Reliable UDP (RDP)
Transport for CORBA

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Agenda

- **Background** – AEGIS Combat System
- **Distribute communication requirements and issues**
- **Overview of Reliable UDP Communication**
- **Reliable UDP transport for CORBA implementation challenges**
- **Performance results**
- **Conclusion**
Aegis Combat System
“The shield of the fleet…”

- A Highly Integrated Total Ship Combat System - A “System of Systems”

- Aegis Weapon System (AWS) primary mission is the Anti-Air Warfare (AAW) capability of the Combat System
  - Detection, control and engagement for air targets
  - Very large and complex
  - Real-Time intensive with very demanding loop closure and control system response time requirements

- Long-Standing Development/Production Program
  - CG-47 Ticonderoga Class Cruisers deployed
  - DDG-51 Arleigh Burke Class Destroyers ongoing
  - Evolving requirements drive continual improvements via Baseline upgrade program
Aegis Processing Roadmap

- Military Processors and Interconnects
- Integrated COTS Processing Infrastructure
- Commercial Co-Processing
- Fully Distributed (Open Architecture)
Requirements

- **Short latency and high probability of delivery for a relatively small number of time-critical messages in the system**

- **Low CPU utilization everywhere to preserve resources needed for tactical processing**

- **High throughput in a few high-volume pathways**

- **Commercially supported products**
Issues

- **Commercial CORBA software out of the box is not suitable for all real-time systems**

- **Standard CORBA uses IIOP (mapping of GIOP over TCP/IP)**

- **TCP/IP obstructs real-time predictability**
  - Retries and delays in acknowledgments
  - Connection loss detection

![Graph showing TCP send with 1 byte response latency for Remote, 100,000 iterations with LynxOS 3.1.0 and Fast Ethernet.]
Solution and Advantages

- **Implement a Reliable UDP/IP (RDP) transport as an alternative to TCP/IP for an ORB**

- **Control maximum latencies with configurable timeouts and retries**

- **Replace of existing capabilities with commercial products**

- **Retain the standards-based application interfaces of CORBA while adapting alternative transports for different environments**
Reliable UDP Communication

- Reliable/Unreliable Unicast and Multicast APIs
  - Configurable timeouts and number of retries
  - Flow control and buffer sizing
  - Optional outgoing message queue

- Unidirectional messaging over a named logical channel that connects two or more endpoints

- Fault tolerant Directory Services provides registration services and endpoint updates

- Low overhead above standard UDP/IP
Reliable UDP (RDP) Transport for CORBA

- **OMG is progressing towards the adoption of a standard for a extensible transport framework**

- **Currently vendors are providing transport frameworks**
  - *Used ORBexpress RT 2.3.2 from Objective Interface Systems (OIS) on LynxOS 3.1.0*

- **Implementation**
  - *Developed concrete C++ classes that were derived from abstract classes provided by the OIS transport replacement framework*
  - *Integrated Reliable UDP into these classes*
  - *Registered the classes with the ORB*
RDP Implementation Challenges

- Establishing a mapping of GIOP to the new transport
  - Required working around violations of the GIOP assumptions (i.e. transport is connection-oriented, reliable, and byte stream oriented)

- Defining addressing information
  - Two strings used for construction of channel names
  - “server_name” is the channel name used for establishing connections
  - “client_name” is a superset of the two channel names used for communicating requests and responses

- Identifying Protocol Properties that are used to control configurable aspects of the transport
  - Acknowledgement timeout, retries, buffer sizes, flow control, thread priorities, keep alive, interface name specification
RDP Implementation Challenges

- **Adding Connection Semantics**
  - **Connection**
    - Defined as two unidirectional channels
    - Used for reading and writing requests and responses
  - **Listen for Connection Requests**
    - Active object permanently opens the receiving side of “server_name” channel and waits for requests
    - Initiates a new connection for each received request
  - **Establish Client Connection**
    - Open sending side of “server_name” channel
    - Create a connection with sending and receiving channel names
    - Sends connection request with unique channel names
    - Closes “server_name” channel, allowing other clients access
RDP Implementation Challenges

- **Reading and Writing**
  - Minimize size dependent overhead
  - Controlling for message size constraints

- **Failure and recovery semantics**
  - Determine if connection has failed or has been closed
  - Control of Reliable UDP reconfiguration processing

- **Memory Management**
  - Avoid memory leaks
Performance Results

- **Oneway Request Latency**
  - CORBA with RDP (sync_with_server)
  - Reliable UDP Send
  - UDP/IP Send with 1 byte response

- **Synchronous Request Response Latency**
  - CORBA with RDP
  - Reliable UDP Send with 1 byte response
  - CORBA with TCP
Oneway Request Latency

CORBA RDP ONEWAY Request Latency (sync_with_server): Remote, Octet Sequence
[LynxOS 3.0.1, Fast Ethernet, ORBexpress 2.3.2]

ORB with RDP overhead ranges from 36 .. 104 µsec for message sizes less than 8 Kb
Sync Request Response Latency

CORBA RDP Synchronous Request Response Latency: Remote, Octet Sequence
[LynxOS 3.0.1, Fast Ethernet, ORBexpress 2.3.2]

ORB with RDP overhead ranges from 120..239 µsec for message sizes less than 8Kb
CORBA TCP vs. CORBA RDP

CORBA TCP Synchronous Request Response Latency: Remote, Double Sequence
[LynxOS 3.1.0, Fast Ethernet]

CORBA RDP Synchronous Request Response Latency: Remote, Double Sequence
RDP QoS Ack Timeout 20ms, Retries 3
[LynxOS 3.1.0, Fast Ethernet]

CORBA TCP results show excessive maximum latencies greater than 1 second

CORBA RDP maximum latencies are controlled by timeout durations and retries
Conclusion

- It is feasible implement an alternative transport to TCP/IP for CORBA to support real-time distributed communications

- CORBA with RDP does not suffer from non-deterministic behavior and excessive maximum latencies as CORBA with TCP

- Important issues relevant to extensible transport frameworks
  - Easy to understand design
  - Zero copy required