QoS Management for NNEW: Requirements, Challenges, and Solutions

Praveen Sharma, Oliver Newell, and William Pughe

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QoS: Quality of Service
NNEW: NextGen Network Enabled Weather

Talk Outline

- ✓ NextGen and NNEW background
- QoS requirements and definition
- Challenges and solutions
- Alignment of QoS vision with FTI and SWIM
- Conclusions

NextGen Weather Mission

- **Poor weather has caused or contributed to [1]**
  - **70% of all aviation delays**
  - **87% of all aviation accidents**
  - **$1.2 billion of fiscal losses**

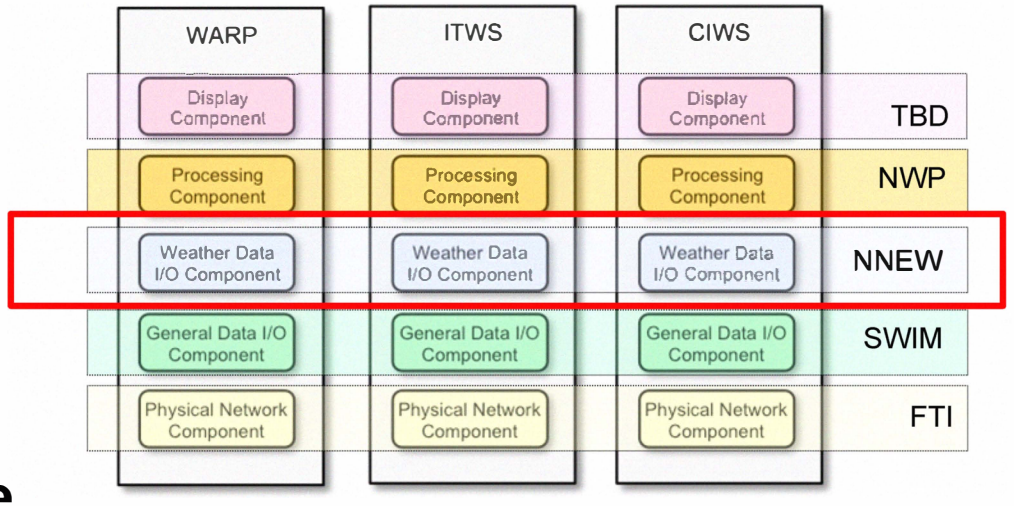
- **Reducing adverse impact of weather on the NAS is one of the important objectives of the NextGen Weather Mission**

Secretary of the Air Force, Michael Wynne, emphasizes the Defense Department's continued commitment to NextGen. [1]

