IST-004527 ARTIST2
Network of Excellence
on Embedded Systems Design

Activity Progress Report for Year 3

JPRA-NoE Integration

# QoS Aware Components

Clusters:

**Adaptive Real-Time**

**Real-Time Components**

Activity Leader:

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*Policy Objective (abstract)*

*QoS management is one important concern in the design of real-time systems. Component-based technology is a relevant approach to complex system development and to allow a smooth integration of software from different vendors. QoS management is an adequate mean to provide a predictable quality to end-users. We will bring together competencies in component-based design for hard and adaptive real-time systems, to produce advances that would be difficult to achieve without all three..*

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# 1. Overview of the Activity

## *1.1 ARTIST Participants and Roles*

Alejandro Alonso (UPM): QoS component infrastructures and notations for QoS specification.

Jean-Marc Jezequel (INRIA): extra-functional modelling.

François Terrier (CEA): QoS information in models.

Jacques Pulou (FTR&D): QoS in component-based middleware.

## *1.2 Affiliated Participants and Roles*

Laurent Pautet (ENST): real-time middleware, timed contract based behavioural typing, component-based adaptive services in mobile networks.

Stefan van Baelen (K.U. Leuven): QoS specifications and negotiation mechanisms.

Marisol García-Valls (U. Carlos III of Madrid): QoS component infrastructures, real-time middleware architectures.

Virginie Watine (Thales): component-based middleware, Co-Chair of MARS group at OMG on CORBA, RTE, etc.

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

Starting date: December 1st, 2004.

Ending date: End of the project.

## *1.4 Baseline*

QoS concepts are starting to appear in component standards, but are far from mature. Partners in this JPRA have expertise in different aspects necessary for progress. An example is the request for proposal at the Object Management Group that is currently demanding solutions for the integration of some QoS facilities in CORBA Component Model.

There is a number of techniques and methods required for the industrial use of QoS aware components such as:

- Notations for the description of components models including functional and QoS (also know as non-functional) aspects. The integration of this information in the interfaces is of primary importance.
- Automatic generation of analysable models from the UML model.
- Composition mechanisms for determining whether the interconnection of two components is feasible and for deriving the non-functional characteristics of a group of connected components. This work is related with the adaptation of component execution to changes in the environment.
- Component frameworks to support the runtime composition of QoS aware components.

## 1.5 Problem Tackled in Year 3

The work in year 3 has been mostly a continuation of the research topics of the previous year. The first issue was the identification of notations for the integrated description of functional and QoS properties in general component models, in order to reason about whether a component or a set of them fulfils a certain set of requirements. The integration of non-functional aspects allows for ensuring this property along the development lifecycle, hopefully, in an automatic way. Partners in this activity have continued their efforts in the standardization of this type of notations in the OMG (*Object Management Group*). The work on the "*UML Profile for QoS and Fault Tolerance*" standard has been subject of a revision considering a number of issues that were submitted by users. As a result, a new version of the standard has been approved on December 2006. The efforts on the "*UML Profile for Modelling and Analysis of Real Time and Embedded Systems*" (MARTE) have concluded with its adoption on June 2007 by the OMG. In addition, these profiles have been used to model safety and time.

The automatic generation of models for analyzing a particular characteristic is one of the major advantages of modelling together the system functional behaviour and QoS. Early evaluations of the system could guide to a better and cheaper end-product. It is intended to do them over the architectural designs; however, these designs are evolving until the architecture is completely specified. Automating such analyses in this changing environment is of great importance to aid engineers. Time and safety are the QoS characteristics that have been modelled in the context of this work. As a natural extension, the automatic generation of models for analysing them have been tackled.

The definition of the composition of QoS aware components has also been subject of research during this year. A UML profile for this job is under development. This work has naturally added a research topic: adaptability in QoS-aware systems. When composing a set of components, it is necessary not only to provide the required functions but the QoS characteristics as well, for setting the contracts. It is also required to determine which is the quality provided by this set as a whole. In addition, if these components can offer or require functions with different quality levels, it is of interest to know for each possible combination its feasibility and the overall provided quality. This information is relevant to statically evaluate the adaptability of a system and to change on runtime the provided quality according to the execution context.

