Poseidon House
Castle Park
Cambridge CB3 0RD
United Kingdom

TELEPHONE: Cambridge (01223) 515010
INTERNATIONAL: +44 1223 515010
FAX: +44 1223 359779
E-MAIL: apm@ansa.co.uk

ANSA Phase III

ANSAwise - CORBA and Real-Time Systems

Chris Mayers

Abstract

Organizations building real-time systems may wish to exploit distributed object technology and integrate real-time and non-real-time systems.

This module of the ANSAwise training programme describes the work done in ANSAware/RT and further planned in ANSA Phase III.

[This presentation draws on material from APM.1452. It also reuses some material from APM.1353]

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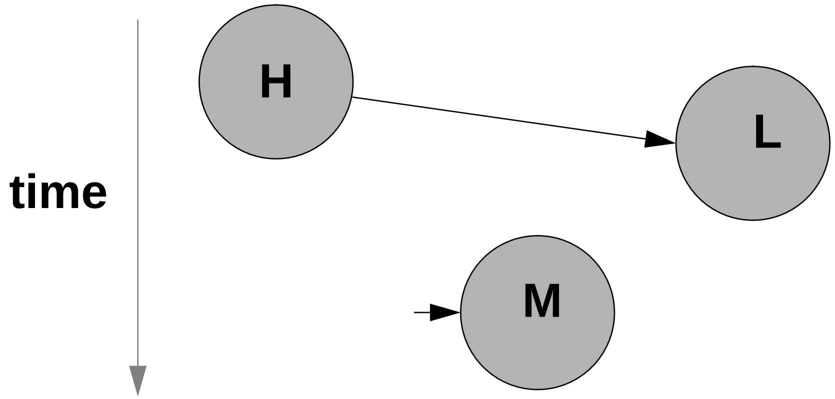
CORBA and Real-Time Systems



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In this session

- *Identify the characteristic properties of real-time systems*
- *Show how these properties affect the design of distributed systems*
  - distributed systems with real-time properties
- *Show how CORBA real-time systems will evolve*

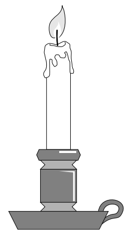
Timeliness

- ***A real-time system is one in which timing is explicitly considered***
  - **in requirements**
  - **in specification**
  - **in design**
  - **in implementation**
- ***Real-time systems require timely responses to events***
  - **even under failure conditions**
  - **even under extreme load conditions**

The nature of real-time systems

- ***Distinctions are usually made between***
  - **non-real-time systems**
  - **soft real-time systems**
  - **hard real-time systems**
- ***The distinctions are not rigid, but are realistic***
  - **the different trade-offs currently result in very different system designs**

Non-real-time systems

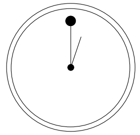


- ***Have no timing requirement***

  - **best-effort is all that is offered**

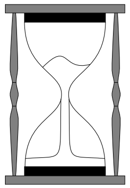
- ***Timings are not monitored***

Soft real-time systems



- ***Typically have an “average case” timing requirement***
  - **for example, 99% of requests to take less than 1 second**
- ***Failure to meet the timing requirement is not critical***
  - **a late response to a request is bad, but may still be useful**
- ***Timing may be monitored***
  - **consistent failure to meet a timing requirement may require human or automatic intervention**
- ***Often based on priority schemes***

Hard real-time systems



- ***Typically have a "worst case" requirement***
  - **for example, all requests must be completed in less than 1 second**
- ***Failure to meet timing requirement is catastrophic***
  - **a late response is useless or even dangerous**
- ***Timing must be monitored***
- ***Failure to meet a deadline requires automated handling***
- ***Based on deadline schemes, usually using priority as well***

Misconceptions about real-time systems

- ***Real-time Means Fast***
  - ***NO*: real-time means predictable timing/*'fast enough*'...**
  - **... acceptable response times in seconds are not unusual**
- ***Real-time Means Assembler***
  - ***NO*: selective programming in assembler may be necessary for performance**
  - **... but it doesn't guarantee predictable timing**
- ***Faster Hardware Solves All Real-time Problems***
  - ***NO*: faster hardware may make new problems solvable**
  - **... but it doesn't guarantee predictable timing, either**

More misconceptions

- ***Real-time is Art, not Science***
  - It may have been in the past...
  - ... this is no longer so

- ***Real-time Problems Are Solved By Conventional Techniques***
  - The nature of timing constraints poses special challenges for systems designers...
  - ... challenges we can handle

Real-Time Architecture

- ***Interoperability***
  - **between applications with different real-time requirements**
  - **... executing on different real-time platforms**
  - **... interworking with non-real-time applications**
- ***Portability***
  - **of applications between real-time platforms**
- ***Support for continuous information flows (multimedia streams)***

