High-performance, Real-time CORBA ORBs for ATM Networks

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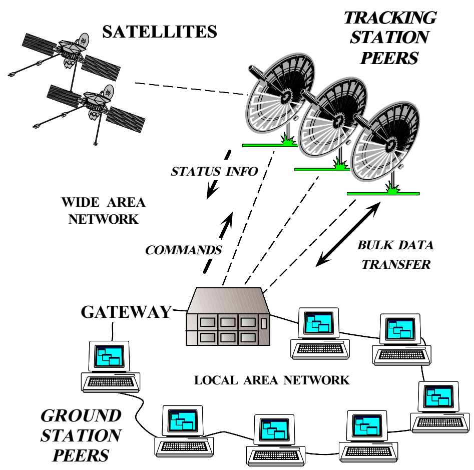
www.cs.wustl.edu/∼schmidt/TAO.html

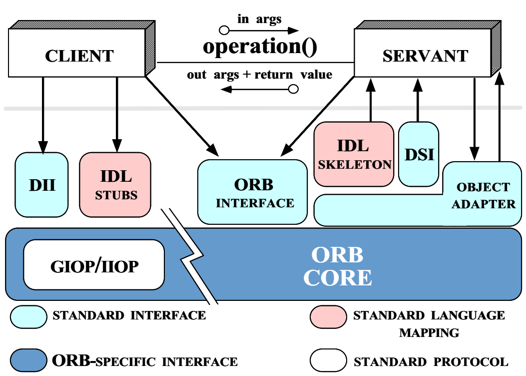
Sponsors
NSF, DARPA, Bellcore, Boeing, CDI,
Kodak, Lucent, Motorola, OTI, SAIC,
Siemens SCR, Siemens MED, Siemens ZT, Sprint

Problem: Lack of Real-time Middleware



- Many applications require QoS guarantees
  - *e.g.*, telecom, avionics, WWW
- Building these applications manually is hard
- Existing middleware doesn't support QoS effectively
  - *e.g.*, CORBA, DCOM, DCE
- Solutions must be *integrated*

Candidate Solution: CORBA



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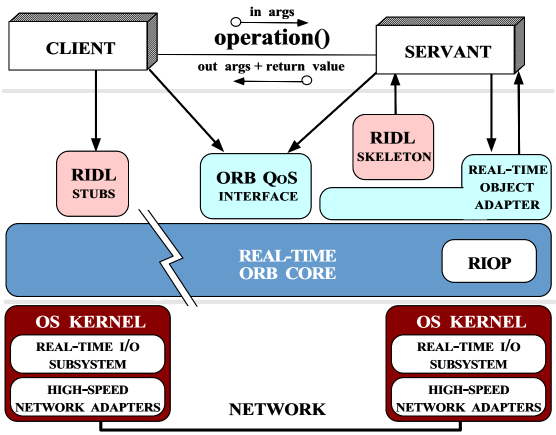
- **Goals of CORBA**
  - Simplify distribution by automating
    * Object location and activation
    * Parameter marshaling
    * Demultiplexing
    * Error handling
  - Provide foundation for higher-level services

Motivation for CORBA

- Simplifies application interworking
  - CORBA provides higher level integration than traditional *untyped TCP bytestreams*
- Provides a foundation for higher-level distributed object collaboration
  - *e.g.*, Windows OLE and the OMG Common Object Service Specification (COSS)
- Benefits for distributed programming similar to OO languages for non-distributed programming
  - *e.g.*, encapsulation, interface inheritance, and object-based exception handling

