Reliable Multicast in the STOW RTI Prototype

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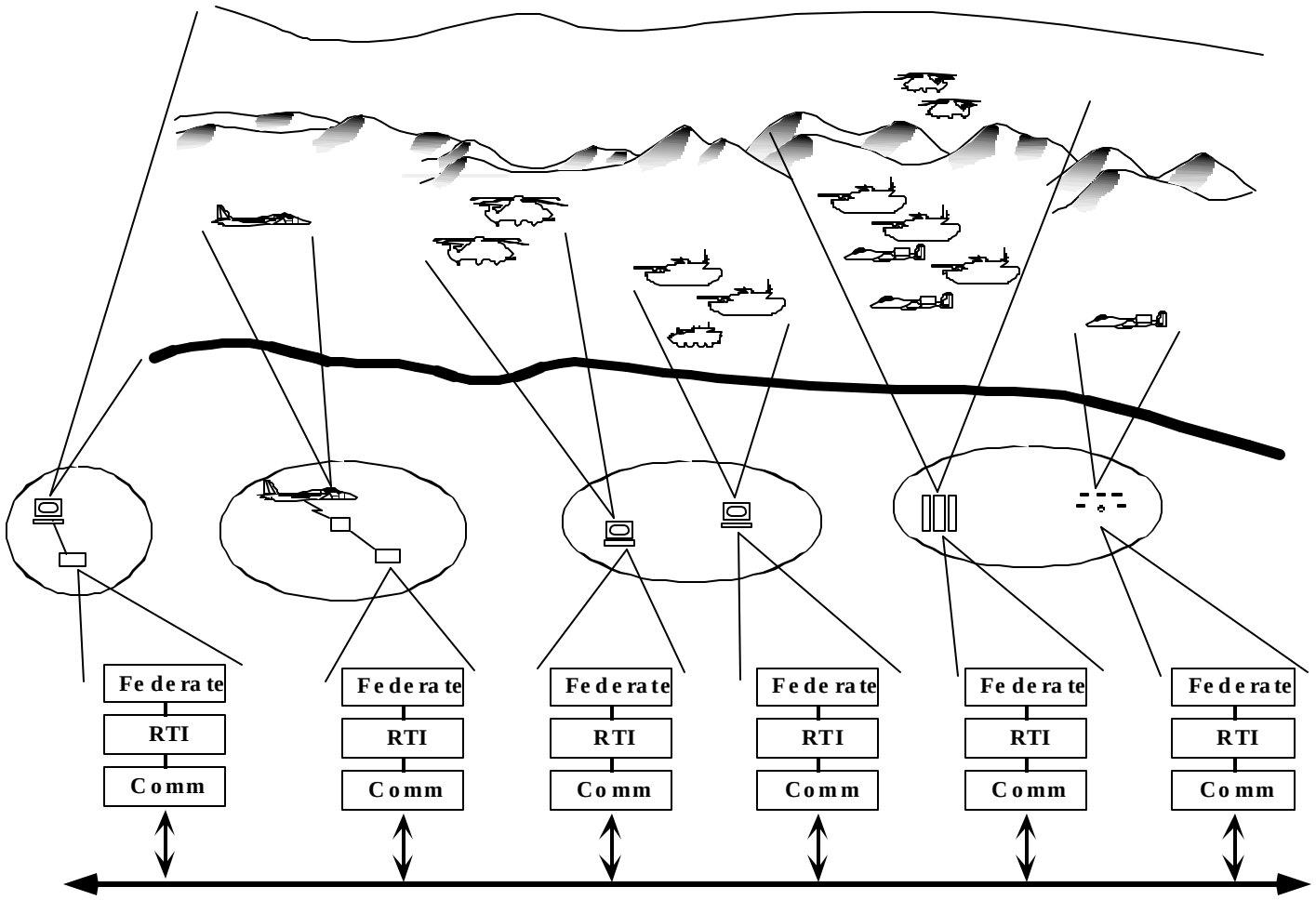
Outline