[1] http://www.jpdo.gov/library/newsletter/200708_JPDO_newsletter.pdf

NNEW's Role in NextGen Mission

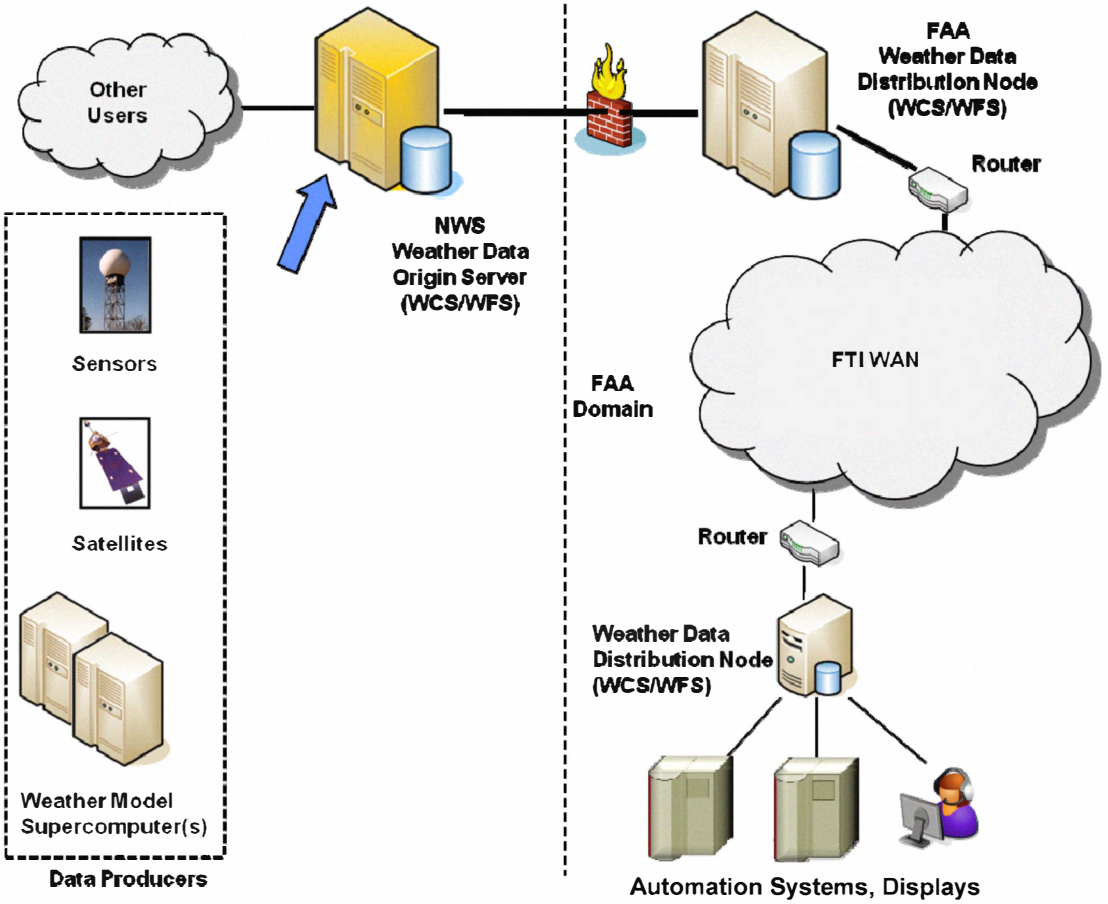
- **Disseminates common and consistent weather information**
- **Provides standardized and composable services for data access and dynamic-data discovery**
- **Uses shared services in the SWIM layer, which in turn relies on the physical FTI network infrastructure**



SWIM: System Wide Information Management
FTI: FAA Telecommunications Infrastructure

NNEW Architectural Components

- **NNEW Producers**
  - Sensors
  - Satellites
  - Model Generators
  - Multi-Agency (FAA/NWS)
- **NNEW Consumers**
  - NAS users
  - Airlines
  - Scientists
  - …
- **NNEW Services**
  - Web Feature Service (WFS) – non-gridded data
  - Web Coverage Service (WCS) – gridded data
  - Registry-repository – dynamic data discovery



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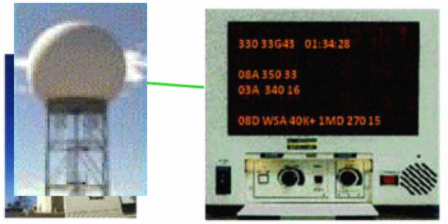
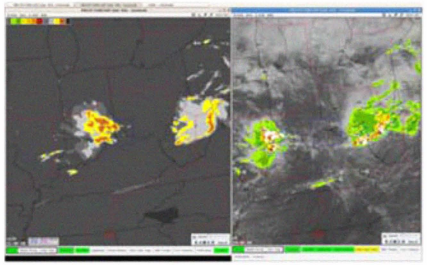
Requirements for QoS

- Different NNEW applications have different needs for
  - Timeliness and Jitter
  - Data rate
  - Data loss
- Different data-types have varying ranges of size, and rate of production or consumption
- Without QoS management, applications may cause "*Tragedy of the Commons*"

