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Hard Real-time CORBA

Title

PCT Requirements Specification

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Summary Sheet

IST Project 2001-37652
HRTC
Hard Real-time CORBA

PCT Requirements Specification

Abstract:

The present ***PCT Requirements Specification*** defines the requirements for the Process Control Testbed that have been set after the initial domain analysis.

This document has been issued in accordance with the document *IST-2001-37652 Annex 1 – "Description of Work"*. The identification of this deliverable is D 4.1.

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Table of Contents

1 Introduction

1.1 Purpose of the document

The present *PCT Requirements Specification* defines the general requirements for the Process Control Testbed that have been set after the initial domain analysis. It covers both functional and attribute requirements, that is the set of functions to be provided as well as the measurable quality concepts to be achieved by the implementation.

1.2 Definitions, acronyms and abbreviations

Definitions

Acronyms

CORBA	Common Object Request Broker Architecture
DCS	Distributed Control System
GUI	Graphical User Interface
GUS	Global User Station
HLA	High Level Architecture
HMI	Human Machine Interface
HRT	Hard Real Time
MIMO	Multiple Input Multiple Output
MPC	Multivariable Predictive Control
OPC	OLE for Process Control
ORB	Object Request Broker
OS	Operating System
PCT	Process Control Testbed
TTP	Time Triggered Protocol

1.2.1 Abbreviations

1.3 References to Project documents

HRTC Project Annex 1 “Description of Work”.

2 Chemical Process Control Overview

This section is a summary of the domain analysis. A more in deep analysis is available in the deliverable D1.1 pertaining to WP1.

Process plants comprise several sectors like: refining, plastics, chemical (inorganic), pharmaceutical, food, cement, water & waste,… Most of these process plants are continuous (except mainly for the pharmaceutical industry where processes are usually batch). These plants are very complex, there are a lot (hundreds) of equipments (columns, vessels, tanks, reactors, valves, pumps, …) which are many times quite integrated by means of mass and energy recycles. Although most processes are well known, it is usually very difficult to get a good deep dynamic physicochemical model of the plant. And when a good model is elaborated it is difficult to simulate as these systems are generally stiff, of high index and nonlinear.

2.1 Process control elements

Any control configuration has the following elements : sensor, actuator, controller and the communication media between them all. Next a brief summary of the new characteristics of the elements and the communication media is presented.

2.1.1 Sensors

The trend is the smart sensor. These smart digital devices offer new functionalities such as:

- Transmission of many data as: operating range, maintenance conditions, etc.
- Remote operation by the user (change of the span, software update, etc.).

- Simpler communication. The digital communication removes the need of digital/analog and analog/digital converters.
- Easy integration in the DCS configuration

But these capabilities are not cost-free, an increase of complexity (with more possibilities of failure, although more means to detect it) is the major drawback when implementing the smart sensors.

2.1.2 Actuators

These devices are mostly control valves in the process industry. The trend is the same as it was in sensors, having intelligent actuators. Besides the intelligent features there is an additional capability, and that is to perform some control functions (basic control, and basic algorithms-PID) thus migrating some basic control loops from the control room to the field. The new valves incorporate control blocks making the control more distributed. These new devices have the same drawback than the sensors, the increase of complexity.

2.1.3 Controllers

Controllers are processors with some hardware and software components:

Software components:
- Control algorithms.
- Application programs.

Hardware components:
- I/O analog and digital ports
- Interfaces to control and field networks

Next figure shows some controllers from different manufacturers.

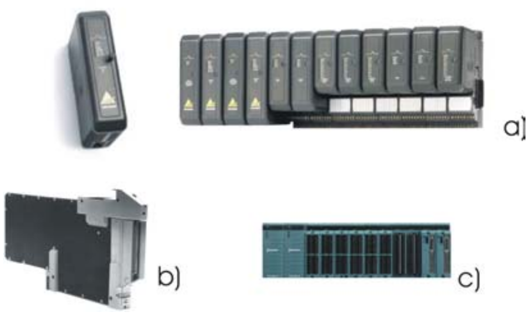

Figure 1: Commercial controllers: a)DeltaV from Emerson Inc., b) a controller from Invensys Inc., and c) FCN controller from Yokogawa Inc.

Besides the basic elements that have been defined, there are other significant components in any control system:

-***HMI***: Human Machine Interfaces
-***Databases***

2.1.4 Communication

Communication advances are making possible the use of the smart sensors and actuators that were mentioned before. There has been an evolution from the traditional analog transport (where a 4-20mA was transmitted indicating the percentage of the process variable measured or the percentage to act on the valve) to the current digital fieldbusses where different "standard" protocols are competing to rule in the field level.

In between there is a hybrid solution, the HART (Highway Addressable Remote Transducer) [1] protocol which superimpose a digital signal to the classical analog one. This enables the use of the existing devices and take the advantages of digital communication. Although this has been widely used in the process industry it seems that the digital fieldbusses will take over finally in the coming years.

The use of the digital signal enables a two way communication, with the analog signal the controller sent information to the valve in a one way mode, now the two way communication permits the valve to send a message back to the controller with its actual state. The digital communication adds the capability of sending more information, not only the process variable value but other information as: device status, diagnostic alerts, configuration parameters, %range, etc.

2.1.5 Digital communication

Plant (information) integration is driving advances not only in the field level but in the control and business levels as well. Next is a presentation of the current protocols used in each control level with special emphasis in the field level where other factors have been determinant in its development.

Field network (fieldbusses)

Fieldbus is a *digital, two-way, multi-drop* communication link among intelligent control devices.

Main benefits:

-Higher accuracy and data reliability
-Multi variable access
-Remote configuration and diagnostics
-Wiring cost savings
-Reduce commissioning time (due to the diagnostic and configuration information available)
-Improve the control through the transfer of some control functions from the control room to field devices.

There are some disadvantages such as that these protocols are not really open and that current instruments may not work with the fieldbus selected. This is one of the reasons (the lack of a single protocol) why this technology is not being applied in existing plants.

Field level buses can be grouped in three categories depending on the device type and the application for which they are designed:

- Sensor bus. These are used with proximity switches, pushbuttons, motor starters, etc. Their application is with simple devices where only a few bits of information have to be transmitted. They indicate or control mostly on and off states. They are not typically intrinsically safe. Designed mainly for discrete manufacturing processes they can be found in process plants. Examples: As-I, Seriplex.[2,3]
- Device bus. These are designed for more complex devices like paper machines, packaging lines, etc. They can handle more information than the (on/off) sensor buses. They are not intrinsically safe. Examples: Profibus DP, LonWorks, Interbus,.[4,5,6]
- Field bus. This is the most appropriate and thus the most important for process plants. They are used in control and diagnostics. These busses provide the communication mechanism between the smart devices (sensors and actuators). This bus is the replacement of the

4-20mA signal. They have usually slower transmission rates than the other two types of buses. They are intrinsically safe. Examples: Foundation Fieldbus, Profibus PA, Device Net, World FIP,… [7,8,9] The use of ethernet in this level is not yet possible due to different factors but it seems that in a not very far future this will be a reality because many efforts are being made to overcome the existing difficulties (non-deterministic, non power in the wire, not intrinsically safe, …)

Control (Automation) Network

In the control network several protocols are available, they are usually based on ethernet (high-speed or fast ethernet). Most used are: ControlNet [10], Profinet, Foundation Fieldbus HSE. Other protocols: Modbus , CAN [11,12], etc.