- **Introduction**
- **Message Transport Services**
- **Reliable Multicast**
- **Discovery Service**
- **Emulation of Reliable Multicast in RTI-s**
- **Performance Measurements**
- **Summary**

Federation using the HLA / RTI



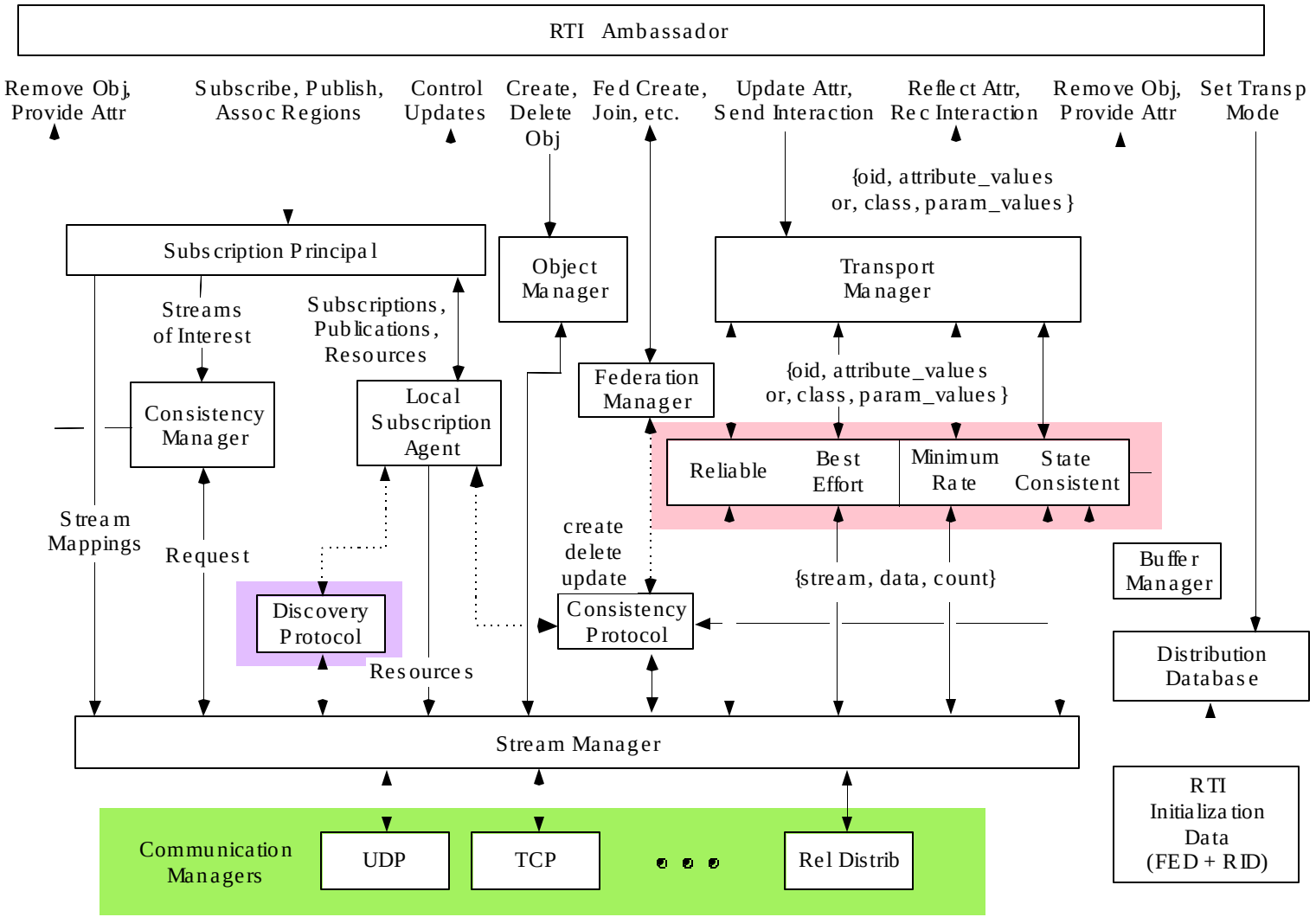
RTI-s Sponsors

- **Defense Modeling and Simulation Office (DMSO)**
  - **Part of larger DoD 1.0 RTI development effort**
  - **Initial implementation of Data Distribution Management Services**
  - **Support initial use of the HLA in a large scale, real-time system**
- **DARPA**
  - **Synthetic Theater of War (STOW) program**
    - » **STOW is an Advanced Concept Technology Demonstration (ACTD)**
    - » **Customer is Atlantic Command (ACOM)**
    - » **An HLA based simulation system**

RTI-s Development

- **STOW Requirements (RTI perspective)**
  - **~ 25 Federate classes on 350-450 host computers**
  - **10 – 20 sites (LANs connected via a WAN)**
  - **10,000 objects (scaleable to 100,000)**
- **MIT Lincoln Laboratory is developing the prototype RTI-s for use by STOW**
  - **Full RTI functionality except for Time and Ownership Management**
  - **Focus on real-time performance and very large exercise scalability**
    - » **Low latency, High throughput, Low bandwidth overhead**
  - **Early availability of RTI (15 Oct 96)**

RTI-s Block Diagram



Message Transport Services

- **Best Effort**
  - **Based on UDP Multicast**
    - » **Permits scaling to large exercises**
  - **No mechanism for reliability or message ordering**
- **Minimum Rate**
  - **Comparable to DIS Transport mechanism**
- **State Consistent**
  - **Ensures delivery of the *latest* attribute value**
  - **No guarantee of intermediate message delivery**
- **Reliable**
  - **Guaranteed delivery of messages**
  - **Messages delivered in order**

