# OMG's Second Workshop on Real-time and Embedded Distributed Object Computing

## *Workshop Program*

### MONDAY – June 4, 2001

**TRACK I**

0900 - 1730 ***CORBA Tutorial***

Dr. Jon Siegel, Object Management Group

This all-day tutorial covers OMG's Object Management Architecture including CORBA, the CORBAservices and CORBAfacilities, the Domain CORBAfacilities, and an afternoon concentrating on the new specifications included in OMG's latest release, CORBA 3. Starting with a brief look at requirements and needs in distributed computing and how UML, the MOF, and XMI fit into the rest of the OMG specifications, the tutorial moves on to cover OMG Interface Definition Language and mappings to various programming languages, structure of the Object Request Broker, interoperability and the standard protocols GIOP and IIOP, and integration with Java and COM/DCOM. The next section of the tutorial covers the CORBAservices and facilities, and the Domain CORBAfacilities.

The afternoon covers the new specifications included in the CORBA 3 release, which fall into three categories: Improved integration with Java and the Internet; Quality of Service Control, and the CORBA Component Model or CCM. The discussion of CCM starts with a closer look at the Portable Object Adapter or POA, on which CCM is based.

**TRACK II**

0900 – 1730 ***The Emerging Real-Time UML Standard: Theory And Application***

Bran Selic, Rational Software

The Object Management Group is extending the Unified Modeling Language (UML) standard by providing a standardized "profile" for real-time systems development. This profile includes specific capabilities for representing various models of time, different models of concurrency, and system resources in general (e.g., physical and logical devices, semaphores, memory). A fundamental feature of the profile is the ability to attach quantitative information to UML models. This is based on a general framework for representing quality of service (QoS) characteristics. This enables the construction of UML models that can be used to predict key real-time characteristics early in the development process. For example, modelers will be able to transfer their UML model -- suitably annotated with relevant QoS characteristics -- to a schedulability analysis tool, where it can be analyzed to determine whether the system will meet all of its deadlines.

In the first half of the tutorial, we describe the key concepts behind the proposed standard. The second half focuses on application of the standard to common real-time problems such as schedulability analysis and performance modeling.

1030 - 1045 Morning Refreshments

1230 - 1330 Lunch

1515 - 1545 Afternoon Refreshments

## TUESDAY, June 5, 2001

0900 - 1500 ***Real-time CORBA Tutorial***

Doug Schmidt, University of California, Irvine

CORBA is an established standard that defines a flexible model for distributed object computing. Until recently, however, the CORBA specification lacked key features required by distributed real-time and embedded (DRE) systems. The Real-Time CORBA (RT-CORBA) specification is a document recently integrated into CORBA 2.4. It provides DRE developers with interfaces and policies to control key quality of service (QoS) properties of the underlying ORB endsystem and network infrastructure.

This tutorial focuses on (1) the RT-CORBA priority and threading model, (2) RT-CORBA mechanisms to select and control communication, processor, and memory resources, (3) RT-CORBA extensions to the Portable Object Adapter (POA), and (4) CORBA QoS framework policies pertaining to DRE applications. The tutorial shows by example how these RT-CORBA mechanisms can be combined to implement predictable DRE applications. Tutorial attendees will learn how to (1) use the RT-CORBA specification to build predictable DRE applications written in C++ and (2) evaluate different configurations and implementations of the specification according to the needs of their application domain.

1030 - 1100 Morning Refreshments

1200 - 1800 ***Demonstration Area Open***

1230 - 1330 Lunch

1500 - 1530 Afternoon Refreshments

1530 – 1730 ***Implementation Technology***

Chair: Victor Giddings – Objective Interface Systems

This session presents research into the implementation and evaluation of Real-Time and Embedded CORBA products. These presentations discuss the "how" rather than the "what" of Real-Time and Embedded CORBA, that is the primary focus of other sessions within this workshop. Not surprisingly, three of the four presentations discuss various aspects of the use and control of concurrency and synchronicity, an important issue in real time and embedded systems development. The remaining paper discusses techniques that might be used to evaluate these and other implementation decisions in selecting a product for a project.

