CORBA and Control Systems Research

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Speech Objective

This a position/vision paper on the extremely important role that CORBA and Real-time CORBA are going to play in advanced control systems development and in particular as a foundation for research in control systems that include high degrees of intelligence.
Presentation Structure

- What’s Control Engineering?
- CORBA in Control Systems
- My own Application Examples
- Research in Control Systems
- Trends and Needs
- A vision
What’s Control Engineering?

Setting the stage
What is Control Engineering?

- The engineering of artificial behavior
- A strongly mathematics-based discipline
  - Model plant-Design Controller-Implement
  - Main corps based on linear models and theories (the Good Old Fashioned Linear Control Theory)
- Advanced topics in multivariable systems, nonlinear systems, robust control, fault tolerance, etc.
Development of Control Systems

- Control systems technology is a real-time endeavor by its very nature
- Depends critically on the availability of real-time computing platforms
- We will focus on two areas that will leverage all the potentiality of CORBA technologies:
  - Distributed control systems
  - Intelligent control systems
The Problem

Control engineering purists lack a full life-cycle engineering vision.
The Result

- Work concentrates exclusively on Plant Modeling and Control Design
- Implementation isn’t considered an issue
- Main work in the area is too narrowly focused
  - *IEEE Transactions on Automatic Control* gets an average rate of 3 readers per paper:
    - The author
    - His PhD Student
    - An anonymous Chinese paper-and-pencil researcher
Challenges and Enemies

Frontiers of complexity
- Non-linearity: the real world
- Size: large scale systems like refineries
- Uncertainty: real world navigation
- Robustness: lack of good models

Computer science is seen as a competitor by control engineering purists
- In: Provides solutions for complexity topics
- Out: Lacks the necessary rigor (in real applications)
CORBA in Control Systems

The very nature of control systems is object oriented
Complex Software

Software facets in control systems
- Conventional software
- Real-time
- Embedded
- Fault Tolerant
- Distributed
- Intelligent

Special Problems
- Size (order of MLOC)
- Integration
- Heterogeneity
- Verification
Complexity and development

- It’s know that complexity affects development:
  - Effort grows with complexity much more than linearly

- There are systems we cannot build:
  - 24x365 (total availability)
  - One-shot (guarantee of work at the first try)
  - HF-LC (High Performance / Low Cost)

- In search of silver bullets:
  - Complex real-time, embedded, fault tolerant, verifiable software engineering?
Plants are Seas of Objects
Controllers’ Object Nature

- They deal with
  - Physical entities
  - Conceptual entities
- Continuous mapping between outer and inner worlds
- Soft and Hard Objects
- Object wrapping provides integration with legacy control systems:
  - DCS and SCADA
  - PLCs
  - Intelligent sensors
- Building controllers as objects, components and agents
Sample Intelligent Roles

- Data Filter
- Data Monitor
- Action Filter
- Action Monitor
- Decision Support
- Advanced Controller
CORBA Topics of relevance

Key issues:
- Encapsulation
- Distribution
- Modularization

Key technologies
- IDL/ORB
- C/C++/Ada/Java mappings
- Real-time
- Fault tolerant
- Minimum
Application Examples

Some examples on the use of CORBA technology in control systems
Risk Management (I)

- Full life-cycle risk management in chemical complexes
  - Fault prevention
  - Fault detection and identification
  - Emergency triggering and management
- Developed as part of ESPRIT DIXIT project
- Repsol’s chemical complex (nine plants) in Tarragona (Spain)
Risk Management (II)
Risk Management (and III)
Robot Teleoperation (I)

- Masters and robotic slaves are connected with dedicated lines to provide real-timeliness necessary for feeling (full force feedback)
- This is a laboratory experiment for robot teleoperation using different robots (real, virtual) and masters (physical force-feedback, GUI based, etc.)
Robot Teleoperation (and II)