The work on QoS management facilities in component infrastructures has been refined during this period of time. Additional functions have been added and a number of programming errors have been fixed. In addition, the API of the Robocop QoS Manager has been the basis for the specification of the resource and quality management in the ISO/IEC 23004 standard, which is specially suited for embedded systems. The integration of QoS in CCM also attempts to provide this type of runtime support.

## 1.6 Comments From Year 2 Review

### 1.6.1 Reviewers' Comments

The task this year consisted of identifying notations for the description of functional and non functional QoS properties using UML profiles, generating analysable models and defining a contract model to express component interaction with regard to QoS.

The original pre-review document was not always very clear. This has been addressed in the revised document. Some document sections have been slightly reshaped according to the three axis of the task and the unclear wording has been fixed.

The collaboration effort between partners is clear.

The deliverable is now accepted as it is.

### *1.6.2 How These Have Been Addressed*

No topics to be addressed.

# 2. Summary of Activity Progress

## *2.1 Previous Work in Year 1*

Some partners cooperated in the development of the OMG standard “UML profile for QoS and Fault Tolerance”, which was finally approved on May 2005.

The main result of this work was the concrete identification of the more concrete integration topics and the start of this work. This final job was done during a meeting that allowed the partners to know each other and discuss their interests. The identified integration topics were:

- Consistent alignment between the QoS modelling style of MARTE (with basis on Schedulability, Performance and Time) and that of the UML Profile for QoS and Fault Tolerance. The fist one is mainly related to time and performance aspects, while the second is more general, as it tries to provide means for specifying any other QoS characteristic. Partners involved: CEA, Inria, UPM.
- With respect to composability, the interest is focused upon the development of a contract model with well-founded semantics with respect to time and execution. This contract model handles (some) QoS characteristics. Partners involved: CEA, Inria, UC3M, UPM
- Finally, the support for the execution of QoS aware components requires components infrastructures with this support. UPM (QoS in the Robocop framework), UC3M, CEA and Thales (CCM based extensions) have done previous work on this topic. They have also proposed containers to simplify components development. The goal will be to interchange the approaches to try to get their particular merits and to propose new concepts for their future evolution.

The work on these topics has started during the previous work period.

## *2.2 Previous Work in Year 2*

The first issue was the identification of notations for the integrated description of functional and QoS properties in general component models. Some partners participating in this activity are active on two OMG standardization efforts that define such notations: OMG standards on UML profiles on “Real-Time and Embedded systems modelling and analysis (MARTE)” and “QoS and Fault Tolerance”. A complementary activity is the definition of catalogs of QoS attributes of a QoS characteristic, in order to try to develop techniques for their modelling. In the “QoS and Fault Tolerance” UML profile it is defined a general catalogue. In addition, QoS attributes for safety have been defined. An activity started during this period of time was the selection of a case study and QoS attributes, model them with different profiles or techniques and compare which is the most suitable in each case,

An important advantage of modelling QoS properties is the possibility of generating automatically models that can be used as input for analysis tools. The suitability of the previously mentioned profiles and attributes has been a subject of work for this year, with special focus on the QoS properties for timing and safety.

Another issue was to define the composition of QoS aware components. In this case, the connection of two components is only feasible if the provider includes the required operations with the proper functionality and QoS features. The common approach is the definition of a contract model where the specificities of the functions to be provided are determined and that

serves as the basis for the evaluation of the feasibility of the composition and the resulted quality.

There are components infrastructures that provide the required support for the execution of components. However, there are no mature infrastructures supporting QoS aware components. In addition to the general functions, support for the negotiation between components, for finding a suitable provider, and with the system, for getting the resources required for the system execution are needed. There are some initial works towards these goals; such as extensions to CCM by Thales and CEA and the QoS support at Robocop done by UPM.

