Supporting Scalability and Adaptability via ADAptive Middleware And Network Transports (ADAMANT)

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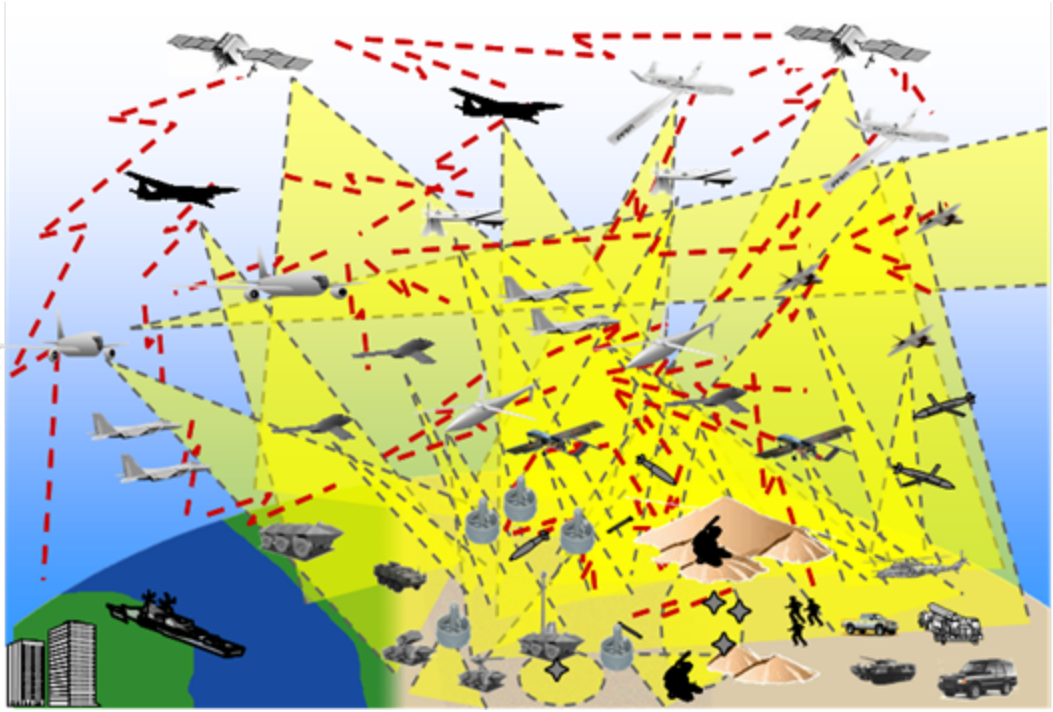
Focus: Time-Criticality, Quality of Service

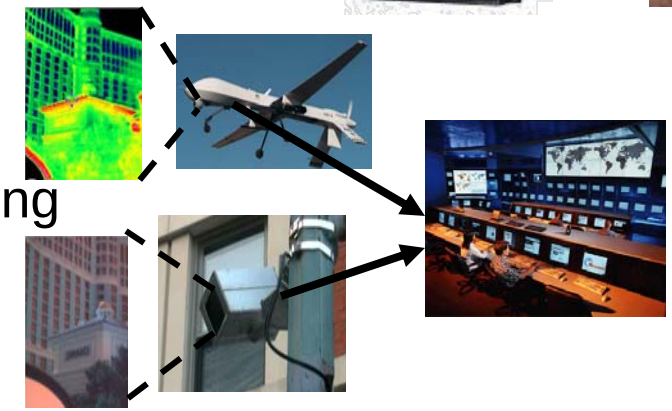
- **Motivation**
  - Existing SOA standards & technologies in use for large-scale data-centric platforms do not focus on timely response
  - Military & emergency systems very often need rapid response, scalability, bandwidth guarantees, fault-tolerance
  - … & need to function under stressful conditions, over connections with “uncivilized” properties, e.g., bursty loss, latency issues, route flaps



Focus: Data Conferencing Applications

- **Characteristics**
  - Multiple continuous data streams
  - Multiple senders/receivers
  - Stream coordination, synchronization

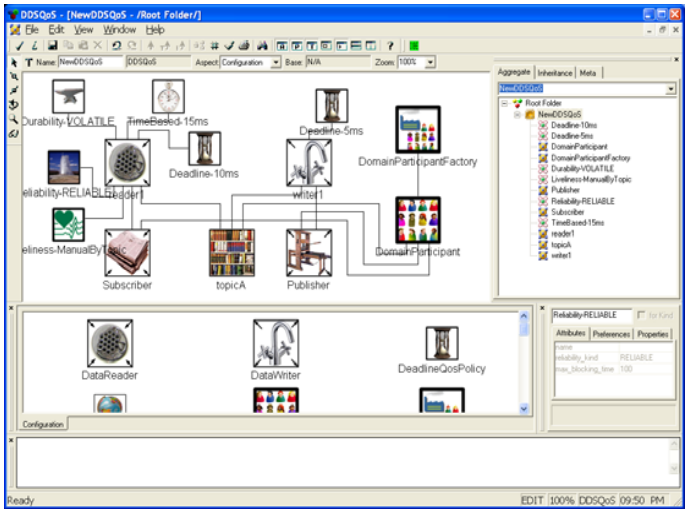
- **Examples**
  - Search and rescue, targeting
  - Stock update correlation
  - Medical telemetry (e.g., wireless ER)
  - Networked scientific application (e.g., weather monitoring)