Real-Time Design Principles

- ***Separate Resources***

- ***Reserve Resources***

- ***Control Sharing***

- ***Let the Application be in Control***

Resource reservation is a key facility

- ***Reservation of resources (pre-allocation) is vital to provide guarantees...***
  - **just as in real life generally**
- ***...but computers often try to share resources***
  - **by multiplexing**
  - **by pooling**
  - **by time-sharing**
- ***It must be possible to reserve resources selectively***

Resources are needed immediately

- *Real-time means that resources must be delivered immediately they are required*
    - **Waiting Is Evil!**
- *Resources include*
    - **CPU**
    - **Memory**
    - **I/O bandwidth**

Resource reservation in distributed systems

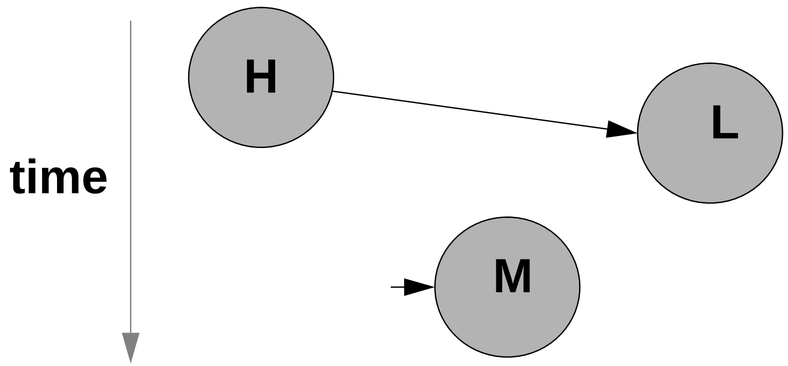
- ***In distributed systems, the resources must be reserved end-to-end***
  - **in the end systems**
  - **throughout the network**
- ***This means end-to-end quality-of-service (QoS) guarantees***

Programming with priorities

- ***Every multi-tasking operating system offers ‘task priorities’...***
  - **... but exactly what do they mean?**
- ***Many such systems evolved from time-sharing environments***
  - **offering round-robin scheduling (task quanta) for tasks of equal priority**
  - **... often with automatic adjustment of task priority**
- ***Real-time systems require strict priority***
  - **highest priority first**
  - **no round-robin scheduling**
- ***Some systems offering ‘real-time’ priorities give you only this***
  - **but strict priority is not enough**

The priority inversion phenomenon

- *Suppose we have a system with three priority levels*
  - high, medium, and low



- *High-priority process synchronizes with low-priority process*
  - ... meanwhile, it can be pre-empted by a medium-priority process
  - ... this is not what is wanted

Solutions to priority inversion

- ***The scheduler's protocol must prevent priority inversions, typically using***
  - **PIP (Priority Inheritance Protocol)**
  - **PCP (Priority Ceiling Protocol)**
- ***The POSIX 1003.4 standard requires PIP***
  - **with PCP as an option**
- ***You'll need a scheduler that prevents priority inversions***
  - **you can buy such systems now**

Priority is not a panacea

- ***Priority is only a measure of importance***
  - **it is not a measure of urgency**
  - **... it does not give you deadline guarantees**
  - **... which are necessary for hard real-time systems**
- ***Separate mechanisms are needed to support importance and urgency***
- ***Priority does not directly help meet the average-case guarantee for soft real-time systems either***
  - **it's not clear how to allocate priorities at design time**
  - **... it's often done by tuning the priorities by hand in the final system**
  - **... this does not assure confidence in the system**