## *2.3 Current Results*

### *2.3.1 Technical Achievements*

These achievements are aligned with the four main research lines:

a. Specification of QoS properties using UML profiles and aspect-based approaches
b. Generation of analysable models from the UML models
c. Composition of QoS-aware components and adaptability
d. QoS support in run-time components frameworks

For each technical achievement, there is an indication of the activity to which is mainly related.

**Task Force of "UML profile for QoS and FT“ (UPM) (a)**

This revision task force at the OMG was a special task created at the end of 2005 and developed during 2006. This task force received 20 issues about the standard "UML Profile for QoS and FT". The task force proposed solutions for 19 of these issues in the standard, and it closed without modifications 1. A new version of the standard was submitted.

The final report of this task force and the new version of the standard were submitted in November 2006 (documents ptc/06-12-01 and ptc/06-12-02), and the revision was accepted at the OMG meeting in Washington in December 2006.

The UML Profile for QoS and FT RTF made changes that:

- improve the alignment of QoS metamodels and UML 2 metamodels.
- make more precise the QoS profiles in the specification of composed constraints.
- a number of typos were removed.

This task force included members from THALES and CEA-LIST.
http://www.omg.org/technology/documents/profile_catalog.htm

**Adoption of MARTE at an OMG Standard (CEA LIST) (a, b)**

The UML™ profile for Modeling and Analysis of Real Time and Embedded Systems (MARTE) has been adopted in June 2007 by OMG [1]. This standard has involved significant collaborative effort between domain experts of the ProMARTE consortium. The CEA LIST members have led the MARTE standardization efforts (and are the chair of the OMG Finalization Task Force for MARTE).

Two important aspects of MARTE are of key interest for the QoS Aware Components integration action. First, the General Component Model (GCM) sub-profile that relies on event- and data-flow component approaches. GCM integrates different specification approaches, which include Lightweight-CCM, AADL, SysML and EAST-ADL2. Second, the MARTE's Non-Functional Properties (NFP) modelling framework which includes a language for extended UML expressions (the so-called VSL, which stands for Value Specification Language). The latter provide specification means to describe semantically rich non-functional annotations.

A case study consisting in a SCADA (Supervisory Control and Data Acquisition) system design has been developed for enabling the analysis of its timing properties. The analysis of this system, as well as a general mechanism that enables the derivation of analysis models from UML models has been examined in the context of a PhD thesis [5]. Further work is still under way to integrate the NFP modelling framework with component-based approaches. Some preliminary work has being carried out in the context of another thesis in the CEA Laboratory. This approach tries to explore the use of NFPs as a run-time interpretable language within a Fractal/Think-based ADL [4].

The MARTE supporting documents include the MARTE specification Beta1 (ptc/07-08-04) and the XMI v2.1 Serialization of the MARTE Profile (realtime/07-05-02) and. It is an OMG Adopted Beta Specification and is currently in the finalization phase. The MARTE Finalization Task Force (FTF) was chartered at the OMG Brussels Meeting on June 29, 2007. The FTF will work on solving issues related to the MARTE specification. Comments on the content of this document should be directed to issues@omg.org by December 21, 2007. The recommendations and report deadline of the MARTE FTF is July 4, 2008.

In addition to the specification itself, we issued a Tutorial (see section 2.3.5) and some related papers [2, 3]. Further papers can be found in http://www.omgmarte.org/

**Generation of Analyzable Models from the UML Models for Safety (UPM) (b)**

Safety-critical systems need to be thoroughly analyzed in order to be certified. Safety engineers build these analyses after the system has been entirely developed, or, at best, along with the functional validation. Early evaluations of the system could guide to a safer and cheaper end-product.

With this background, UPM conducted a previous work to create analyzable models, in particular: FMECA and FTA, from UML design models. During this year, this work has continued, with two key tasks. The first one was to transfer the analyzable models into a commercial safety tool, where the models are indeed analyzed. The second one was the validation of all this work. In collaboration with Thales ATM, an air traffic management architecture was modelled, including safety aspects. Then, the safety models were generated and served as input for a commercial analysis tool

**Composition of Quality-Adaptable Components (UPM) (c)**

The goal of this effort is to define modelling techniques for the composition of components that provide or require several quality levels and mechanisms for evaluating the overall quality. The UML Profile for "*Quality of Service and Fault Tolerance*" is suitable for defining non-functional aspects of software architectures and it has been taken as the basis for this work. Although it includes some mechanisms for modelling components with the characteristics described in the previous paragraph, there is no evidence whether it provides enough support.