Business Network

This network is ethernet with TCP/IP as this type of application is what TCP/IP was designed for. There is an intermediate protocol Ethernet/IP [13](IP standing for Industrial Protocol) that claims it can be used in this (business) layer and in the control layer.

Next figure shows the different layers with the main protocols available in each one.

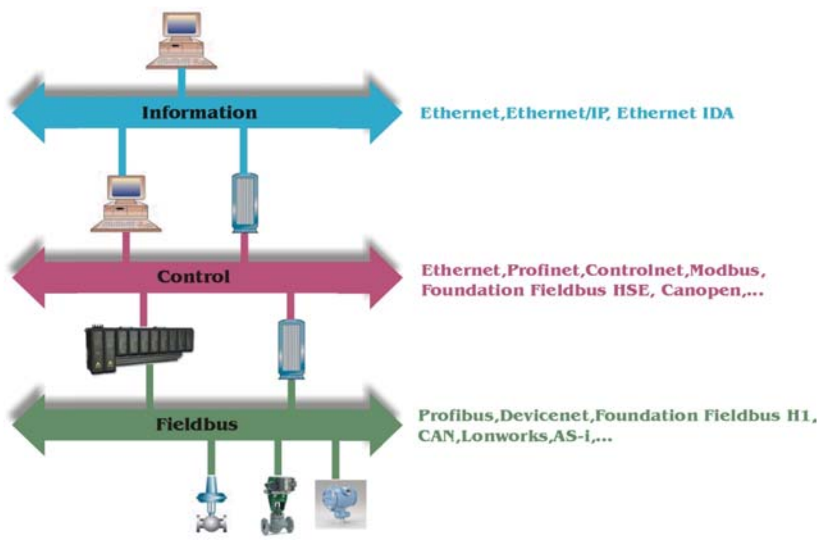

Figure 2: Network layers and protocols

Next figure shows the statistics for the main fieldbusses.

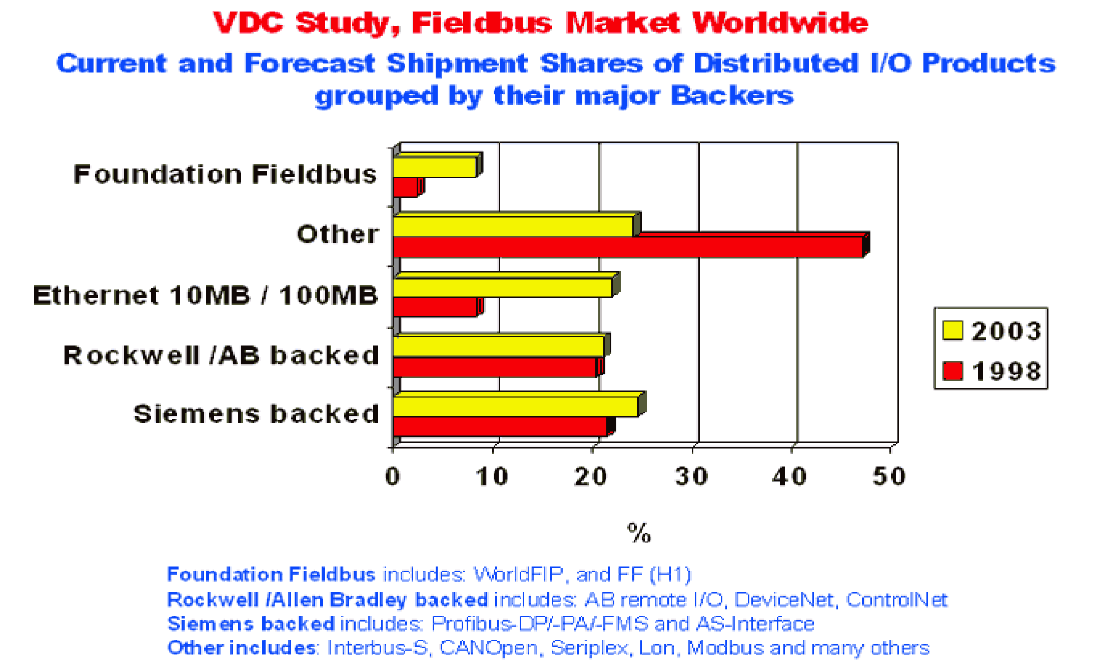

Figure 3: Network statistics. HMS Industrial Networks

Next figure shows the protocol requirements of each control layer.

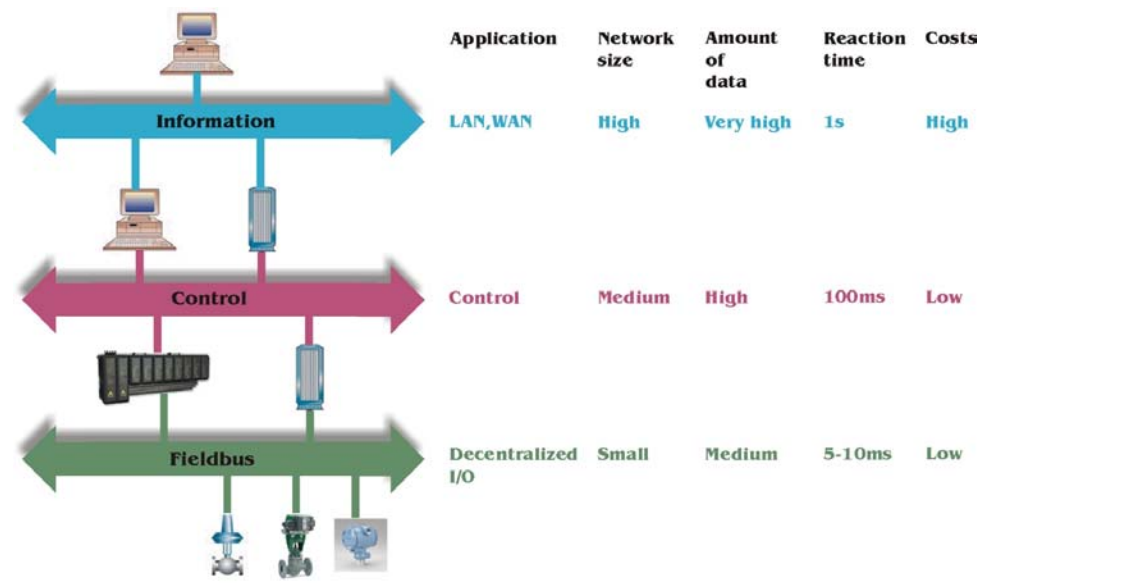

Figure 4: Main requirements of the protocols depending on the layer applied.

2.2 Process control levels

The control system applied on process plants have been traditionally separated into several levels:

Field level. This level is dedicated to the instruments (sensors and actuators) and to the basic regulatory control. It is communicated via fieldbus.
Process control level. This level takes over the advanced and supervisory control (advanced controller, multivariable controller, model predictive control,…). This level also computes a local optimization. It is communicated via an ethernet based protocol.
Business level. The upper level is dedicated to global optimization, scheduling and planning. It is communicated via ethernet.

Next figure shows the different levels integrated in a process plant.

