PROJECT DaRT

1. Primary Topics and Objectives

The DaRT project team was created in December 2004 (from a previous CNRS team) with High Performance System on Chip (HPSoC) as main research theme. The main focus has been on modelling (architecture, application), simulation, and synthesis (including compiler optimization). In contrast to many other high performance research activities, architecture innovation has not been the main focus of DaRT. Rather, the group's activities concentrated on modelling and optimization.

Main Objectives:

- Developing and applying Model Driven Engineering (MDE) technology to high performance embedded computing
- Bringing more dynamics into modelling (integrating multi-dimensional dataflow with control, integrating dataflow with modelling of time, dynamic reconfiguration);
- Integrated and consolidated modelling framework for high performance, embedded computing that covers all relevant aspects (architecture modelling, application modelling, optimizations, synthesis)

  Apart from many individual scientific and technical contributions, a main result is Gaspard2, an integrated development environment (IDE) based on Eclipse and UML.

2. International Standing and Reputation in the Field

The team has earned significant international recognition for its work on model driven engineering for high performance, embedded computing. The work has resulted in a long list of publications, good citation count of key publications, two invited papers, two best paper awards and an invited talk at the ACM Conference on Languages, Compilers, Tools and Theory for Embedded Systems in 2011. The impact in the international community would have been higher if the newly proposed repetitive MoC inspired by ArrayOL would have been more widely appreciated, which is not the case, although the team's work on this topic has been solid and well grounded.

3. Major Achievements and Impact (Theory, Research Software, etc.)

The team has achieved several excellent results and made impact in various ways. Scientifically many individual results have been produced as witnessed by 29 journal papers, 107 conference papers and over 140 peer reviewed publications in total. The set of contributions show considerable breadth from the theory of modelling, to architecture innovations, to synthesis and mapping methods.

In addition to scientific contributions, several practical results with potential industrial relevance have been achieved. The team has contributed to the MARTE standard and , beside

several other tools, Gaspard2 tool has been developed, which has been used in several industrial contract projects. The start-up company Axellience has been founded based on the model transformation technology of the DaRT project.

A major result has been the Gaspard2 tool. A huge amount of engineering effort has been invested in this tool. It is now considered to be stable and usable. However, its future is uncertain because the team is not committed to its further development and maintenance. The tool has accumulated too many features and functions to be easily maintainable with moderate effort.

In summary, the contributions have been numerous and the impact considerable. The team has exhibited extraordinary energy and produced many results but sometimes the focus could have been clearer. While the team had high ambitions and great enthusiasm, the will to re-focus and consolidate was underdeveloped.

4. Industry Transfer and Partnership

The project has significantly developed a MDE methodology and supporting tools which has stirred considerable interest in the industry. Measurable transfer has been limited probably due to the complexity of the involved issues in an industrial setting.

One start-up company has been founded based on one of the project's technologies (MDE).

The Gaspard2 tool set has been used in several industrial contract cooperation projects of the team, e.g. with Valeo, Eurocopter, Thales RT (even if the direct users are only academic teams).

The team has made several contributions to the MARTE standard.

5. Training of Personnel

10 PhD students have been graduated by the team during this project.

6. Principal Strengths of the Project

The team has shown considerable enthusiasm to break new grounds in model driven engineering by exploring a number of innovative aspects. This has resulted in many interesting results.

7. Plan for the next period (4 years)

The team presented the plans of a new project called DreamPal. The aim is to develop an architecture for next generation 3D FPGAs (HOMADE) and a methodology to program it. It is based on a programming language like Forth and the K-framework for

formal verification of program properties and resource usage. The target applications are in the avionics, smart camera and transportation domains.

This plan is very promising, scientifically challenging, and industrially relevant. It is recommended to include expertise regarding architecture and future development of manufacturing technology in the project.

8. Risks/difficulties faced by the project

At the time DaRT started, the MDE methodologies were not well understood and the MDE tools were not mature, which required high engineering effort from the team when developing Gaspard2.

UML is a very general and flexible modelling language, but the link to synthesis is weak; it is therefore difficult to generate high quality implementations from UML models.

MARTE is a very general and broad standard; thus it is unclear if the contribution by DaRT project to MARTE will be used in industrial practice.

The model of computation for repetitive, high performance computing based on ArrayOL turned out to be very abstract and difficult for designers to adopt.

Since Gaspard2 has become a very feature rich tool with many backends, it will be difficult to maintain. As a consequence, there are no plans by INRIA to develop it or maintain it further.

9. Recommended actions and suggested measures of success

The plan for a next project includes the development of a 3D FPGA architecture. Since the research on course grained reconfigurable architectures is very popular with many active groups, it is important to define the objectives of the project carefully. What exactly should be the contribution of this team and what could make potentially high impact? For many practical and economic reasons it is tremendously hard to get new architectures and new programming languages adopted! Thus, the team should make a clear statement about the expected impact. If it includes the adoption of a new architecture or language, the arguments should be strong and convincing.

Since manufacturing technology develops rapidly and is hard to predict, it is mandatory that the team has access to competence for FPGA architectures and for manufacturing technology. This competence may be inside the team or available through tight cooperation.

Since the objectives of DaRT have partially become too broad, it is recommended to plan for a *consolidation phase* in the next project. The consolidation phase could be 6-12 months and would require time to re-focus, to evaluate the results, re-formulate the goals, and narrow down the objective to focus on the most promising branches of the project.