In the context of this work, the suitability of the profile for this job has been analysed and additional mechanisms are needed for defining:

- The quality levels provided or required by a component for each quality characteristic.

- The feasible combinations of quality levels for a set of components and the overall resulting quality levels.
- The responsibilities of architectural components in the adaptation process
- The modes in which a service can be shared and the modes in which a provision need to be supplied by several providers.

The result of this work is the extension of the *Quality of Service and Fault Tolerance* profile for modelling these features, which relies on a formal metamodel. The building of a tool for performing analysis of the composability of a set of components is currently under development. A SCADA system will be used for validation. A draft document describing the current status of this work can be found in:

http://www.dit.upm.es/jfbriones/public/qos_component_composition.pdf

**QoS properties for functional composition in service-based real-time applications (UC3M) (c)**

UC3M has developed a characterisation of QoS properties for service-based applications to enable functional composition in networked embedded systems. Contributions to the composition of applications in real-time have been made by developing algorithms that are able to make calculations with respect to selected parameters. This work has been done in collaboration with the University of Aveiro and UPM.

**Rule-based approach to model adaptation policies (INRIA) (c)**

In spite of new methods and technologies in software engineering such as CBSE, or AOP, it is still difficult to talk about adaptation since adaptation policies might impact the architecture, the configuration data, and some extra-functional features as well.

The Inria team designed a rule-based approach to model adaptation policies that enables the description of both architectural and functional adaptation and to relate them with extra-functional properties. This result has been presented at the Ecoop workshop on Model Driven Software Adaptation (M-ADAPT'07, Berlin 2007).

The Inria team has also developed in the beginning of 2007 a tool supported approach allowing the evaluation of arbitrary complex adaptation policies at design time. The underlying concept is the reification of extra-functional concerns into so-called extra-functional components encapsulating both the monitoring of the relevant properties and the adaptation policies. Building on recent advances in executable meta-modelling techniques, these component-based architectures can be given operational semantics encompassing both functional and extra-functional aspects. This operational semantics then makes it possible to run simulations in order to get performance estimates with respect to some operational profiles. The approach was evaluated with a design example of a hand-held wireless video player where the designers can choose among several adaptations policies that try to maximise the frame rate in function of the bandwidth changes.

**The QoS for CCM specification (CEA LIST)** (d)

The QoS for CCM specification defines how to implement QoS properties on top of the CORBA Component Model (CCM). The implementation mechanism is chiefly based on an interception of the call chain and a negotiation of required QoS properties during connection setup. The CEA-LIST participated in the finalization task force for this specification (http://www.omg.org/techprocess/meetings/schedule/Qos_for_CCM_FTF2.html).

Since some issues were too disruptive to be solved within the FTF, it is planned to setup a revision task for this specification in which the CEA-LIST will participate as well.

**Adding Connectors to CCM (CEA LIST)** (d)

Together with Thales, the CEA-LIST aims to standardize so-called connectors for CCM. In standard CCM, interactions are restricted to synchronous CORBA calls, events and streaming. This restriction is quite important, since embedded systems often do not support an ORB. But even if this is the case, there is no standard way to customize quality of service properties of an interaction, for instance the policies of a real-time CORBA ORB.

The connector based middleware has been presented on the Artist2 funded workshops “Networks for Reconfigurable Embedded Systems” in Portugal (see section 2.3.5 below) and “Foundations of Component-based Design” in Salzburg/Austria.

The connector specification for CCM overcomes this restriction by treating interactions as first class citizens and allowing for configuration properties. We currently aim - together with Thales - to standardize connectors within the scope of the DDS for CCM submission (by motivating that a general connector approach is better than adding specific interaction mechanisms).