**"The Design And Performance Of Real-time CORBA Event And Notification Services"**

Carlos O'Ryan University of California, Irvine

This presentation discusses design patterns and optimization techniques used in the implementation of Real-time Event and Notification CORBA Services. The presentation will describe how to develop flexible, event dispatching and scheduling mechanisms that can provide real-time guarantees. Next, it will show how to federate multiple instances of the Event and Notification Services to minimize latency for colocated suppliers/consumers, while still allowing highly scalable, location transparent communication with remote objects. Finally, the paper presents benchmarks that empirically demonstrate the predictability, low latency, and high utilization achievable with a Real-time Notification Service.

**"An Efficient And Scalable Server-side Asynchrony Model For Real-time CORBA"**

Darrell Brunsch, Douglas C. Schmidt, and Carlos O'Ryan, University of California, Irvine

Unlike an ordinary client or server, a "middle-tier server" passes requests between multiple clients and servers. The overhead of threading in commonly used architectures motivates the need for a different solution. In this presentation, we describe a model for extending the benefits of the CORBA asynchronous method invocation (AMI) model to an asynchronous method handling (AMH) model in a server. Using both AMI and AMH, a middle-tier server can leverage the properties of a message oriented model and execute in a more scalable and predictable way.

**"Evaluating Thread Pool Strategies For Real-time CORBA"**
Irfan Pyarali, Marina Spivak, and Ron Cytron, Washington University

We describe two general strategies for implementing RT-CORBA thread pools. The first strategy uses the Half-Sync/Half-Async pattern, where I/O thread(s) buffer the clients' requests in a queue and worker threads then process the requests. The second strategy uses the Leader/Followers pattern to demultiplex I/O events into threads in a pool without requiring additional I/O threads. We evaluate each thread pool strategy in terms of its consequences on (1) feature support, (2) scalability, (3) efficiency, (4) optimizations, and (5) bounded and unbounded priority inversion incurred in each implementation. Our evaluation helps application developers and end-users understand the schedulability, scalability, and predictability consequences of a particular thread pool implementation used by their RT-CORBA ORB.

**"Evaluation Criteria In The Selection Of Embedded And Real-Time CORBA Object Request Brokers"**
Charles Rush, Objective Interface Systems

This presentation identifies a criteria set to be used in the evaluation of real-time and embedded Object Request Brokers. These criteria will be discussed as they relate to the requirements of an embedded or real-time application. A simple Criteria-Score-Weight evaluation process will be presented that engineers and managers can adapt for their own needs. The criteria are divided into Business and Technical categories and their corresponding subcategories, supporting the evaluation criteria.

## WEDNESDAY, June 6, 2001

0845 - 0900 ***Opening Remarks*** – Andrew Watson, Object Management Group

0900 - 1030 ***Scheduling Policies and Mechanisms***
Chair: Dr. Shahzad Aslam-Mir, Vertel Corporation

Scheduling is the 'glue' of any distributed stable, deterministic, predictable real-time system. Whether a given real-time system is classified as hard or soft real-time, one of its essential ingredients will be a schedule that is used to orchestrate and co-ordinate the internal sub-tasks of which it may be composed. Now that distributed embedded hard real-time middleware has become a reality, it is important for such scheduling technologies to be investigated in the context of CORBA. This session focuses therefore on leading edge research into the scheduling policies and frameworks for such stringent real-time distributed middleware.

**"QoS Control Of Video Streams Using Quality Objects And The CORBA Audio/Video Service"**
Craig Rodrigues & David Karr, BBN Technologies - Yamuna Krishnamurthy & Irfan Pyarali, OOMWorks

This presentation will describe an ongoing research collaboration between the Quality Objects group of BBN Technologies, OOMWorks. We are investigating the application of Quality Objects (QuO) middleware developed at BBN to control the QoS requirements of a high-performance distributed video application. The video streams in this application are transmitted and controlled by the CORBA Audio/Video Streaming Service developed by OOMWorks. The presentation will describe the work done to date by BBN and OOMWorks, provide some of their experimental results, and describe the advantages and disadvantages of using CORBA middleware for developing distributed applications with complex QoS requirements.