Solution Approach: ADAptive Middleware And Network Transports (ADAMANT)

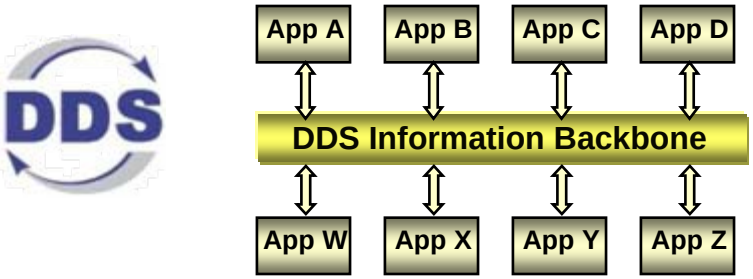
DDS QoS Modeling Language (DQML)

- Domain-specific modeling language
- Abstract away low-level tedious implementation details
- Manage QoS semantic compatibility
- Encapsulate higher-level QoS profiles for application types



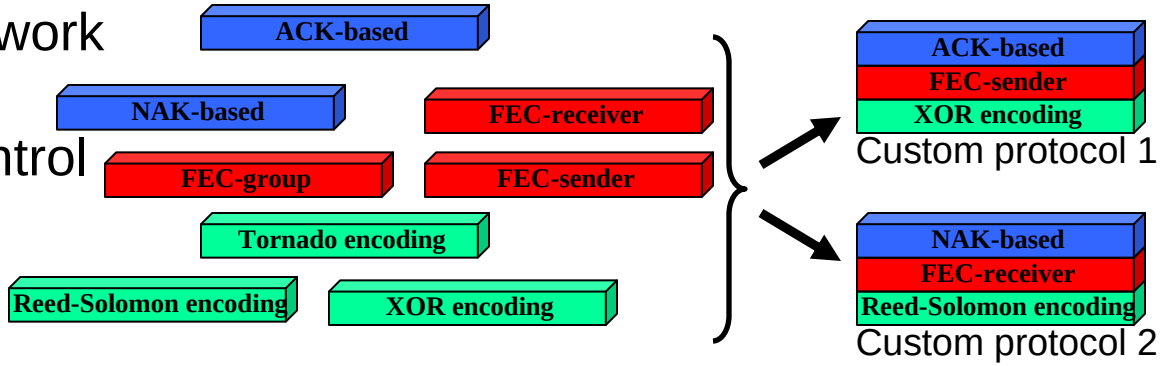
Data Distribution Service

- Robust standardized pub/sub API
- Fine-grained QoS policy control



Ricochet++

- Transport protocol framework
- Composable modules
- Fine-grained protocol control
- Autonomic adaptation