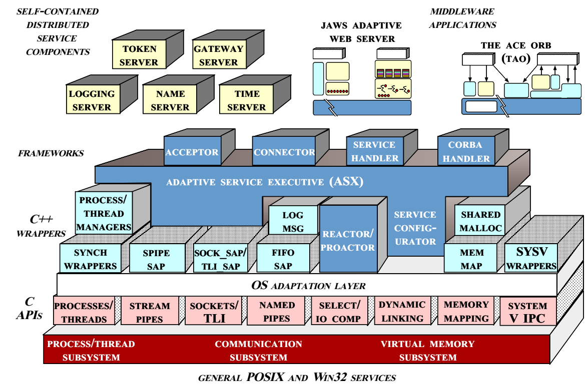
The ACE ORB (TAO)



www.cs.wustl.edu/~schmidt/TAO.html

- **TAO Overview**
  - A high-performance, real-time ORB
    - ∗ Telecom and avionics focus
  - Leverages the ACE framework
    - ∗ Runs on RTOSs, POSIX, and Win32
- **Related work**
  - QuO at BBN
  - ARMADA at U. Mich.

The ADAPTIVE Communication Environment (ACE)



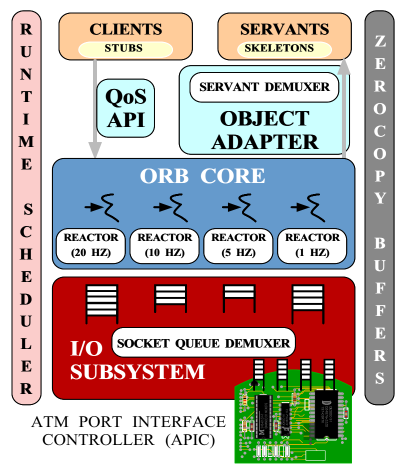
www.cs.wustl.edu/~schmidt/ACE.html

- **ACE Overview**
  - Concurrent OO networking framework
  - Ported to C++ and Java
  - Runs on RTOSs, POSIX, and Win32
- **Related work**
  - x-Kernel
  - SysV STREAMS

ACE Statistics

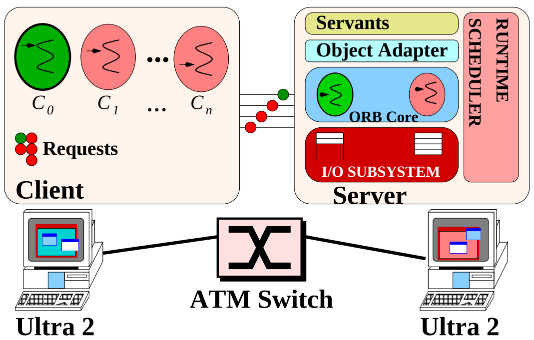
- ACE contain > 125,000 lines of C++
  - Over 10 person-years of effort
- Ported to UNIX, Win32, MVS, and embedded platforms
  - *e.g.*, VxWorks, LynxOS, pSoS
- Large user community
  - www.cs.wustl.edu/~schmidt/ACE-users.html
- Currently used by dozens of companies
  - Bellcore, Boeing, Ericsson, Kodak, Lucent, Motorola, SAIC, Siemens, StorTek, etc.
- Supported commercially
  - www.riverace.com

TAO's Real-time ORB Endsystem Architecture



- **Solution Approach**
  - Integrate RT dispatcher into ORB endsystem
  - Support multiple request scheduling strategies
    - ∗ *e.g.*, RMS, EDF, and MUF
  - Requests ordered *across* thread priorities by OS dispatcher
  - Requests ordered *within* priorities based on *data dependencies* and *importance*