**"Extending Real-Time CORBA For Next-Generation Distributed Real-Time Mission-Critical Systems"**
Christopher D. Gill and Ron K. Cytron, Washington University

Next generation distributed real-time mission-critical systems must adapt swiftly to changing environmental conditions, and effectively respond to transient opportunities and hazards. To achieve both (1) re-use and flexibility across system families and generations and (2) optimized real-time performance in these systems, this presentation will describe key enhancements to the Real-time CORBA 1.0 and Dynamic Scheduling Real-Time CORBA approaches: (1) support for hybridizing static and dynamic scheduling techniques, (2) support for variable-period tasks, (3) flexible rate selection and execution eligibility strategies, (4) cooperative interaction with resource managers, and (5) integrated resource adaptation mechanisms.

**"Applying Meta-Programming Techniques to Dynamically Order Equivalence Classes in Open Distributed Real-Time Systems"**
Angelo Corsaro, Ron Cytron, and Chris Gill, Washington University

In an open distributed real-time system, no assumption can be made regarding the scheduling policy that an end system will use. However, to realize an open architecture, it becomes necessary for such systems to reason about the importance of their activities. This is true for activities that originate on an end system as well as those activities that migrate there. We describe a scheme that addresses these concerns. The upcoming OMG Dynamic Scheduling specification is taken as case study for this presentation.

## 1000 - 2000 *Demonstration Area Open*

## 1030 - 1100 Morning Refreshments

## 1100 – 1230 *Real-Time Design and Modeling*
Chair: Andrew Watson, Object Management Group

Designing and modeling real-time applications can take many forms. This session will explore several possible alternatives for both designing and modeling real-time systems. This session will explore the use of UML (Unified Modeling Language), an OMG standard, and the proposed real-time extensions to the UML standard for modeling Real-Time CORBA. It will also look at the use of UML for modeling complex real-time architectures. Additionally, the design of a real-time ORB and the use of real-time Java features to reduce the costs of developing and maintaining distributed middleware and applications that possess stringent QoS (quality of service) requirements will also be explored.

**"Modeling RT CORBA Using The Profile In UML For Schedulability, Performance And Time"**
Peter Kortmann & Ben Watson, Tri-Pacific Software Inc.

The Real-Time PSIG is in the process of recommending a sequence of RFPs to address how to incorporate real-time into the UML specification. The first of these RFPs, "A UML Profile for Schedulability, Performance and Time" called for "proposals for a UML profile that defines standard paradigms of use for modeling of time, schedulability, and performance related aspects of real-time systems" that would: enable the construction of models that could be used to make quantitative predictions regarding these characteristics; facilitate communication of design intent between developers in a standard way; enable interoperability between various analysis and design tools. This presentation introduces the work-in-progress of the RFP submission team.

**"The Design Of A Real-time CORBA ORB Using Real-time Java"**
Carlos O'Ryan, Mayur Deshpande, and Douglas C. Schmidt , University of California, Irvine

This presentation discusses the architecture and design of a Real-time ORB called ZEN; this architecture eliminates common sources of overhead and non-determinism in ORB implementations. We also evaluate the applicability of several Real-time Java features in the implementation of Real-time ORBs. We illustrate how the ORB can support multiple transport protocols efficiently using Real-time Java features and how the ORB can be designed to automatically select the minimum set of components used by an application. Finally, we propose extensions to the Real-time CORBA programming model that support Real-time Java effectively.