Developing Data Conferencing Taxonomies & Configuration Patterns

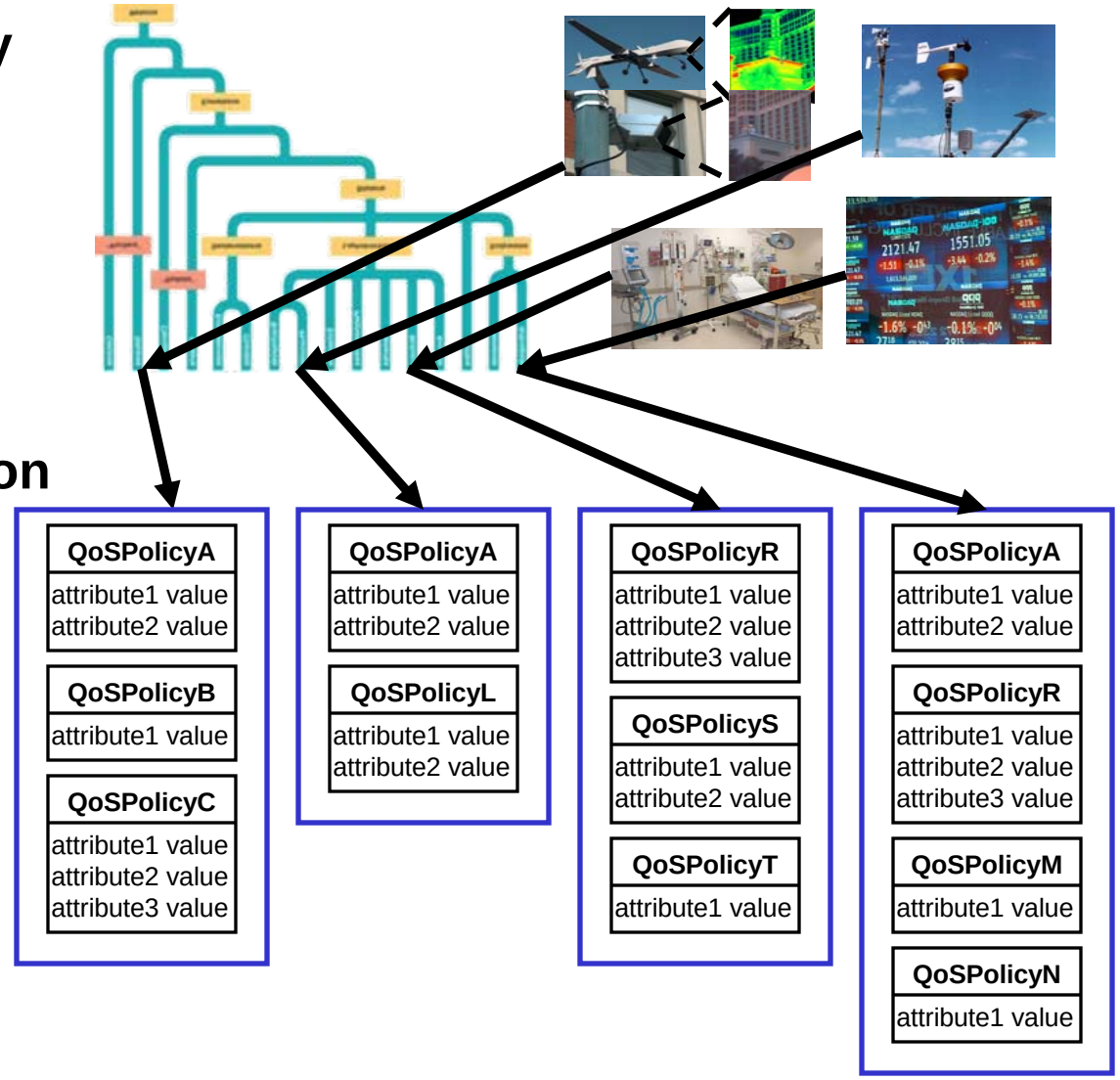
Data conferencing variability

- Reliability
- Deadlines
- Data type
- Amount of data
- Frequency of data updates

Develop taxonomies based on variability

DQML to leverage application taxonomies

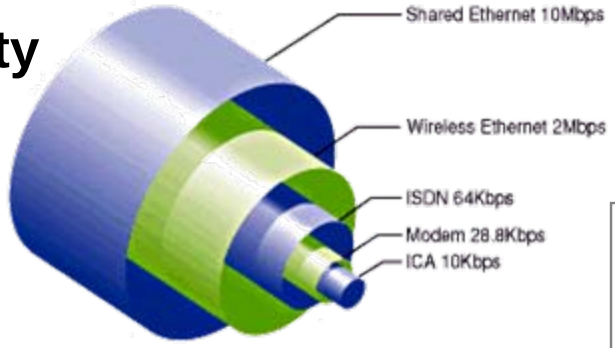
- Map to DDS QoS policies
- Use/Create DDS policy patterns

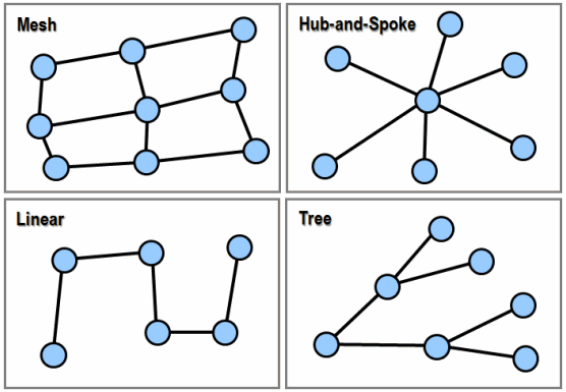


Maintaining Specified QoS via Ricochet++ Autonomic Adaptation

Environment Variability

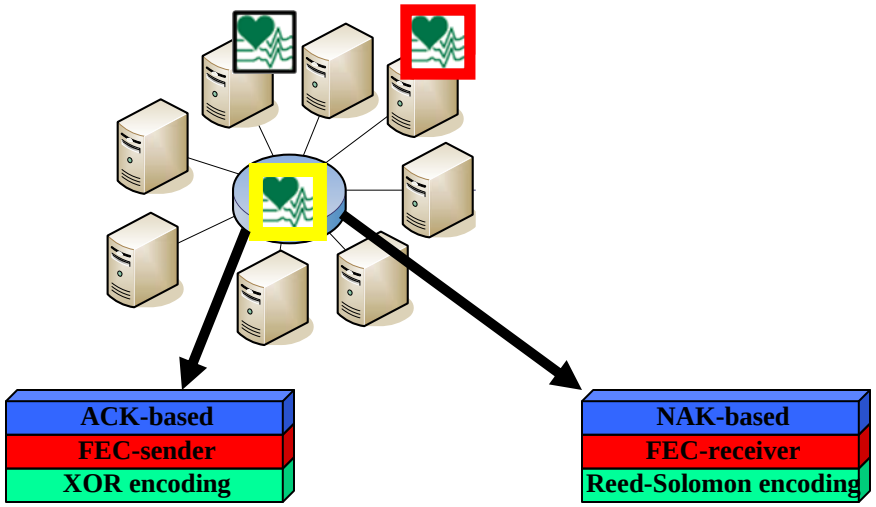
- Network bandwidth
- Latency
- Network congestion
- Network topology
- Route flaps





