Applying CORBA to embedded time-triggered real-time systems

S. Aslam-Mir (Sam)
Principal CORBA Architect – Vertel USA
sam@vertel.com

Synopsis

- Motivation

  Time Triggered vs Event Triggered
- Real-time CORBA present applicability
- Real-time CORBA for the masses MEMs, and the smart transducer interface.
- *Fault-tolerance with real-time capability.
- First order penetration of CORBA into the control plane of mission-critical systems
- Conclusions

Motivation

- For integrated safety-critical real-time systems the time-triggered approach is preferred.
- Safety critical real-time systems prefer functions (in avionics terms) to be kept apart – avoids failure propagation – ***Partitioning***
- ***Composability*** *desire* – lowers cost to develop a more complex integrated sub-system.
- Partitioning and composability in safety-critical real-time systems determine its predictability (value-time tuple)
- Temporal (time) predictability in the face of failures is **difficult** to achieve in event triggered systems – this is because FDI and Reconfiguration has to occur in a fixed/bounded well known time – thus time-triggered is preferred over event triggered.

Motivation

Achievable

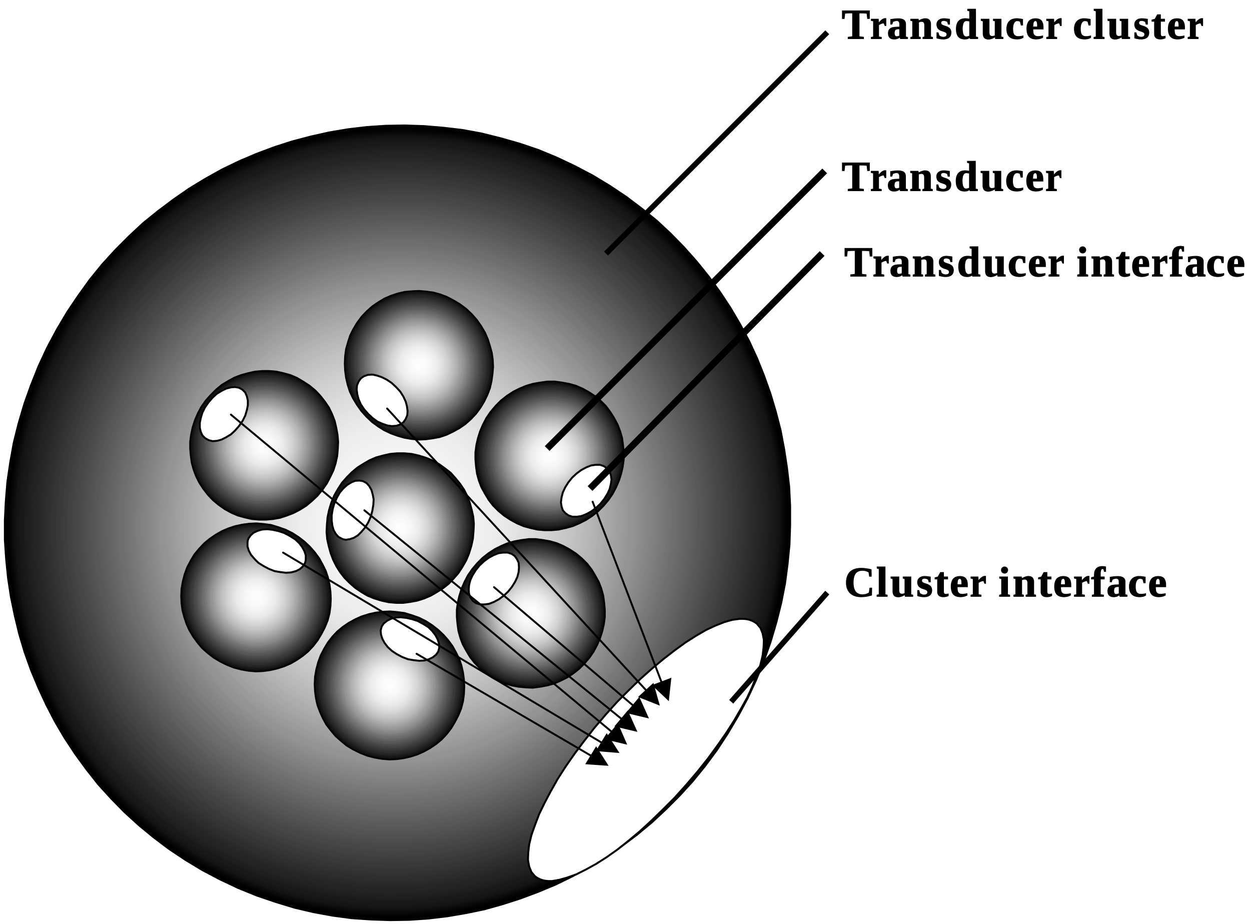
at

LOW-LOW-COST

What is the new approach

- Chose a generic TTP/C like protocol over several others like Honeywell SAFEbus (777bus), ARINC 629, FlexRay, NASA Spider
- Created a canonical transducer cluster to model the device(s) called **smart transducer** for OMG specification.
- ***ORBOS-01-10-02/04***
- . . comprises the integration of one or more MEMS sensor/actuator elements with a microcontroller that provides the following services across standard interfaces:
  - signal conditioning
  - calibration and conversion to standard units
  - diagnostic and maintenance
  - real-time network interface
- The idiosyncrasies of the smart sensor/actuator can be hidden behind a standard CORBA interface neatly.
- In the future, smart transducers will be manufactured in ***mixed signal*** technology on a single die.

Smart Transducers



Limitations of present RTCORBA applicability into RT control-loops.

- Application to Time-triggered systems is difficult as it stands for the present
- Support for integrated fault-tolerance and load balancing in one shot does not exist
- Difficult/expensive to achieve well bounded deterministic latency and jitter because of probabilistic models for things like contention resolution on buses like VME and Ethernet
- The above are costly
- *Proving partitioned composable properties of present RTCORBA based systems is costly and difficult if at all.*

