

High-performance Distributed Object Computing with Real-time CORBA

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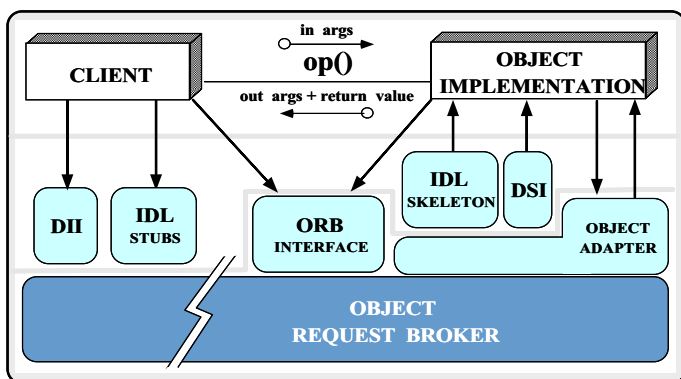
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Motivation

- Typical state of affairs today is the “Distribution Crisis”
 - Computers and networks get faster and cheaper
 - Communication software gets slower, buggier, more expensive
- *Accidental complexity* is one source of problems, e.g.,
 - Incompatible software infrastructures
 - Continuous rediscovery and reinvention of core concepts and components
- *Inherent complexity* is another source of problems
 - e.g., latency, partial failures, partitioning, causal ordering, etc.

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Candidate Solution: CORBA

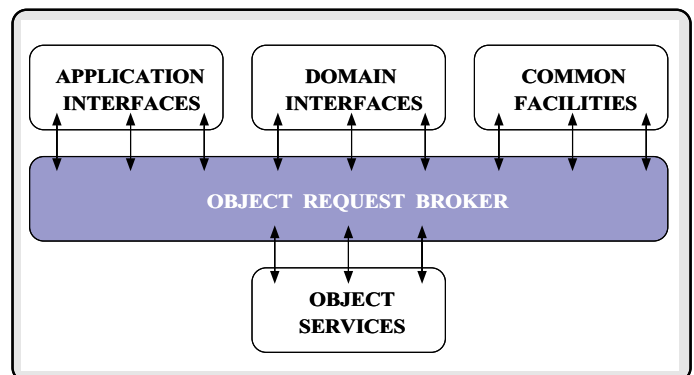


Goals

1. Simplify development of distributed applications
2. Provide flexible foundation for higher-level services

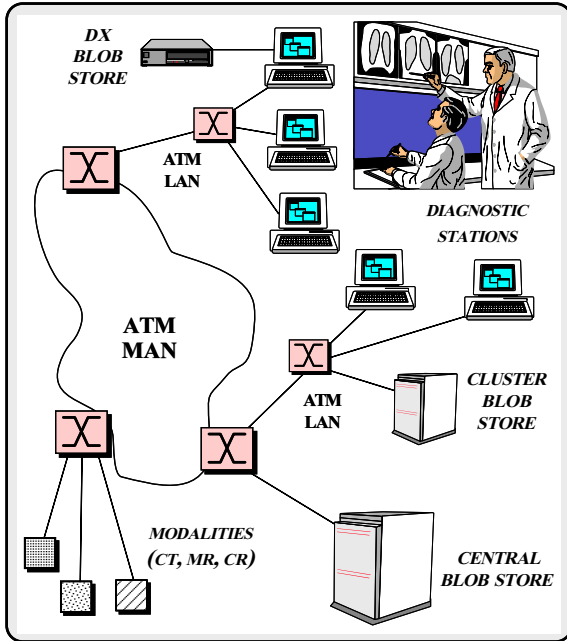
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OMA Reference Model Interface Categories



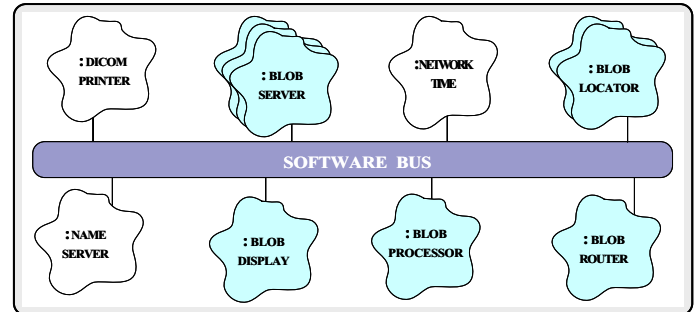
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Example 1: Distributed Medical Imaging