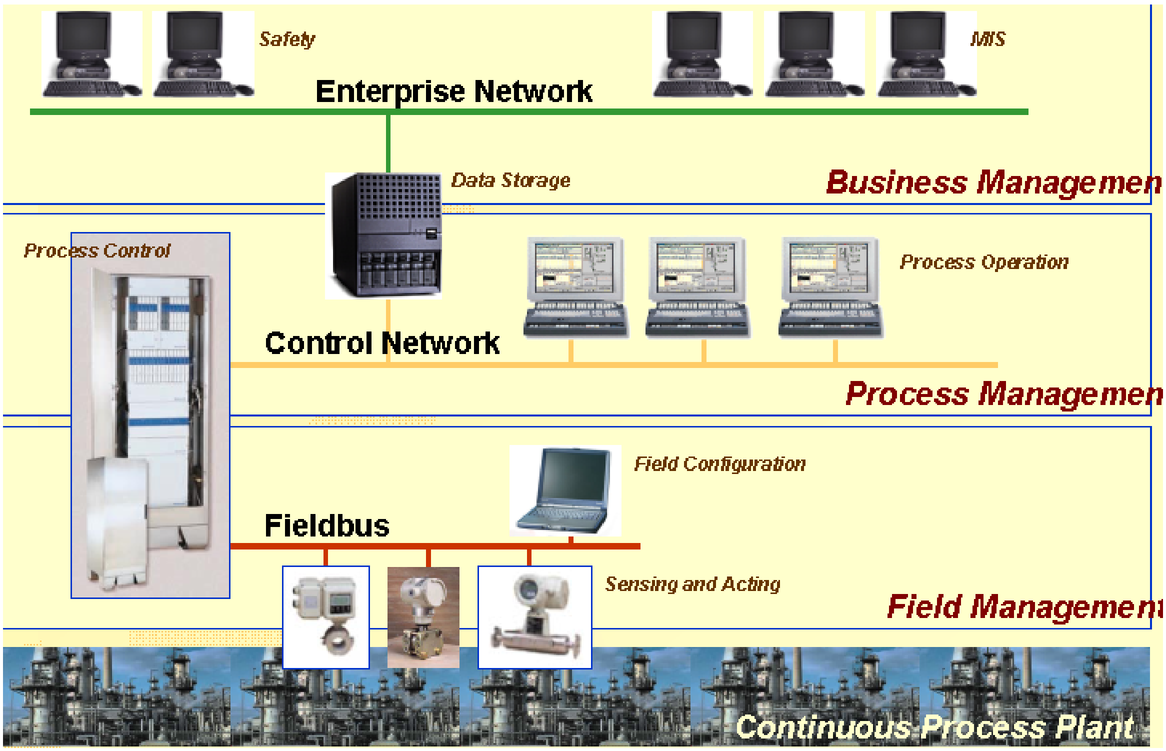

Figure 5: Process plant integration.

Although these levels have been always present in the process industry , the control implementation has been evolving along the years. From the first direct digital control (where all the devices were connected separately) to the control room (where the control was centralized to a single computer); to the traditional Distributed Control System implementation (where several devices are linked to a controller and there are several distributed controllers that are connected to the DCS console); to the future (where the control is totally distributed to field with the loops in individual devices). Nowadays we are still in the traditional DCS but migrating slowly to the future solution.

Next figure shows the trends for fieldbus networks.

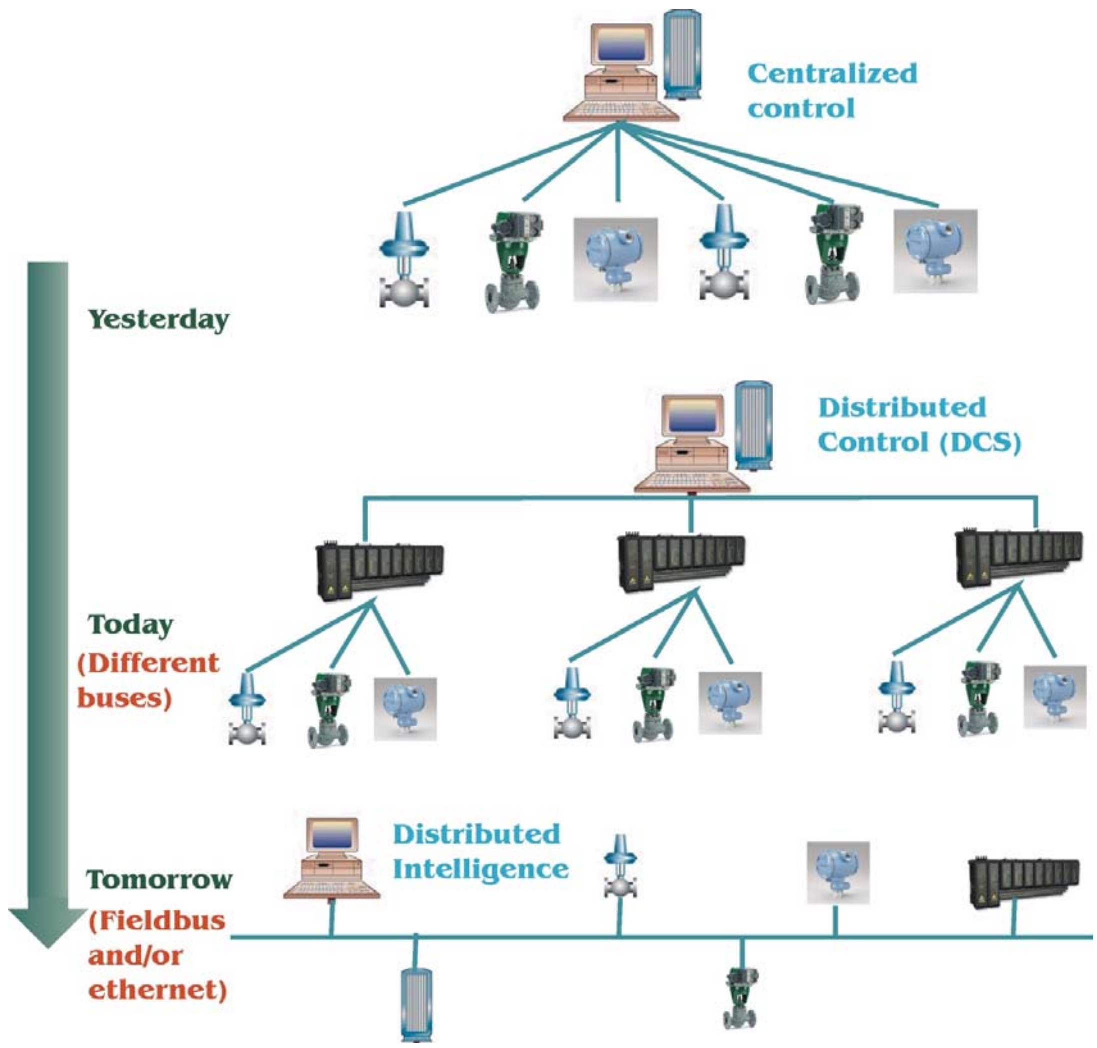

Figure 6: Network trends.

2.3 Control manufacturers

Today, the concept of complete information integration throughout the plant is being incorporated by the process control companies. These major companies have a common philosophy and all of them present their own approach to the total plant information integration, from business to field level. Next section presents the solutions provided by the four largest companies devoted to process control: Emerson(Fisher-Rosemount), Honeywell, Invensys (Foxboro) and Yokogawa. The information has been gathered from the companies catalogues and web pages and it is presented as it appears.