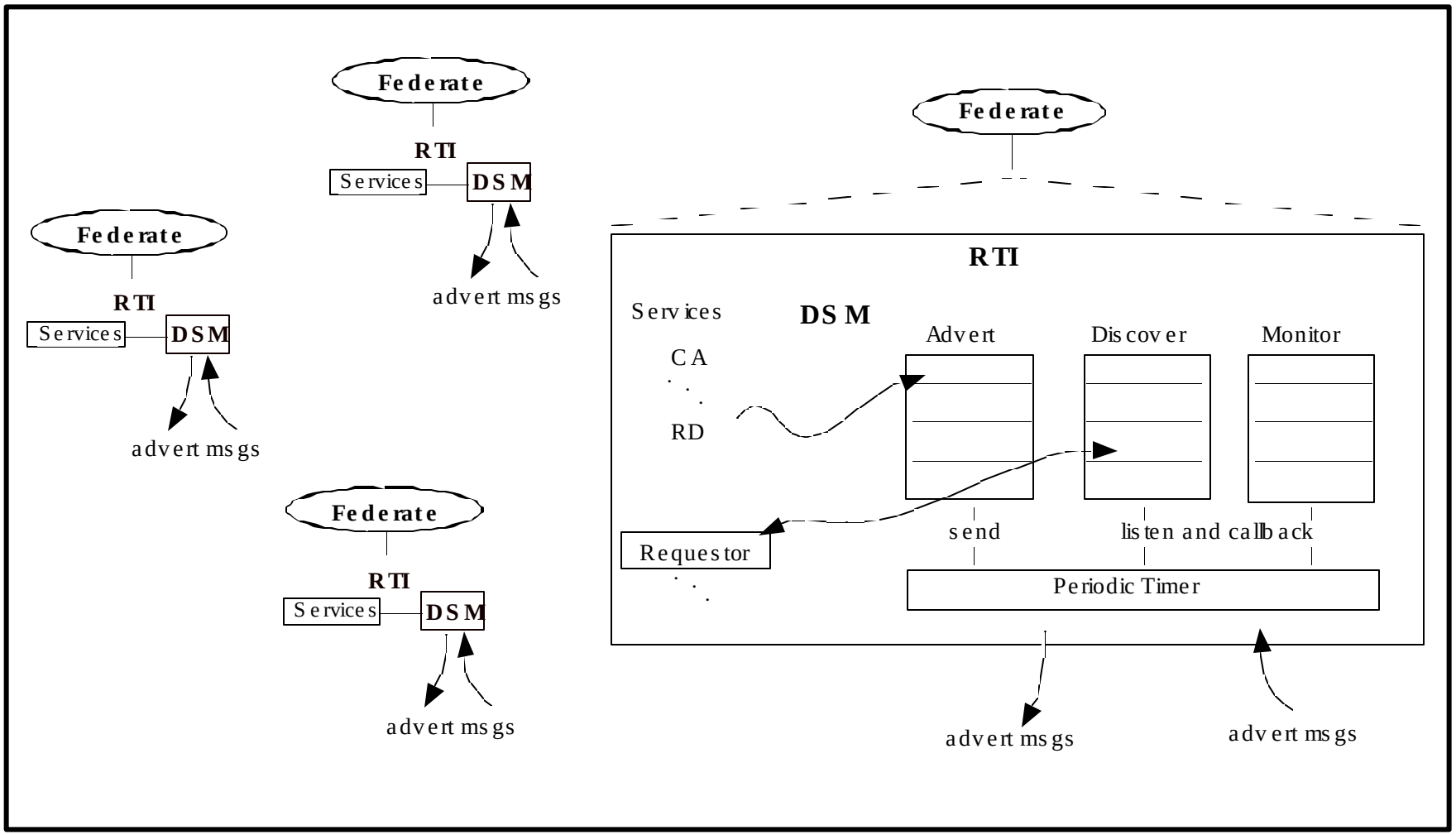
Reliable Multicast

- **Reliable Multicast Protocols**
  - **RAMP, RMP, SOM (MTP-2)**
  - **Based on UDP to support multicast**
  - **Some provide reliability based on NACKs**
  - **May be optimized for single sender (one-to-many)**
  - **Some are optimized for a fixed set of senders and receivers**
- **Emulation of Reliable Multicast in RTI-s**
  - **Dynamic message routing based on streams**
  - **Reliability provided by use of TCP protocol**
  - **Does not consume UDP multicast groups**
  - **Multicast emulated via use of hierarchical topology of Reliable Distributors (exploders)**

Discovery Services

- **General purpose mechanism to facilitate contact between distributed service providers and clients**
  - **Predates similar capability in CORBA**
  - **Supports multiple providers of same service type**
- **Provider advertises its service**
  - **Service type**
  - **Qualifier: discoverer can screen for desired value**
  - **Invariant data: constant provider info (eg. socket addr)**
  - **Variant data: time-varying provider status info**
- **Client discovers available providers**
  - **Only receives advertisements from appropriate providers**
  - **Initiates connection with provider based on information in advertisement (eg. Invariant data)**
- **Clients may monitor status of providers**
  - **Fault detection**
  - **Load balancing**