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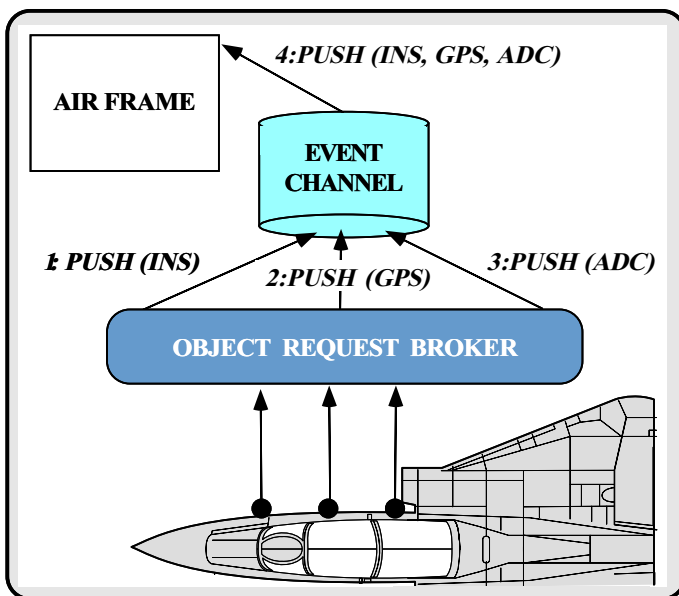
Distributed Objects in Medical Imaging



- "Blob" == Binary Large Object

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Example 2: Real-time Avionics



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Observations

- CORBA is well-suited for certain *communication requirements* and certain *network environments*
 - e.g., request/response or oneway messaging over low-speed Ethernet or Token Ring
- However, current CORBA implementations exhibit high overhead for other types of *requirements* and *environments*
 - e.g., bandwidth-intensive and delay-sensitive applications over high-speed networks
- Performance limitations will ultimately impede adoption of CORBA

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Key Research Questions

- “Can CORBA be used for performance-sensitive applications on high-speed networks?”
 - Goal is to determine this empirically
- “What are the strategic optimizations for Gigabit CORBA” ?
 - Goal is to maintain strict CORBA compliance
- “What changes are required to provide Real-time CORBA?”
 - Goal is to provide end-to-end QoS guarantees

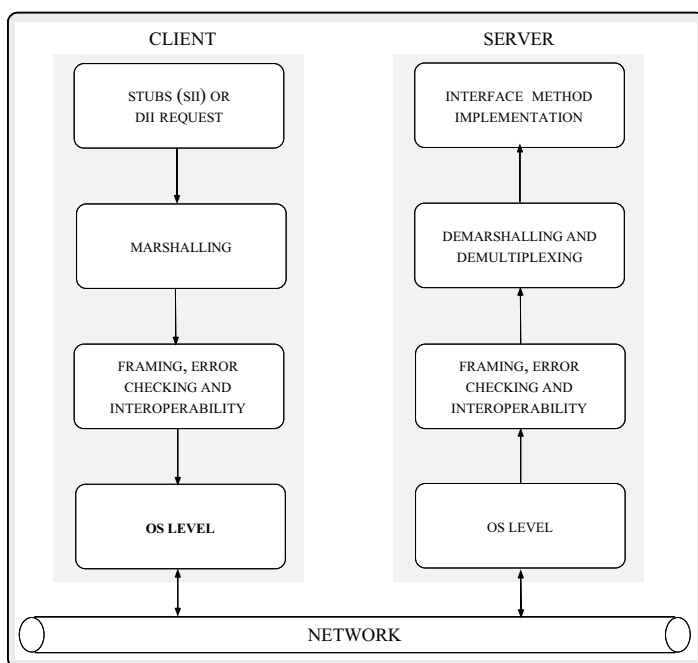
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Pinpointing CORBA Overhead

- *Presentation layer overhead*
 - e.g., typed and untyped data
- *Data manipulation and data copying overhead*
 - e.g., message management
- *Demultiplexing and operation dispatching overhead*
 - e.g., layered and de-layered demultiplexing
- *OS/network/protocol integration*
 - e.g., ATM/host adapters, resource reservation and scheduling

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General Path of CORBA Requests