With the end of the project Compare in December 2006, CEA-List showed that the CCM connector extension is applicable to small (64KB RAM) targets running the OSEK operating system.

The national project "*Usine Logicielle*" aims to develop a software factory, treating the whole development chain from a UML model towards execution machinery based on CCM as well. In particular, we support a specific QoS parameter: fault-tolerance. The modeling is based on the Papyrus UML editor (http://www.papyrus-uml.org).

A first prototype of a specific connector that manages the transparent communication between replicas (including vote of results) has been implemented.

**QoS support in run-time components frameworks (UPM) (d)**

MPEG, a working group in ISO/IEC, is currently working in the standardization of an Application Programming Interface (API) for Multimedia Middleware (M3W), that as explained in the introduction, will allow application software to execute multimedia functions with a minimum knowledge of the inner workings of the multimedia middleware as well as to support a structured way of updating, upgrading and / or extending the multimedia middleware.

The Application Programming Interface mentioned above and a realization technology is specified in detail in ISO/IEC 23004 part 1-7. ISO/IEC 23004 part 8 is the reference software provided for this standard. Part 4 defines and API for resource and quality management. UPM has participated in this part since its beginning. The API provides the basic means to allow QoS-aware components to notify its quality information, to search for components providing a given quality and compose quality information. It is based on the HOLA-QoS quality management middleware.

This standard will include a reference implementation of this API to let final users experiment with the proposed API. UPM developed an initial version of a reference implementation for part 4 that includes a quality and a resource manager. Currently, UPM is upgrading this initial version to make it compatible with a recent new version of a reference implementation of the components runtime environment and associated tools.

### 2.3.2 Individual Publications Resulting from these Achievements

[1] Object Management Group, “UML Profile for Modelling and Analysis of Real-Time and Embedded systems (MARTE)”, Final Revised Submission (realtime/07-06-01) - June 25, 2007

[2] F. Thomas, H. Espinoza, S. Taha, S. Gérard, "MARTE, le futur standard OMG pour le développement dirigé par les modèles des systèmes embarqués temps réel", journal Génie Logiciel, n°80, March 2007.

[3] F. Lagarde, H. Espinoza, and S. Gérard, “Improving UML Profile Design Practices by Leveraging Conceptual Domain Models”, 22nd IEEE/ACM International Conference on Automated Software Engineering (ASE'07), November 2007 (accepted paper).

[4] F. Loiret, D. Servat and L. Seinturier, “A First Experimentation on High-Level Tooling Support upon Fractal”. In Proceedings of the 5th International ECOOP Workshop on Fractal Component, 2006.

[5] H. Espinoza, “An Integrated Model-Driven Framework for Specifying and Analyzing in Functional Properties of Real-Time Systems”, PhD Thesis, University of Evry, FRANCE. September 2007

[6] J. Fernández-Briones, M.A. de Miguel, J. P. Silva, A. Alonso, “Application of Safety Analyses in Model Driven Development”, In 5th IFIP Workshop on Software Technologies for Future Embedded & Ubiquitous Systems. Springer-Verlag May 2007.

[7] M.A. de Miguel, J. Fernández-Briones, J.P. Silva, A. Alonso, “Model Based Integration of Safety Analysis and Development”, In 9th IEEE Object-Oriented Real-Time Distributed Computing, IEEE Computer Society. May 2007. pp. 323-324

[8] Iria Estévez-Ayres, Marisol García-Valls, L. Almeida, P. Basanta-Val. Two composition algorithms for real-time service-based applications. Techincal Report UC3M.

[9] Franck Chauvel and Olivier Barais, “Modelling Adaptation Policies for Self-Adaptive Component Architectures”, Ecoop Workshop on Model Driven Software Adaptation, Berlin, july 2007.

### 2.3.3 Interaction and Building Excellence between Partners

The interaction between the members of this activity has helped to enrich the different views and approaches of the research topics. The interaction has been make possible by partners meetings held in some of the workshops listed below and in the context of the OMG. A PhD student of UPM visited THALES for three months, in order to perform the modelling and analysis of the safety properties of the ATM architecture. There collaboration between partners in some projects, such as e-MAGERIT (UPM and UC3M) or Inflexion (THALES and CEA-LIST).