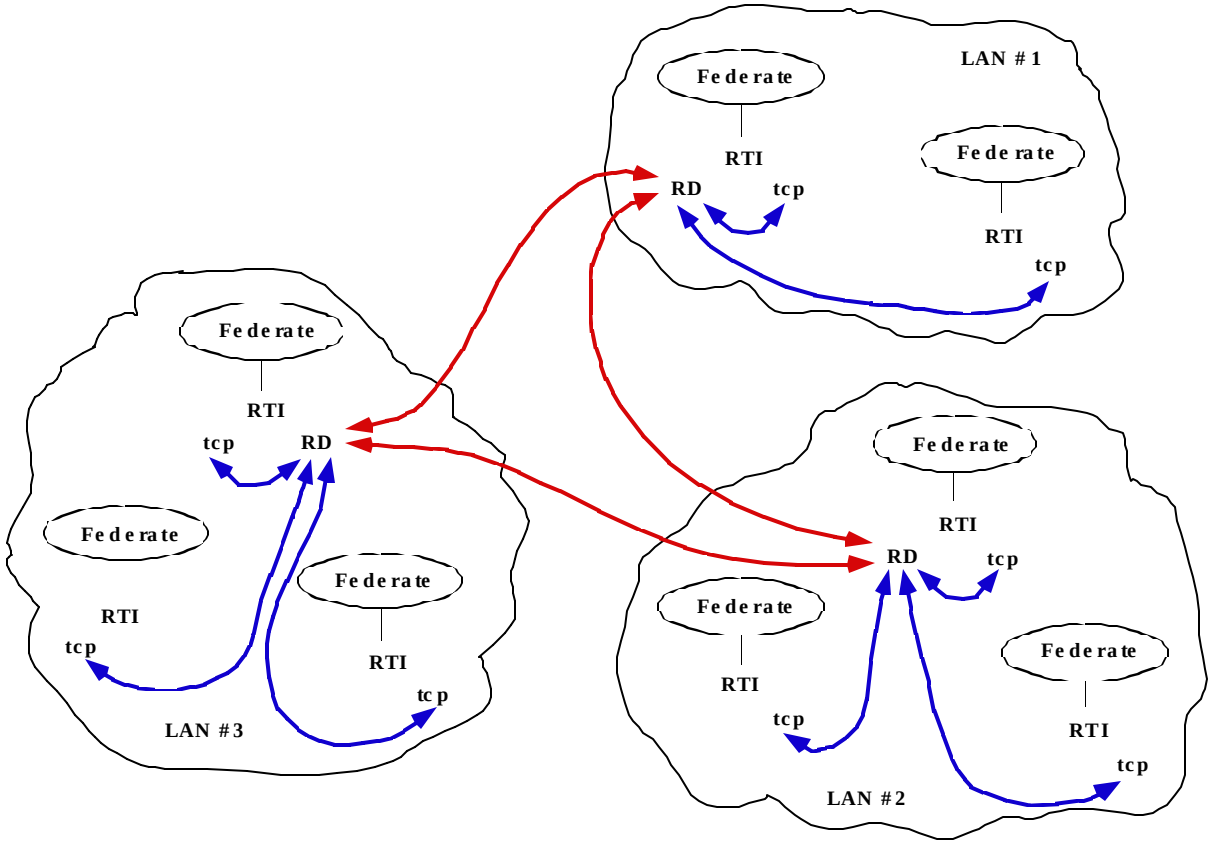
Discovery Service Manager (DSM)



Implementation of Reliable Multicast in RTI-s

- **Based on TCP point-to-point connections**
- **Reliable Distributor services a number of clients that wish to send and / or receive reliable message traffic**
- **Clients connect to appropriate Reliable Distributor using information provided by the Discovery Service**

Sample Network Topology for Reliable Servers / Clients



- **STOW is using fully connected mesh**
  - **Could configure Server connections as a-cyclic tree**

Features of RTI-s Reliable Multicast

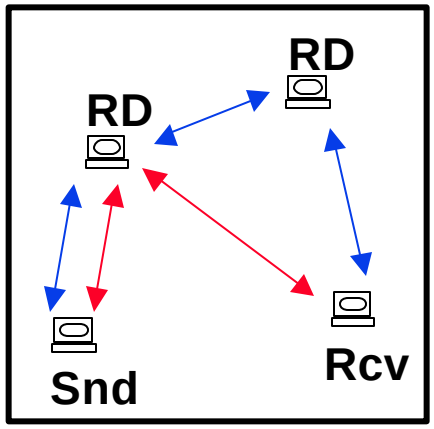
- **Robust**
  - **Outgoing message queue (accommodates bursty traffic)**
  - **Re-establishing connectivity (fault tolerance)**
- **Provides atomic message delivery within a stream based protocol (TCP)**
  - **Framing of received messages**
  - **Reassembly of fragmented messages**
  - **Fragmentation of large outgoing messages**
- **Configurable Server hierarchy**
  - **Auto-configuration for small Federation Execution, or in a small scale testing environment**
  - **Configurable server / client topology for larger Federations that span LANs and WANs**
  - **Stand-alone or integrated servers**