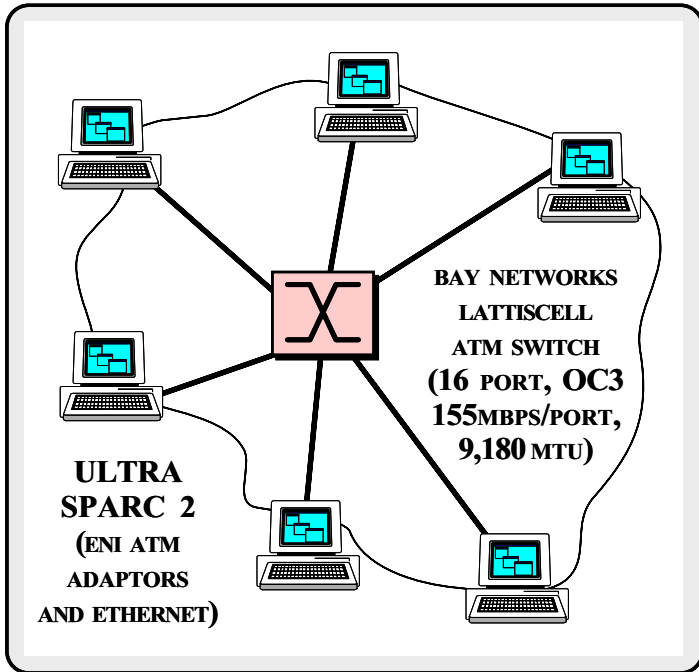
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Experimental Setup

- Enhanced version of TTCP
 - TTCP measures end-to-end data/request transfer
 - Enhanced version compares C, ACE C++ wrappers, Orbix 2.0.1 and VisiBroker 2.0, and Blob Streaming
- Parameters varied
 - 100 Mbytes of typed data
 - Types included scalars, floats, structs, and sequences
 - Sender buffer sizes ranged from 1K to 128K
 - Socket queues were 8k (default) and 64k (maximum)
 - Network was 155 Mbps ATM and “loopback”

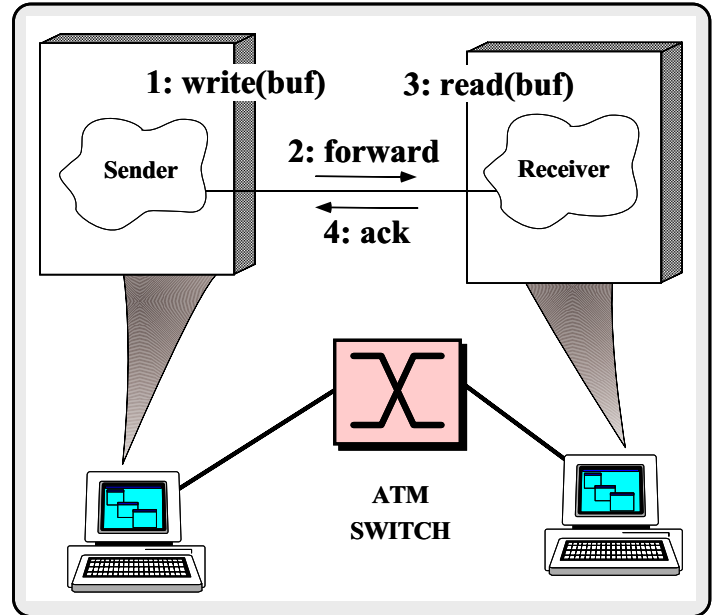
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Network/Host Environment



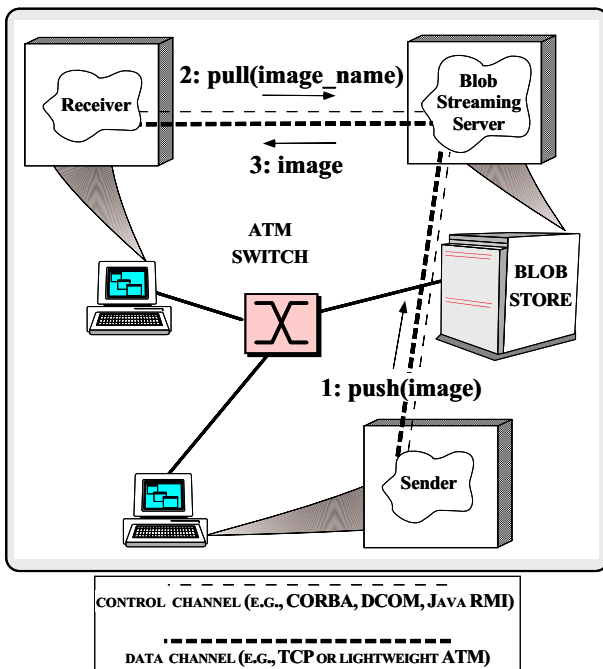
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TTCP Configuration for C and ACE C++ Wrappers