2.3.1 Emerson. Plantweb.[14]

PlantWeb field-based architecture is an automation solution that delivers asset management, process control and management execution through three key components:

- Intelligent field devices
- Standards & platforms
- Integrated modular software

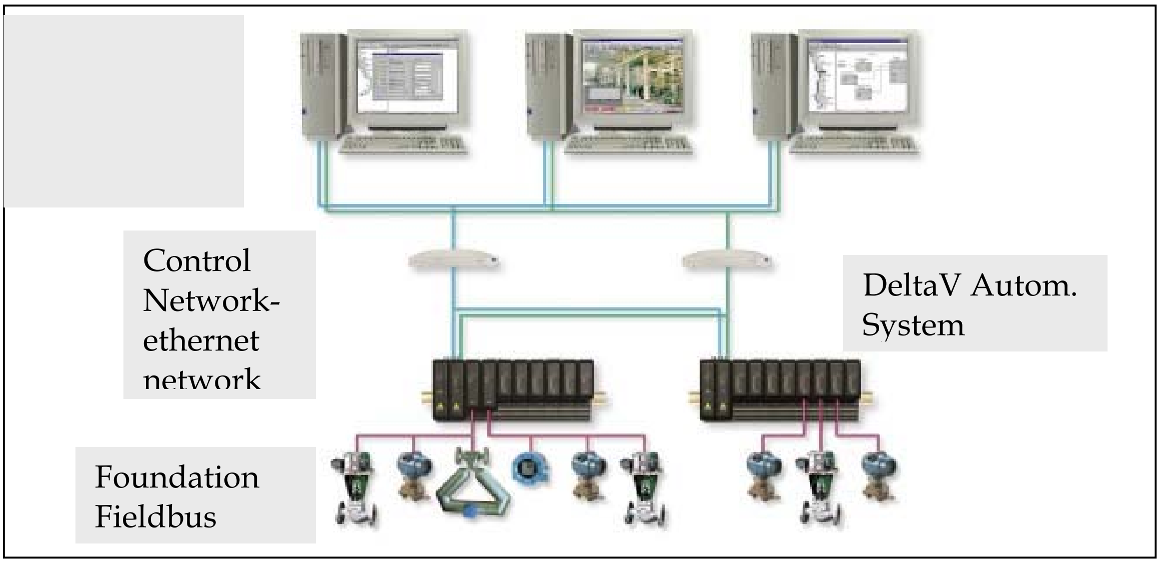

Figure 7:Emerson Plantweb architecture

In the simplest interpretation, PlantWeb works like this:
•Intelligent field devices gather information
•Delta V™ automation system provides easy management and delivery of the information for process control and management execution functions
•AMS software processes the information to add asset management functionality

2.3.2 Honeywell. Plantscape. [15]

Its advanced architecture encompasses a high-performance controller, advanced engineering tools, and an open control network.
PlantScape makes use of the latest technology that includes:
•a powerful Microsoft Windows 2000-based Server with dynamic data caching, alarming, human/machine interface, history collection, and reporting functions;
•HMIWeb™ Technology, providing secure, advanced user interface HMI capabilities based on an open industry standard html file format and Web Browser access;
•a compact Hybrid Controller that provides truly integrated control;
•object-oriented tools to quickly and easily build reusable control strategies;
•ControlNet, an open, state-of-the-art producer/consumer control network;
•FOUNDATION Fieldbus, for integration of measurement and control devices; and
•secure Internet Browser based on-line documentation and support

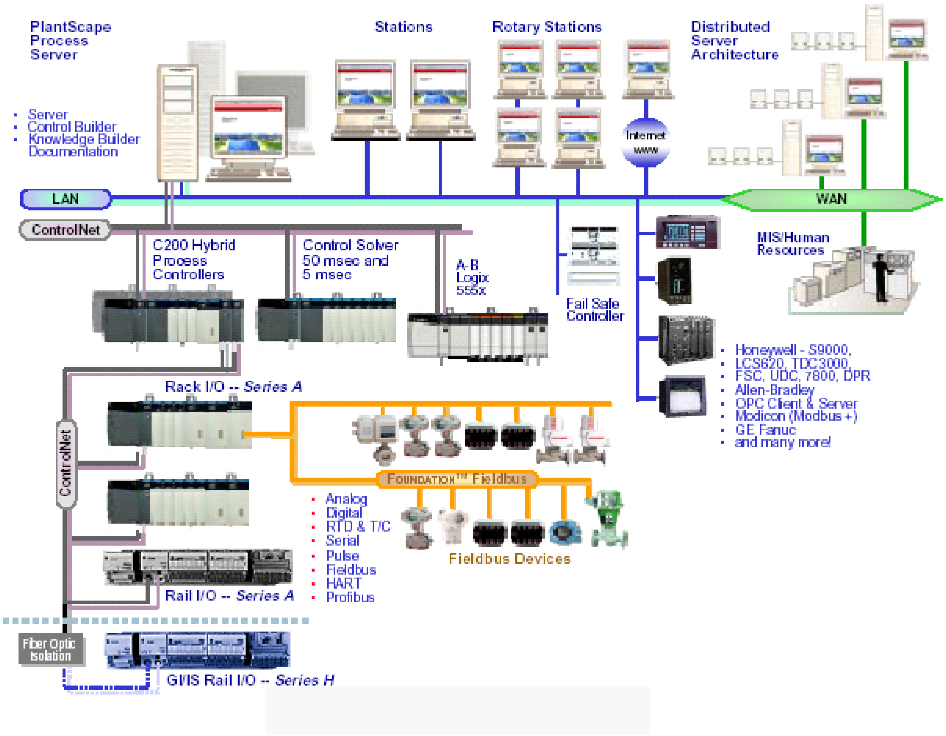

Figure 8: PlantScape System Architecture

2.3.3 Invensys. I/A Series. [16]

A hierarchical perspective, ranging from enterprise-wide information protocols down to the instrument bus.

•Enterprise information: generally Ethernet/ TCP/IP

•Control bus: Ethernet/TCP/IP is now the standard.

•The I/A Series incorporated the first Ethernet control bus (Nodebus – Redundant).

•Redundant fieldbus to remote I/O.

•Instrument bus: Intelligent field device integration (for example, HART, FOUNDATION fieldbus, Profibus, FoxCom). Invensys/Foxboro introduced the first all-digital intelligent instrument bus.

