Real-time and Embedded Distributed Object Computing Workshop

Arlington, VA USA
July 15-18, 2002

Complete Workshop Program

MONDAY – July 15, 2002

TUTORIAL TRACK I

0900 - 1700 ***Real-Time and Minimum CORBA***
Bill Beckwith, Objective Interface Systems

The OMG Real-time CORBA specification extends CORBA for use in real-time systems. Real-time CORBA provides a clean infrastructure for building distributed applications with time constraints. In addition, the Minimum CORBA specification offers a feature-optimized version of the CORBA specification that allows application designers to depend on the reduced feature sets of lightweight ORB implementations. This tutorial will review the following specifications: Real-time CORBA 1.0, Real-time CORBA 2.0: Dynamic Scheduling, Minimum CORBA

TUTORIAL TRACK II

0900 – 1445 ***Real-Time UML***
Bruce Douglass, I-Logix, Inc.

The Unified Modeling Language is a powerful language for describing and specifying systems. It can be effectively applied to all kinds of software systems including real-time embedded systems (RTES). This tutorial focuses on the key aspects of the UML relevant to RTES, including capturing functional and performance requirements, identifying objects and classes within RTES, and tying requirements to class models, concurrency, and distribution design. It also discusses behavioral descriptions using sequence diagrams and statecharts and the role of objects in high-reliability and safety-critical RTES design. The discussion includes the elements of the UML Profile for Schedulability, Time and Performance, recently adopted into the UML standard by the OMG. A development process specialized for RTES, called ROPES, is briefly discussed in terms of the development activities performed and the UML views used and generated.

1500 – 1700 ***Safety Critical Systems Design***
Bruce Douglass, I-Logix, Inc.

Software is assuming an ever-increasing role in the control of potentially dangerous equipment. This applies to fly-by-wire aircraft, nuclear power plants, industrial control systems, and smaller-scale devices, such as drive-by-wire automobiles, microwave ovens, and medical equipment. Despite this trend toward relying on software to provide safe and effective control of hazardous materials and systems, very few opportunities exist for engineers to get training and education in even the basic concepts of safety engineering. This class introduces the engineering of safe and reliable systems, particularly those that depend heavily on software. Basic safety concepts are discussed and analytical methods are provided to improve and ascertain the safety of critical systems. Examples illustrate the analytical and procedural methods.

1030 - 1045 Morning Refreshments
1215 - 1315 Lunch
1445 - 1500 Afternoon Refreshments

TUESDAY - July 16, 2002

TUTORIAL TRACK I

0900 - 1215 ***Modeling Behavior with UML: Interactions and Statecharts***
Bruce Douglass, I-Logix, Inc.

The UML provides very good tools for specifying behavior application systems. Behavior may be specified for individual classes, subsystems, components and use cases with statecharts and activity diagrams. Behavior may also be specified for elements acting in collaboration using interactions diagrams using sequence and collaboration diagrams. Statecharts, an enhanced form of state machines developed by Dr. David Harel of I-Logix, form the basis for all behavior in the UML. Statecharts provide the ability to specify both hierarchical and concurrent behavior. Activity charts, while intimately related to statecharts, are used effectively to model algorithmic behavior. Sequence diagrams are used to show how collections of individual elements work together in collaboration to produce system-wide behavior. Emphasis is on object-oriented models, but these methods and techniques apply well to structured systems development as well. Examples show how to apply these technologies to real-time and embedded systems.

TUTORIAL TRACK II

0900 – 1030 ***The UML Profile for Schedulability, Performance and Time***
Ben Watson, Tri-Pacific Software

The UML Profile for Schedulability, Performance and Time is a recent Object Management Group (OMG) standard that provides a set of stereotypes and tagged values to express a system's non-functional, time related characteristics. The profile identifies a way of thinking about QoS and introduces the concept of model processing for various model analysis tools. This tutorial explains the profile and the concepts employed to derive the stereotypes and tagged values. Its concepts include resources and resource usage, time and timing mechanisms, concurrency, performance, and schedulability. Of particular interest for this workshop is a schedulability model for Real-Time CORBA 1.0 and Real-Time CORBA 2.0. The tutorial includes examples for embedded and real-time CORBA applications.