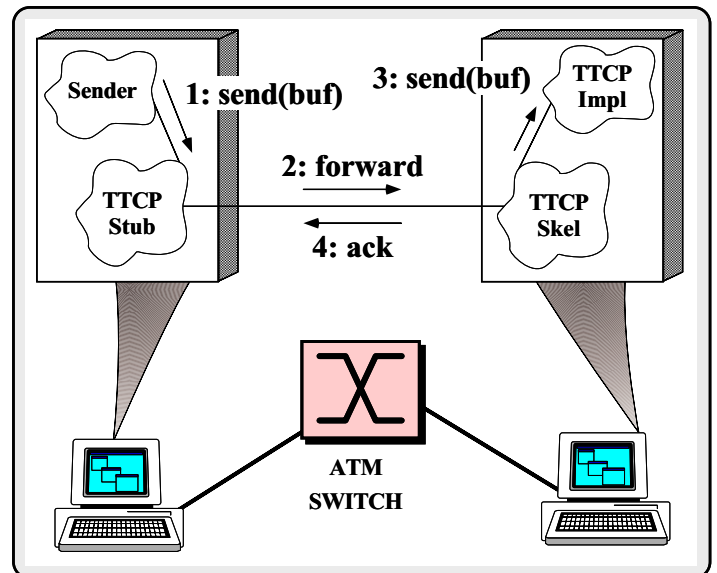
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Blob Streaming System Architecture



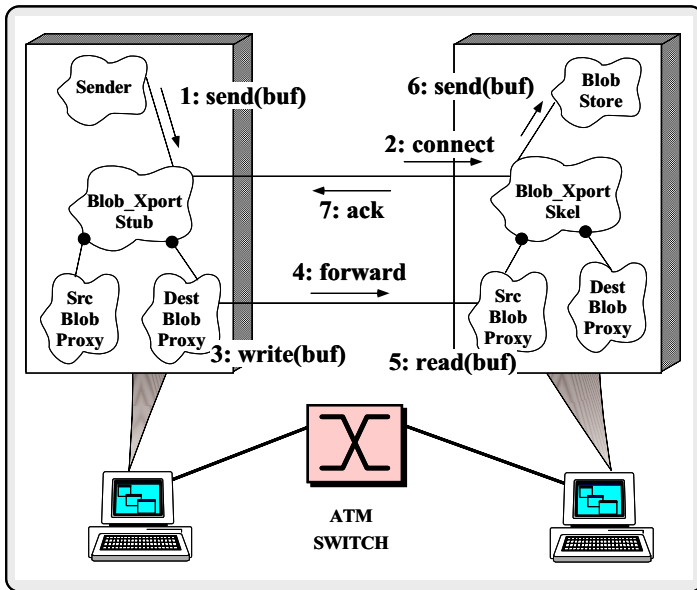
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TTCP Configuration for CORBA Implementation



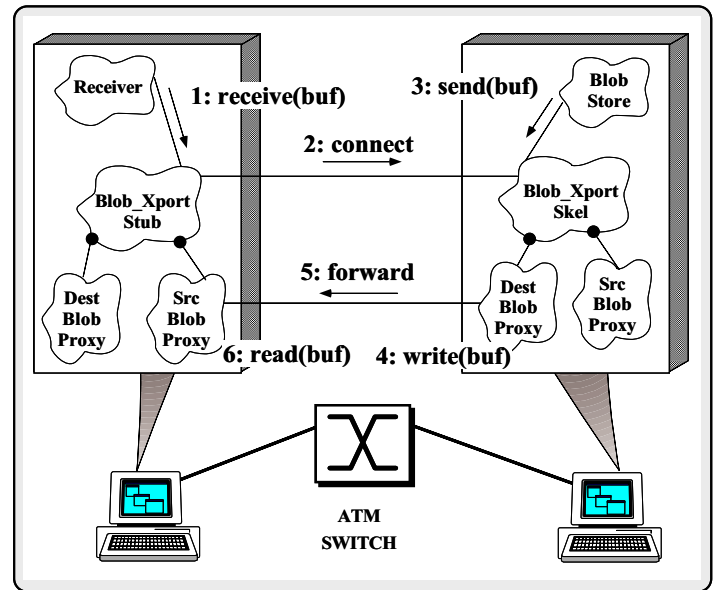
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TTCP Configuration for Blob Streaming (Push Model)