Air Traffic Control – Real-Time Surveillance Data
Data Size: *Small(1-2KB)* Latency: *~ 500msec* Priority: *Critical*
Rate: *1-2 messages/sec* Jitter: *Minimal* Data-Loss: *None*

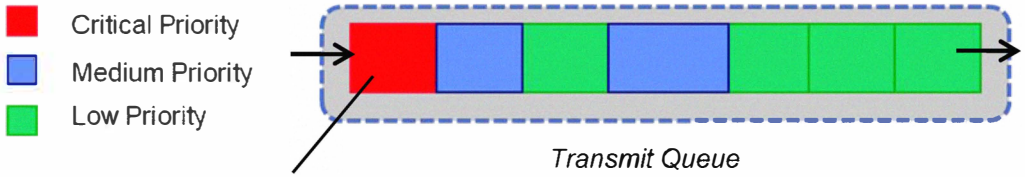


Air Traffic Control – Terminal Area Wind Shear Advisories
Data Size: *Small (1-4KB)* Latency: *~(0.5-1)sec* Priority: *High-Priority*
Rate: *1-2 messages/sec* Jitter: *Minimal* Data-Loss: *None*



En-Route Weather
Data Size: Medium *(5-30 MB)* Latency: *~(10-20) sec* Priority: *Medium*
Rate: *0.05-0.1 messages/sec* Jitter: *Minimal* Data-Loss: *None*

Accident Investigation - Access to Archived Data
Data Size: *Varied (~1GB)* Latency: *Best Effort* Priority: *BestEffort*
Rate: *Flexible* Jitter: *Moderate* Data-Loss: *None*



Critical Priority traffic stuck behind large number or large size of traffic of lower priorities at a constrained site (queues, or hardware interfaces, e.g.)