1045 – 1215 ***Introduction to Model Driven Architecture***
Jon Siegel, Object Management Group

Because each middleware platform works best in a particular network niche (such as behind the firewall, or over the Internet), today's enterprise must deal with a multitude of platforms and connectivity paradigms. OMG's new Model Driven Architecture (MDA) unifies and simplifies this environment by defining software fundamentally at the model level, expressed in the standard Unified Modeling Language (UML). An application's base model specifies every detail of its business functionality and behavior in a technology-neutral way. Working from the base model, MDA tools use OMG-standard mappings to generate interfaces and most or all of the implementation code for one or more target middleware platforms. Tools also generate cross-platform invocations, allowing easy interworking with other applications wherever they reside. MDA supports applications over their full lifecycle starting with design and moving on to coding, testing, and deployment, through maintenance, and eventually to evolution to a new platform when an application's existing platform becomes obsolete. Another benefit: because industry standards defined in the MDA are platform-independent, they can be used by every enterprise even in industries that haven't converged on a single middleware platform. The MDA became the base architecture for OMG standards in September 2001.

1030 - 1045 Morning Refreshments

1200 - 1800 Demonstration Area Open

1215 - 1315 Lunch

1315 – 1330 ***Opening Remarks* – Program Co-Chairs**
Christopher D. Gill, Washington University
Andrew Watson, Object Management Group

1330 – 1500 ***Model-driven Approaches to RT Software Development***
Chair: Jon Siegel, Object Management Group

Notations that cannot represent a system's non-functional, time related characteristics have in the past limited the use of modeling when designing RT applications. Furthermore, a lack of control over the quality of generated code has left RT designers unable to take advantage of automatic code generation from high-level models. However, today both these constraints are disappearing. Papers in this session will cover UML-based techniques for modeling schedulability, performance and time characteristics of RT applications, and the use of model-based design approaches such as OMG's Model Driven Architecture (MDA).

Non-Functional Analysis for UML Models - A Case Study: Model Processing for Analysis
Ben Watson, Tri-Pacific Software, Inc.

The UML Profile for Schedulability, Performance and Time is a recent OMG standard that provides a set of stereotypes and tagged values to express a system's non-functional, time related characteristics. The profile identifies a way of thinking about QoS and introduces the concept of model processing for various model analysis tools. This presentation is a brief introduction to the profile, the concepts behind the profile and a case study of the implementation of a model processor for schedulability analysis using the profile. We will present the conceptual models used for the implementation and apply the model processor to a sample UML model to show a complete cycle through the analysis process.

Applying the Model Driven Architecture to Distributed Real-time and Embedded Applications
Balachandran Natarajan and Nanbor Wang, Washington University - Aniruddha Gokhale, ISIS, Vanderbilt University - Douglas C. Schmidt, University of California, Irvine

Distributed real-time and embedded (DRE) application developers face many challenges when using the traditional distributed object computing (DOC) middleware. The talk focuses on how (1) the MDA paradigm can be applied to resolve these challenges and simplify the development of DRE applications and reusable, QoS-enabled component-based services and (2) pattern-oriented middleware enables MDA modeling and synthesis tools to rapidly develop, assemble, and deploy DOC middleware and component-based services tailored for the needs of DRE systems.

Model-Integrated Computing For Composition of Complex QoS Applications Using The Generic Modeling Environment (GME)
Sandeep Neema, Ted Bapty, Jeff Gray - Vanderbilt University

This presentation will: - describe a domain specific modeling environment for specifying adaptive QoS behavior of middleware-based systems; - describe and demonstrate the modeling language, and a representative application; - describe and demonstrate the tools for simulating the design's QoS behavior; - describe and demonstrate the creation of executable Contract Definition Language (CDL) for implementation of a system.

1500 – 1530 Afternoon Refreshments

1530 – 1730 ***Performance Issues for Use of RT-CORBA and/or RT-JAVA***
Chair: Andrew Watson, Object Management Group

As the popularity of distributed technologies has grown, so has the interest in their use for real-time and embedded systems. With the maturity of RT-CORBA and quickly maturing RT-JAVA products, it becomes necessary to evaluate the performance of these technologies for use in embedded systems. This track will provide first hand data and experience in using these real-time, distributed technologies.