Ricochet++ for adaptation

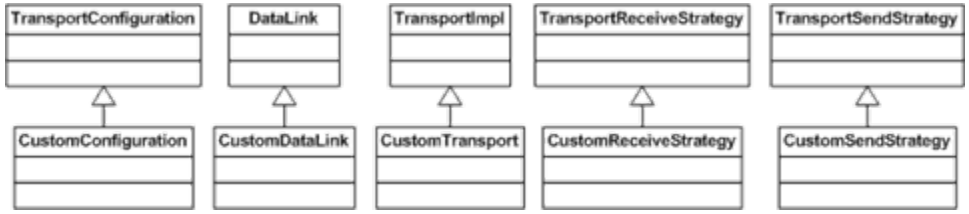
- Environment monitored for relevant changes
- Autonomic adaptation based on environment
- Maintain required QoS

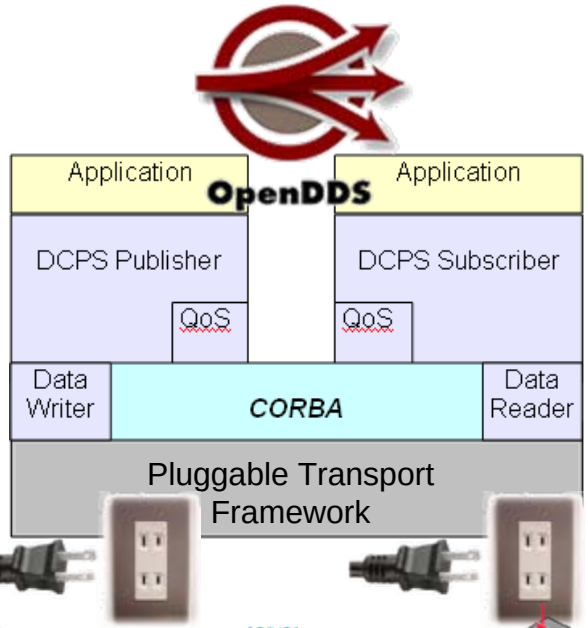


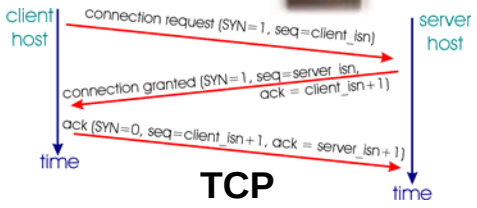
OpenDDS Pluggable Transport Framework

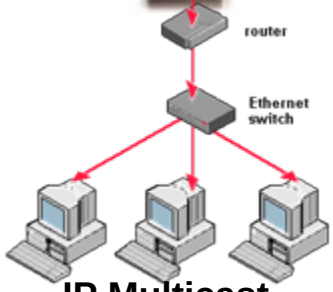
Pluggable Transport Framework supports:

- Standard transport protocols (e.g., TCP, UDP, IP multicast)
- Custom transport protocols
  - Inherit from key classes
  - Define custom behavior
  - Application creates transport object, associates transport with publisher/subscriber



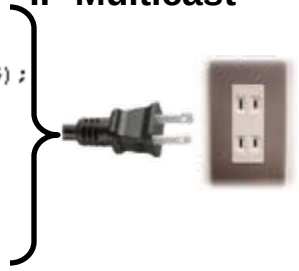






Developed Ricochet pluggable transport

```
// Create the Ricochet transport and configuration objects.
OpenDDS::DCPS::TransportImpl_rch ricochet_impl
  = TheTransportFactory->create_transport_impl (transport_impl_id, "Ricochet", OpenDDS::DCPS::DONT_AUTO_CONFIG);
OpenDDS::DCPS::TransportConfiguration_rch config
  = TheTransportFactory->create_configuration (transport_impl_id, "Ricochet");
    ⋮
// Attach the transport to the publisher.
OpenDDS::DCPS::AttachStatus status = publisher_impl->attach_transport(ricochet_impl.in());
```

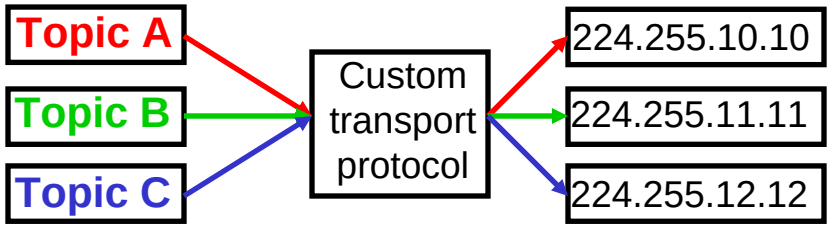


OpenDDS Pluggable Transport Framework: R&D Challenges

Application developer must manage correlation between:

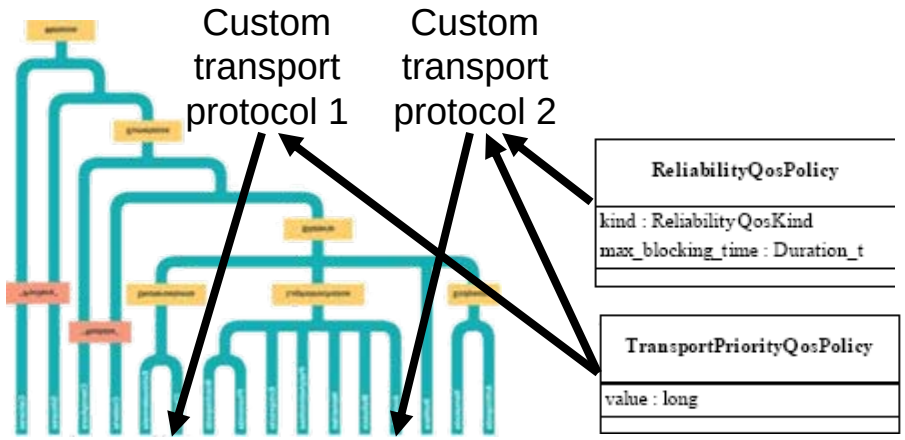
- QoS policies and transport protocols
- Transport protocols and topics
  - Transport protocols associated with publisher/subscriber
  - Topic associated with data reader/writer

```
// Create the UDP transport protocol.
OpenDDS::DCPS::TransportImpl_rch udp_impl
  = TheTransportFactory->create_transport_impl (transport_impl_id, "SimpleUdp",
                                                OpenDDS::DCPS::DONT_AUTO_CONFIG);
  ⋮
// Attach the UDP transport to the publisher.
OpenDDS::DCPS::AttachStatus status = pub_impl->attach_transport(udp_impl.in());
  ⋮
// Create the datawriter and add reliability QoS.
DDS::DataWriterQos dw_qos;
pub->get_default_datawriter_qos (dw_qos);
dw_qos.reliability.kind = ::DDS::RELIABLE_RELIABILITY_QOS;
DDS::DataWriter_var dw =
  pub->create_datawriter(topic.in (), dw_qos, DDS::DataWriterListener::_nil());
```



Develop taxonomy of transport protocols

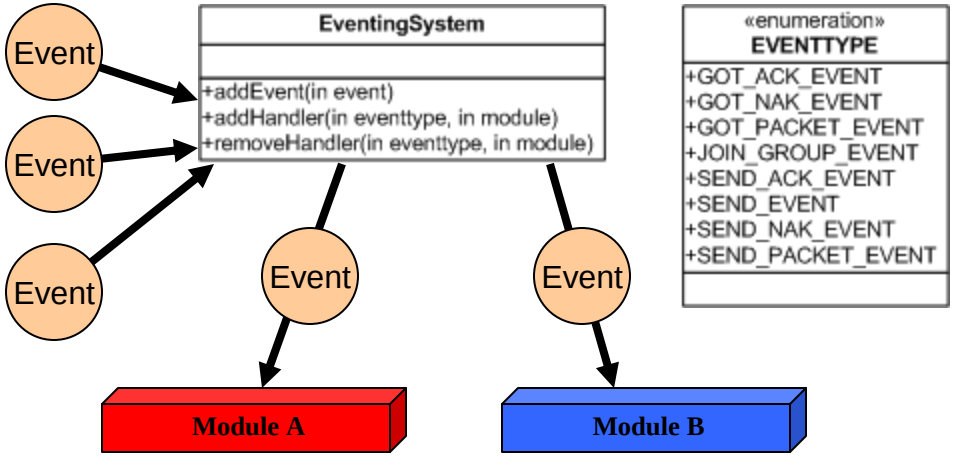
- Protocols registered based on properties in taxonomy
- Middleware maps relevant QoS policies to appropriate transport protocol(s)



Ricochet++ Transport Protocol Framework: Status

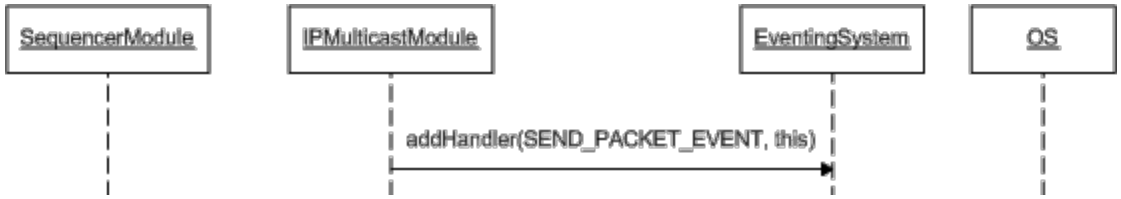
Eventing architecture

- EventingSystem singleton per process
- Defines events of interest, e.g.,
  - SEND_PACKET_EVENT
  - GOT_PACKET_EVENT
- Provides event injection into the system
- Provides event notification to ***modules***
  - Receive events
  - Process events
  - Potentially send out events



