to tune the System-on-Chip architecture for the target application evaluating a set of metrics (e.g. energy, latency, throughput, bandwidth, QoS, etc.) for the next generation of embedded multimedia platforms. This overall objective is two-fold.

From one side, the MULTICUBE project will define an automatic multi-objective DSE framework to find design alternatives that best meet system constraints and cost criteria, strongly dependent on the target application, but also to restrict the search space to crucial parameters to enable an efficient exploration. In the developed DSE framework, a set of heuristic optimization algorithms must be defined to reduce the overall exploration time by computing an approximated Pareto set of configurations with respect to the selected

figures of merit. Once the approximated Pareto set has been built, the designer can quickly select the best system configuration satisfying the constraints.

From the other side, the MULTICUBE project will define a run-time DSE framework based on the applications of the results of the static multi-objective design exploration to optimize the run-time allocation and scheduling of different application tasks. The design exploration flow results in a Pareto-optimal set of design alternatives with different speed, energy, memory and communication bandwidth parameters. This information can be used at run-time by the operation system to make an informed decision about how the resources should be distributed over different tasks running on the multi-processor system on-chip. This resource distribution cannot be performed during the design exploration itself, since it depends on which tasks are active at a particular point in time.





MULTICUBE tool environment and design flow linked to the five workpackages

The goal of MULTICUBE is to cover the gap between the system-level specification and the definition of the optimal application-specific architecture. MULTICUBE activities are driven by the idea to cover this gap by building a stack of tools and accurate methodologies directly targeted to specific multi-core architectures. In the MULTICUBE design flow, the specifications of the target architectures and applications will be provided as inputs to the design flow. A SystemC-based multi-level modeling methodology for multiprocessors will be developed. Once received the target architecture as input, we will provide to the next step the system model to evaluate different architectural alternatives in terms of metrics. Then, the Design Space Exploration framework will be defined to sail

over architectural solutions following several heuristic optimization algorithms. This step is implemented as an optimization loop, where the selected architecture instance generated by the DSE framework is given back to the estimation framework for the metrics evaluation. The tool integration phase in MULTICUBE will be performed to implement an automatic system optimization engine to generate, for the target MPSoC architecture, either the best architectural alternative (if the exploration is done statically) or the best tasks scheduling and allocation solution (if the exploration is done at run-time)

MULTICUBE
will focus on
multi-objective
design space
exploration for
embedded
System-on-Chip
architectures

Summary of MULTICUBE Objectives

- Innovative static and run-time design exploration methods to increase system development productivity while achieving predictable system properties, particularly cost, performance and power consumption.
- To establish strategic cooperation with China, by including ICT -Chinese Academy of Sciences and STM-China as strategic partners from a region with the fastest economy growing rate and technology market for consumer electronics
- Integrated design tool suite that responds to the needs of industry for designing and prototyping embedded systems.
- Increased interoperability of tools from SME vendors as a general-purpose design exploration tool will be applied for embedded systems design;
- Development of an open tool framework facilitating new entrants and the integration of the tool chain including associated standardization.
- Development of multi-level optimized tools respecting trade-offs when co-developing hardware and software

Key Issues

- Increased productivity of system development through a fast, reliable DSE process allowing finding an optimized solution in a short time. DSE will be performed at system-level, thus avoiding costly, low-level analysis steps (i.e. ISS simulations).
- Improved competitiveness of European companies that rely on the design and integration of embedded systems in their products by reducing costs and time to market.
- Stimulate high-tech European SMEs (such as ESTECO) that offers general-purpose innovative design solutions and tools to apply them for embedded systems design.
- Reinforced European scientific and technological leadership in the engineering of complex systems both at the industry side (STM as a large company and DS2 as a SME) and the academic and research side (IMEC, Politecnico di Milano, ALaRI, University of Cantabria and Institute of Computing Technology).