Priority is useful

- ***Well supported***

- ***Well accepted***

- ***Well understood***

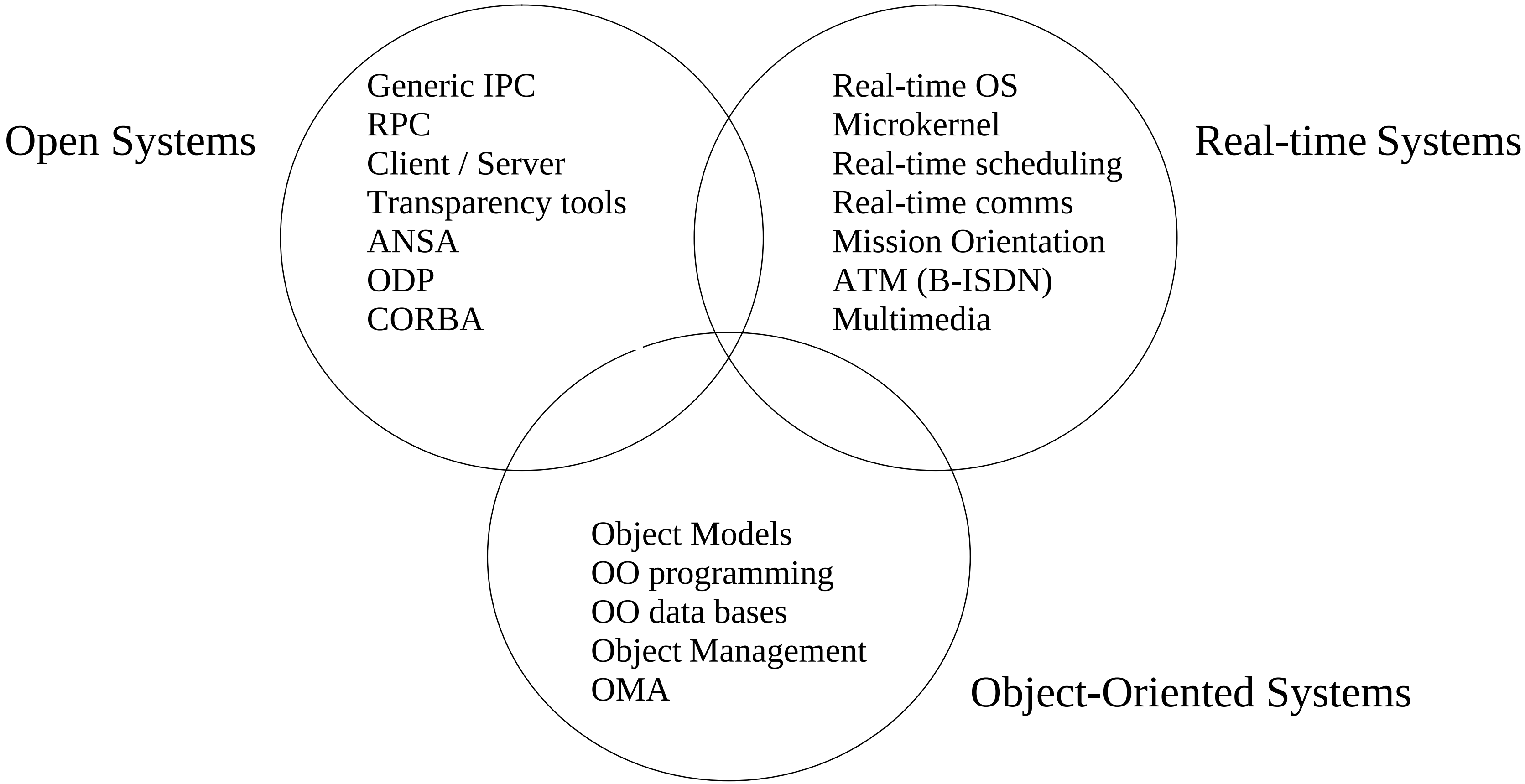
Priority in real-time distributed systems

- *The same issues arise in a remote procedure call*
  - strict priority
  - prevention of priority inversion
- *This means that*
  - both end systems must support this
  - the RPC must convey the priority information between the systems
- *This is done with a modification to the RPC mechanism*
  - making it a Timed RPC

Real-time Unix solves many problems

- ***The POSIX 1003.4/4a Real-Time extensions meet many of the needs***
  - **and convergence is beginning to deliver usable products**
- ***There are still some gaps***
  - **no support for deadlines for hard real-time systems**
  - **no generalized support for resource reservation**