Protocol Modules

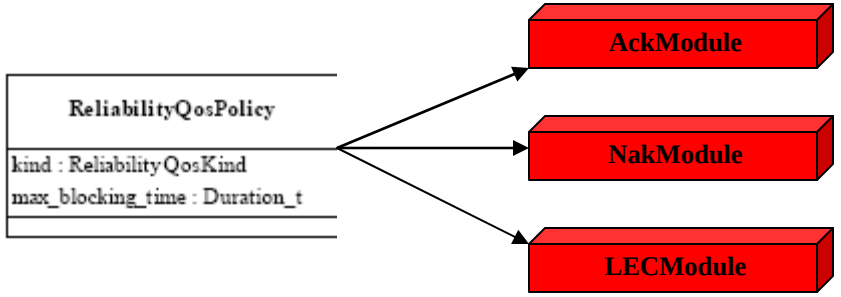
- Register for events of interest
- Inject events of interest
- Define behavior when event is delivered
- Existing modules
  - IPMulticastModule
  - SequencerModule
  - MuxModule
  - AckModule
  - NakModule



Ricochet++ Transport Protocol Framework: R&D Challenges

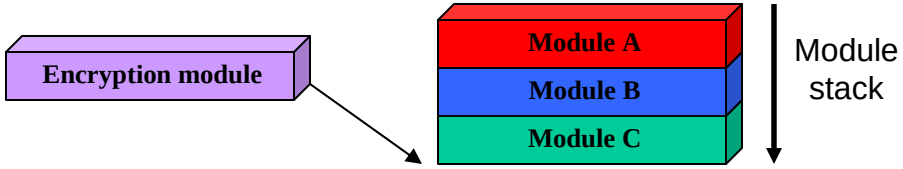
Mapping QoS policy values to Ricochet module properties

- Reliability -> ACK or NAK? both?
- Lateral Error Correction (LEC) between reliable and best-effort
- Have DSML handle this (i.e., leapfrog DDS QoS policies)?



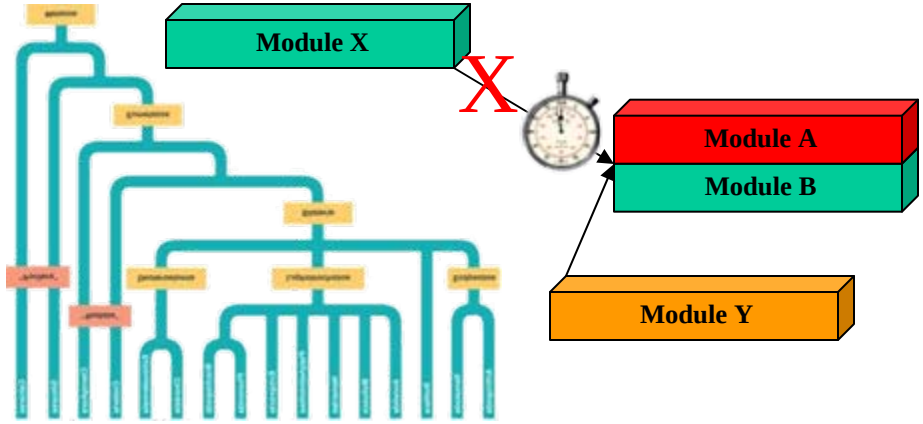
Managing module flexibility

- Module ordering, e.g.,
  - encryption after data manipulation
  - previous module consumes data needed by next module
- mutual exclusion (e.g., multiple encryption policies)
- timeliness, symmetry



Automated management for modules

- develop taxonomy of policy types
- insertion rules (e.g., if/conflict resolution, where)
- run-time support



Preliminary Test Environment

Using Emulab Environment (www.emulab.net)

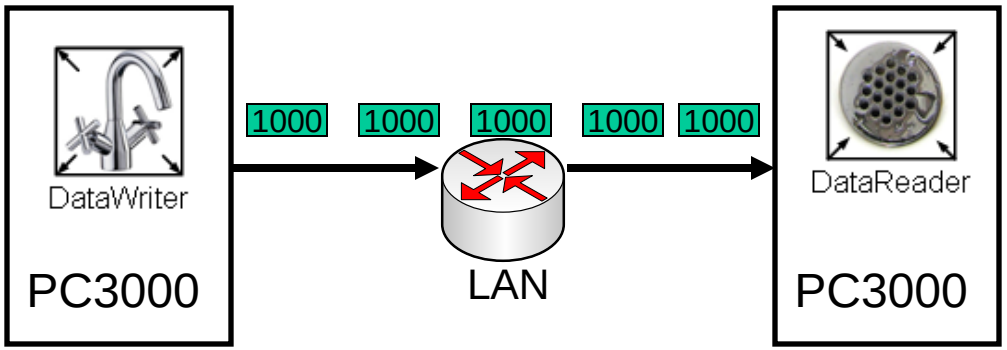
- PC3000 (64-bit Xeon, 3 GHz)
- Fedora Core 6
- Lossless LAN