A Comparison Of Using Alternate IPC Mechanisms Within An ORB Framework
Chuck Abbott, Objective Interface Systems

An increased interest in real-time and embedded CORBA is causing CORBA application programmers to take a harder look at alternate, non-default, IPC mechanisms for better speed and predictability. The default intra-host, inter-process communication mechanism for most ORB applications is TCP over the loop-back adapter. TCP provides a reliable, standard mechanism of IPC with very good location transparency, but in some cases lacks the needed throughput and timeliness requirements for real-time and embedded applications. This presentation will explore alternative mechanisms such as shared memory and message queues, which can be used in an ORB framework to decrease latency, and increase both throughput and predictability.

Benchmarking Real-Time and Embedded CORBA ORBs: Beyond the Obvious
Brad Balfour, Objective Interface Systems

When faced with the task of selecting an ORB for their embedded or real-time application, the first thing that most developers do is find out how fast the ORB is. There is a lot more information that can, and should, be gathered. Much of it is unique to the analysis of embedded and real-time CORBA and won't be found by studying benchmarks of enterprise and desktop ORBs. Additional areas to be explored include: Determinism/Predictability, Throughput, Scalability, Footprint and RT CORBA Priorities and Priority Inversion. This presentation will examine ORB benchmarking in light of Embedded and Real-Time concerns and to propose additional measures and relate them to ORB characteristics.

Empirical Analysis of Real-Time Java Performance and Predictability
Angelo Corsaro and Douglas C. Schmidt, University of California, Irvine

In this presentation we empirically analyze most of the RTSJ features and compare the performance of the RTSJ RI with other popular and emerging real-time Java implementations. These results clarify the current status of available Real-time Java implementations and indicate what application domains these implementations can target. We also provide an analysis of the data structure and techniques that can be used to implement efficient and predictable RTSJ asynchronous event dispatching and scoped memory.

The Performance of ZEN: a Real-time CORBA ORB using Real-time Java
Ray Klefstad, University of California, Irvine

Our presentation at the last OMG conference presented the design goals and design of ZEN: a real-time CORBA ORB for real-time Java. This presentation illustrates how ZEN can be configured to select the minimal set of components used by an application to keep footprint small for embedded systems. We will also show how we utilized the features of the Real-Time Specification for Java (RTSJ) and the design patterns we used to implement ZEN. This presentation concludes with an overview of the performance of ZEN's throughput latency, predictability, and footprint using jRate - an ahead-of-time compiler for real-time Java based on the GNU Java compiler, gcj.

WEDNESDAY, July 17, 2002

0900 - 1230 *Approaches for Real-time High Confidence Systems*

Chairs: Dock Allen, MITRE Corporation
Yuval Levy, Vertel Corporation

Real-time systems often are required to provide high levels of confidence, including fault tolerance, security, safety, and sanctuary. Integrators of these systems are looking for frameworks that are based on open standard and proven technologies. The OMG offers these broad specifications with technology support from many vendors and organizations. This session will discuss various approaches, including research and implementation experiences, that can provide the building blocks for trusted and high confidence systems

Providing Both Real-Time and Fault Tolerance Support to CORBA Applications
Priya Narasimhan, Carnegie Mellon University

The OMG's Real-Time CORBA and Fault-Tolerant CORBA specifications make it possible for today's CORBA implementations to exhibit either real-time (RT) or fault tolerance (FT) in isolation. However, supporting RT and FT simultaneously is challenging because the two QoS properties often impose conflicting requirements on the system. This presentation discusses how both RT and FT can be provided for CORBA applications, focussing on strategies (i) to reconcile the conflicting requirements, (ii) to identify and to resolve the resulting RT vs. FT tradoffs, and (iii) to continue to deliver adequate RT+FT QoS, even in the face of faults and changing resources.

Adding Fault-Tolerance to Real-Time CORBA Systems
Balachandran Natarajan and Christopher D. Gill, Washington U. - Aniruddha Gokhale, ISIS, Vanderbilt U. – Joseph K. Cross and Sylvester J. Fernandes, Lockheed Martin Tactical Systems

Open standard middleware has not explicitly addressed the constraints of dependable distributed real-time and embedded (DDRE) applications that require support for multiple quality of service (QoS) properties, such as dependability, and predictability. In this talk we (1) describe requirements for a class of DDRE systems that include both high reliability and predictable behavior, (2) show that naïve application of CORBA implementations to such systems can lead to poor solutions and (3) propose a solution that provides a better compromise between dependability and performance guarantees, and provide empirical data on how the solution improves the applicability of CORBA to DDRE systems.

