

# ARTIST 2

Network of Excellence

IST-004527 ARTIST2:  
Embedded Systems Design

Activity Progress Report for Year 2

JPRA-Cluster Integration  
**Development of UML for  
Real-time Embedded Systems**

Clusters:

Real Time & Components

Activity Leader:

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*Policy Objective (abstract)*

*A framework for handling central aspects of Real time Systems in UML-based notations, and in UML-based system development. This will influence standardization and allow European UML-based tool providers to have a larger impact.*

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## 1. Overview of the Activity

### 1.1 *ARTIST2 Participants: Expertise and Roles*

Dr. Sébastien Gérard – CEA (Fr)

*Areas of his team's expertise: standard modelling and RT/E domains.*

Dr. Susanne Graf – VERIMAG (Fr)

*Areas of his team's expertise: modelling of real-time components.*

Pr. Jean-Marc Jezequel – INRIA (Fr)

*Areas of his team's expertise: UML Meta-model.*

Dr. Julio Medina - Cantabria university (Sp)

*Areas of his team's expertise: model-based schedulability analysis.*

### 1.2 *Affiliated Participants: Expertise and Roles*

Pr. Ivica Crnkovic – MdB

*Areas of his team's expertise: component models.*

Dr. Stefan van Baelen - K.U. Leuven (Be)

*Areas of his team's expertise: QoS specification.*

Dr. Bernhard Josko – OFFIS (Ge)

*Areas of his team's expertise: real-time UML.*

Dominique Potier – Thalès Research and Technology (Fr)

*Areas of his team's expertise: standardization and case study from the aerospace or telecommunication domain.*

Dr. Matthias Grochtmann – DaimlerChrysler (Ge)

*Areas of his team's expertise: specification, design and implementation of automotive systems.*

### 1.3 *Starting Date, and Expected Ending Date*

Starting date: September 1<sup>st</sup>, 2004.

Expected ending date: End of the project.

In fact, the expected ending date is setup to the end of the project but this activity will probably continue after because this standard will have to be implemented and disseminated.

### 1.4 *Baseline*

Since the adoption of the UML standard and its new advanced release UML2, this modelling language has been used for development of a large number of time-critical and resource-critical systems. Based on this experience, a consensus has emerged that, while a useful tool, UML is lacking in some key areas that are of particular concern to real-time and embedded system designers and developers. In particular, it was noticed that first the lack of quantifiable notions of time and resources was an impediment to its broader use in the real-time and embedded domain. Second, the need for rigorous semantics definition is also a mandatory requirement for a widespread usage of the UML for RT/E systems development. And third, specific constructs were required to build models using artefacts related the real-time operating system level such as task and semaphore.

Fortunately, and contrary to an often expressed opinion, it was discovered that UML had all the requisite mechanisms for addressing these issues, in particular through its extensibility facilities. This made the job much easier, since it was unnecessary to add new fundamental modelling concepts to UML – so-called “heavyweight” extensions. Consequently, the job consisted in defining a standard way of using these capabilities to represent concepts and practices from the real-time and embedded domain.

Hence, this specification of a UML™ profile adds capabilities in one hand for modelling Real Time and Embedded Systems (RTES), and in other hand for analyzing schedulability and performance properties of UML specifications. This new profile is intended to replace the existing UML Profile for Schedulability, Performance and Time [UML profile for Schedulability, Performance, and Time, version 1.1., formal/05-01-02, 2005]. This extension, called the Marte profile, should address specification, design, and verification stages of the development cycle of RTES. It wants to address the two branches of the V cycle, i.e. modelling and validation& verification. Modelling capabilities have to ensure both hardware and software aspects of RTES in order to improve communication/exchange between developers. It has also to foster the construction of models that may be used to make quantitative analysis regarding hardware and software characteristics. Finally, it should enable interoperability between developments tools used all along the development process.

## **1.5 Problem Tackled in Year2**

Continue the year1 work in order to develop a UML-based proposal defining model constructs for modelling and analysing of real-time and embedded systems. Special focus is put on representing resources, timing, RT/E qualities of service, communication modes, execution modes, component model.

Within this year 2, we also continued to review and suggest changes to the Open Management Group (OMG - responsible for defining the UML standard) by providing inputs on standardization of UML profiles specific to real-time systems: the UML profile for MARTE.

The second year of this activity has been also time to start experiments of the Marte standard through realizations of case studies and connections with analysis tools such as schedulability analysis tools.

## **1.6 Comments From Previous Review**

### **1.6.1 Reviewers' Comments**

This report is accepted as it stands.

This task is aimed at defining a UML profile for real-time and embedded systems, to standardise it at the OMG and to integrate it in the ‘platform for component modelling and verification’.