Using DDSBench for benchmarking

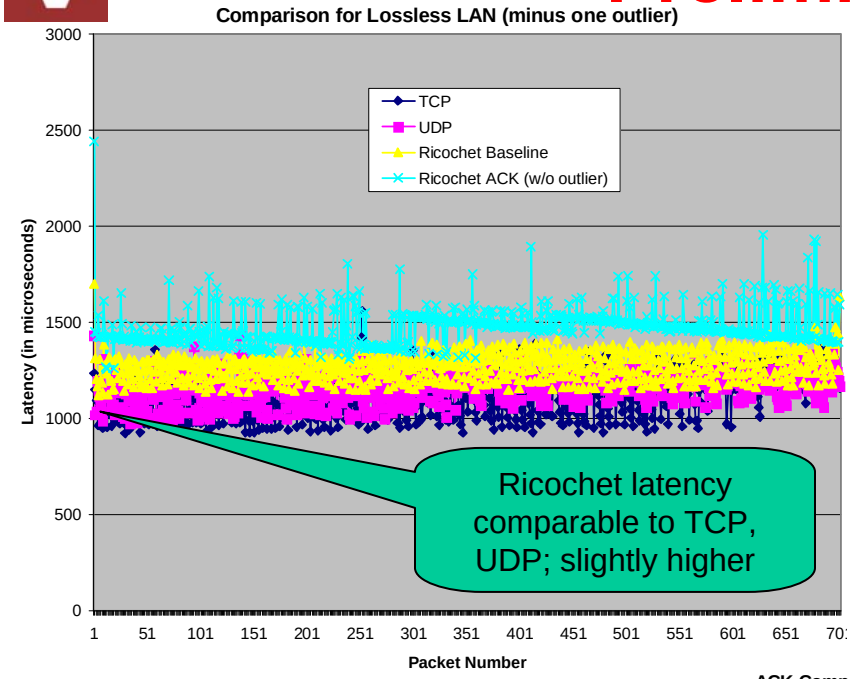
- Developed by MobiLab Research Group, Universita degli Studi di Napoli Federico II, Naples, Italy (http://www.mobilab.unina.it)
- Flexible interface for testing DDS implementations