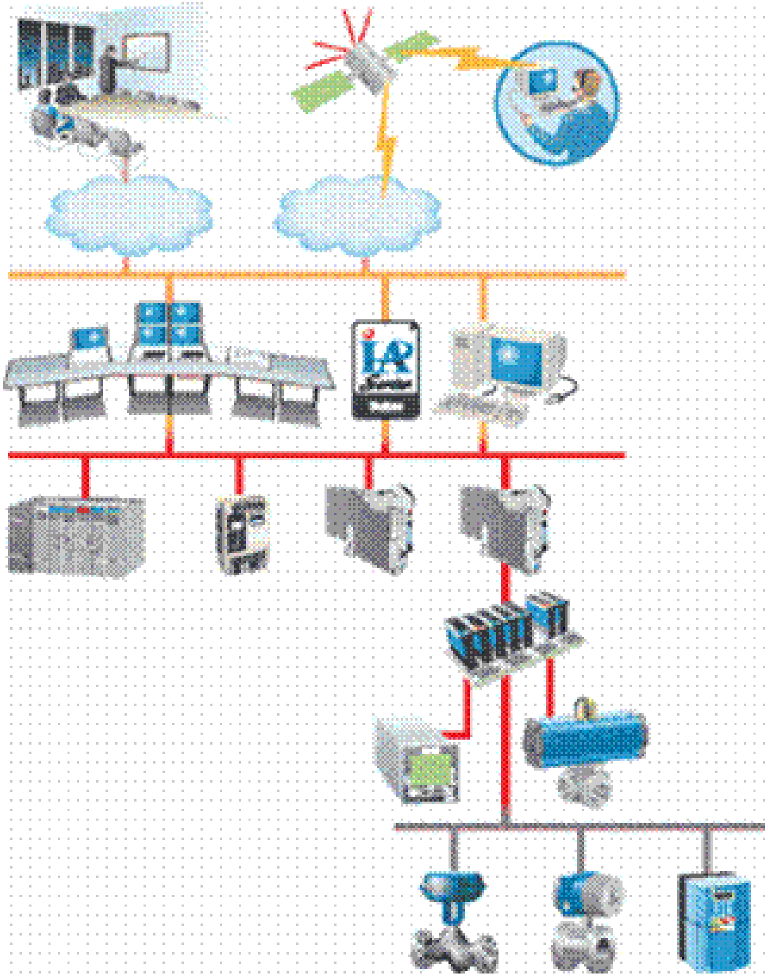

Figure 9: Invensys I/A Series system architecture.

2.3.4 Yokogawa. STARDOM. [17]

The STARDOM network-based control system (NCS) is a series of products that materializes a NCS.

STARDOM actualizes an NCS by: (1) offering highly reliable controllers performing autonomous control as the core of a system;(FCN and FCJ **Autonomous Controllers)** (2) linking integrated and scalable control, operation, and monitoring software featuring web-based human interface functionality with the autonomous controllers, via high-speed connections to the Internet to build a system; and (3) offering Application Portfolios that enable effortless implementation of advanced functions and users to apply their know-how in a secure manner. (VDS **Versatile Data Server Software)**
STARDOM allows decentralization and autonomy of control functions, integration of data, messages, and events, and features a web-based human interface based on internet technologies. It may well be the first system that makes the most of the internet world in the sphere of control.

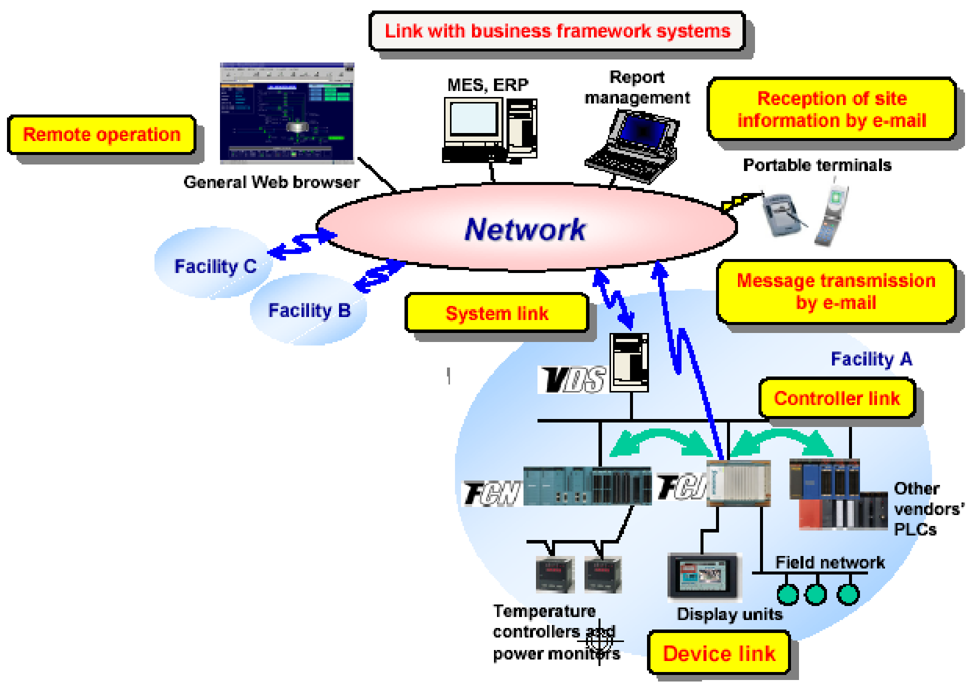

Figure 10 :Global infromation integration from Yokogawa.

3 CORBA for Process Control Systems

3.1 Complex Software Controllers

The process of incorporation of information technology (IT) into industrial processes is making profound modifications in production systems. Control and monitorization technology is leaving the *islands-of-automation phase*, entering a new phase of complete systems integration. While enterprise integration architectures (EAI) are hot topics in advanced business engineering, at the production level where controllers live, the incorporation of new technology and designs is confronting difficult problems.

In most cases the problems are mainly due to classical barriers posed to innovation in production systems: lack of predictability, need for non-stop operation, lack of reliability and availability, less than ideal market maturity, exploitation managers resilience, etc.

Two main objectives are being pursued in this effort, namely Complete Horizontal Integration (CHI) and Complete Vertical Integration (CVI). CHI deals with the integration of business units, business-to-business integration or supply chain integration. In this project we do address more intensively the topic of CVI. It is the time to start thinking in plant-wide integration reaching even the lowest levels in production plants: sensors, actuators and basic controllers.

Complete vertical integration means that integration paths are available from sensors to management information systems (and back). This implies that some of the limitations that the underlying information technology pose to the design space for monitorization and control systems should be eliminated.

3.2 Distributed Object Computing

Distributed object computing (DOC) is gaining an increased audience in information technology and, in new tech sectors, it is the technology of election for new system implementation. From global experience in last years it is pretty clear that –besides other advantages- DOC technology enhances systems integrability, making easier the construction of complex information applications. DOC technology can supply us with some tools needed for better development of complex, integrated control systems.

Software technology is of extreme relevance in any area of engineering activity. In the case of automatic control systems, we can say that it is not only relevant but a mandatory technology in a wide variety of control system implementations. Control engineers must know more about software because it is as basic as differential equations for the proper construction of control systems.

On of the areas of increasing relevance for software-intensive control systems construction is the field of object-oriented computing and in particular the field of distributed object computing.

While there are many research developments in DOC, three are the main contenders in the DOC wars: COM, CORBA and Java. But it is pretty clear that the only widely available technology that is addressing -more or less- the full range of topics in our automatic control business is CORBA. The three main objectives we are looking for in a software technology for control systems are embeddability, real-time behavior and robustness guarantees. All they are being directly addressed by CORBA specifications: Minimum CORBA, Real-time CORBA, CORBA Messaging and Fault-Tolerant CORBA. It is worth note however that some commercial products are ignoring the real-time market because they think it is a very small market.

It should be clear however, that selection of any one of these technologies does not hamper the application of the others. In fact, in relation with Java and CORBA, it is worthy note that both distributed object models are pretty the same, and evolution of distribution for Java applications is being fostered over CORBA compliant brokers. On the other side, CORBA interoperability specifies mappings to COM and OLE Automation, making possible the integration of COM based applications in broad-class CORBA systems.

While CORBA has been developed for distributed applications, the transparent integration mechanism it offers serves also for non-distributed applications. Some broker implementations provide local transports that do not use network protocols and hence do not induce a big overhead[1]. This means that the programmer can transparently decide where to put the objects and CORBA can do it with a minimal impact in performance.