Smart Transducer technology - low cost RTCORBA use for the masses -

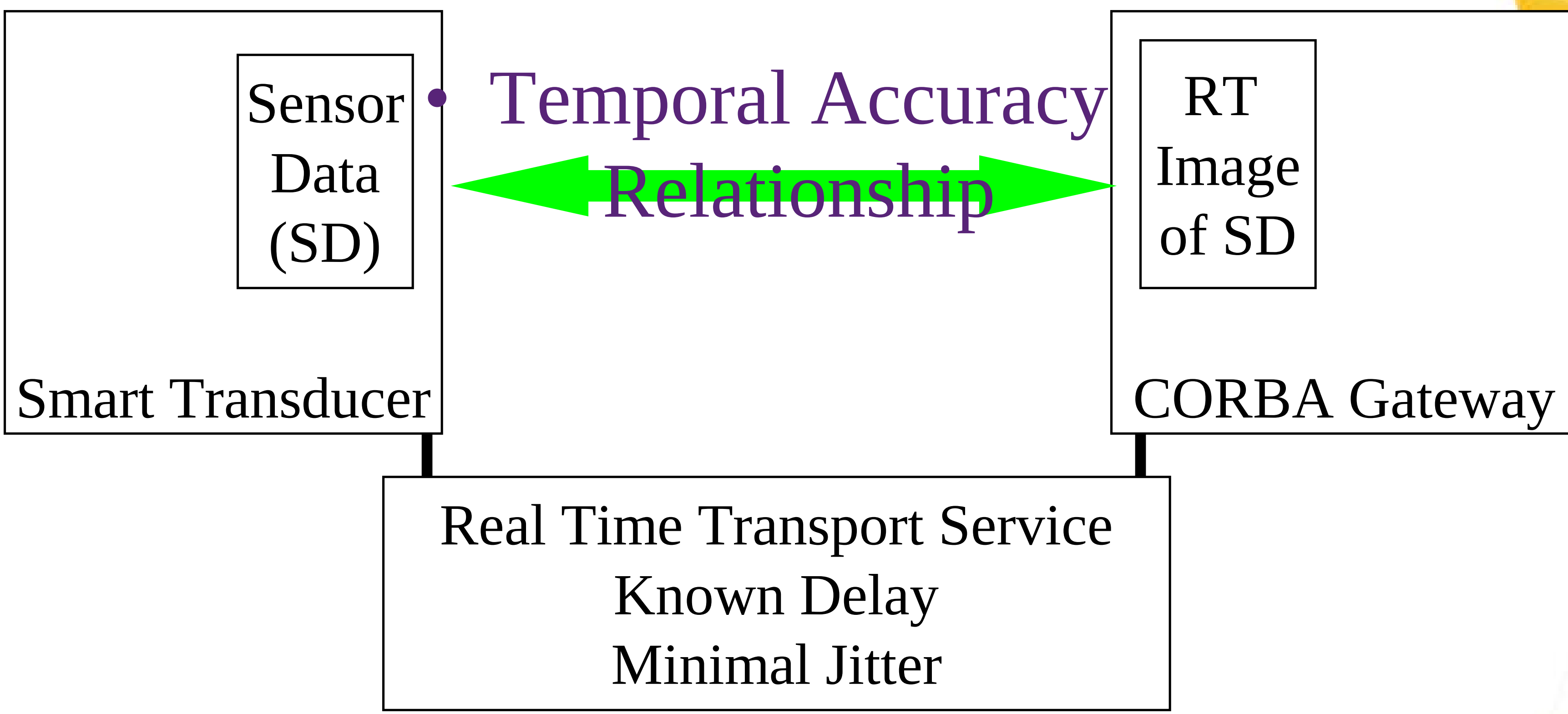
- No noise pickup from long external signal transmission lines.
- Better Diagnostics--Simple external sensor failure modes (e.g., fail-silent, i.e., the sensor operates correctly or does not operate at all).
- "Plug-and-play" capability if the sensor contains its own documentation on silicon.
- Reduction of the complexity at the system hardware and software and the internal sensor failure modes can be hidden from the user by a well-designed fully specified smart sensor interface.
- Cost reduction in installation and maintenance.

The Smart Transducer interface

- An RT-interface is a common boundary between subsystems that allows the timely exchange of *observations* between these subsystems.
- An observation is a *n-tuple*
- *<Name of an RT-entity, time of observation, value of observation>*.
- Communication across an RT interface is only possible, if the participating subsystems share a ***common set of concepts*** concerning
  - Common notion of time and its representation
  - Meaning of the names of RT entities
  - Shared code-space for the representation of values
  - Access protocol to the information.
- A universal smart transducer interfaces must specify this *common knowledge*.

Conceptual model

All nodes have access to a global time of known precision.