Several QoS use-cases are listed in NextGen-Net-Enabled Weather Use Cases-V3-2

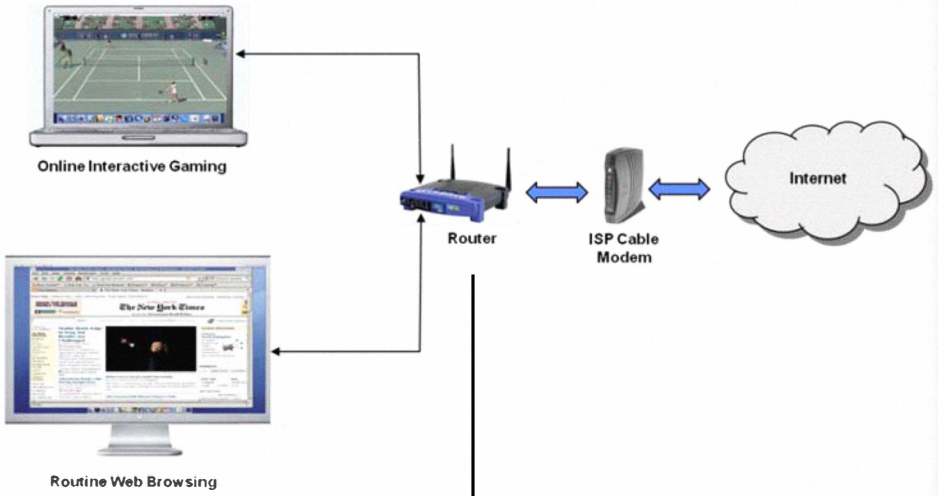
QoS Definition

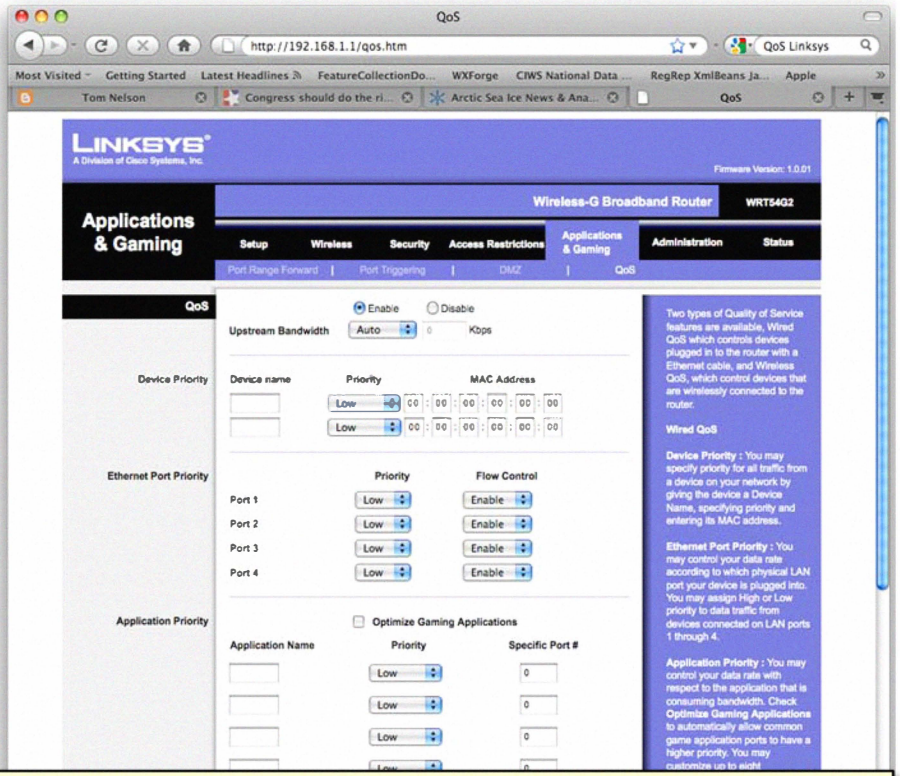
"Delivering the Right Information at the Right Time to the Right People in the Right Form"

What does this definition really mean

?

QoS Illustration in Everyday Life





- Interactive gaming requires low latency for real-time 'feel'
- Link to Internet can become bottleneck
- Prioritization of network traffic needed to avoid game 'jitter'

- Many home routers support QoS features
- Separates on-line gaming (real-time) traffic from routine traffic
- Packet prioritization by MAC address or Ethernet Ports
- QoS feature is localized to home router – QoS info not used by ISPs (yet)

QoS in NNEW

- In the context of NNEW QoS implies:
  - Satisfying varying bounds on timeliness, data rates, jitter, and data loss
  - Supporting these requirements in an end-to-end and cohesive manner to provide a common-weather picture to the NAS
  - Fulfilling the requirements in a secure, load-balanced, and fault-tolerant manner

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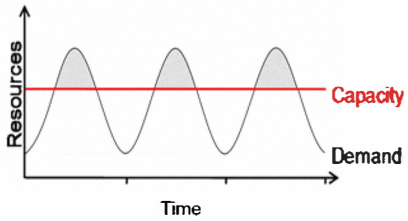
Challenges in Providing QoS to NNEW

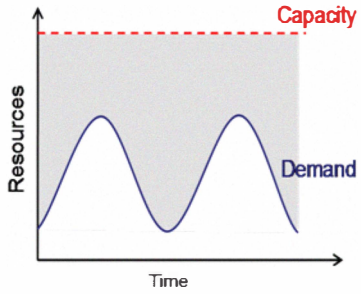
1. Several potential bottlenecks in the end-to-end pathway
   - Any-one bottleneck can adversely impact the entire system

2. Inability to accurately predict resource requirements due to:
   - Shift in messaging paradigm
     - Point-to-point to publish-subscribe
   - Dynamic data-access patterns
     - Varying size and rate requirements of users
     - Varying number of messages per user
     - Varying number of users of the same or differing priorities