3.3 Object-oriented Real-time Systems

Object-oriented Real-time Computing (ORC) is the technology of choice for complex real-time systems. Three main choices compete in this area: RT-CORBA, DRTSJ and Ada95. Ada95 while good has become a niche technology and DRTSJ is not yet available.

Real-time CORBA is relatively new but it is evolving at a relatively fast pace. It has been developed as a compromise usable in many fields and hence it has only a fixed priority model in the main specification (Real-time CORBA 1.1), but it also addresses other dynamic priority models perhaps better suited for control applications in other specifications.

We should mention the strong bias in RT-CORBA to telecoms, that make it sacrifice strong predictability. Real-time ORBs are being deprecated by mainstream ORB vendors and hard real-time ORBs are far in the future. Next major issues for our business will be pluggable transports (that are not very politically correct because they are not IIOP) and real-time services; like the scheduling service, real-time events or transactions. Other relevant issues are combinations of specifications; for example Real-time + Fault-tolerant or Real-time + Minimum.

Remember that ignoring software topics in control systems research is a big mistake. Not big, but critical for the discipline. Control engineering is not only a discipline of mathematical modeling and differential equation solving. Control engineering is the discipline of *artificial behavior* and software is what makes the behavior. CORBA is a good tool to support our designs, but we must work hard to make CORBA more oriented towards control systems engineering.

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[1] SCIlabs ICa Broker supports the so-called local transports with zero invocation cost, TAO's smart proxies can queue invocations in order to reduce net load and increase performance and Visibroker's SmartAgent uses also shared memory to communicate client and server when detects that they are in the same host.

4 PCT Overview

Besides all the classic services needed for a control system, major manufacturers provide several new features oriented towards more open (which most of the times is arguable) accessible, safer and easier to use (which many times imply more difficult to maintain and needs more commissioning services) systems. These new capabilities can be summarised in:

◎Information integration.

Fieldbus, control and business networks interconnection allow the information integration. All the plant information is available throughout the system. Even remote access through internet, SMS,… The available information is related to: operation data, control and optimization data, laboratory data, validation data, inventories data, scheduling and planning data, maintenance data and economic management data. *This integration is not yet fully implemented and many problems have still to be solved.*

◎Safety management (alarms, sequence of events)

Safety is a very important issue for the process industry. Control manufacturers provide safety through several strategies:

- Redundancy. Redundant networks (control networks and even fieldbusses) and redundant controllers (and critical control components). In case of failure the redundant component automatically and smoothly takes over.
- Alarm management and sequence of events. Alarm status is available for any area from any HMI. Sequence of events registration mechanisms are available in order to recreate what happened after an alarm or emergency.

◎Real time databases

Databases to store process data, maintenance data, etc. are available and can be accessed in real time from a remote node for any purpose: trends, analysis, maintenance...

◎Hot swapping

A device can be replaced with minimum disturbance to the rest of the components. A smooth transition allows performance continuity.

◎"Easy of use"

All the solutions are concerned in providing a very friendly and easy to use interface. Ease of use with strong control features is presented in the manufacturers solution.

◎Reconfigurability

Automatic software updates and upgrades, parameter and algorithms configuration changes, etc. are available and provided with the digital communication.

The list of services presented implies the integration of heterogeneous platforms and diverse software components that form a complex distributed system. As presented, there are industrial solutions that tackle this problem but the solutions are neither complete nor open.

To achieve this integration it seems that middleware can be a good option. CORBA [18] is an open standard that fits quite well to solve this problem. But control applications run with real time (usually hard real time) requirements and current CORBA implementations do not provide this feature. The extension of CORBA to use it in the control of complex systems in a hard real time framework is the main objective of this project. In order to identify the specific needs and problems that may appear when applying this approach a representative process control testbed (taking into account the classic control and the new trends commented) is going to be developed. Several experiments will be carried on to prove the adequacy and lacks of (current) CORBA based control systems.

Next different use cases are presented (in UML [19] notation) that provide the baseline for the requirements and further design of the PCT.

Sequence of Events Generation

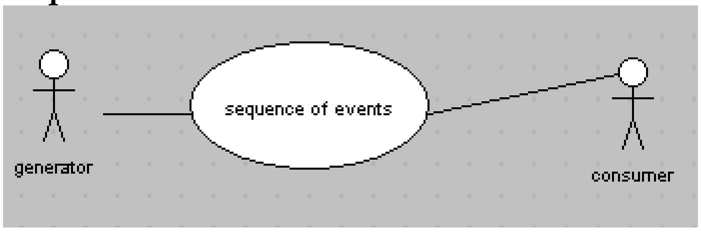

Figure 11: Use Case Sequence of Events

Actors: Generator and Consumer.
Flow of events: One or several nodes will act as event generators. After a sequence has been generated the Consumer will register the sequence and will order it. The Consumer will compare the ordered sequence with the original.

Distributed Simulation

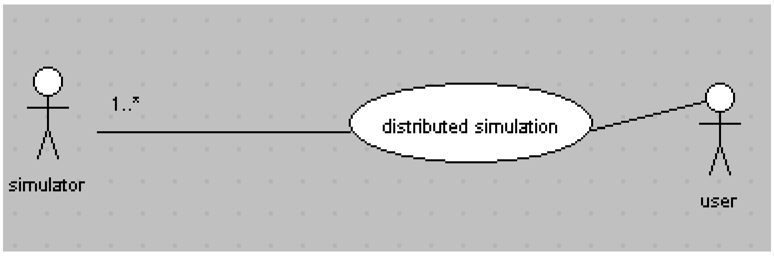

Figure 12: Use case distributed simulation

Actors: Simulator and user.
Flow of events: Several Simulators do execute a simulation of a model and communicate between them to perform the distributed simulation of the whole system. A User will get the results and will initiate and reinitiate it.

Legacy System Integration

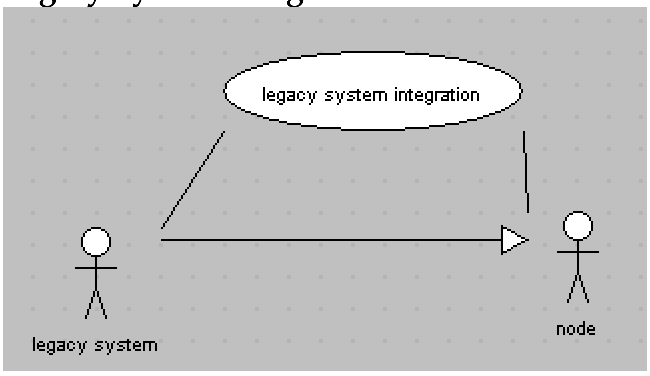

Figure 13: Use case Legacy system integration

Actors: Legacy System and Node.

Flow of events: A Legacy System communicate with any Node of the system in order to receive data to perform a task or to transmit data for a Node's task.

Fault generation

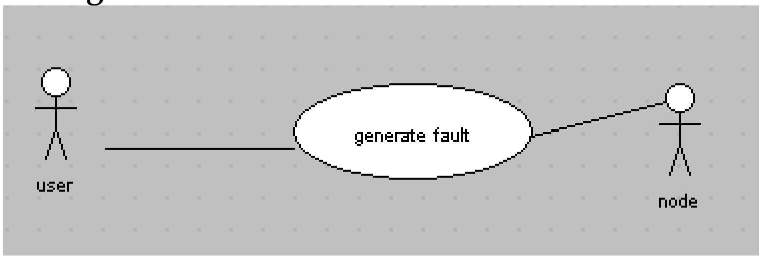

Figure 14: Use case Fault generation

Actors: User and Node
Flow of events: The User generates explicitly a fault in the system, several Nodes are affected by this fault. The performance of the system (set of Nodes) is then evaluated.