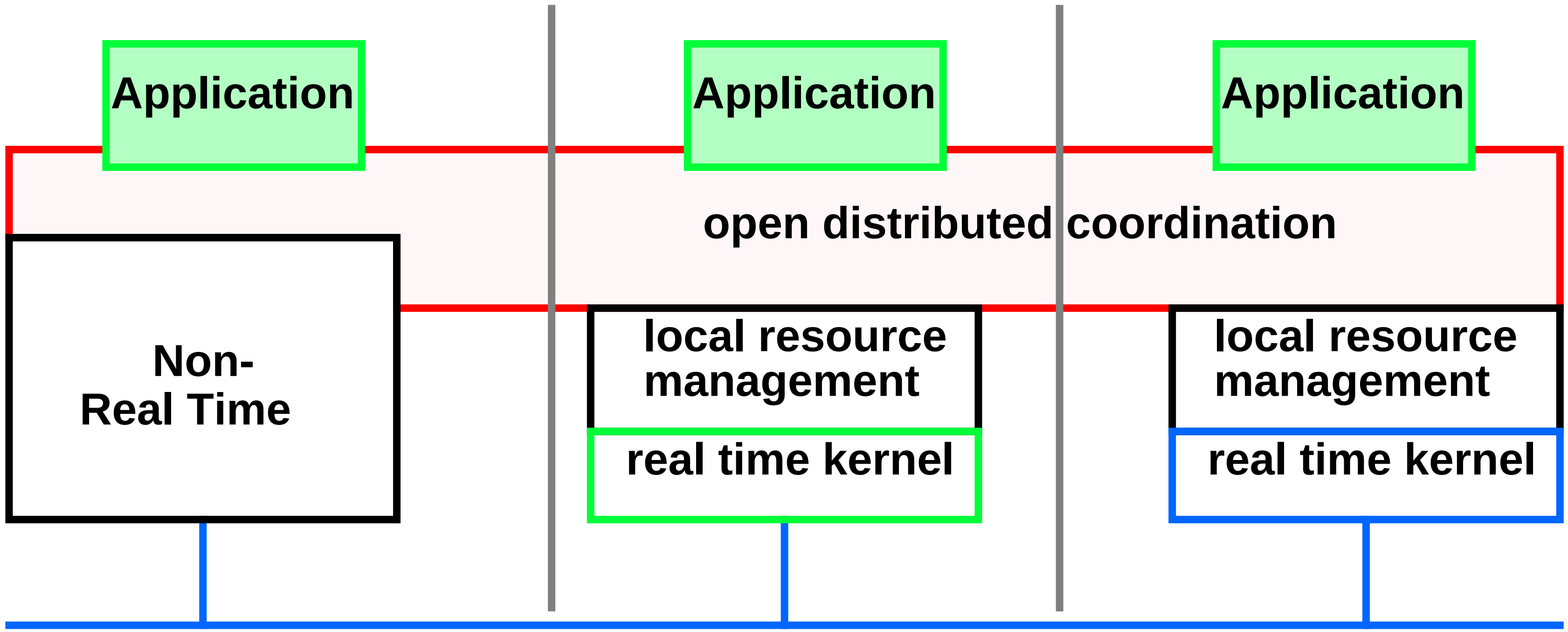
The wider picture - contributory technologies



ANSA Phase 3 Activities in Distributed Real-Time

- ***ANSAware/RT***
  - a version of ANSAware supporting some of the features described earlier
  - interworking with ANSAware 4.1
- ***Distributed Interactive Multimedia Architecture (DIMMA)***
  - re-engineered ORB infrastructure