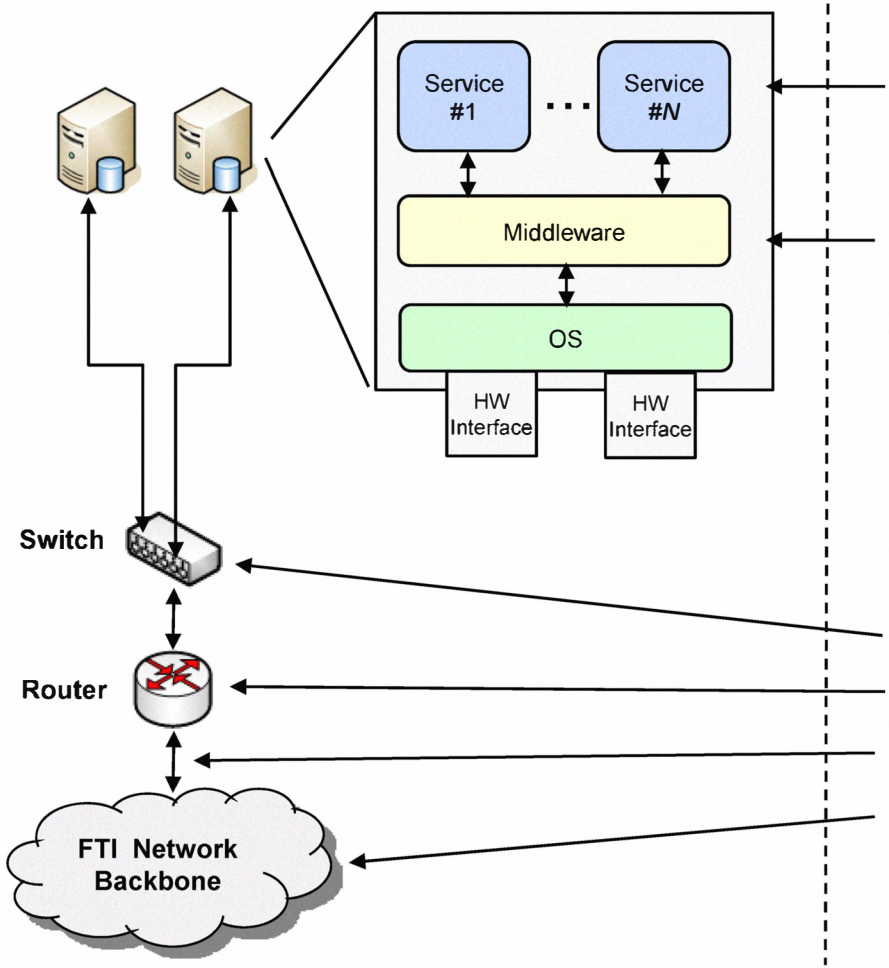
Cost of under provisioning

3. Economics of over-provisioning
   - Either pay for over-provisioning for (50% over) the peak traffic resulting in underutilization of resources
   - Or suffer adverse quality



Risk for over provisioning

Challenge 1: Potential QoS Bottlenecks Across the Different Layers



Application Layer - Contention for

- Middleware
- OS (CPU/memory/file IO)
- HW interfaces

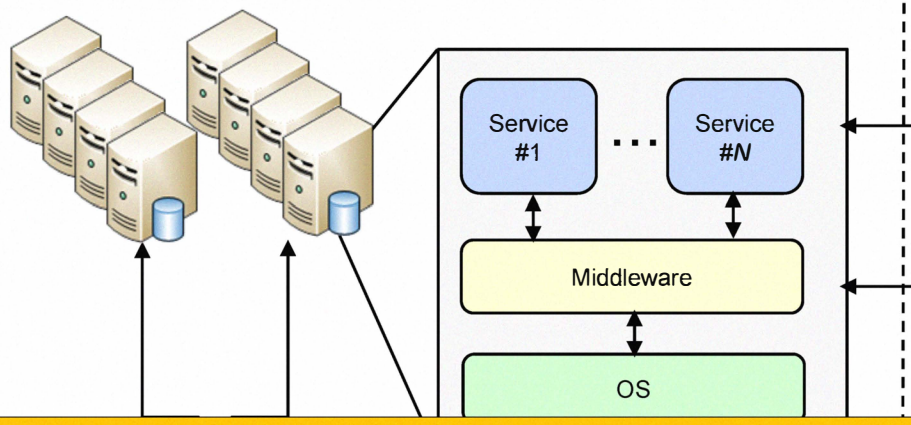
Middleware Layer - Contention for

- Messaging Queues
- OS (CPU/memory/file IO)
- HW interfaces
- Other Services, such as Persistence, Transaction, & Security