Continuously Available Scalable Objects (CASO): An Elaboration of Fault-Tolerant CORBA
Russell L. Carter, FTOCO, LLC

We describe an implementation of a subset of FT-CORBA that uses modern group communication algorithms to provide optimal failover characteristics consistent with the motivation for the ACTIVE replication style specified in FT-CORBA. This implementation addresses the deficiencies in FT-CORBA that prevent enforcement of at-most-once invocation semantics. These deficiencies are excised by integrating the application object's fault tolerance semantics with those of FT-CORBA.

1000 - 2000 Demonstration Area Opens

1030 - 1100 Morning Refreshments

(Approaches for Real-time High Confidence Systems)

High Performance Distributed Computing (HiPer-D) Testbed
Leslie Madden & Paul Werme, Naval Surface Warfare Center Dahlgren Division

The High Performance Distributed Computing (HiPer-D) Program at the Naval Surface Warfare Center/Dahlgren Division (NSWC/DD) was established to explore distributed computing concepts, technologies, and architectures, and to evaluate their applicability to complex Navy shipboard systems. This talk will address our experiences to date with CORBA and fault tolerance, our ongoing efforts to use CORBA in our Dynamic Resource Manager (DRM) to monitor and control network QoS, and our plans to use CORBA to develop open APIs for the DRM.

An ORB for High-Assurance Avionics/Safety Critical Real-Time CORBA
David Haverkamp, Rockwell Collins

This presentation explores the fundamental requirements for a high assurance CORBA ORB for safety critical avionics. It describes our comparison of several open-source CORBA ORBs. For performance tests, we used the standard DII-COE tests. We then overview the issues with porting an open-source ORB to a safety critical real-time operating system. Followed by a description of some changes to an existing open-source CORBA implementation in terms of design patterns and refactorings related to DO-178B compliance. Components of this presentation will relate to the Rockwell Collins response to the OMG Safety Critical RFI.

High Assurance Security for Embedded Distributed Systems
Bill Beckwith, Objective Interface Systems

Because the design of embedded systems frequently is driven by performance, footprint security features are frequently omitted. Yet embedded systems and their inter-communications are often the most accessible target of the potential attackers. This presentation will discuss: issues and challenges in providing high assurance embedded, security, an ongoing initiative to collaborate on a common, high, assurance security infrastructure for embedded systems.

1230 - 1330 Lunch

1330 – 1415 *Distributed Real-Time Embedded Systems Middleware For Network-Centric Combat Systems (Sponsor Presentation)*

Chair: Gary Toth, ONR

Joseph K. Cross, Lockheed Martin
Louis P. DiPalma, Raytheon Electronics Systems Co.
Michael W. Masters, Naval Surface Warfare Center
Trudy Morgan, US Navy SPAWAR
Richard E. Schantz, BBN Technologies
David C. Sharp, The Boeing Company

1415 – 1500 *Department of Defense Industry Case Studies using RT-CORBA*

Chair: Andrew Watson, Object Management Group

The maturity of RT-CORBA as a product line has resulted in the serious consideration of this technology for use in DoD weapon systems, traditionally a very conservative industry in adoption of commercial technologies. This track will highlight the feasibility and success of RT-CORBA for use in military systems as presented in these case studies.

The Role of Middleware in Distributed Real-Time Embedded (DRE) Systems for Network Centric Combat Control (A Sensor-to-Shooter Perspective)
Louis DiPalma & Robert Kelly, Raytheon Electronic Systems
Peter Kortmann, Ben Watson & Russ Johnston, Tri-Pacific Software
Victor Fay Wolfe & Lisa DiPippo, University of Rhode Island
Trudy Morgan, SPAWAR Systems Center SD

The employment of RT-CORBA based middleware in the context of DRE Naval Combat Systems is gaining momentum. The “Sensor-To-Weapon” problem will be used as the basis to elucidate the need for DRE Middleware. Experiences employing CORBA along with legacy DRE Naval Combat Systems middleware will be shared. Details will be provided regarding the necessary steps that must be taken in the employment of RT-CORBA-based middleware. Additionally, current and proposed research associated with extending the QoS components of CORBA middleware will be presented.