The request for proposal has been issued at the OMG by the RTESS task force and is now in the process of specification, which is a heavy load.

The report activity progress and the detailed technical view are very clear and detailed.

### **1.6.2 How These Have Been Addressed**

No required comments here.

## 2. Summary of Activity Progress

### 2.1 Previous Work

The first year of this activity has been dedicated to firstly influence on the writing of the request for proposal (RFP) of the new UML profile for real-time and embedded systems. This RFP expresses all the requirements the new standard will have to satisfy. The RFP, document referenced at OMG web server as realtime/05-02-06 (UML Profile for Modelling and Analysis of Real-Time and Embedded systems (MARTE) RFP)) has been voted in the context of the Real-time, Embedded, and Specialized Systems (RTESS) Platform Task Force in February 2005: UML Profile for Modelling and Analysis of Real-Time and Embedded systems (MARTE) RFP , realtime/05-02-06, <http://www.omg.org/cgi-bin/doc?realtime/05-02-06>.

Within the second half year period, the job consisted in both following action (main part of this work has been performed within the French CARROLL-Protes project):

– To setup an OMG submitter team in order to answer to the RFP. The team that has been organized is called the ProMARTE team: [www.promarte.org](http://www.promarte.org). This team consists of the main companies (end users and tool providers) involved in this aspect at the OMG. It is composed of: Artisan, Carlton university, CEA, IBM, I-Logix, INRIA, Looked-Martin, Thales, Tri-Pacific.

– To write the initial submission of the ProMARTE team that has been delivered in November 2005: Joint UML Profile for MARTE Initial Submission, realtime/05-11-01, <http://www.omg.org/cgi-bin/doc?realtime/2005-11-01>

Within this first year, in the context of the Omega project, Verimag aimed at the definition of an UML profile appropriate for real-time embedded systems based on the existing SPT profile. The extension done in Omega introduces a notion of "observer" and emphasizes the importance of capturing the relevant events which make reference to the system at execution and is used to capture its dynamic properties.

### 2.2 Current Results

#### 2.2.1 Technical Achievements / Outcomes / Difficulties encountered

##### **A consolidated architecture for the Marte profile**

The Marte profile architecture model consists of three main packages:

– The Time and Concurrent Resource Modelling package (TCRM); it defines basic model constructs for time and resource, especially concurrent resources. This foundational concepts are then refined in both following package in order to fit with both modelling and analyzing concerns.

– The Real-Time and Embedded application Modelling package (RTEAM); it enables modelling of RT/E application. It concerns mainly defining in one hand high-level model constructs to depict real-time and embedded features of application, and in other hand to enable the description of execution platforms, software as well as hardware.

– The Real-Time and Embedded application Analysis; it provides a generic support for analyzing annotated models. This generic framework is also refined in order to cope with schedulability and performance analysis. It is also expected that the generic framework for analysis will be specialized/extended to support other kind of quantitative analysis, such as power consumption, memory use or reliability.

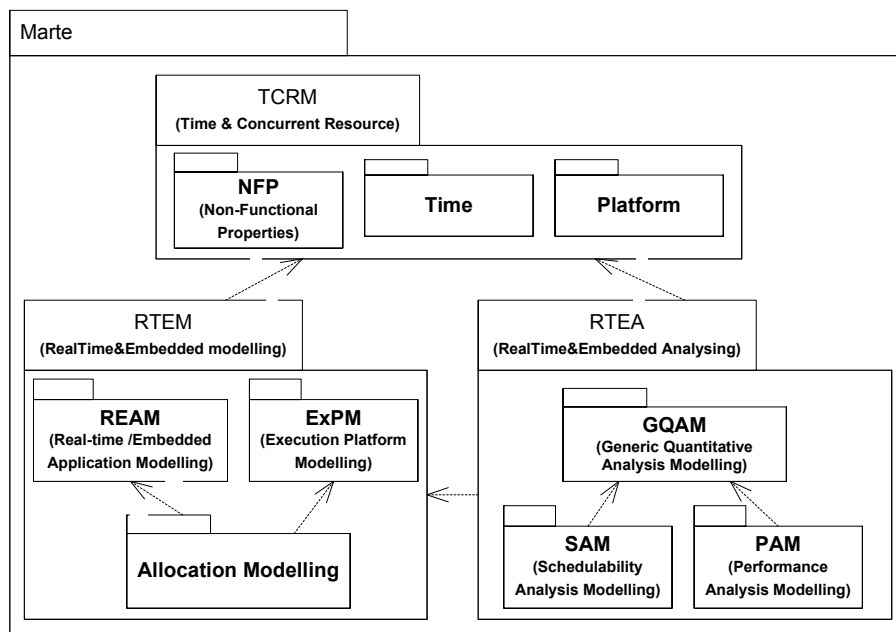


Figure 1. Current architecture of the Marte profile.