**"A UML Profile for Modeling Complex Real-Time Architectures"**
Bran Selic, Rational Software

The high initial investment required to implement complex real-time systems means that they are often required to have a long operational lifetime. Consequently, the architecture of such systems must be designed to accommodate new and sometimes unexpected requirements. In this presentation, we describe how the basic modeling concepts of the industry-standard UML can be used to clearly specify the software architectures of complex real-time systems. We also explain how such specifications can be automatically enforced in the initial development and protected against corruption during subsequent evolution.

## 1230 - 1330 Lunch

1330 - 1515 ***Users' Roundtable***

Moderator: Tom Rutt, Lucent Technologies

This panel will provide end users who are considering the use of CORBA with a chance to hear the first hand experiences of those pioneering projects now deploying high performance, real-time or embedded CORBA based applications.

Panelists: Louis P. DiPalma, Raytheon Electronic Systems

Jeanna Gossett, The Boeing Company

John F. Masiyowski, Raytheon

Kevin Rice, GST, Inc.

1515 - 1545 Afternoon Refreshments

1545 - 1730 ***Implementers' Roundtable***

Moderator: Andrew Watson, Object Management Group

This panel of vendors of Real-time CORBA implementations, chaired by Andrew Watson, will focus on the products and plans of the companies represented. Panelists will briefly introduce their products, product \ plans, standards conformance plans and suggestions for future standardization in this area. This will be followed by an open discussion with all workshop participants on the topic.

Panelists: Shahzad Aslam-Mir, Vertel Corporation

Bill Beckwith, Objective Interface Systems

Ken Black, Highlander Engineering

Mark S. Gerhardt, TimeSys Corporation

S. Ron Oliver, Top Graph'X

Douglas C. Schmidt, University of California, Irvine

1800 - 2000 ***Workshop Reception hosted by Objective Interface Systems***

## THURSDAY, June 7, 2001

0845 – 0915 ***Sponsor Presentation*** – Objective Interface Systems

0915 - 1115 ***Quality of Service***

Chair: Steve Grimaldi, Objective Interface Systems

As Real-Time CORBA becomes ubiquitous in distributed systems, the requirement to address quality of service (QOS) has arisen as an area where application developers need to focus in order to deliver their mission-critical systems. This session delves deeply into QOS concepts for real-time and embedded system development. Topics presented address modeling, meta-programming, API, and CASE tools.

**"CORBA QoS Management with CIM/WBEM"**

André Barros De Sales & Michelle Sibilla, Institut de Recherche en Informatique de Toulouse (IRIT)
François Jocteur-Monrozier, Centre National d'Etudes Spatiales (CNES)

We focus on how to model CORBA QoS and its relationships between Operating System QoS and Networks QoS. In order to reach interoperability of management system, we chose the DMTF/CIM approach (that is a common data model for describing overall management information in a network/enterprise environment) to model CORBA QOS Management Information (MIB). We developed a new approach to deal with management of large number of complex systems called SUMO (SUpervision and Mastery for Functioning of Space Operations) based on CIM/CORBA/Java implementation. SUMO offers integrated management services (in particular, fault tolerance and security for the CORBA environment). We present an overview of QOS CORBA management in SUMO.

**"Meta-Programming Techniques to Configure Open Standard RT CORBA Middleware Declaratively"**

Joseph K. Cross, Lockheed Martin Tactical Systems

The problem addressed in this presentation is the dependencies of applications on their supporting infrastructure that are introduced by vendor-specific configuration mechanisms. These "knobs and dials" make a middleware product adaptable to the demands of real-time embedded systems, but make the systems dependent on the middleware products. Our approach to this problem is based on a meta-programming technique, which we call a quality connector. Quality connectors allow an application that uses RT CORBA to specify the QoS it requires of the middleware. If the requested QoS is achievable, then a quality connector configures the middleware components to provide it.