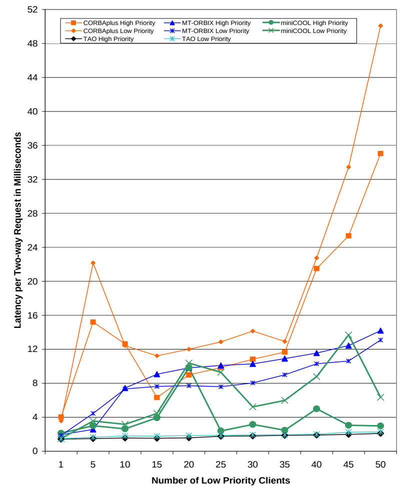
Real-time Experiments over ATM



www.cs.wustl.edu/~schmidt/RT-perf.ps.gz

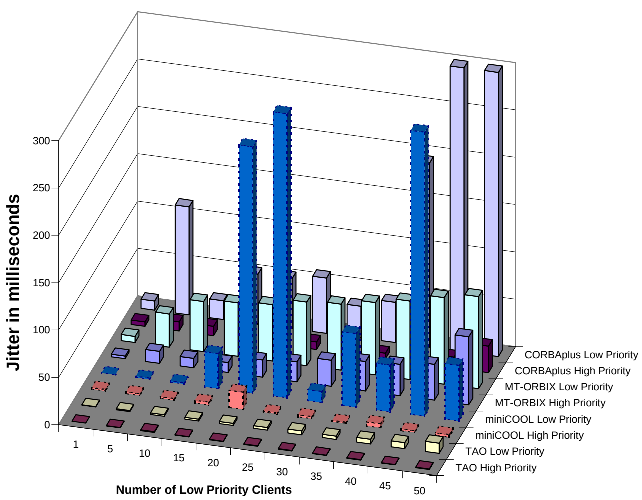
- One high-priority client
- *1..n* low-priority clients
- Server factory implements *thread-per-priority*
  - *Highest* real-time priority for high-priority client
  - *Lowest* real-time priority for low-priority clients

ORB Latency Results over ATM



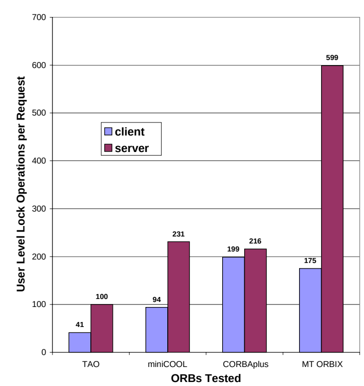
- **Synopsis of results**
  - COOL's latency is lower for small # of clients
  - TAO's latency is lowest for large # of clients
  - TAO avoids priority inversion
    - *i.e.*, high priority client always has lowest latency

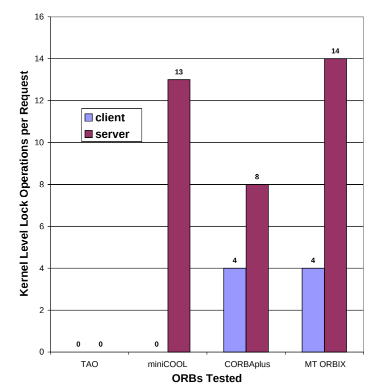
ORB Jitter Results over ATM



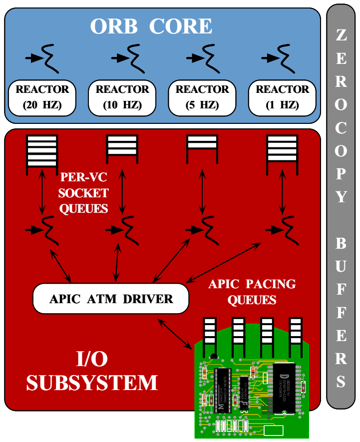
- **Definition**
  - Variance from average latency
- **Synopsis of results**
  - TAO's jitter is lowest and most consistent
  - MT-Orbix's jitter is highest and more variable

User-level and Kernel-level Locking Overhead





Integrating TAO with a Real-time ATM I/O Subsystem



- **Key Features**
  - Vertical integration of QoS through ORB, OS, and ATM network
  - Real-time I/O enhancements to Solaris kernel
  - Provides rate-based QoS end-to-end
  - Leverages APIC features for cell pacing and zero-copy buffering

Concluding Remarks

- Developers of distributed applications confront recurring challenges that are largely application-independent
  - *e.g.*, service initialization and distribution, error handling, flow control, event demultiplexing, concurrency control, persistence, fault tolerance
- Successful developers resolve these challenges by applying appropriate *design patterns* to create communication *frameworks* and *components*
- CORBA ORBs are an effective way to achieve reuse of distributed software components
- The next-generation of ORBs will provide much better support for real-time QoS over ATM