Control loop

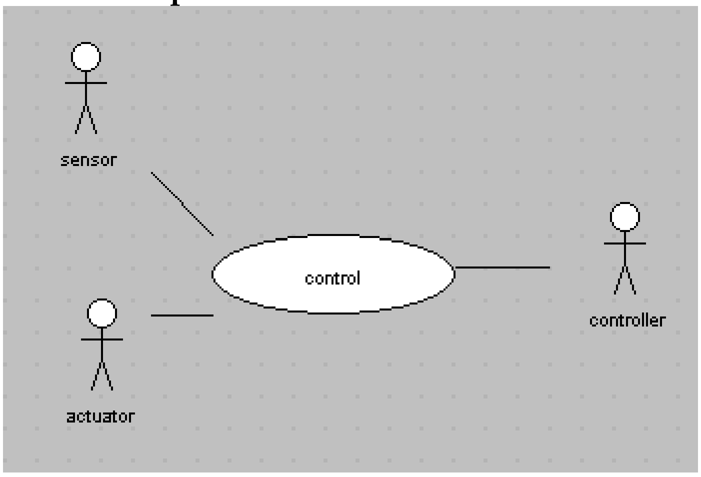

Figure 15:Use case Control loop

Actors: Sensor, Actuator and Controller
Flow of events: A Sensor will transmit a signal, the Controller will receive this signal, will execute an algorithm and will transmit another signal. The Actuator will receive the signal transmitted by the Controller.

Intensive data traffic

Figure 16: Use case Intensive data traffic

Actors: Node and Consumer
Flow of events: Some Nodes will transmit high amount of data to the system and some Consumers will receive these data, the quality of the received data will be checked by the Consumers.

Simulation-control interaction

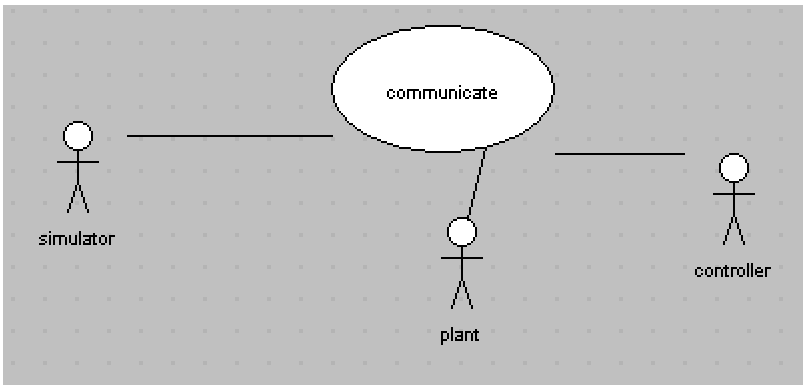

Figure 17:Use case Simulation-control interaction

Actors: Simulator, Plant and Controller.
Two different scenarios are depicted using this global use case.

Simulation control interaction: Control of a simulated plant

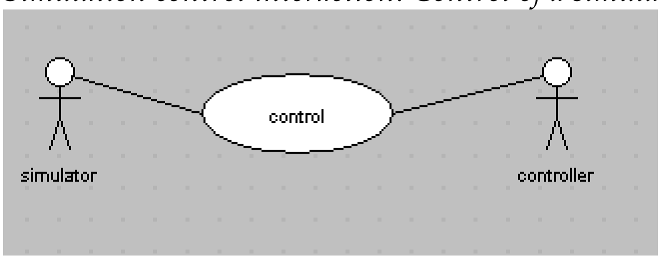

Figure 18: Use case Control of a simulated plant.

Flow of events: A Simulator sends data to and receives data from the Controller, the Controller receives the data from the Simulator, then performs an algorithm and sends back the new computed data.
Simulation control interaction: Control of a plant with simulation data.

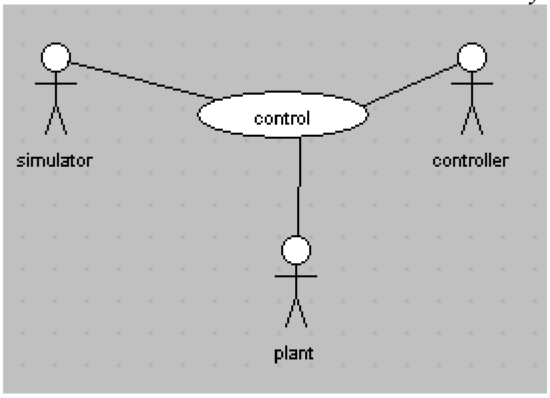

Figure 19: Use case simulation based plant control

Flow of events: The Simulator sends data to the Controller, the Plant sends data to the Controller, the Controller based on the data (model) of the Simulator and the data of the Plant, sends a signal back to the Plant, the Plant receives this signal and actuate.

Several network segments

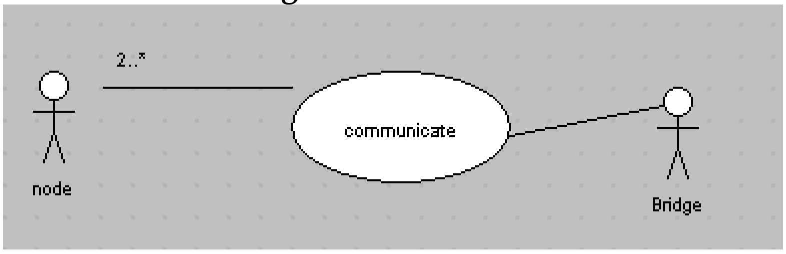

Figure 20: Use case several network segments

Actors: Node and Bridge
Flow of events: A Node in a network segment sends data, a Bridge gets this data a sends them to another network segment, a Node in this second segment receives the data.

Concurrent access

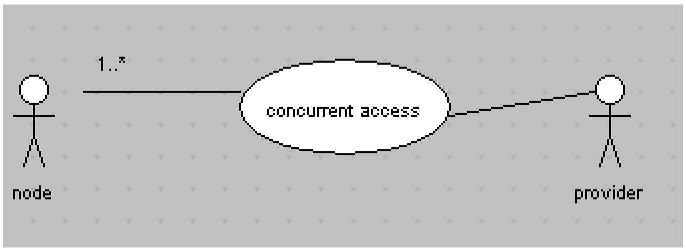

Figure 21: Use case concurrent access

Actors: Node and Provider.
Flow of events: The Provider serves data and multiple Nodes access them concurrently.

5 PCT Requirements

5.1 Purpose of the PCT

The main objective of the distributed process control testbed will be to identify (mainly hard real time) requirements for distributed control systems and perform experiments in conditions of systems heterogeneity and legacy integration. Experiments will be done using conventional IIOP and the new real-time protocol.

5.2 General Requirements.

The general requirements of the process testbed of the HRTC project are derived from the current industrial process control exposition of section 2. These requirements are:

GR1. Representativity

The PCT has to be representative of the basic characteristics of a process plant control system. This is of great importance if the result has to be significant for an industrial environment. The type and number of components as well as the network topology/ies will be derived from this requirement.