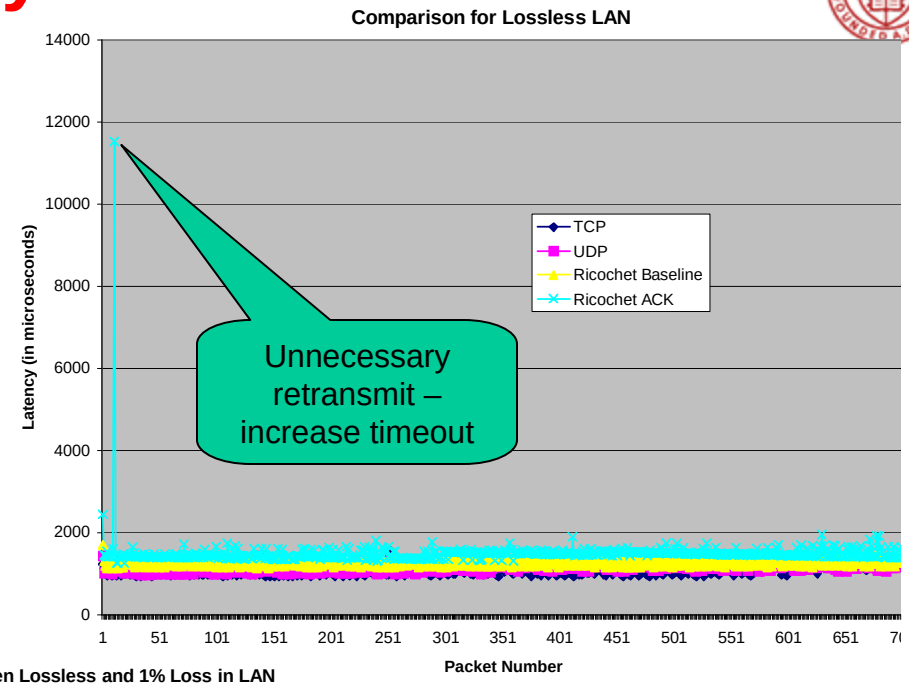
Testing scenario

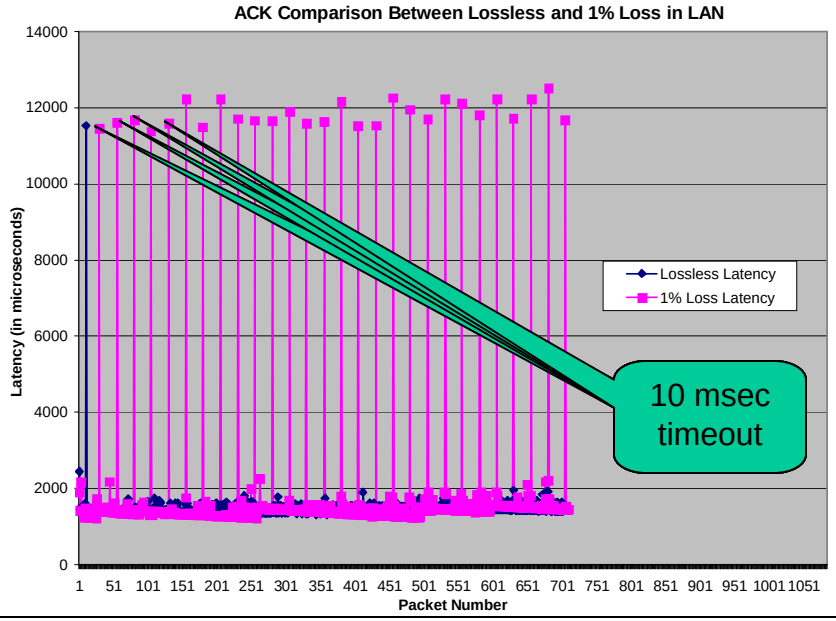
- Using latest OpenDDS
- 1 data writer on one machine, 1 data reader on another machine
- Data packet size of 1000 bytes
- 700 messages sent



Preliminary Results







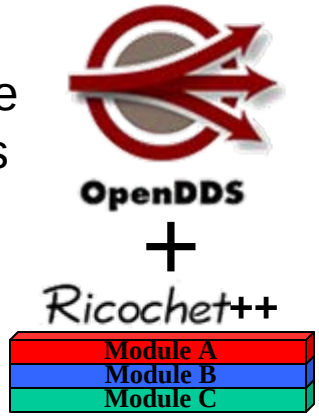
Concluding Remarks

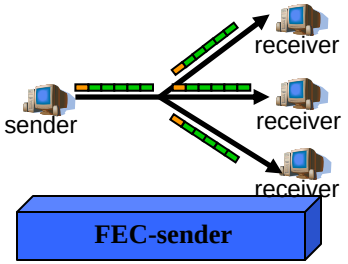
Initial ADAMANT[1] work started

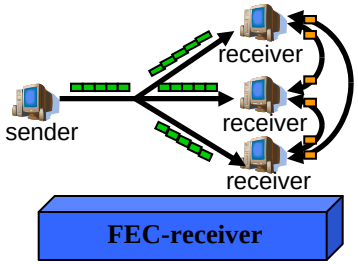
- Ricochet++[2] framework in place
- Composable transport modules promising research area
- Integrated with OpenDDS[3]
- Flexible
- More modules needed

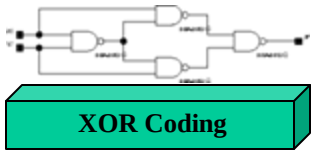
Lessons learned

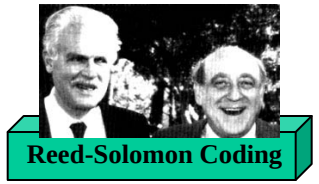
- More in-depth performance analysis needed
  - For individual modules
  - For groups of modules
- More seamless integration with Ricochet++ and OpenDDS
- Fine tune modules
  - Reduce baseline latency
  - Reduce jitter

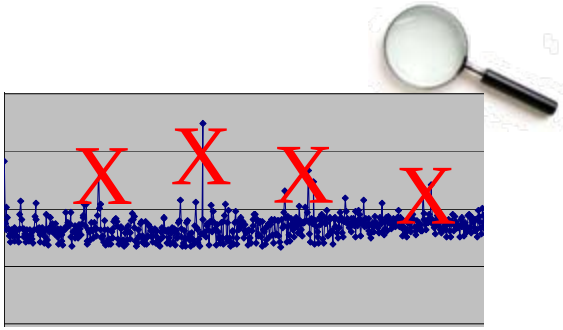


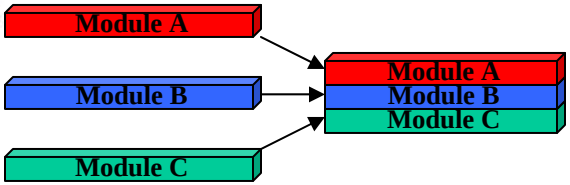












[1]http://www.dre.vanderbilt.edu/~jhoffert/ADAMANT
[2]http://www.cs.cornell.edu/projects/quicksilver/Ricochet.html
[3]http://www.opendds.org