CORBA in Control Systems
The Use of Embedded Real-time CORBA in the Architecture of Control Systems: A Case Study

James L. Paunicka Ph.D. – Boeing Phantom Works
Eric Martens – Boeing Phantom Works
Shahzad “Sam” Aslam-Mir – PrismTech (USA)
Introduction

- The use of CORBA in a real-time control system in a feed-forward of feed-back path in a regulative capacity has to date not been thought possible.
- Researchers are now beginning to use RTCORBA constructs over highly predictable transports to just start to experiment with closed loop control using a CORBA interconnect.
- The presentation will introduce an esteemed team from Boeing that did just that.
- The creation of more and more sophisticated control system software placed in modern aircraft, cars and ships in a distributed fashion makes CORBA based models an attractive solution.
- Real-time CORBA offers powerful heterogenous, multi-language, open extensible attraction to the control systems software designer.
Importance of CORBA in control systems implementation

- Dependable
- Maintainable
- Scalable
- Configurable and re-configurable.
CORBA in Control

The classical control system model

inputs $\Sigma$ outputs

ACTUATORS \quad PLANT \quad SENSORS

CONTROLLER

Control laws

Gain Schedules
The classical control system model using some CORBA interconnects.
CORBA almost never used in feedback path in control critical loop paths
CORBA in Control

An alternative approach – a software component based model

ACTUATOR

+ \[ \Sigma \]

Soft transducer

System

RESOURCE MANAGER

QoS contracts

SENSOR

Soft transducer

Dynamic Scheduler
**CORBA in Control**

**Current generation use of RTCORBA -**

Open-loop system. Absence of feedback loop with a-priori design.
CORBA in Control

Adaptive use of RTCORBA – building towards FT-RT CORBA

Intelligent middleware – self-regulating
Historical and continued permeation of myths

- CORBA is too slow, and heavyweight for use in microcontrollers, PLC and so on.
- CORBA lacks the hard real-time capability to facilitate use in mission critical control paths – even RT CORBA!
- CORBA lacks dependability semantics that would be required to say build a control system for an aircraft.
- RT-CORBA, and FT-CORBA are immiscible and so its use in flight control, or such critical control arenas in never going to be possible.
- All types of CORBA lack the semantics to effectively build very large scale embedded real-time fault tolerant structures.
- CORBA is synchronous, event driven RPC, and cannot grow to meet either an asynchronous real-time world or more importantly it and Time-triggered systems are at odds with one another!
Example closed loop control systems using CORBA in their control plane.
Simple sensory data reporting in Telecommunications

Internal Command and Control

- Naming Service
- Fault Tolerance
- Log Service
- Notification
- ORB
In Next Generation Switching Equipment, ORB Communication Project and FT

Control of Service availability

- Cold Replication N+M
- Active Hot Replication 1:1
- Cold Replication N+M

CORBA control nodes

Distributed Software Infrastructure
Control of waveform stability on SDR

- SDR demonstrates that CORBA can be effectively applied to control and regulate the operation of a soft radio
  - e.g. The General Dynamics DMR is successfully executing during independent Navy shipboard Technical Evaluation
  - The DMR SATCOM waveform is nearing successful completion of US Government Joint Interoperability Test Command (JITC) authorization

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Control of automotive sensory information

- Internet and Wireless communications
- System integration
- Drive-by-wire technology

Distributed Processors

Disparate Elements

http://www.daimlerchrysler.de/index_e.htm
Automobile industry

- Cars and trucks more than simple modes of transportation
- AutoPC: PC class hardware to provide services support platform for the future internet-based services (C++, Java)
- Control functions (real-time, C++) and infotainment (C++, Java) functions
- High-end car has more than 80 microprocessors for control systems and infotainment systems
Car’s Information Highway –

Body
(Comfort, Safety, Lighting, Instrumentation)

Climate Control

Control Panel

Lighting Control

Stand-By Heating

Air Bag

Wiper Wash

Sun-Roof

Remote keyless entry

DC Motor

Sub Bus

ITS-Bus / MOST

Driver Information Systems

Central ECU & Gateway

Dashboard

HVAC/Aux Gauges

Multi-use Display/Controller

Cellular

Navigation

HiFi Radio/Audio

Telematics

Video Monitor

Telematics

Distributed Software Infrastructure
Simple IDL interfaces remove dependency on a single supplier

New services with minimal impact in the existing system

Interoperability between existing and new applications

Platform independent services so changes in hardware will have minimal impact on the system
Control of laser positioning and irradiation

Used in Laser lithography at the <16 Angstroms Internal
Command and Control – very precise control

management

Laser controllers

OS: Windows NT, Green Hills Integrity
CPU: PPC750
Bus: cPCI
A detailed case Study:

Boeing Phantom Works team
CORBA in Control

Analysis of where we are today -

- A lot of myths have been dispelled in the last 2 years
- CORBA has grown in cases through very high quality implementations to meet the challenges of hard real-time control capability to facilitate use in mission critical control paths – even RT CORBA – kudos to all ORB implementers
- There is a specialist OMG movement in the real-time SIG to look at creating specifications for RT fault-tolerance (for dependability) and better still a control systems movement -
  - Talk to Prof. Ricardo Sanz and Prof. Herman Kopetz
  - TTP protocols have come into the CORBA fold.
  - Read John Rushby’s analysis of TTP vs FlexRay and CAN and other controller protocols.
  - Get involved in the RT SIGs CORBA in control systems activity.
Conclusions

- CORBA continues to grow and meet the challenges of new types of systems being developed.
- CORBA allure for large scale, open flexible interoperable system design continues and now stretches to closed loop feedback control system implementation.
- Real-time CORBA, with dependability aspects rolled in and some specialized specifications for standard control system ‘components’ specified is a very attractive option for control system designers.
- CORBAs permeation into DSPs for transducer banks, Microcontrollers and general purpose processors now makes it possible to have CORBA on all parts of a modern sophisticated control system.
- CORBA continues to spread its gospel of open heterogenous, and extensible system implementation in the control system community today.
Thank You