Determining Whether CORBA is Suitable for Implementing Real-Time Airborne Radar Applications
Carolyn B Boettcher and Robert Moore, Raytheon Electronic Systems

Modern airborne radars execute on a distributed network of processors that communicate over high speed busses, such as FibreChannel. The radar application itself is a subsystem within a larger distributed system where the various subsystems in the mission avionics cooperate to achieve mission objectives. We will discuss the quality of service requirements for the internal and external radar communications, then present lessons learned about using the TAO ORB in an embedded environment and about the CORBA services we are applying.

1500 – 1600 *Poster Session*

Chair: Andrew Watson, Object Management Group

These papers, covering a variety of topics, will be presented as posters available for viewing any time during Wednesday and Thursday. The posters' authors will be available to discuss their work during this hour-long session on Wednesday afternoon.

Successfully Introducing CORBA into the Signal Processing Chain of a Software-defined Radio
David Dohse et al, General Dynamics Decision Systems

Introduction of CORBA into the signal processing chain of a Software-Defined Radio (SDR) is possible without incurring onerous overhead costs. Over the past three years General Dynamics Decision Systems has incorporated CORBA into such environments making possible the development of a common set of applications for a variety of platforms. The presentation illustrates use of drop-in CORBA objects facilitating the tailoring and enhancement of features through software updates that incorporate capabilities quickly and cost-effectively without major equipment upgrades. Extending minimum CORBA with Real-time mechanisms for thread pools and priority management is discussed relative to increased system stability.

The Design and Performance of an Asynchronous Method Handling Mechanism for Real-time CORBA
Mayur Deshpande, Carlos O'Ryan and Douglas C. Schmidt, University of California, Irvine

In this presentation we will describe how we designed and implemented a server-side asynchrony mechanism, called Asynchronous Method Handling (AMH) in The ACE ORB (TAO). The AMH Implied-IDL specification will also be illustrated. Example use-cases of AMH and a representative implementation of a middle-tier-server will be discussed. Empirical evaluation of the AMH model for middle-tier servers in comparison to other common CORBA server models, such as thread-pool or thread-per-connection will be illustarted. Using the results of our benchmark, we will present scenarios where AMH is a good fit.

A Case Study: Applying CORBA to Internet Multiplayer Video Games
John Collins, Parthenon Technologies, Inc.

Professional video game development studios have traditionally developed large portions of their game applications in-house using proprietary methods. Recently as the expected quality and complexity of the game applications increase, code re-use has become a widely recognized objective. There is a trend in the industry for growing numbers of developers to seek middleware to handle such tasks as 3D graphics rendering, physics simulation, networking, etc. Since the industry’s middleware needs include interoperability, platform- and language-independence, scalability, fault-tolerance and meeting real-time constraints, CORBA seems to be a natural choice for building video games. This presentation illustrates solutions to greatly simplify CORBA software development and user configuration for this industry.

High Level Validation of CORBA Architecture and Services Using a Discrete Event Simulation Approach
Emmanuelle de Gentili and Jean François Santuuci, University of Corsica

From the deployment of a distributed network based on the use of the CORBA architecture, we initiate an original approach in order to simulate the communication between components of a network; this approach is based on the discrete event modeling and simulation of the behavior of objects involved in the CORBA architecture
From UML specifications or from a program code (Algorithm) of CORBA services, the use of formalism DEVS combined with our definitions results in a generic behavioral model allowing the code verification or the validation of the UML Specification at high level before the physical implementation of architecture and services.

Stateful Distributed Objects - Unifying Distributed Object Interfaces with Publish-Subscribe Data Dissemination
J. Russell Noseworthy, Object Sciences

This presentation describes IKE 2, which is distributed object computing middleware that supports the creation of interoperable real-time distributed applications. These applications appear in many domains, such as telecom, aerospace, military testing and training ranges, and financial services. IKE 2 combines the concepts of CORBA distributed objects and anonymous publish-subscribe data dissemination to provide a programming abstraction known as a stateful distributed object (SDO).