Network Layer - Contention for

- Switch and Router Queues
- Bandwidth to FTI core
- Bandwidth Cost and Latency of the core network
- Other Services, e.g., Persistence, Transaction, & Security

Suggested Solutions for Addressing Potential Bottlenecks



Application Layer

- Classify and Prioritize users based on the data requested and importance of user to the NAS
- Direct users to Servers* based on their priority

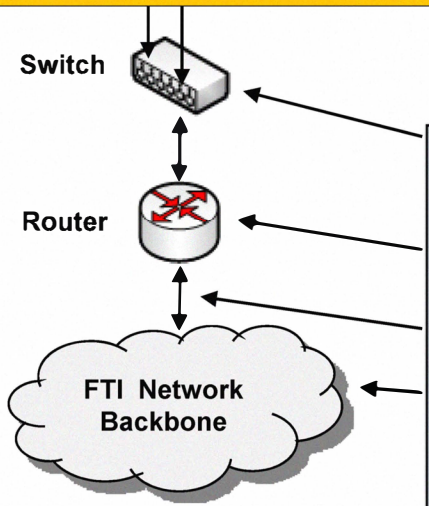
Middleware Layer

- Segregate MOMs based on User Priority, and resource intensiveness of data-types

Providing multi-layered and coherent QoS

- Comes with built-in support for QoS
- Used in Air-traffic control in UK
- Considered for Euro Control's Single European Sky Effort

- Investigating DSCP classification of ActiveMQ packets



Network Layer

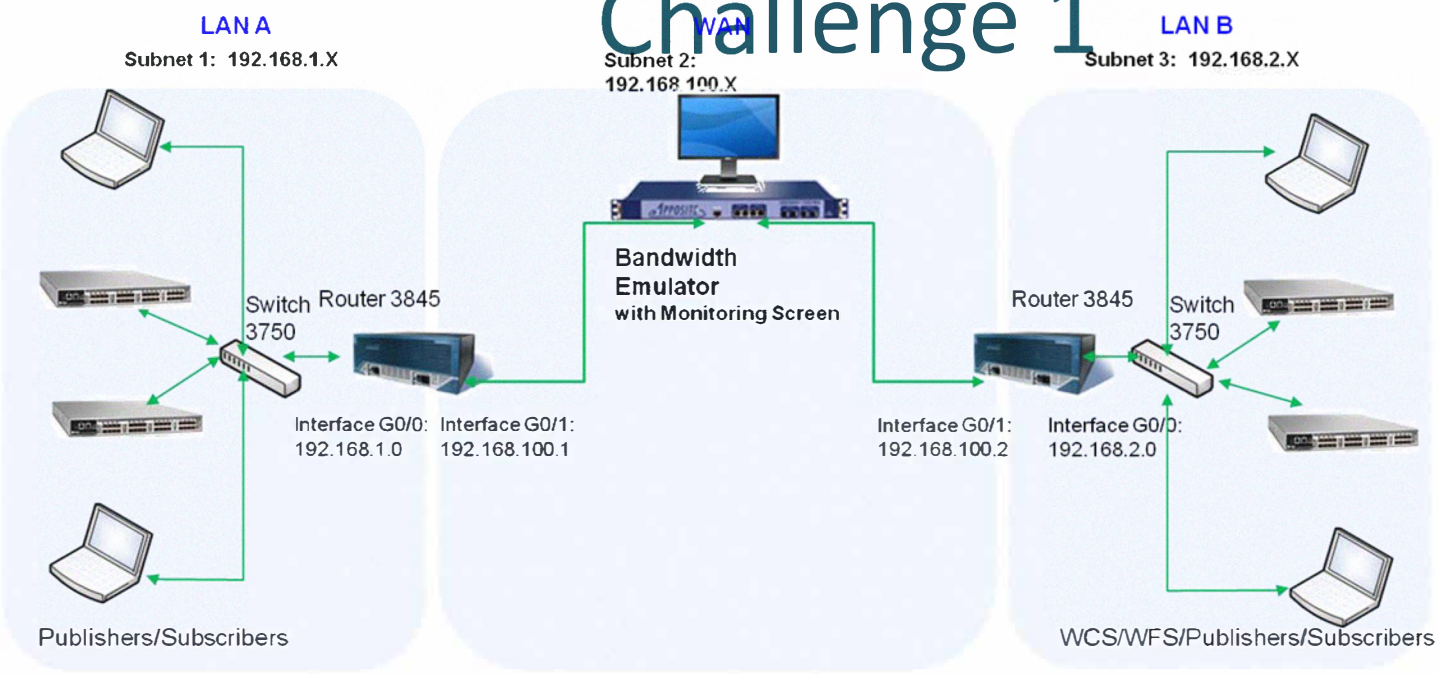
- Configure Switch and Router for QoS
- Segregate traffic using VPNs and MPLS TE
- Optimize BW usage by converging Weather Service BW usage.