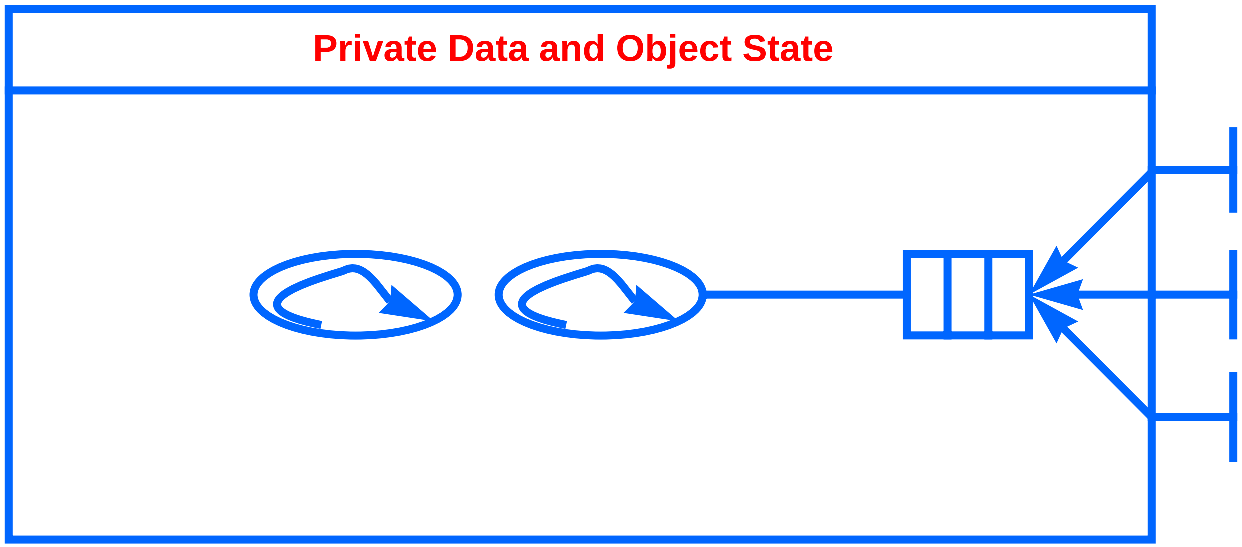
ANSAware/RT 1.0



ANSAware/RT

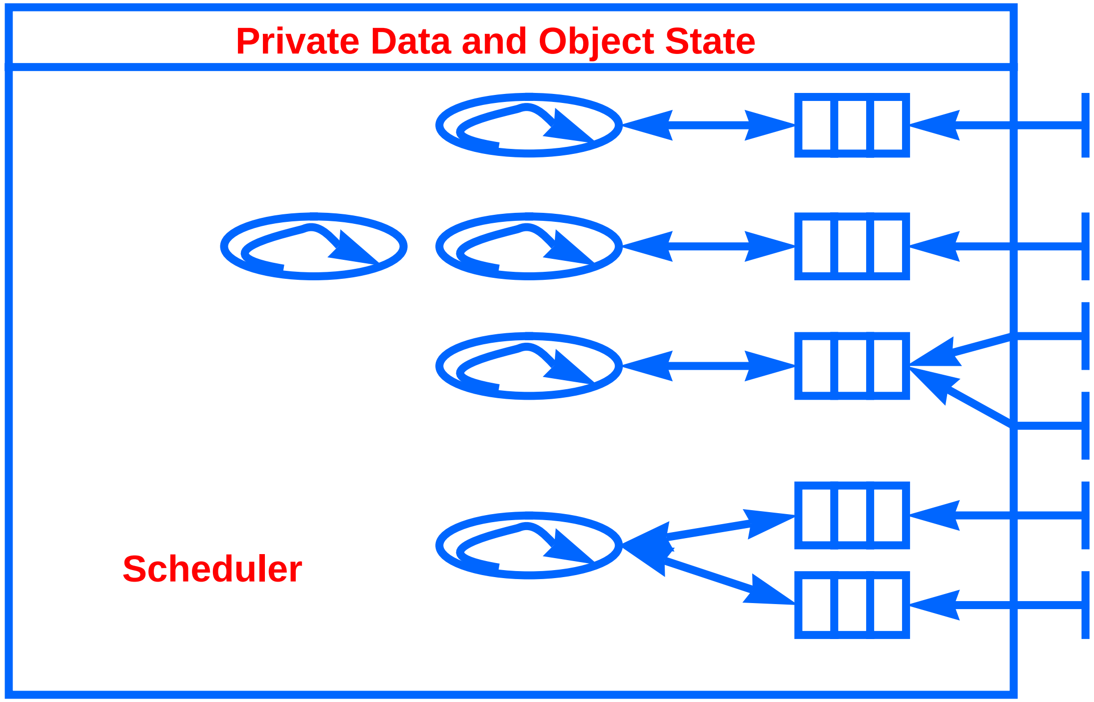
- ***CPU resource control***
  - **by flexible tasking model and scheduling policies**
- ***Communications resource control***
  - **by parallel protocol stacks and Timed RPC**
  - **with associated quality-of-service**

Tasking: ANSAware 4.1 Engineering Model



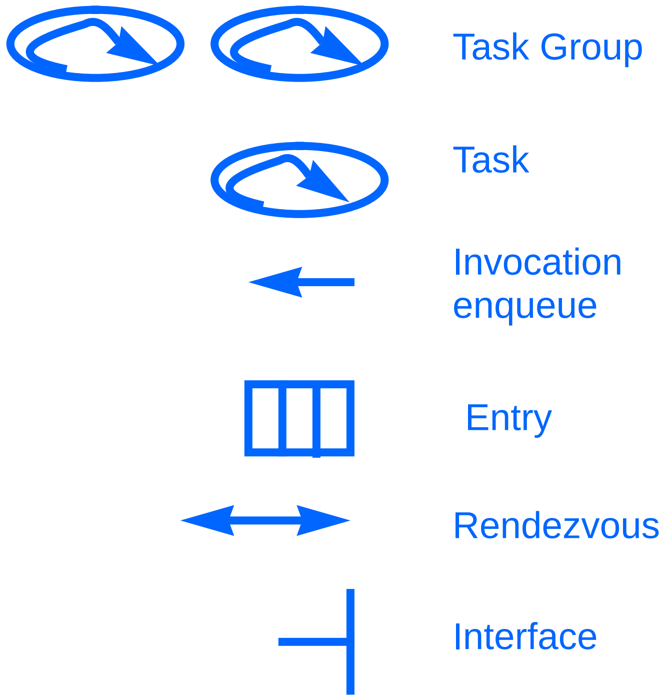
time-sharing based design --- efficient in resource sharing