Different RT Transport Protocols supported

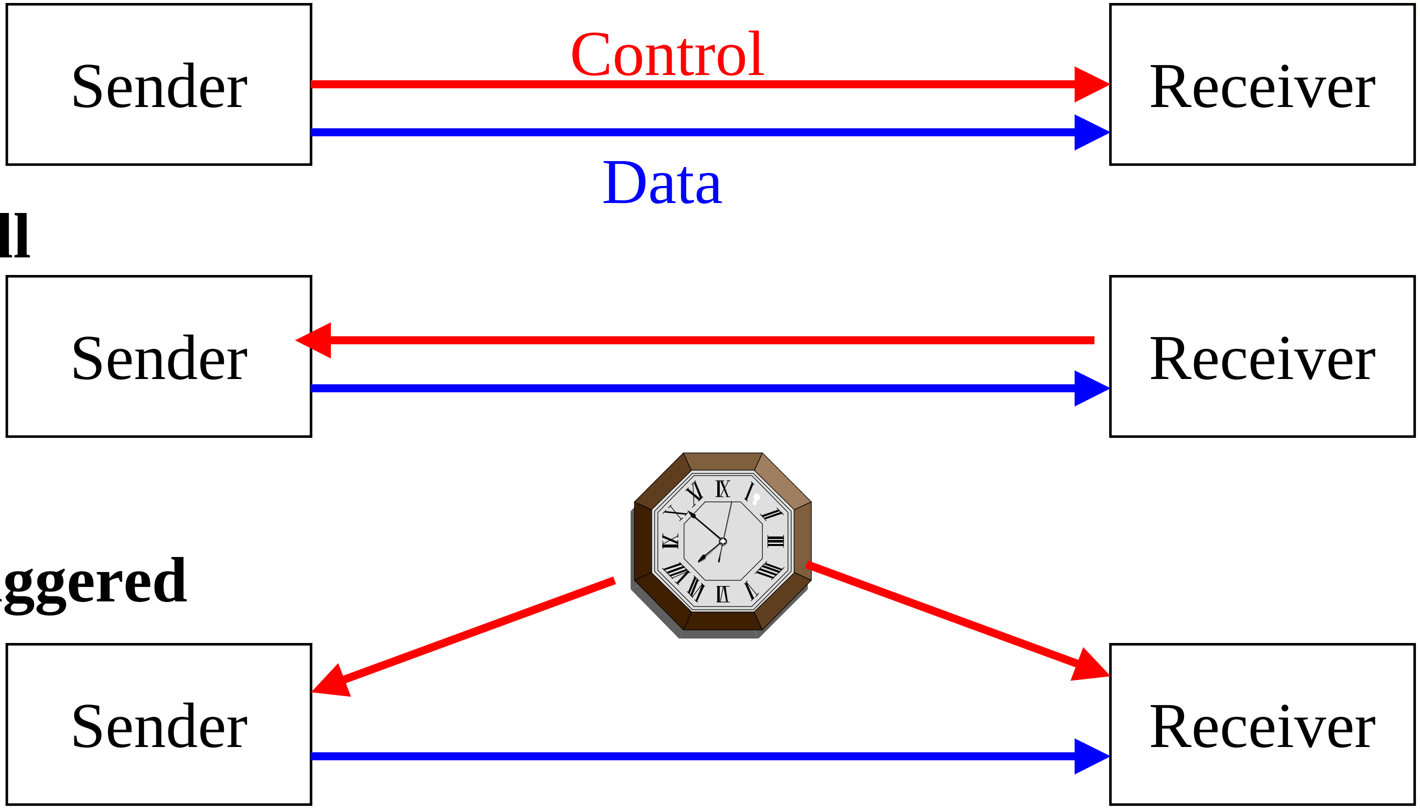
Runtime model

Traditional flow control in uni-directional data transfer

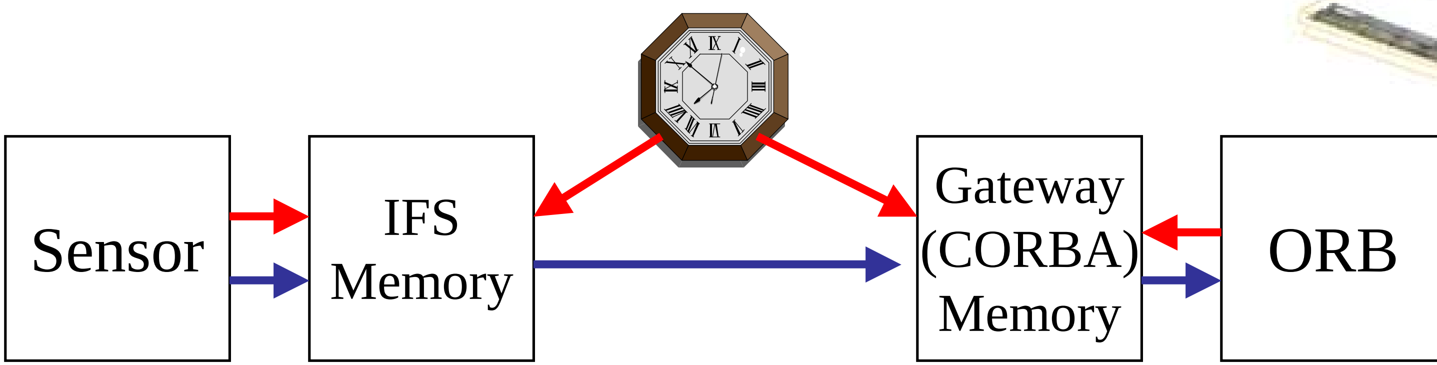
data push

data pull

time-triggered