Performance Measurements

- **Latency**
  - **Limits the ultimate responsiveness of a system**
  - **Defined as elapsed time between invocation of the *updateAttributeValues* in one Federate, and the corresponding invocation of the *reflectAttributeValues* method in the second Federate**
- **Throughput**
  - **Defined as the number of transactions per second that can be processed by a system on a sustained basis**

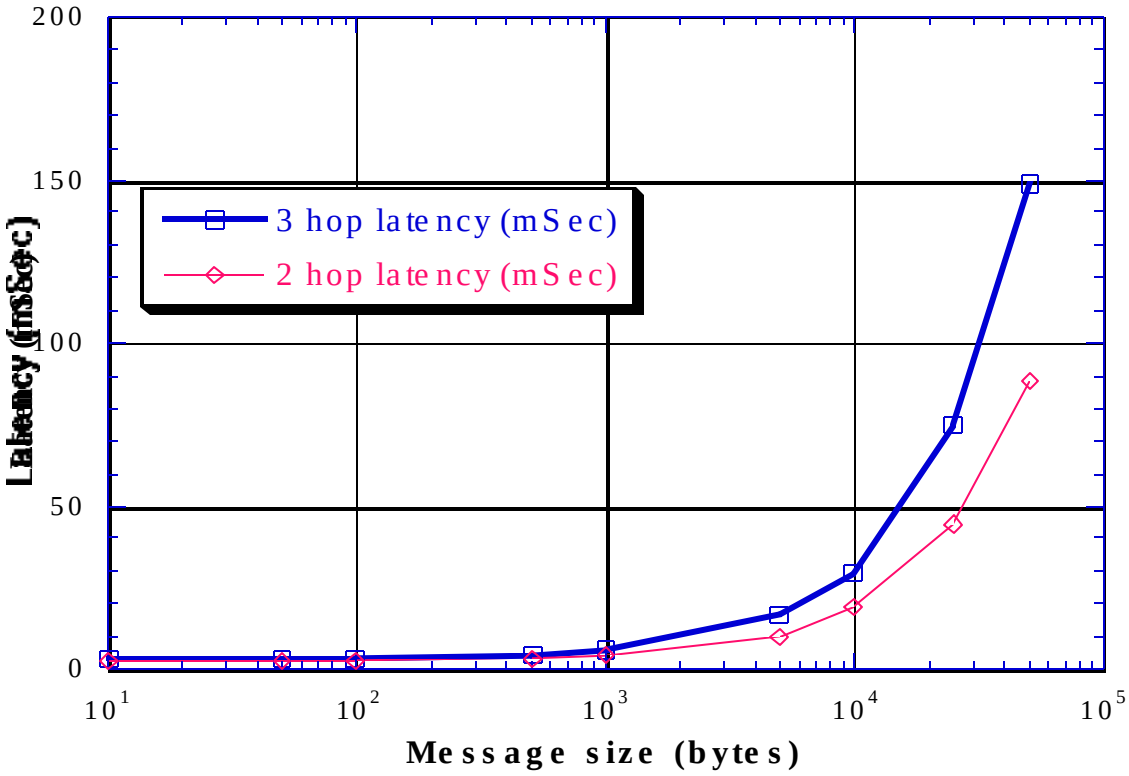
Latency Performance