Kavis Virtual Arm

6 DOF Master
Real-time video for supervision (I)

- Electricity production:
  - Reduction of personnel
  - Electric market de-regulation
  - Effective operation of networked plants
  - Continent-wide integration

- Gathering of separate Distributed Control Systems
  - Safety measures: real-time visualization of operations

- This is a real-time video system for large DCSs a CORBA-based infrastructure
Real-time video for supervision (II)

- Real time WAN video
- Remote visualization for operation of hydraulic power plants
Real-time video for supervision (III)

CCL: Hydroelectric Plant

Multicast Video-Net

VideoDataBase

CORBA Control-Net

CCI: Operation

CCI: Security
Real-time video for supervision (IV)

- Video Multiplexor
- Outdoor Camera
- Camera
- Audio amplifiers
- Microphone
- MPEG Compressor
Electric Utilities Integration

- IEC 61850 Emergent Standard for interoperability in electric utilities Substation Automation Systems
- IST project DOTS:
  - Mapping the IEC 61850 functional specification to CORBA interfaces
  - Component implementation for
    - IEDs (Intelligent Electronic Devices)
    - RTUs (Remote Terminal Units)
  - Real-time, embeddable, modular brokering
Electric Utilities Integration

- Pushbutton
- Camera
- Doorbell
- Configuration Terminal
- GPS
- Operator Terminal
- 10BaseT
- 10BaseT
- 10BaseFL
- Ethernet Hub
- IED-1
- IED-2
- Electric Utilities Integration
Trends and Needs

Where are we going?
What do we need?
Research In Control Systems

- Research is focused in the development of new methods of achieving better systems performance in varying conditions.
- Extremely wide spectrum of activities that range from the development of mathematical modeling technology to the details of process scheduling.
- Our research activity is focused in methodologies and tools for the construction of complex controllers (large industrial processes or autonomous robots).
- Our present work is focused on pushing CORBA down to the sensor level.
CORBA and Control Systems

RT-FT-E CORBA will obviously be of extreme help in the implementation and deployment phase of control systems.

But (what is more important) the core OMA concepts will also serve as a design guideline that will enable the modular design, development and deployment of complex control systems.
Present work

- Strategic Control
- Tactical Control
- Operational Control
- Advanced Control
- Complex Loops
- Simple Loops
- Sensors & Actuators

Continuous Process Plant

CORBification Frontier

MIS

User Interface

CORBA Worlds

Non CORBA Worlds
Challenges

- Make it small!
- Make it fast!
- Make it dependable!
- Make it hard-predictable!
- Make it formally verifiable!
- Make CORBA more control systems oriented !!!
Reuse and Freedom?

- **Design freedom** is necessary in the complex control systems domain
- **Design restrictions** (in the form of design decisions) simplify development sacrificing flexibility

- How can we get both?
  - No-compromises frameworks
  - Agent libraries
  - Transparent RT middleware
Core Ideas

페 The rationale:
   - It is impossible to fight the NOT INVENTED HERE syndrome

페 The solution:
   - Let the people do what they think they need
   - Do not define ULTIMATE solutions
   - Provide reusable assets that can be adapted to any problem in a domain
A Vision?

Control and artificial intelligence
Control and Artificial Intelligence

- Control engineering is not mathematics but about **behavior engineering**
- Not exclusively a discipline based on differential equations but on any other type of model of the world

- Minds are control systems:
  - Control engineering = Artificial Intelligence
  - Plant models = Mental models of the world
Why we need integration?

- To build TotalPlants?
  - Complete Vertical Integration/Complete Horizontal Integration
- To achieve total safety?
- To be the first in the market?
- To spend few $?

In advanced control systems research we need integration to **reach human-like complexity** levels in artificial minds:
  - Functional encapsulation
  - Modularity
  - Composability
HAL 9000 will be CORBA based

CORBA::minds::speak()
CORBA::minds::dream()

Dr. Chandra ... ... shall I dream?