MicroQoSCORBA: A QoS-Enabled, Reflective, and Configurable Middleware Framework for Embedded Systems
A. David McKinnon, Tarana R. Damania, David E. Bakken, Kevin E. Dorow and Wesley E. Lawrence, Washington State University

MicroQoSCORBA is a new CORBA development environment that was designed from the ground up with respect to device constraints and the granularity of configuration that is needed for the deeply embedded systems market. MicroQoSCORBA is unique in its ability to be tailored for both the environment and application constraints. This presentation will first focus on the underlying design and architecture of MicroQoSCORBA. Secondly, we will overview the implemented Quality of Service (QoS) modules (e.g., security, fault-tolerance, real-time behavior). Finally, we will present profiling data that will illustrate the various trade-offs incurred when various environmental and application constraints are changed.

Creating End-To-End Middleware Services Via Configuration
Pradeep Gore, OOMWorks - Sanjai Narain and Kirthika Parmeswaran, Telcordia Technologies

In order to create end-to-end middleware services, multiple applications must be logically integrated into a service architecture. This architecture is implemented via configuration steps.. The task of integrating these components with their customized options quickly and in a formal manner such that they satisfy the end-to-end service requirement and can be diagnosed for integration errors is nontrivial and tedious. This poster describes an approach for solving these problems by using the Service Grammar technique. This method is based on formalizing the notion of service associated with protocols or distributed algorithms. The ideas pertaining to the Service Grammar technique are illustrated in this poster in the context of an end-to-end CORBA Notification service application.

1500 – 1600 Afternoon Refreshments

1600 - 1730 ***Vendors' Roundtable***
Moderator: Andrew Watson, Object Management Group

In this panel, vendors of Real-time CORBA implementations will briefly describe their future plans, ideas on standards conformance, suggestions for future standardization, or whatever else is on their minds. This will be followed by questions from the floor and (if past experience is any guide) lively discussion by all workshop participants.

Panelists:
Bill Beckwith, Objective Interface Systems
Ken Black, Borland Software Corporation
Peter Kortmann, Tri-Pacific Software
Yuval Levy, Vertel Corporation
Douglas C. Schmidt, University of California, Irvine

1800 - 2000 ***Workshop Reception hosted by*** **DARPA IXO**

THURSDAY, July 18, 2002

0900 - 1030 *Network and OS Support for DRE Middleware and Applications*

Chair: Douglas C. Schmidt, University of California, Irvine

Commercial-off-the-shelf (COTS) hardware and software is being evaluated and/or used in an increasing range of mission-critical distributed real-time and embedded (DRE) applications. Due to substantial progress over the past decade, COTS middleware based on Real-time CORBA has matured to the point where it is no longer the dominant factor in the overhead, non-determinism, and priority inversion incurred by DRE applications. As a result, the focus has shifted to the operating systems and networks, which are once again responsible for the majority of end-to-end latency and jitter. The presentations in this session evaluate the suitability of popular COTS operating systems and networks and illustrate how their capabilities can be used effectively by Real-time CORBA middleware and DRE applications.

Evaluation of Advanced QoS Mechanisms in the Linux and Linux Based Operating Systems and their Implications for Building Distributed, Real-time Systems

Gautam Thaker and Patrick Lardieri, Lockheed Martin Adv. Tech. Labs

Building medium scale (few hundred nodes) military DRE systems upon standards compliant, COTS hardware, OS, and middleware while simultaneously reducing test and validation costs is our long term goal. Evaluating the degree to which such COTS components provide QoS mechanisms that pervasively enforce fixed priority preemptive scheduling is a key step in engineering such systems. Our presentation summarizes in progress experimental results on the boundedness of end-to-end latencies distributed tasks experience on various real-time Linux variant, including Timesys, and RT middleware. We also attempt to connect observed behavior to theoretical and simulation models of the experiments.

Using a Real-Time, QoS-based ORB to Intelligently Manage Communications Bandwidth in a Multi-Protocol Environment

Bill Beckwith, Objective Interface Systems

The end-to-end latency of a distributed real-time system is frequently more dependent on the jitter and bandwidth (Quality of Service or QoS) provided by the available communications infrastructure than by processor contention. Thus, a critical component in distributed real-time systems is the intelligent management of communications QoS. The presentation discusses measurements of the affect of using various QoS parameters on a system based on a real-time, QoS-based ORB implementation.