### Difficulty: Dissemination issue due to privacy rule of an ongoing work at OMG

Actually, OMG ongoing work performed in OMG consortium such as the ProMarte one considered to be private until final vote. So, the only available documents related to Marte in the year 2 was the initial submission that provides only outline of the proposal and go not in details of the proposed concepts. So, only members of the ProMarte consortium can access the full information of the standard, i.e. CEA (the leader of the activity), INRIA, Thales and Cantabria University.

### 2.2.2 Publications Resulting from these Achievements

[EMDGT06] Huáscar Espinoza, Julio Medina, Hubert Dubois, Sébastien Gérard, and François Terrier: Towards a UML-Based Modelling Standard for Schedulability Analysis of Real-Time Systems, MARTES Workshop at MODELS Conference, available at <http://wo.uio.no/as/WebObjects/theses.woa/wa/these?WORKID=45427>, 2006.

[TGRT06] Yann Tanguy, Sébastien Gérard, Ansgar Radermacher, François Terrier : Model Driven Engineering for Real Time Embedded Systems in the journal: Ingénieurs de l'automobile, March-April 2006.

[GE06] Sébastien Gerard and Huascar Espinoza: Rationale of the UML profile for Marte, capter of the book: From MDD Concepts to Experiments and Illustrations, isbn 1 905209 59 2, p.43-52, 2006.

[EMDG06] Huáscar Espinoza, Julio L. Medina, Hubert Dubois, Sébastien Gérard. A UML-Based Modelling Standard for Quantitative Analysis of Real-Time Systems. CEALIST/DTSI/SOL/LLSP Internal Report.

[EDG+05] Huáscar Espinoza, Hubert Dubois, Sébastien Gérard, Julio L. Medina Pasaje, Dorina C. Petriu, C. Murray Woodside: Annotating UML Models with Non-functional Properties for Quantitative Analysis. MoDELS Satellite Events 2005, Lecture Notes in Computer Science, Springer, p. 79-90.

[EDMG05] Huáscar Espinoza, Hubert Dubois, Julio L. Medina, Sébastien Gérard. A General Structure for the Analysis Framework of the UML MARTE Profile. In Proc. Workshop MARTES:

Modelling and Analysis of Real-Time and Embedded Systems, Satellite event of MoDELS 2005. Montego Bay – Jamaica, 4 October 2005

[OMG'05] ProMarte consortium, Joint UML Profile for MARTE Initial Submission, realtime/05-11-01, November 2005, available at: <http://www.omg.org/cgi-bin/doc?realtime/05-11-01>.

### 2.2.3 Keynotes, Workshops, Tutorials

#### **Workshop: MARTES 2005**

#### **Modelling and Analysis of Real Time and Embedded Systems MoDELS/UML 2005, Int. Conf. on Model Driven Engineering Languages and Systems**

*Montego Bay, Jamaica, Oct. 4, 2005*

Verimag and CEA have been the initiators of this workshop on model-driven development and real-time and embedded systems as a follow-up event on the successful workshop series on Real time embedded systems SIVOES and SVERTS. MARTES has been hold in October 2005 as a satellite event of the MODELS conference. The workshop attracted a number of interesting submissions and participants. The results of the workshop, as well as 2 best papers have been published in an LNCS volume. <http://www.martes.org/>

Presently, we are actively preparing the second edition, to be held on October 2 or 3, 2006 in Genova, Italy in conjunction with the 9th International Conference on Model Driven Engineering Languages and Systems, MoDELS/UML 2006.

#### **Summer school: MDD for Distributed Real Time Embedded Systems**

*Brest, France – September 4-8, 2006*

This summer school was co-organized by CEA. It is the third edition of a series of summer school which focuses on model-driven related issues in the context of real-time and embedded systems development. The main goal of this summer school series is to provide participants with the most up-to-date information needed to understand and apply MDE approaches to the development of distributed, real-time and embedded systems. For that purpose, we have gathered experts from a variety of research labs and industries to give seminars that provide insights into the ongoing research works and practical applications related to MDE for DRES <http://www.mdd4dres.info>

#### **Tutorial: Status and perspectives of the UML profile for Marte**

#### **MDD for Distributed Real Time Embedded Systems Summer School**

*Brest, France – September 4-8, 2006*

Sébastien Gérard gave this tutorial on Marte. The current architecture of the new OMG standard for real-time and embedded systems has been presented and some specific technical focuses has been done: the non-functional property framework, the sub-profile for modelling software execution resources and the sub-profile for model-based schedulability analysis.