Runtime model



Information Push

Ideal for Sender

Time-Triggered

Communication System

Information Pull

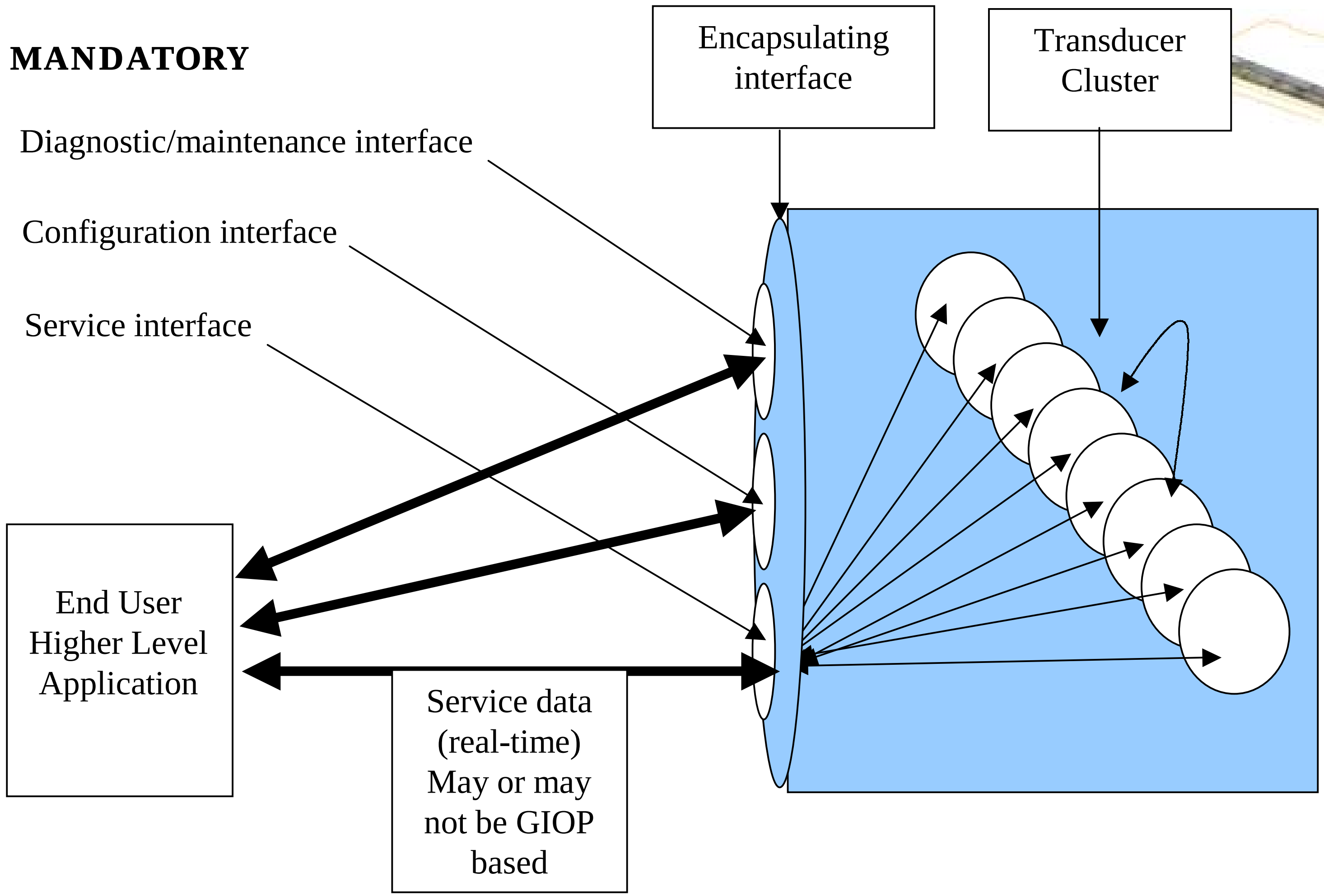
Ideal for Receiver

The ST interfaces

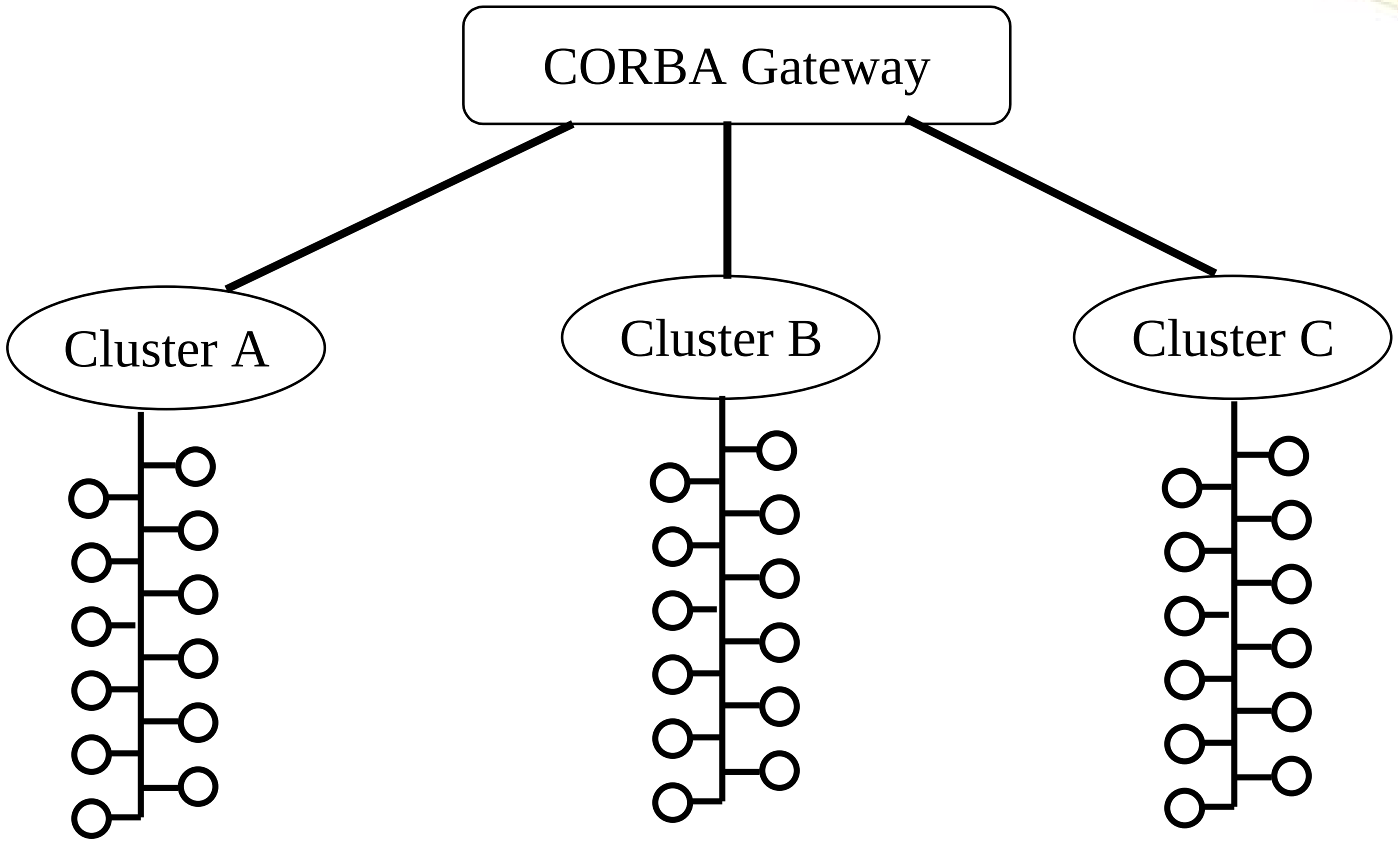
- **Real-Time (RS) Service Interface-TT:**
  - Contains RT observations
  - Time sensitive
  - In control applications periodic
- **Diagnostic and Maintenance (DM) Interface-ET**
  - Sporadic Access
  - Requires knowledge about internals of a node
  - Not time sensitive
- **Configuration Planning (CP) Interface-ET:**
  - Used to install a COTS node into a new configuration
  - Not time sensitive
- The ST Submission supports all three of these interfaces.