Using Prioritized Network Traffic to Achieve End-to-End Predictability

Yamuna Krishnamurthy, Irfan Pyarali, Pradeep Gore, OOMWorks LLC and Craig Rodrigues, BBN Technologies

Real-Time CORBA (RT-CORBA) allows application developers to preserve end-to-end priorities of the various activities in an application process. Though RT-CORBA specification details the real-time ORB, thread priorities, and application scheduling requirements, it is less explicit about the communication transport and the underlying network. Unless the behavior of the communication transport and the network is carefully considered and modeled, however, "in-transit" activities will be at the mercy of the network idiosyncrasies and end-to-end predictability in the system as a whole will be difficult to achieve. In our presentation we will discuss our research involving the use of Differentiated Services technology to prioritize the RT-CORBA traffic in the network.

1030 - 1045 Morning Refreshments

1045 - 1215 *Deeply Embedding Distributed Objects*

Chair: Victor Giddings, Objective Interface Systems

Distributed object technologies, particularly CORBA, are being applied in “deeply embedded” systems that are severely resource constrained, particularly in “footprint”. These pioneering applications, and the middleware products that support them, are addressing the contention between resource demand and resource constraints. Sources of resource demand may be inherent in the distributed object technology or implementation-specific. The presentations in this session address these issues in several novel ways.

A Protocol for Representing Individual Hardware Devices as Objects on a CORBA Network
William Nagel, Nicholas Anderson, Patrick Beasley, Stage Logic, LLC

The presentation will discuss research into a "Hardware CORBA ORB". An HCO will allow very low power/specialized devices on a distributed network to register with a non-local ORB as CORBA objects, thus alleviating the necessity for an ORB to reside on the device. The device--ORB communications protocol, the ORB itself, and implementation results will be discussed.

Aspect Formulation for Developing Small-Footprint CORBA Event Channels
Frank Hunleth, Ravi Pratap, Ron K. Cytron, Washington University

To address the difficulties associated with re-factoring middleware to obtain suitable subsets for use in embedded systems, we have designed a framework, called FACET, for building a real-time CORBA Event Channel using Aspect Oriented Programming. FACET consists of an essential core onto which additional features are weaved in as needed by the given application. FACET's core is currently predicated on CORBA, and we are thus faced with generalizing FACET so that it can support both CORBA and non-CORBA environments. Our aim is to strategize the event channel's transportation mechanism so it can be useful in ever wider contexts.

The C Language Mapping - Does it meet the needs of Embedded Real-time Applications?
Anurag-Verma, Yuval Levy, Vertel

Today CORBA is being used in systems ranging from the enterprise to the embedded. Each of these systems uses the implementation that meets their application requirements. In the real-time embedded world, the majority of developers choose C as their programming language because of speed and footprint concerns. The OMG C Language Mapping addresses the issue of a small footprint pretty well as compared to other language mappings. However, it does not detail all necessary aspects. Topics that will be discussed in the presentation will include memory management, CORBA Any, real-time support, POA and servant mapping, exception handling, and type-safe memory allocation and de-allocation for complex IDL types.

1215 - 1315 Lunch

1315 - 1515 ***Real-Time Scheduling***
Chair: Steve Grimaldi, Objective Interface Systems

> Operating system scheduling is one of the most challenging decisions an engineer faces. That task is further complicated by the notion of distributing a problem over multiple systems. This session presents relevant work in the distributed real-time system domain.

Hybrid Resource Management Middleware for Dynamic Real-Time Systems
Lonnie R. Welch, Purvi Shah, Shikha Jain, Ohio University

Adaptive resource management and real-time CORBA must be used carefully in the context of mission-critical real-time systems. A centralized resource management approach may not scale well. A decentralized resource management approach, wherein the objects allocate resources (as is permitted by some real-time CORBA-based middleware) may lead to an unstable system; furthermore, it is unlikely that autonomous objects will achieve an allocation state that is optimal or that meets real-time constraints. This talk discusses lessons learned while exploring the interaction of centralized resource management middleware with autonomous, real-time CORBA-based objects in the context of the US Navy's Hiper-D shipboard computing testbed.