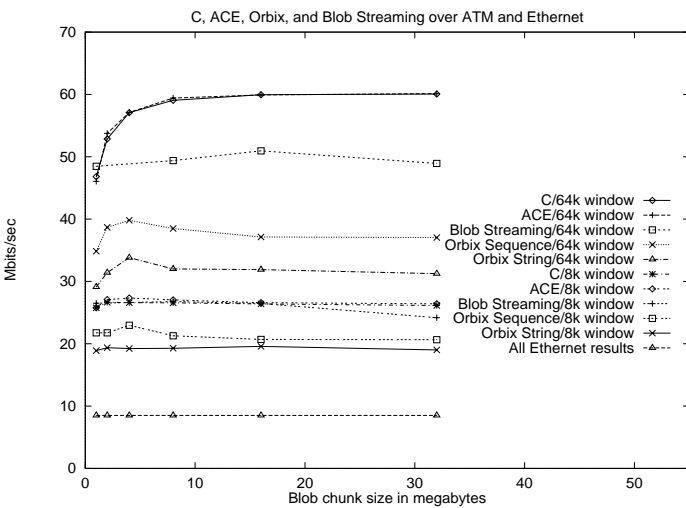
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TTCP Configuration for Blob Streaming (Pull Model)



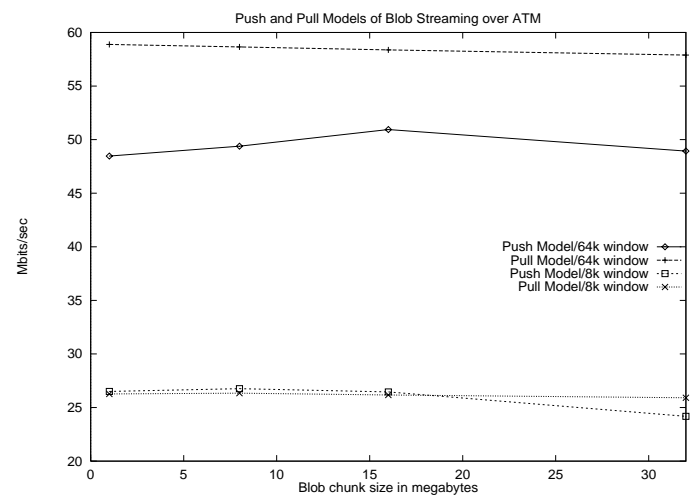
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Push Model Performance over ATM and Ethernet



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Pull Model Performance over ATM



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High-Cost Functions

- C and ACE C++ Tests

– Transferring 100 Mbytes with 1 Mbyte buffers

| Test | %Time | #Calls | Name |
|----------------------------|-------|--------|-------|
| C sockets (sender) | 93.9 | 112 | write |
| C sockets (receiver) | 3.6 | 110 | read |
| C sockets (sender) | 93.2 | 13,085 | read |
| C sockets (receiver) | 4.5 | 102 | write |
| ACE C++ wrapper (sender) | 94.4 | 112 | write |
| ACE C++ wrapper (receiver) | 3.2 | 110 | read |
| ACE C++ wrapper (sender) | 93.9 | 12,984 | read |
| ACE C++ wrapper (receiver) | 5.6 | 102 | write |

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High-Cost Functions (cont'd)

- Orbix String and Sequence

| Test | %Time | #Calls | Name |
|---------------------------|-------|--------|--------|
| Orbix Sequence (sender) | 53.5 | 127 | write |
| Orbix Sequence (sender) | 35.1 | 223 | read |
| Orbix Sequence (sender) | 7.3 | 1,108 | memcpy |
| Orbix Sequence (receiver) | 84.6 | 12,846 | read |
| Orbix Sequence (receiver) | 12.4 | 1,064 | memcpy |
| Orbix Sequence (receiver) | 3.2 | 101 | write |
| Orbix String (sender) | 45.0 | 127 | write |
| Orbix String (sender) | 35.1 | 223 | read |
| Orbix String (sender) | 10.8 | 1,315 | strlen |
| Orbix String (sender) | 6.0 | 1,108 | memcpy |
| Orbix String (receiver) | 70.7 | 12,443 | read |
| Orbix String (receiver) | 16.1 | 2,142 | strlen |
| Orbix String (receiver) | 10.0 | 1,064 | memcpy |
| Orbix String (receiver) | 3.0 | 101 | write |

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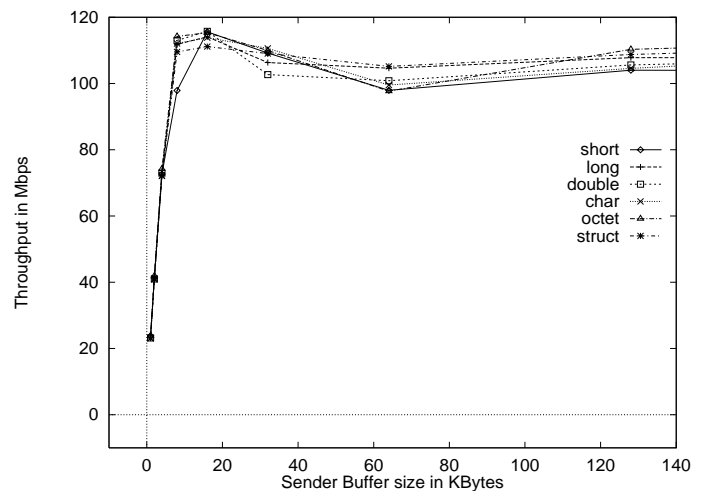
High-Cost Functions (cont'd)