Tasking: ANSAware/RT 1.0



more flexible design --- resource separation and reservation

Legend

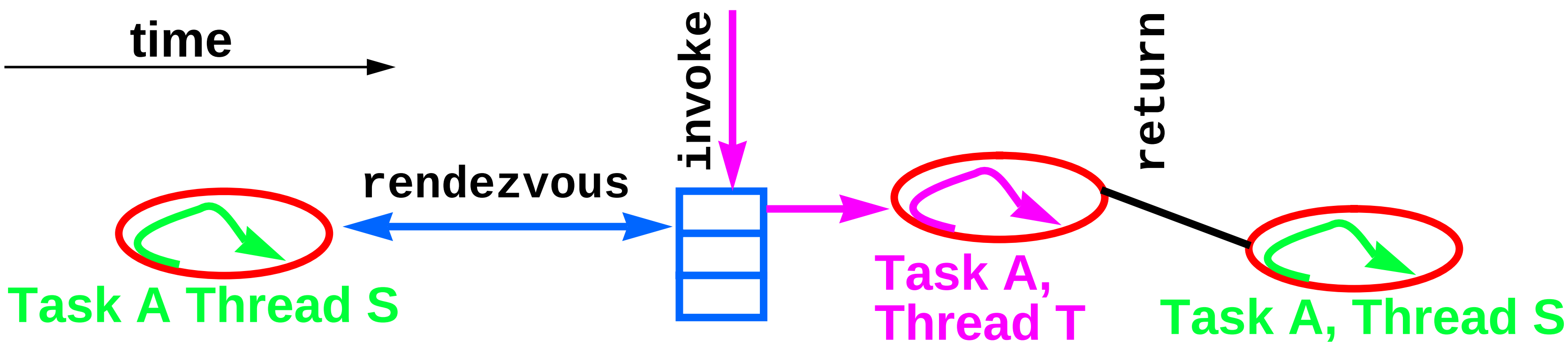

Task Group
Task
Invocation enqueue
Entry
Rendezvous
Interface

Entries

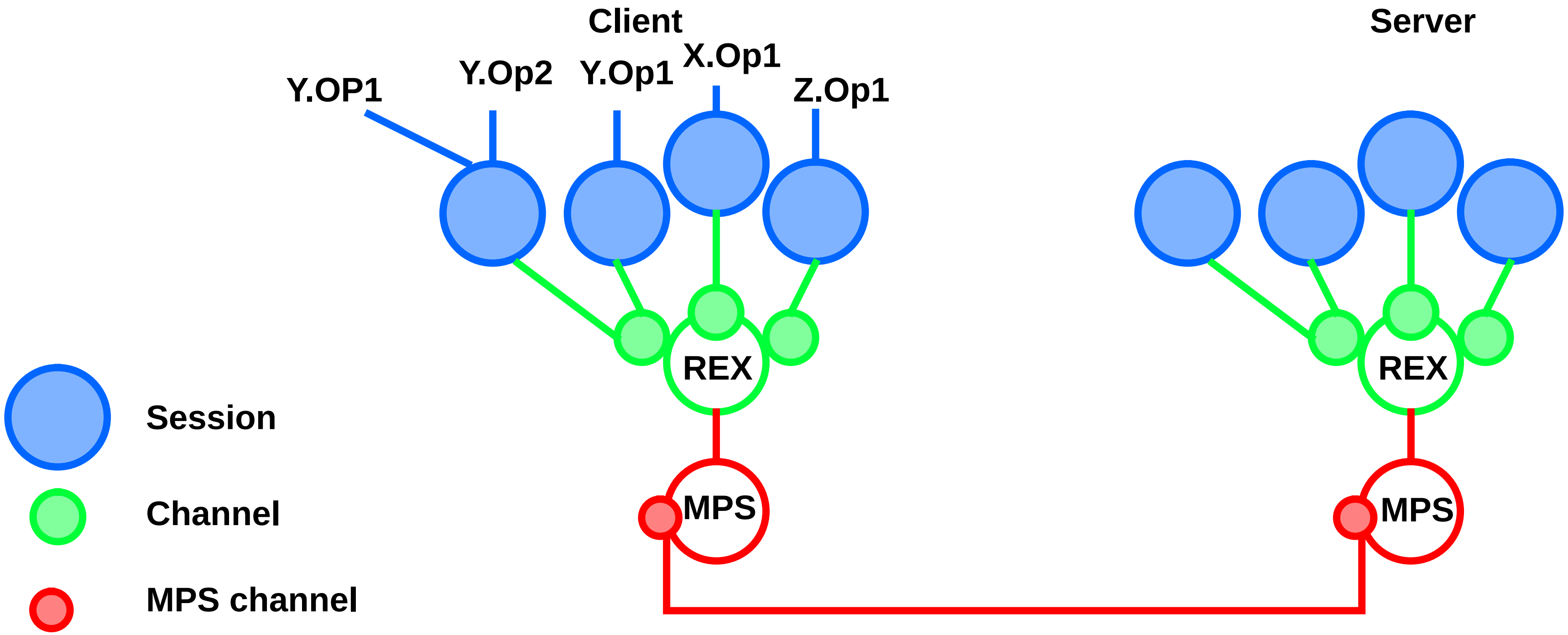
- ***An entry is a thread queue***
  - **a scheduling point with its own scheduling and processing policies**
- ***There is a default entry to which all new interfaces are bound***
- ***Applications can***
  - **create entries**
  - **bind interfaces to entries**
  - **unbind interfaces from entries (reverting to the default)**
  - **destroy entries**