**"High Level API For CORBA-Compliant High-Precision Real-Time Programming"**

H. Miyazaki and K.H. (Kane) Kim, UC Irvine

This presentation focuses on application programming interfaces which enable intuitive easy-to-understand specification of timing requirements imposed on object methods and remote method calls in CORBA objects. The programming model adopted here and called the time-triggered message-triggered object (TMO) programming scheme, can be supported by an appropriately constructed middleware such as TMOES but without introducing a new compiler. Specific aspects discussed include:

(1) Major features of an API facilitating high-level real-time CORBA object programming:
- facilities and styles for constructing time-triggered methods,
- message-triggered methods,
- lockable data structures,
- interface definition, etc.

(2) Potential benefits of migrating some of the features into the ORB
(3) An example application constructed.

**"MicroQoSCORBA: A Reflective, QoS-Enabled, Configurable MicroCORBA With CASE Support"**

A. David McKinnon, David E. Bakken, John C. Shovic, Washington State University

The spectrum of embedded applications spans widely varying requirements for one or more of: performance, timeliness, reliability, fault tolerance, security, memory usage and power consumption. We are defining and implementing MicroQoSCORBA to provide a spectrum of service levels for many of these requirements, many of them non-network centric. The MicroQoSCORBA developer will then be able, at design time, to pick and choose from the multiple QoS implementations so that a given application's resource usage and delivered QoS (performance, tolerance to failures, security, etc.) can best be meet. This presentation will focus on the underlying design and architecture of MicroQoSCORBA.

1115 - 1130 Morning Refreshments

## 1130 - 1230 *Case Studies I*

Chairs: Dock Allen, MITRE & Christopher D. Gill, Washington University

Three case studies sessions reveal how CORBA is being applied to real-world embedded and real-time systems. The presentations span a breadth of domains, including consumer devices, software defined radio, defense and space systems, and high-tech manufacturing. The systems range in scale from embedded devices to distributed command and control, from high to low real-time predictability, and include cases that stress the performance limits of current technology. Several presentations describe sucessful integration of CORBA technologies across multiple products, vendors, and languages. These sessions publish the valuable experiences and insights of people who are applying CORBA in practice, to deploy real embedded and real-time systems.

**"Real-Time CORBA Experiences in an Avionics Domain"**
Jeanna Gossett, David Corman and David Sharp, The Boeing Company

Real-time CORBA middleware is being utilized at Boeing in a variety of avionics research and development projects, both internally funded and funded for government research. The basis for these projects is the Boeing-funded software initiative, Bold Stroke, which uses The ACE ORB (TAO) as a core component to provide the distributed object computing foundation necessary for highly configurable and reusable avionics applications. In addition to providing required functionality, the use of standards-based middleware provides important additional benefits such as platform independence, interoperability, and leveraging of commercial technology for military applications. This presentation focuses on the experiences and lessons learned when using RT CORBA in an avionics domain.

**"Developing Real-time Embedded Object Oriented Applications With CORBA"**
Joey Garon, Vertel Corporation

This session discusses OO architectures used to achieve high reliability, performance, and flexibility in complex embedded real-time systems. Popular tradeoffs in achieving determinism, minimal footprint, and high reliability, all while maintaining high performance thruput will be described. Examples will be drawn from the experiences with next-generation optical network elements and medical equipment that employ real-time embedded CORBA, and consumer electronics devices (e.g. set-top boxes and wireless PDAs). Finally, new challenges facing the implementors of CORBA-based real-time embedded systems and the possible impact on the evolution of possibly new CORBA specifications will be given.

1230 - 1330 Lunch

## 1330 - 1500 *Case Studies II*

Chairs: Dock Allen, MITRE & Christopher D. Gill, Washington University

**"Applying CORBA In A Contemporary Real-Time Embedded System"**
Bruce Trask, Contact Systems

We make large high-performance robots. Key to the functionality and performance of these robots is the CORBA middleware that acts as the communication infrastructure between multiple processors running hetergeneous environments. Being able to design our domain-specific software on top of and in concert with CORBA-compliant middleware has been key in developing next generation machines. This presentation will discuss the domain design challenges encountered and how the following CORBA middleware capabilities have been used as part of the solution: CORBA Messaging Framework; Real-Time Event Service; Naming Service; Java ORBs with C++ Real-Time ORB; Advanced use of the POA; ORB-controlled concurrency models.