Servers* : Origin Server, Distribution Server, and Registry Repository

Suggested Solutions for Addressing Potential Bottlenecks

QoS Issue	Strategy
CPU/Memory/IO contention on single physical node	• Additional cores, memory, I/O interfaces • OS-Level basic process priorities • OS/VM thread priorities • OS-Level POSIX real-time priorities • Memory locking (prevents process paging/swapping) • Move to multiple nodes
Middleware messaging latency	• Use priority features supplied with middleware • Enhance middleware's QoS features if needed • Separate message broker instances for different traffic priority classes
OS Network I/O latency	• Tune OS network transport parameters (e.g. queue depth, TCP driver parameters)
Hardware interface latency	• Multiple hardware interfaces • Not likely to be a bottleneck since hardware queues tend to already be limited in size.
Switch and router latency	• Employ QoS features of enterprise class switches • Multiple LANS/multiple switches
Bandwidth	• Blend edge router QoS capabilities with core FTI QoS capabilities to minimize bandwidth need • Overprovision
Core network latency	• Configure edge switches/routers to provide all possible 'hints' to core network w/respect to efficient routing of prioritized packets.

Challenges 2 and 3, and testing Challenge 1



Lincoln Test bed

- Designed a small testbed emulating the FTI environment
- Designing a testbed-application to
  - Approximate resource requirements (challenge 2) and minimize over-provisioning costs (challenge 3)
  - Test potential bottlenecks (challenge1)

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Alignment with SWIM's Vision