Rendezvous

- *A thread may wait at an entry to rendezvous and allow execution of another thread (e.g. an invocation)*
  - the rendezvous can have an associated time-out

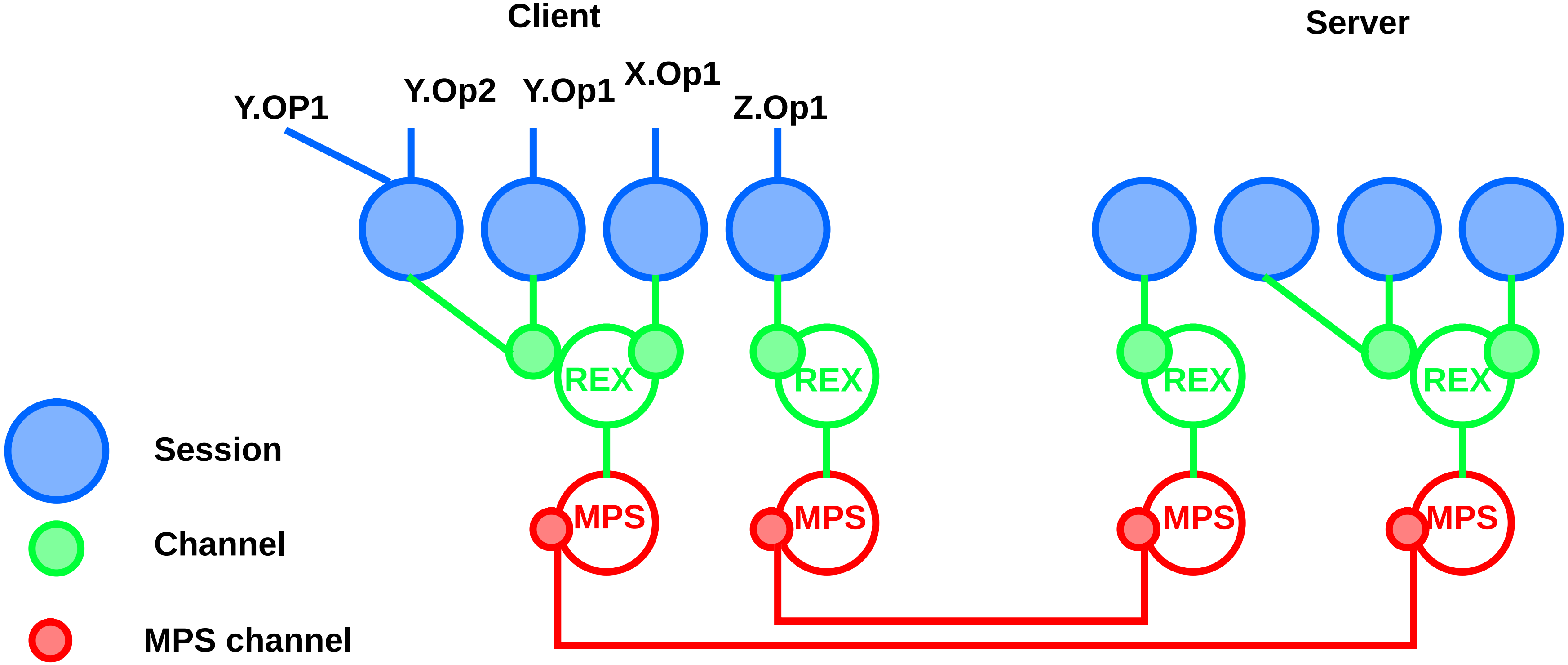


ANSAware 4.1 Communication System



multiplexing whenever possible --- efficient resource usage

ANSAware/RT 1.0 Parallel Protocol Stacks



resource allocation to specific channels

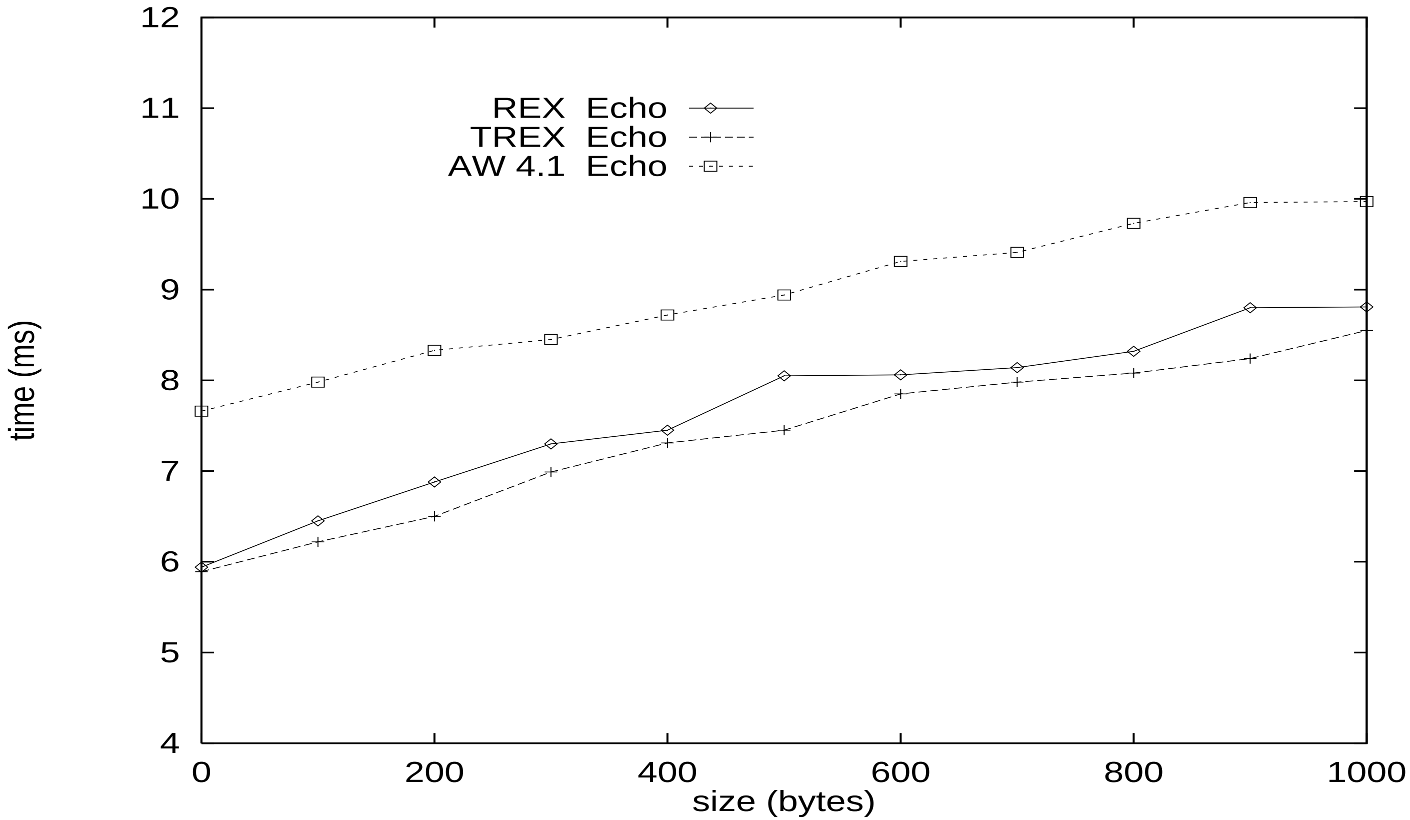
ANSAware Timed RPC

- ***TREX (Timed Remote EXecution) RPC protocol***

  - **efficient cut-down version of ANSAware REX RPC protocol**

  - **supports priority and deadline**

RPC Performance



CORBA and Real-Time

- *CORBA IDL does not allow specification of*
  - quality-of-service
  - streams
- *Resource reservation and control is an ORB engineering issue*
  - vendor-specific
- *A modular ORB infrastructure with standard interfaces is needed*

CORBA Real-Time Products

- *Teknekron Object Bus*
- *IONA Real Time Orbix*
  - built on VxWorks

Related needs and issues

- *Typical related needs are*
  - fault tolerance
  - automated recovery
  - load balancing
- *No programming language provides adequate support for real-time*
  - this will have to be provided by auxiliary tools

General principles

- *Design in real-time capability from the start*
- *Do not change the problem to fit the hardware*
- *Partition functions between objects with real-time aims in mind*
- *Specify testability interfaces*
- *Construct from general components into special configurations*

Summary

- ***Distributed real-time is a topic of the ANSA Phase 3 programme***
  - **ANSAware/RT supported over OSF/1, LynxOS, HP-UX/RT**
  - **Advanced work in the DIMMA activity**
- ***Decide whether your needs can be met by specific systems***
  - **do not be fooled by features simply labelled as 'real-time'**
  - **beware of systems that claim to offer simply 'real-time' priorities**
- ***For more on this topic***
  - **see *Misconceptions about Real-Time Computing* by John A. Stankovic (IEEE Computer Oct 1988)**