Smart Transducers

Functional view



Structure -



Coupling fault-tolerance with real-time capability . .

- Real-time and Fault-tolerant CORBA cannot be applied to the other side of the Gateway together – why ?
- Temporal (time) predictability in the face of failures is **difficult** to achieve in event triggered systems as such (mathematical literature supports this in addition to empirical research)
- This is because FDI and Reconfiguration has to occur in a fixed/bounded well known time – thus time-triggered is preferred over event triggered.
- TTP/C model chosen for the other side to allow for bounded response in the face of failures that has been proven.
- Literature source at provided at end for comparison and support.

Permeation of RTCORBA into the control plane of mission-critical systems

- Traditional certification hurdles have been a problem with RTCORBA based control loops, thus limited its applicability to life-critical control loops.
- Where low latency, and absolutely minimal jitter are required for hard/brittle real-time control something else is used
- TTP/C married to new forms of GIOP offer a new solution.
- It fuses the substantial fault-tolerant, highly deterministic, overload protection, discovery reconfiguration and isolation advantages of using TTP/C with the interoperability and standards based approach of RTCORBA together.

Conclusions

- **TTP/C like protocols plus RTCORBA based GIOP will stimulate the evolution of dynamic closed-loop CORBA for control and automation to much greater levels.**
- **Smart transducer interface brings real-time time-triggered systems into the CORBA fold without sacrificing any of their strengths**
- **TTP/C like protocols offer many advantages in terms of low cost, mass production, and several mathematically provable properties required by mission critical fault-tolerant real-time systems..**
- **Major adoption in process by standards bodies OMG, TTP Forum.**
- **Major adoption by industry for TTP/C based systems – <u>Honeywell in AFCS, and Audi in automotive system (in preference to CAN!) .</u>**
- **CORBA approach using e*ORB-C/C++ Edition prototype.**
- **<u>How much cheaper ? 400$ compared to $15</u>**

Useful sites with papers-

- www.ttpforum.org.
- www.tttech.com
- University of Vienna – Professor Kopetz work
- On time-triggered systems UCI Professor Kane Kim's work in TT systems is a useful second reference point for time-triggered systems.
- Rushby J. September 2001 – "Comparison of Bus Architectures for Safety-Critical Embedded Systems." CSL Tech. Report. SRI International, Menlo Park CA 94025