**"Applying CORBA in a Contemporary Embedded Military Combat System"**
Robert E. Kelly, Jr. & Louis P. DiPalma, Raytheon Electronic Systems

An overview of modern embedded Combat Control (CC) Systems onboard the Navy's submarine will introduce the system architecture and interfaces. Motivation and constraints for system middleware will be presented, and the current middleware composition will be described. Data exchanged via CORBA will be categorized and the CORBA services employed will be identified. Lessons learned in the infusion of CORBA and issues associated with the integration of CORBA with the legacy Real-Time middleware will be detailed. Next generation CC middleware and a longer-term plausible migration to RT-CORBA will be outlined.

**"Realtime Image Analysis with CORBA in an Industrial Production Environment"**
Lothar Werzinger, KRONES AG

This presentation will highlight the architecture of the inspections system used by Krones. The system is distributed (up to 10 autonomous inspection units) and has a central Windows NT computer for the HMI (human machine interface). It will also illustrate the realtime constraints faced, i.e inspection of up to 40 images per second, and other system aspects including image acquisition, image analysis and the result preparation via an event channel using CORBA as its communication infrastructure.

## 1500 - 1530 Afternoon Refreshments

## 1530 - 1700 *Case Studies III*

Chairs: Dock Allen, MITRE & Christopher D. Gill, Washington University

**"Embedded Real-Time CORBA Requirements for Software Defined Radios"**
Byron Tarver, Annamarie Miller, Eric Christensen, Motorola, IISG

Motorola has been using an ORB within its Software Defined Radio (SDR) development for the past 4 years embodied in the Digital Modular Radio currently being delivered to the US Navy. The major issues addressed were:

- supporting software deployment and real-time reconfiguration across multiple CORBA capable processors executing a single radio application
- posturing the software for dynamic reallocation within the SDR and portability to other SDR platforms.
- establishing non-transactional and persistent data flow nature of waveform signal processing applications

This discussion addresses the benefits, uses, and lessons learned from Motorola's SDR development and use of custom and commercial ORBs.

**"CORBA In SIGINT Systems"**
John F. Masiyowski, Raytheon

CORBA provides a flexible, dynamic, implementation-independent solution to the information exchange between systems via computer networks. The advantages of distributed object-computing fits perfectly into the SIGINT systems. Previous systems were primarily vertical "stovepipe" systems that did not interoperate very well. CORBA changes all of that while adhering to an industry standard. CORBA technology has been incorporated into these SIGINT systems to continually enhance system capabilities and improve system interoperability and maintainability. CORBA represents a significant leap from socket level network programming and application development. CORBA allows the application domain developer to concentrate on the application versus the specific and low-level mechanics of network socket level programming.

**"Applicability of Real-time CORBA in future GSFC Satellite Flight Software"**
Kevin Rice, NASA-GSFC

This presentation outlines NASA Goddard Space Flight Centers (GSFC) exploration of using CORBA in satellite flight software. The goal of this work is to determine whether Real-time CORBA can be used to replace portions of custom flight software, saving development time and money, as well as exploring the use of CORBA as an advanced satellite service for future missions, either on-board or on the ground. It will outline GSFC's flight software heritage up to the present time, give an overview of the internals of the Microwave Anisotropy Probe's (MAP) flight software, and discuss the current state of the studies phases.

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PROGRAM COMMITTEE

Chair: Andrew Watson, Object Management Group

Members:

Dock Allen, MITRE
Shahzad Aslam-Mir, Vertel
David Barnett, Highlander Engineering
Bill Beckwith, Objective Interface Systems
Ken Black, Highlander Engineering
Bruce Douglass, I-Logix
Victor.Giddings, Objective Interface Systems
Mark Gerhardt, TimeSys
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