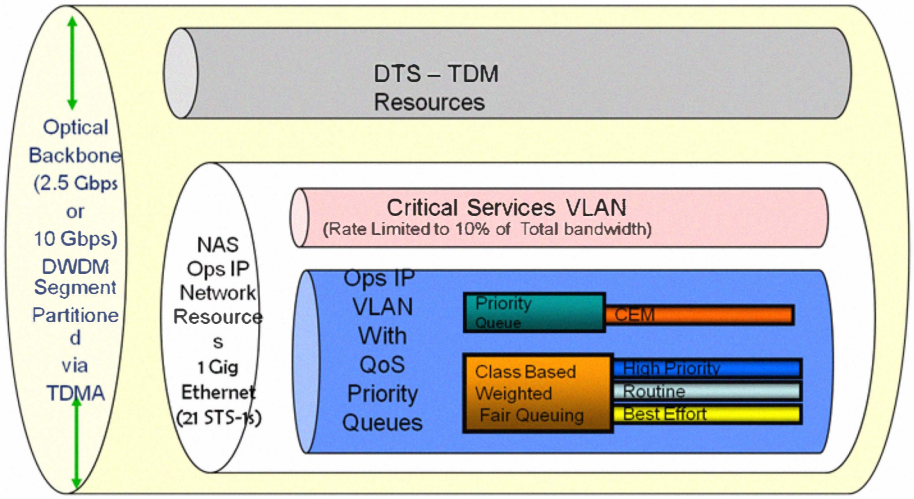
- Using SWIM- recommended software for application and middleware QoS management
  - Apache Camel/Fuse Mediation Router
  - Apache ActiveMQ/ Fuse Message Broker
  - Apache ServiceMix/Fuse ESB
  - Apache CXF/Fuse ServiceFramework

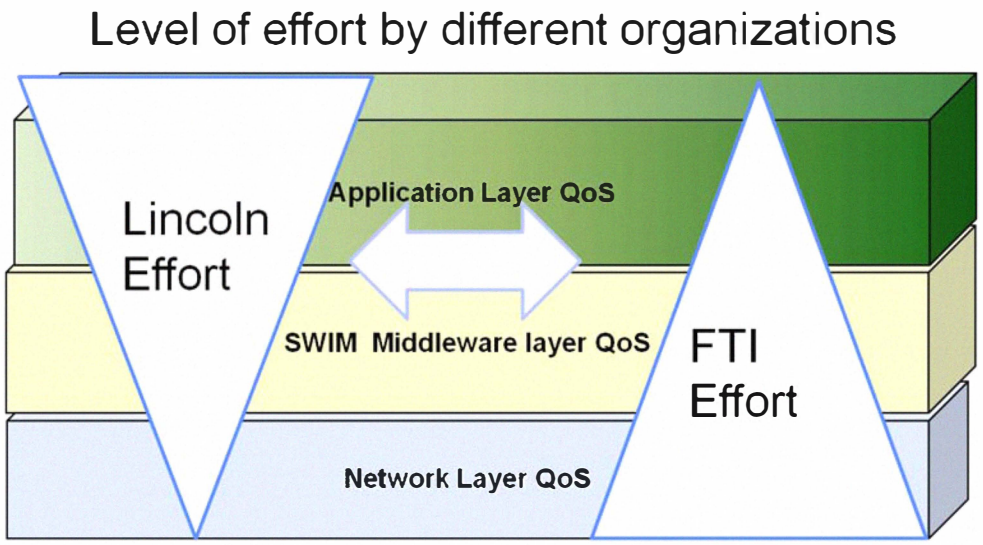
- Sponsored student project with Tufts University to support Diffserv bits in Apache ActiveMQ
- Patch submitted for incorporation into future release

Alignment of Network QoS with FTI

- **Collaborating and cooperating with FTI's network management team**

- **Selecting priorities at the application and middleware layer that aligns with the FTI proposed priorities at the routers and switch layers**





Picture communicated to us by Dr. Edwin J. Zakrzewski, ITT Corporation, Supporting FAA Telecommunications Services Group. This is a "Harris Draft Concept".

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Conclusions

- Providing multi-layered QoS provisioning approach that
  - Coherently addresses QoS issues across all the layers
  - And, it is cost-effective

- QoS management entails
  - Classifying and prioritizing users using policies consistent across all the layers
  - Redirecting users to appropriate WCS/WFS based on their QoS needs (Application-layer)
  - Using multiple brokers as well as queues, selecting the broker's optimizing parameters, and investigating DDS and marking of ActiveMQ packets (Middleware-layer)
  - Configuring routers and switches – traffic conditioning and scheduling (Network-layer)

- Our suggested solutions align with the QoS vision of the SWIM and FTI programs

Questions, Comments, or Suggestions

Network-layer QoS (In the testbed Routers)