<http://www.mdd4dres.info>

#### **Tutorial: UML for Real Time Systems**

#### **Artist Summer School on Component & Modelling, Testing & Verification, and Stastical Analysis of Embedded Systems**

*Nässlingen, Sweden, September 29 to October 2, 2005*

Sébastien Gérard gave this tutorial on UML for real-time systems. The talk has been focused on native concepts of UYML2 for real-time and on its extensions (profiles) especially dedicated to real-time modelling and analysis.

<http://www.artist-embedded.org/FP6/ARTIST2Events/SummerSchools/Artist05.html>



### 3. Future Work and Evolution

#### 3.1 *Problem to be Tackled over the next 18 months (Sept 2006 – Feb 2008)*

Before explaining the job scheduled for this activity within the next 18 months, let's remain what is the OMG standardization process. It consists mainly in four stages:

- Request For Proposal (RFP): this stage consists in defining a set of requirements that will be considered has to be considered in a new standard. For Marte, it is the document referenced as: realtime/05-02-06.
- Initial Submission (IS): this document is time to OMG consortium to post their intend to answer to the RFP. The level of granularity of this document is not defined. It can be very detailed but also only a high level description of the work intended to be provided by the consortium. In the case of Marte, only one consortium has declare its intend to provide a solution to the Marte RTF, the ProMarte consortium ([www.promarte.org](http://www.promarte.org)). CEA (chairman of this consortium, which is also co-chaired by Ben Watson from Looked Martin), Thales and INRIA are part of this consortium and are main of the contributor through the CARROLL-PROTES project (<http://www.carroll-research.org/uk/projects/projets.htm>). The Marte initial submission is referenced as realtime/05-11-01.
- Revised Version. This is a detailed document considered as the future OMG standard for a given RFP. This document is part of the job planned in the next 18 months of work of this activity.
- Final Version. Once the revised version has been voted, an OMG group (usually build from the consortium that has proposed the revised version of the standard) is build in order to manage the finalization task force for the standard. Within this period, the standard is made available to other people than these one of the consortium, and these reviewers can raise issues against this standard in order to debug/improve this latter. At the end of this period, the FTF produce the final version (for Marte, the v1.0). This period is only dedicated to debug the standard and is not place for introducing new concepts! For that purpose, people will have to wait the next iteration in the standardization process called the revised task force that will produce the version 1.1.

So, in this context, the next 18 months period will be split into 2 parts:

- Until March 2007, we will continue on the writing of the standard itself. The vote for this standard is scheduled to happen in Q1 of 2007. In parallel, we will have to make some proof of concepts defined in this standard. The version of the document that should be provided in March 2007 is called a revised version (the version after the initial submission).
- From April 2007 until Feb 2008, we will work on applying this standard and give feedback to OMG in order to prepare the final version that should be due by mid of 2008. In addition of that, we will spend a lot of effort for the dissemination of the standard in order this latter may be considered by industrials and academics in their future projects and researches.

#### 3.2 *Current and Future Milestones*

- Year 1: preliminary work for standardizing an OMG profile for real-time and embedded systems.



- Vote the Marte RFP (realtime/05-02-06) *achieved in February 2005*.
- Marte initial submission (realtime/05-11-01) *achieved in November 2005*.
- Year 2: Revised version of the standard. The official revised version of the standard documents was initially due to Q4 2006, but has been postponed to Q1 2007.
- Year 3: Follow-up of the revised version of the standard.
  - Vote of the Marte revised version scheduled for March 2007.
  - Milestone 4 (scheduled within Q4 2007): Artist feedback report on Marte.
- Year 4: Final version of the standard.
  - Marte final version scheduled within Q3 or Q4 2008.

### **3.3 Indicators for Integration**

Joint work of members of this cluster on requirement analysis of RT/E domains for modelling has contributed to the success of the standardization of the Request for Proposal of the UML profile for MARTE.

Workshop organization related to this subject, the MARTES workshop series held within the Models conference series is another indicator of integration: first edition was collocated with Models2005 in Montego Bay (Jamaica) and the second edition will be held within the Models2006 in Genova (Italy).

Participations of Artist members to the summer school MDD for DRES held in Brest (France) in September 2006.

Last but not least, Common work of Artist members that are also OMG members (i.e. CEA, Thales and INRIA) participating to the writing of the standard itself.

### **3.4 Main Funding**

The activity is mainly funded by the CARROLL initiative, a common research programme between Thalès, CEA and INRIA. In particular, by the PROTES project of CARROLL which aims to initiate within the OMG an RFP (Request For Proposals) and submit a proposal for a UML profile for embedded systems.

The IST project Atesst (<http://www.atesst.org/>) is also contributing to fund this activity for CEA.