- Blob Streaming

| Test | %Time | #Calls | Name |
|--------------------------|-------|--------|--------|
| BlobStreaming (sender) | 48.8 | 327 | write |
| BlobStreaming (sender) | 44.8 | 232 | read |
| BlobStreaming (sender) | 1.3 | 2,055 | memcpy |
| BlobStreaming (receiver) | 77.2 | 12,546 | read |
| BlobStreaming (receiver) | 16.4 | 12,734 | memcpy |
| BlobStreaming (receiver) | 1.4 | 102 | write |

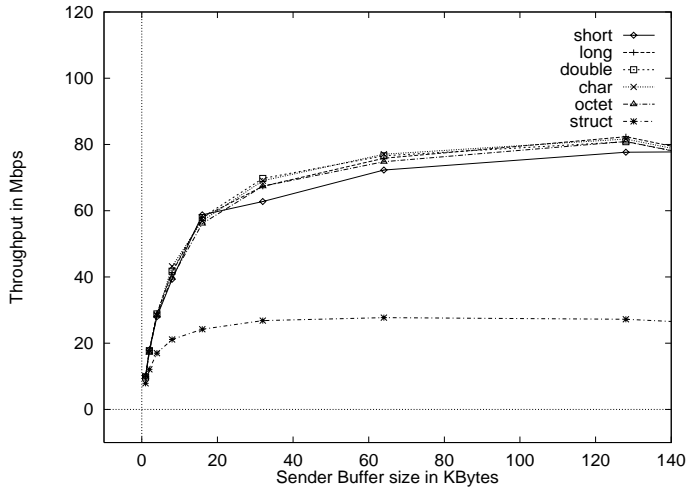
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C/C++ Remote Data Transfer Results

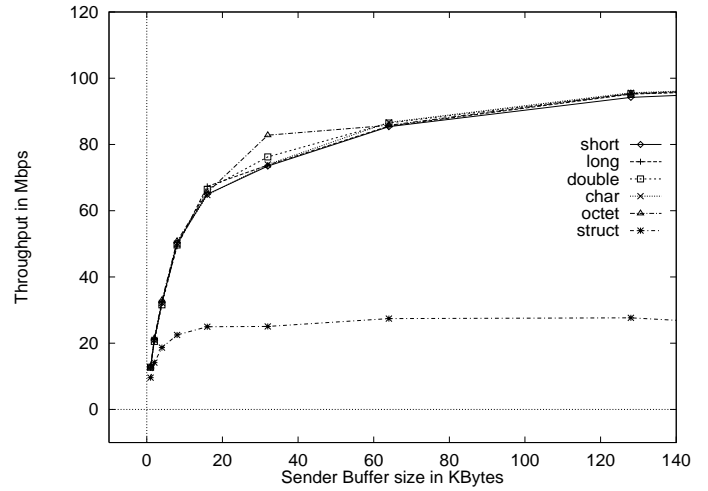


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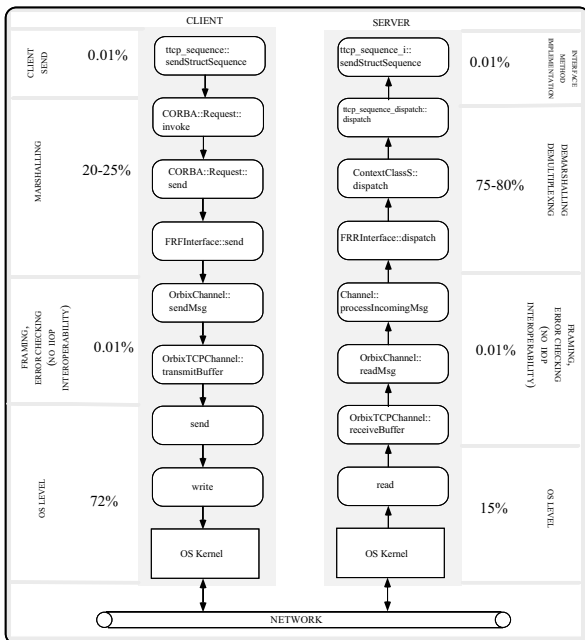
Orbix Remote Data Transfer Results