GR2. Reconfigurability

This requirement is not related with the reconfiguration of the control but with the reconfiguration of the PCT itself. It is important that the PCT can change easily and adopt different configurations, architectures and topologies in order to comply with the first requirement.

GR3. Testability

The testability requirement completes the first two. Once there is a reconfigurable PCT that is representative of a process plant control system it is necessary that it allows mechanisms to make some experiments and to measure the results.

GR4. Cost-adapted

This is a constraint requirement. The PCT has to be designed with its cost in mind. There is no use in designing a PCT that can not be fully constructed.

GR5. Non-risky.

The process industry is a risky industry. It has to have many protective systems as it usually handles hazardous and dangerous chemicals. The process used for the PCT will not have any risk as the PCT is going to be developed at the university.

5.3 Specific Requirements

These requirements are derived from the general requirements and the use cases presented in the previous chapter.

Representativity

SR1. The PCT shall contain a physical plant (with sensors and actuators)

The physical plant is the reason for all the rest of components so it has to be present in the PCT, although the nature of the process is not of major concern for the experiments to be carried on.

SR2. The PCT shall contain at least an intelligent device as a CORBA Object (sensor or actuator)

These components are the links between the process and the control, they have to be intelligent as this is what there is in industry and they have to be CORBA to allow the communication and transport experiments.

SR3. The PCT shall contain a simple controller as a CORBA object

This component close the loop with the process. It is not important the type of controller so it can be fairly simple. It has to be CORBA to allow the communication and transport experiments.

SR4. The PCT shall contain a commercial DCS as a CORBA Object

The DCS will show the integration capability of legacy systems under CORBA in a real-time environment.

SR5. The PCT shall contain a simulation as a CORBA object.

As simulation is being every day more integrated in the process control architecture in different stages, it is interesting to test how a simulation object with CORBA can interact with the rest of the elements of the control architecture.

SR6. The PCT shall use Ethernet networking

The use of ethernet comes from the current trends in industry. It is being used in the control layer and its application in the field level is being profusely investigated.

SR7. The PCT shall use TCP/IP transport protocol.

This is necessary for the IIOP protocol used by CORBA and because it is a widely used protocol.

SR8. The PCT shall use a predictable network transport

A transport that allows predictability has to be present in this PCT as to say predictability is essential for hard real-time.

SR9. The PCT shall have several network segments

Process industries are large and complex, this means that the problem (the control) is handled through decomposition. Each subset of a plant is communicated through a network segment and all these segments are linked together.

SR10. The PCT shall use heterogeneous transports

The integration of heterogeneous transports in the same system and the way they can interact is interesting as a possibility can be to combine both in some way as a future alternative architecture.

SR11. The PCT shall permit communication redundancy

Safety is of major importance in the process industry. To guarantee normal operation under (network) failure redundant communication is provided. The PCT has to incorporate this feature to be representative of the industry case.

SR12. The PCT shall be able to run tests for scalability

Thousands of signals can be found in a process plant. This feature is quite relevant for real time communication. As the PCT will contain only a few physical devices it is important to establish mechanisms to test how the performance achieved is affected when scaling to an industrial dimension.

SR13. There will be methods for precise enough time synchronization of all nodes in the application

The need of synchronization is present in some types of control (as MIMO control) and when managing a sequence of events.

SR14. The PCT shall contain a Database as a CORBA object

Historical modules (or databases) are an important component in any control architecture. Trends, performance analysis, and many other applications need past data.

SR15. The PCT shall contain at least one HMI as a CORBA object.

A HMI is necessary to follow the experiments and to check the online performance.

Reconfigurability

SR16. The PCT components shall be modular

Modularity is the way to get a truly reconfigurable architecture where different modules can be assembled to have an specific topology that fits the experiment to be carried on.

SR17. The PCT HW components shall be hot-replaceable

Modularity was related with changing the topology, but reconfiguration is to change a component itself as well. The change of (for example a controller) a HW component on line under CORBA and check how it affects performance is important (and it is a feature present in today process control solutions).

SR18. The PCT SW components shall be hot-replaceable

The change of (updating a configuration) a SW component on line under CORBA and check how it affects performance is important (and it is a feature present in today process control solutions).

Testability

SR19. Every node in the PCT shall be visible

Every node in the PCT shall be visible and accessible from a node placed in any other part of the system.

SR20. Every data interchange shall be loggable

This is important to keep track of what has happened and to analyze an experiment.

SR21. All interchanged data shall be time tagged –if necessary- with precision enough.

This requirement is necessary to perform different experiments as those related with distributed events.

SR22. The PCT shall contain enough storage space for registering any experiment

The storage of every experiment is important for its analysis and to draw further conclusions.

SR23. The PCT will enable experimentation with a simple control loop

A simple control loop will serve as the first step to identify the real time properties and behavior of the transports being used and to devise new hard real time requirements for control.

SR24. The PCT shall enable experimentation with intensive data Traffic.

The response under critical conditions as heavy loads in the net will be studied under this experiment. This can be found in a real plant when accessing to the historical database.

SR25. The PCT shall enable experimentation with dynamic loads

In the process industry there is a mix between time triggered events and state triggered events (not known in advance). This can lead many times to dynamic loads in the net. This test will address the problems that show up in these cases.

SR26. The PCT shall enable experimentation with distributed events, to generate a SOE.

After a failure, a series of events occur in the plant. The analysis of this sequence of events is in some cases of major importance as it can help to discover what really happened and why. The capability to properly measure the sequence of events by the available transport is the aim of this test.

SR27. The PCT shall enable experiments to test the interaction between simulation objects and control objects.

This experiments will help to see requirements and difficulties derived of the interaction between objects running with a "simulated time" and objects running with real time.

SR28. The PCT shall enable experimentation with components interacting in different network segments

This experiments will show what difficulties arise when trying to operate a control (hard real-time) loop which components are in different network segments.

SR29. The PCT shall enable experiments to test the interaction between simulation objects (distributed simulation)

Distributed simulation adds some important benefits over non-traditional simulation, specifically component reuse and interoperability are two important advantages. Some tests on a distributed simulation will help to discover the drawbacks (mainly timing properties) of a distributed simulation.

SR30. The PCT shall enable experimentation with multiple concurrent access to data.

The current trend towards information integration can lead to a massive access to the same data at the same time. This can have important consequences that can affect the control performance. It is important to run some experiments to see the quality/quantity of this effect.

SR31. The PCT shall enable experimentation with hot-replaceable components.

Hot swapping is available today in any commercial industrial solution. Experiments to characterize the effects of a replacement in a real time environment are important to devise new HRT requirements.

SR32. The PCT shall enable experimentation to generate some typical faults.

As safety is of major concern in the process industry it is important to devise the behavior of the system under some faults that can be found typically in the plants.

SR33. The PCT shall enable experimentation with integrated legacy systems.

The capability and ease of CORBA to integrate legacy systems is important as many legacy systems can be found in the control system of a process plant.

Cost Adapted

SR34. The PCT installation cost will be adjusted to the budget assigned in the project description.

No-Risk

SR35. The physical plant shall not work with hazardous species.

The PCT is being built in the university environment so the species used in the physical process of the PCT must be usable in a non specifically adapted space.

SR36. The physical plant shall not work under dangerous operating conditions.

The physical process will work under normal operating conditions as it is being built at the university where there are no facilities to deal with dangerous operating conditions.

6 Reference List

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