Reliable Transport Service in RTI-s



3 Sun Ultra 1/140's and 1 SGI Onyx, using 10Mbps Ethernet

Time: Snd updates, Rcv reflects, Rcv updates, Snd reflects; divide result by 2

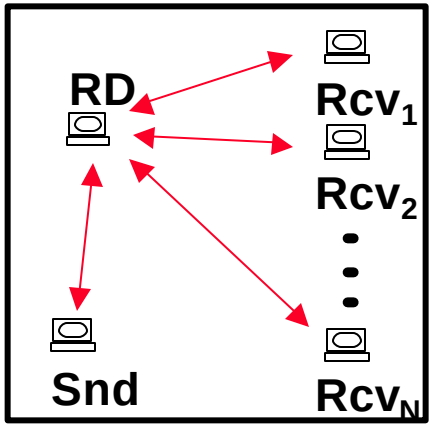


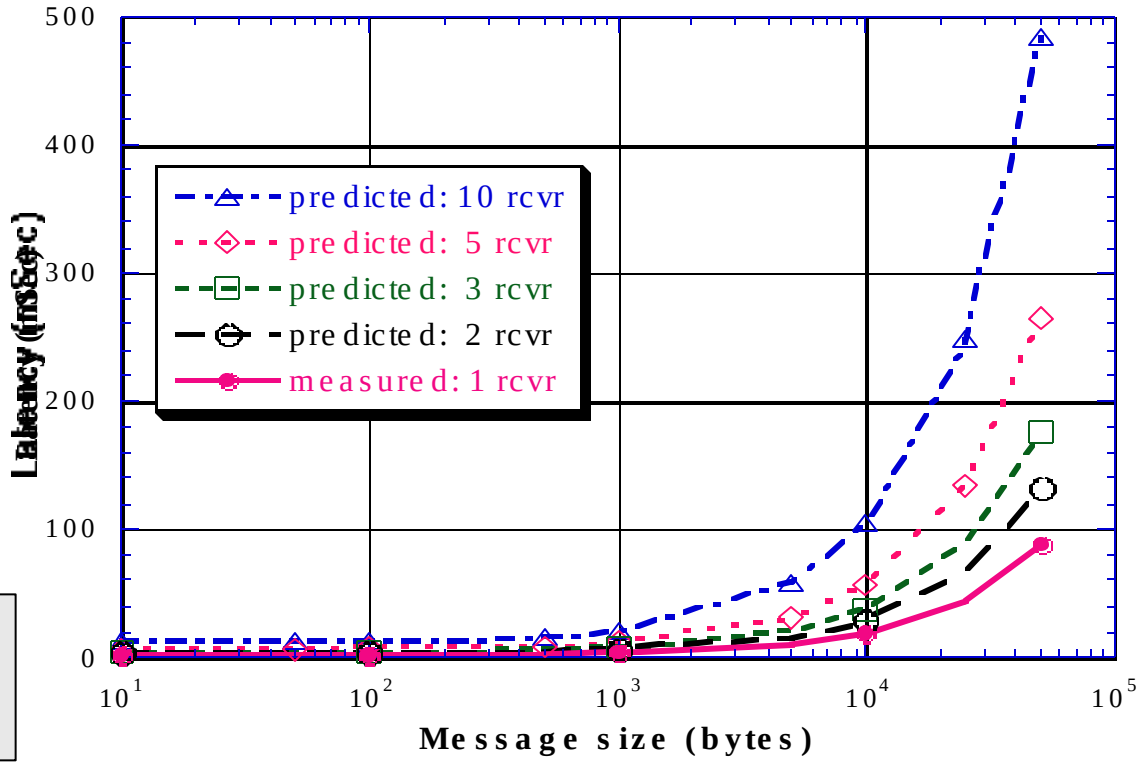
- **Dominated by Ethernet bit rate**

Latency Performance

with Receiver "Fan Out"

Reliable Transport Service in RTI-s



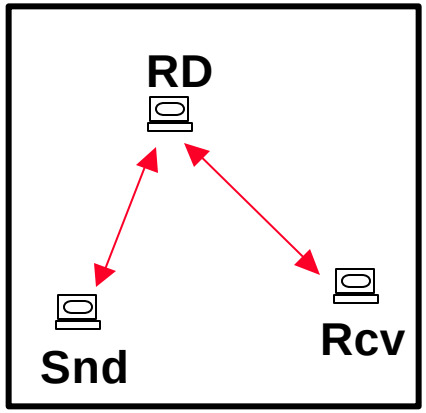


Predicted Latency for N th Receiver:

$L_{R_N} = L_{R_1} / 2 + (N * L_{R_1} / 2)$

Throughput Performance

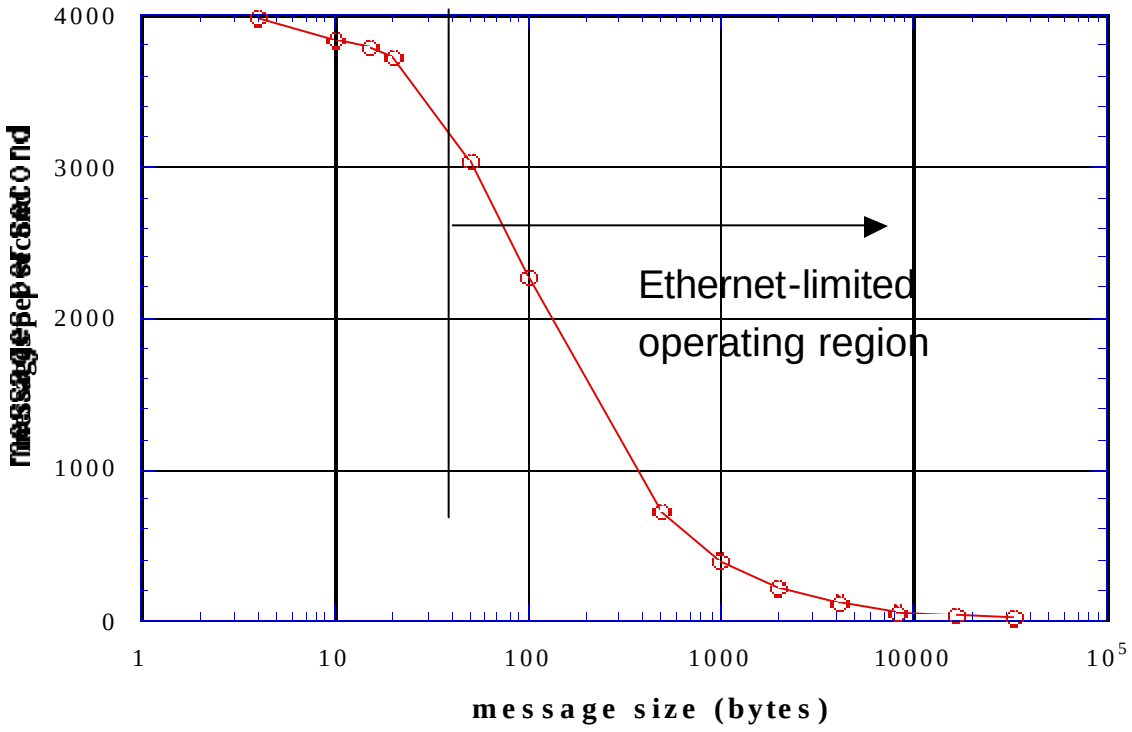
Reliable Transport Service in RTI-s



3 Sun Ultra 1/140's, using 10Mbps Ethernet

Snd updates, Rcv reflects

Rates are sustained, with no packet loss



Future Work

- **Continue evaluation of Reliable multicast performance in the context of STOW**
- **Deliver rti-s/C to STOW, 24 March 97**
- **Merge rti-s with RTI 1.0 to create RTI 1.1**
- **Re-visit evaluation of available reliable multicast protocols**

Summary

- **Reliable Message Transport Service in RTI-s emulates reliable multicast protocol**
  - **Based on TCP point-to-point connections**
  - **Reliable Distributors service clients and interconnect with other RDs**
  - **Provides adequate performance for STOW**
- **Discovery Service provides mechanism for Service providers to find each other, and for clients to find servers**
  - **Provides connection information**
  - **Allows monitoring of providers status**