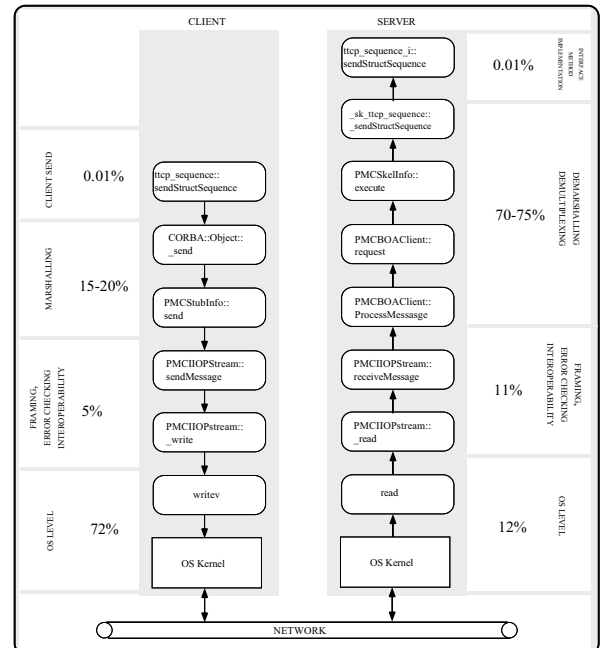
VisiBroker Remote Data Transfer Results



Analysis of Orbix Overhead



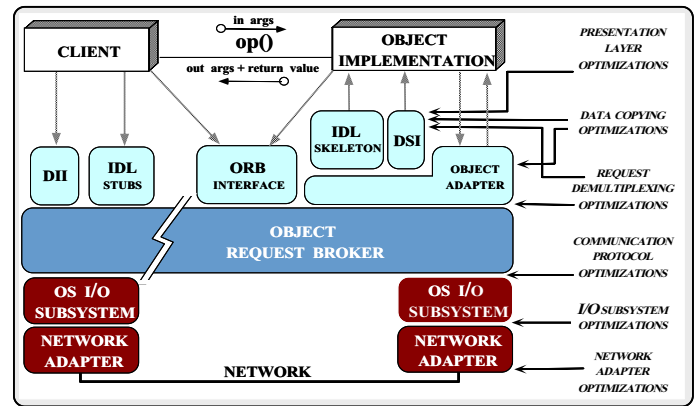
Analysis of VisiBroker Overhead



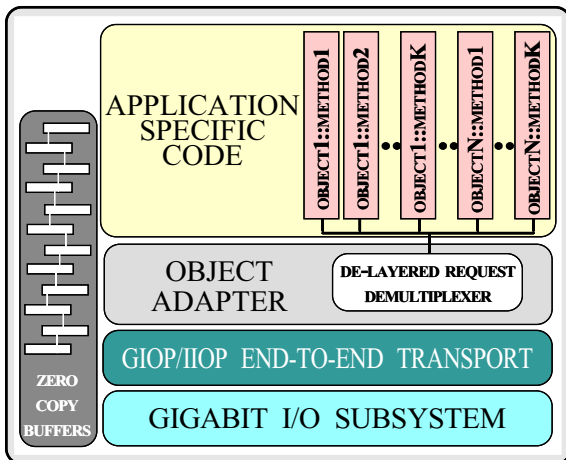
Summary of Throughput Results

- For bytestreams
 - VisiBroker performed > 80% cf C/C++ versions
 - Orbix performed 70% cf C/C++ versions
- For scalars and floats
 - Remote: 75–80% cf C/C++ versions
 - Loopback: Orbix performed 65–68% cf C/C++ versions, VisiBroker achieved similar throughput for large sender buffer sizes
- For structures
 - Remote: 31% cf C/C++ versions
 - Loopback: 16% cf C/C++ versions