### 2.3.4 Joint Publications Resulting from these Achievements

CEA-LIST, UPM and THALES have collaborated in the Task Force that produced the new version of the UML profile for QoS and Ft.

UPM and UC3M have collaborated on the definition of the API included in the ISO/IEC 23004 part 4.

### 2.3.5 Keynotes, Workshops, Tutorials

**Tutorial: MARTE: A New Standard for Modelling and Analysis of Real-Time and Embedded Systems ,**
**19th Euromicro Conference on Real-Time Systems (ECRTS 07),**
*Pisa, Italy, July 3rd, 2007.*

This Conference is a forum aimed at covering state-of-the-art research and development in real-time computing. Papers on all aspects of real-time systems are presented. It is the largest real-time conference in Europe (http://feanor.sssup.it/ecrts07/)

**Workshop: International workshop on UML & AADL'2007-09-20**
**(Held in conjunction with the 12th IEEE International Conference on Engineering Complex Computer Systems, ICECCS07)**
*Auckland, New Zealand. July 11 - 14, 2007*

This workshop seeks contributions from researchers and practitioners interested in all aspects of the representation, analysis, and implementation of DRE behaviour and/or architecture models. The main interest topics were:

- Modelling RT/E using modelling languages such as UML and/or AADL, ACME…
- Defining a suitable architecture based process development
- Methods and tools for undertaking an MDA approach

**Workshop: NeRES 2007 - Networks for Reconfigurable Embedded Systems (Artist2 workshop): http://www.artist-embedded.org/artist/Motivation-and-Goal.html**

The workshop seeks flexible approaches to reconfigurability with the goal to improve resource efficiency, exploiting paradigms such as flexible modes, flexible scheduling, dynamic QoS management, stateful schedules, etc, particularly at the network level.

**Workshop: Modelling and Analysis of Real-Time and Embedded Systems**
**(Held in conjunction with the ACM/IEEE 9th International Conference on Model Driven Engineering Languages and Systems, MODELS)**
*Genova, Italy, October 2, 2006*

In the area of distributed, real-time and embedded systems (DRES), model-orientation has been applied fruitfully for many years. However, DRES have some very specific requirements. The purpose of this workshop is to provide an opportunity to gather researchers and industrial practitioners to survey existing efforts related to model-based design and analysis of DRES.

DRES have been designed in a model-oriented way since the forerunners of UML SDL and ROOM. The MDA initiative of OMG — for "Model Driven Architecture" – follows up by the idea that future process development will be centered on models, thus keeping application development, and underlying platform technology as separate as possible. The aspects

influenced by the underlying platform technology concern mainly non-functional aspects and communication primitives.

http://www.artist-embedded.org/artist/MARTES-2006,496.html

# 3. Future Work and Evolution

## *3.1 Problem to be Tackled over the next 12 months (Sept 2007 – Aug 2008)*

The work on this activity will continue the most important topics identified, that are the development of techniques and methods required for the industrial use of QoS aware components, such as:

- Notations for the description of components models including functional and QoS (also know as non-functional" aspects). The integration of this information in the interfaces is of primary importance.
- Automatic generation of analysis models for the QoS properties modelled.
- Composition mechanisms for determining whether it is feasible components interconnection and for deriving the non-functional characteristics of a group of connected components and the resources needed to fulfil them and support for adaptability.
- Component frameworks to support the runtime composition of QoS aware components and to interact with the QoS management subsystems.

### Specification of QoS properties

The standardization efforts on notations for specification QoS properties have produced two mature standards, the UML profiles with this aim: MARTE and "QoS and FT". The partners in these activities have used them to specify successfully in some practical works two QoS properties: safety and time. The activities for this year will be to compare these approaches and try to combine the best features of each of them. Model transformation between these two profiles will be also investigated on relation two safety and time QoS characteristics.