Global Scheduling and Binding in a Real-Time Embedded Distributed System
Lisa Cingiser DiPippo, Victor Fay-Wolfe, Oleg Uvarov and Angela Uvarova, University of Rhode Island;
Trudy Morgan, USN SPAWAR Systems Center; Lou DiPalma, Raytheon; Peter Kortmann, TriPacific Software, Inc.

We are developing middleware services and techniques for global real-time scheduling and real-time binding that will work within the standards of Real-time CORBA. Our Binding Service allows a client to bind to the server that will most likely be able to service this request, and future requests, within timing constraints. Our Real-Time Scheduling Service dynamically assigns priorities to tasks in the real-time distributed system. If Scheduling Service determines that system is overloaded when the new task is included, then it performs a load shedding algorithm that chooses a task to shed from the system in order to maintain schedulability of the entire system.

Transparent Resource Management for QoS-Enabled DRE Systems
Ossama Othman, University of California, Irvine

Interprocess communication, platform heterogeneity, concurrency and stringent quality-of-service (QoS) requirements are an inherent part of distributed real-time and embedded (DRE) applications. Resource management is fundamental to these issues, and can be handled by a middleware-based load balancing service transparently and efficiently. This approach allows integration of additional components to DRE systems with minimal impact to performance and improves availability due to the inherent redundancy introduced by the load balancing service. Emphasis will be on required functionality, design and implementation details, and empirical results illustrating the benefits of utilizing a load balancing service.

Towards a Mechanism-Level Model for CORBA Scheduling Strategies
Chris Gill and Fred Kuhns, Washington University, St.Louis

In this presentation we offer a plausible mechanism-level model for previously observed performance differences between the RMS+MLF and MUF scheduling strategies, that at a policy level should have behaved much more similarly. This model is based on mechanism behavior and sources of overhead at the operating system and middleware levels. We postulate this model as a basis for further experimentation, and to offer preliminary guidance for selecting dynamic scheduling strategies, to developers of distributed real-time and embedded applications.

1515 - 1530 Afternoon Refreshments

1530 - 1700 *Composable Real-Time and Embedded Systems*

Chair: Christopher D. Gill, Washington University

A growing number of distributed real-time and embedded systems have cross-cutting quality of service (QoS) requirements that are increasingly tedious and error-prone to program using current-generation software development paradigms. This session examines next-generation approaches that are emerging to allow QoS policies and enforcement mechanisms to be composed in-place with the middleware and application components to which they apply.

Towards Model-Based and CORBA Component Model-Based Applications For Real-Time Systems
David Sharp, Boeing

This presentation describes our DARPA Information Technology Office (ITO) Model-Based Integration of Embedded Software (MoBIES) program work towards infusing CORBA Component Model technologies into the Boeing Bold distributed real-time embedded (DRE) architecture. The Bold Stroke architecture is being applied on several large-scale military embedded systems and has demonstrated the suitability, benefits, and challenges of CORBA-based DRE middleware for these systems. Our MoBIES work has extended this work towards a CCM-inspired real-time component model incorporating support for facets, receptacles, event sources/sinks, homes, and factories, etc, and in a vision for multiple view model-based approaches to real-time component integration, configuration, and analysis.

Towards a Real-time CORBA Component Model
Nanbor Wang, Krishnakumar Balasubramanian and Chris Gill, Washington University

This presentation demonstrates how DRE applications can benefit from CCM capability to provide a more robust development environment particularly by extending CCM component deployment metadata to support QoS requirement specifications for DRE application. The presentation will also explain by example how the CIAO capabilities are developed and will present empirical results illustrating their performance and predictability for representative DRE application use cases.

Fine-grained Middleware Composition for the Boeing NEST OEP
Venkita Subramonian, Washington U.

The DARPA Networked Embedded Software Technology (NEST) program identifies a class of Distributed Real-time and Embedded (DRE) systems in which around 100 - 100000 highly resource constrained computing nodes cooperate in a networked environment. Systems in this class are being used increasingly in fields like advanced avionics and space systems. Our presentation will describe techniques we are using to compose a middleware framework for the Boeing NEST Open Experimental Platform (OEP), and the implications of our work for this class of systems.

Real-time and Embedded Distributed Object Computing Workshop

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