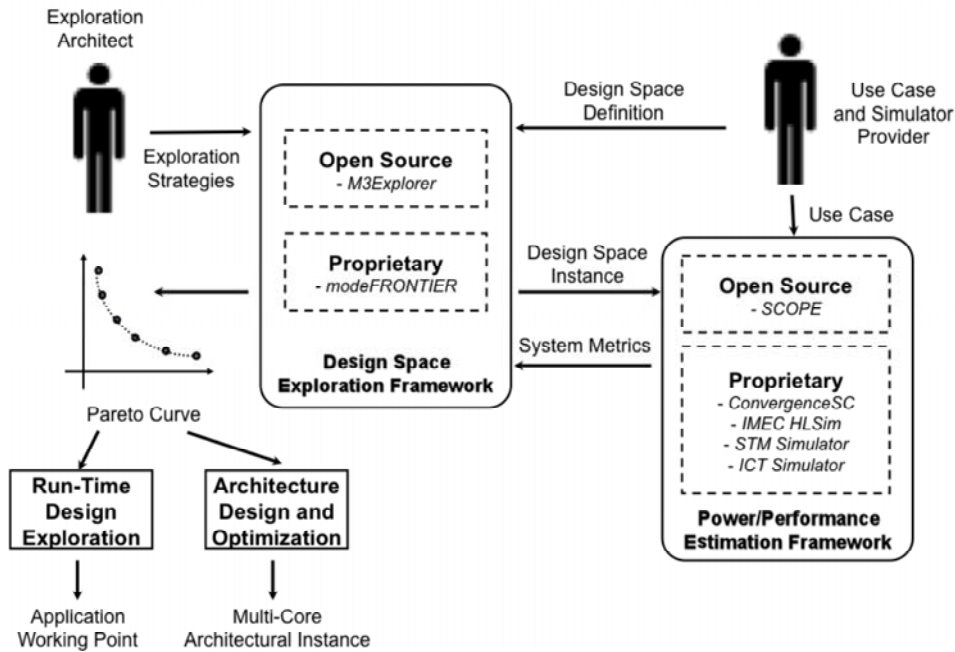
Expected Impact

The MULTICUBE design methodology is implemented at system-level in a set of open-source and proprietary EDA tools to guarantee a large exploitation of the results of the MULTICUBE project in the embedded system design community. The overall goal is to support the competitiveness of European industries by optimising embedded HW/SW systems while reducing the design time and costs. To ensure a wide applicability of the proposed DSE framework, the MULTICUBE project is strongly industry-driven. Two European industrial partners (STM Italy and DS2) and STM China have defined the requirements of the design tools and they will validate step-by-step the results of the exploration tools to design a set of target industrial applications. The integration of design tools and the commercial exploitation of the tools are in charge of an European SME, ESTECO. ALaRI is mainly in charge of dissemination and exploitation activities. The research and technological development are carried out by IMEC, Politecnico di Milano, University of Cantabria and the Institute of Computing Technology.

Description of the work performed in Year 1 (First Reporting Period)

During the first year, the overall MULTICUBE design flow has been defined to support the automatic Design Space Exploration (DSE) of embedded systems. The MULTICUBE design flow is based on two main frameworks: the DSE Framework (developed in WP3) and the Power/Performance Estimation Framework (developed in WP2). According to the Exploitation Plan defined in WP5, the design flow is based on the synergy of the open-source exploitation model and the proprietary exploitation model. According to this twofold exploitation plan, in the DSE framework there are the open-source M3Explorer prototype tool and the modeFRONTIER proprietary tool provided by ESTECO. Similarly, the Power/Performance Estimation Framework is based on two different sets of open-source and proprietary tools developed by the project partners. Two types of users can interact with the MULTICUBE design flow. From one side, the Use Case Simulator Provider is the user in charge of giving the executable model of the target architecture and application. The target architecture must be configurable in terms of a set of design space parameters. From the other side, the Exploration Architect defines the exploration strategies to be used to identify the set of Pareto points corresponding to the optimal architecture configurations and application working points. Once obtained the design space definition, the DSE framework starts an optimisation loop interacting with the estimation framework in order to find the optimal system configurations in terms of the target power/performance metrics. In the optimisation loop, the DSE Framework generates the next design space instance to be simulated to obtain an estimate of the system metrics. In the automatic loop, the system metrics are fed back to the DSE tool to refine the exploration process. Once the design space exploration process terminates, the resulting set of Pareto points are provided to the system architect representing the multi-objective trade-offs. If the set of configurable parameters contains also a set of parameters related to the

application, the approximated Pareto set generated by the Design Space Exploration Framework is taken as input from the Run-Time Design Space Exploration module to select the application working point meeting the constraints.



MULTICUBE Design Flow

Main Achievements of Year 1 (First Reporting Period):

- Definition of the overall MULTICUBE design flow for automatic design space exploration of embedded systems (**WP1**).
- Definition of the requirements of the design tools to be developed (**WP1**).
- Definition of the specifications of the industrial use cases to be used in the project to validate the MULTICUBE design flow (**WP1**).
- Definition of the specification for the design flow integration (**WP1**). The formal specification of the tool interface, based on the XML standard, is of fundamental importance for granting the seamless integration of design tools into a common design environment.
- Release of the open-source prototype tool for performance and power estimation. The tool (**MULTICUBE-SCoPE**) developed in **WP2** can dynamically generate system models corresponding to the configuration parameters received from the DSE tools and can feed back the required system metrics to guide the exploration process.
- Release of the open-source prototype exploration framework (**MULTICUBE Explorer**). The tool (developed in **WP3**) enables a fast automatic optimization of parameterized system architectures towards a set of multiple objective functions.
- Retargeting of **modeFRONTIER** optimization tool to the discrete domain used in the embedded systems field (**WP3**).
- Set up of the strategic cooperation with Chinese partners.
- Definition of the initial dissemination and exploitation plans (**WP5**).