### Generation of analysable models from the UML models

The work done on this topic has demonstrated the feasibility and interest of this approach from theoretical and practical points of view. The planned work related with the support to safety using the "QoS and FT Profile" is to adapt it with other safety models (current work has need done with the EUROCONTROL model) and to extend it to further safety analysis, in order to give the designer a wider range of options.

### Composability of QoS components

The composability of the QoS components it is a research topic far from being solved. This is more the case if we consider their adaptation to the context. The development of tools to analyze the composability of the safety QoS characteristic will be refined and validated with a sound model, such as the SCADA system already developed. Additional work will be done towards tools to analyze other quality aspects of a component-based system. Finally, one ambitious goal will be the simulation of the quality behaviour of the system in response to user wishes and/or other changes in the environment.

**QoS support in run-time components frameworks**

QoS run-time support is required for making it possible the use of this types of components. The standardization of an API for QoS and resource management (ISO/IEC 23004-4) is an important milestone. UPM plans to continue the development and refinement of the mentioned reference implementation.

## *3.2 Current and Future Milestones*

1. (achieved) Year 1: Identification of the concrete integration topics: modelling of QoS properties in design models and components frameworks.
2. (achieved) Year 2: Study and dissemination of the approaches from different partners. Definition of case studies for comparing the approaches and begin its modelling. The work has concentrated on UML profiles for the description of extra-functional properties and on evolutions of CCM and Robocop as the components frameworks.

   *The partners have presented and distributed their recent work and view mainly on three topics: specification of QoS (extra-functional) properties, automatic generation of analysable models and run-time components frameworks. A case study has been proposed for the experimentation with these techniques. It is the simplified specification of a SCADA system. The modelling of functional and extra-functional properties with this case has already started. The information on CCM and Robocop frameworks has been distributed among the interested partners and their crossed analysis is under way.*

3. (achieved) **Year 3: Completion of the use cases using the different modelling approaches. Comparison and identification of guidelines on their use. Refinement of the modelling of some specific QoS properties and automatic model generation.**

   *Partners have continued with the development of UML profiles standards and have used them to model time and safety characteristics for some industrial and real use cases, such as the SCADA system. The automatic generation of analysis models have also been performed successfully for these cases. In addition, a profile for supporting QoS components composability is under development. This topic is a basis for dealing with adaptability to the context at design and run time.*

4. Year 4: Propose a modelling technique that combines the best features of both for some selected extra-functional properties. Propose requirements for future QoS support on components framework. Develop prototypes for proving the validity of some of the new identified new features.

## *3.3 Indicators for Integration*

This activity will strengthen the links between the communities of component-based development, adaptive middleware, and hard real-time, in order to create a momentum for developing technology for QoS in real-time systems. The interaction between partners can be shown by the following activities:

- Selection of a common example (SCADA) for exercising the notations and tools developed by UPM and CEA-LIST. This will help to compare and learn from the work of different partners, as the use case is known in detail.
- UPM and UC3M have collaborated in the reference implementation of the middleware complaint with ISO/IEC 23004 part 4.
- Cooperation between Thales, UPM and CEA-LIST in the OMG standardization efforts related with the UML profiles for QoS and FT and MARTE.

### *3.4 Main Funding*

Main funding for UPM came from THREAD (Soporte integral para sistemas empotrados de tiempo real distribuidos y abiertos), which is a national research project. CICYT (Spain), Ref. TIC2005-08665

e-MAGERIT: Research project of Comunidad de Madrid, SPAIN, (S-0505/TIC/0251). UPM and UC3M participate in this project.

Part of the work from CEA and THALES is funded with the French project Inflexion.

Funding for IRISA relies from the following projects:

- AOSD network of excellence (2005-2009)
- French national RNTL Faros research project 2006-2009, on contract-based component design and deployment.
- French national RNTL OpenEmb research project 2006-2009
- SPEEDS ITEA project 2006-2009

# 4. Internal Reviewers for this Deliverable

Juan A. de la Puente (UPM)

Jose M. Drake (UC)