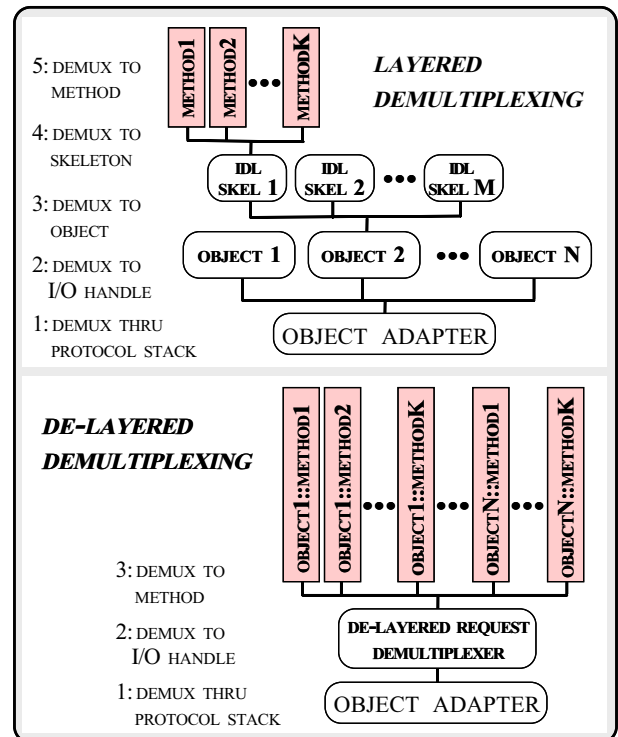
Gigabit CORBA Optimizations



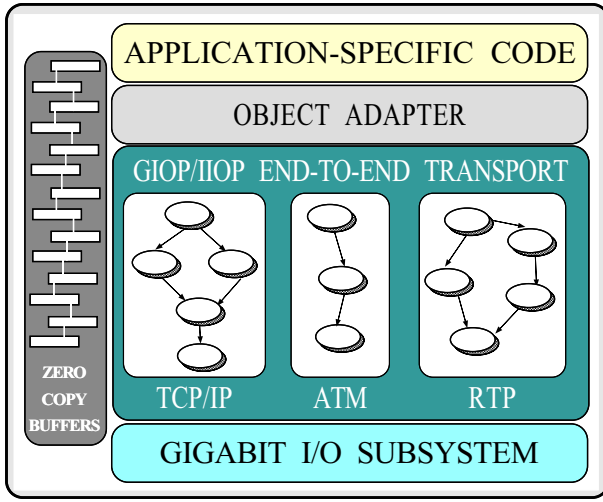
Real-time CORBA



Demultiplexing Optimizations

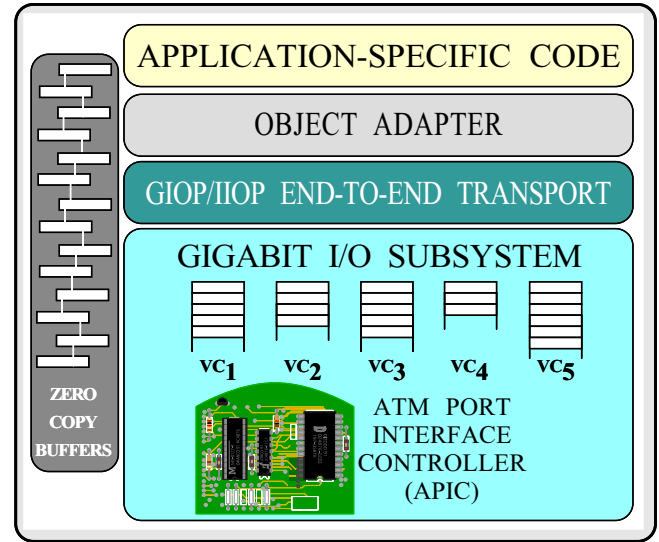


Multi-Protocol Support



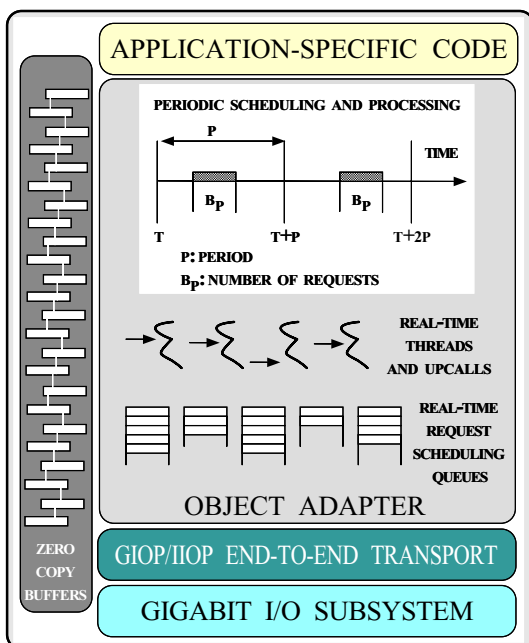
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I/O Subsystem Optimizations



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Real-time Scheduling Optimizations



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Concluding Remarks

- CORBA is a promising architecture for distributed computing
- Conventional CORBA implementations are not tuned for high-performance or real-time systems
 - Note, low-speed networks often hide performance overhead
- Ultimately, an integrated approach is the best solution
- Optimizations must be applied at multiple layers
 - e.g., network/OS/protocol/ORB

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