Network QoS Assurance through Admission Control*

by

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Outline

- Setting the context and overview
- Network QoS Basics
  - DiffServ/CoS
- DARPA ARMS Multi-Level Resource Management (MLRM) Overview
- Bandwidth Broker in MLRM
- Highlights of Bandwidth Broker
- Network QoS
- Research Focus
- Our Network QoS Solution
  - In Comparison

Setting the Context and Overview

- Network QoS (Quality of Service) is the focus
- In best-effort networks with changing topology and load,
  - No guarantee can be given that critical messages reach their destination within strict performance bounds.
    - Hence, no performance guarantee for higher level transport and applications using the transport can be given
- Our solution
  - Makes use of standard DiffServ (Differentiated Services) and CoS (Class of Service) capabilities of routers and switches
  - Makes use of a Bandwidth Broker with admission control capabilities
    - To avoid congestion and thus provide a measure of performance guarantee
  - In contrast with IntServ (Integrated Services) / RSVP (Resource Reservation Protocol)
    - Scales better
- Being researched, developed and integrated as part of a multi-layer middleware resource management service as part of the DARPA ARMS (Adaptive and Reflective Middleware Systems) program
  - Using the CORBA middleware and component model

Differentiated Services (DiffServ) and Class of Service (CoS) Concepts

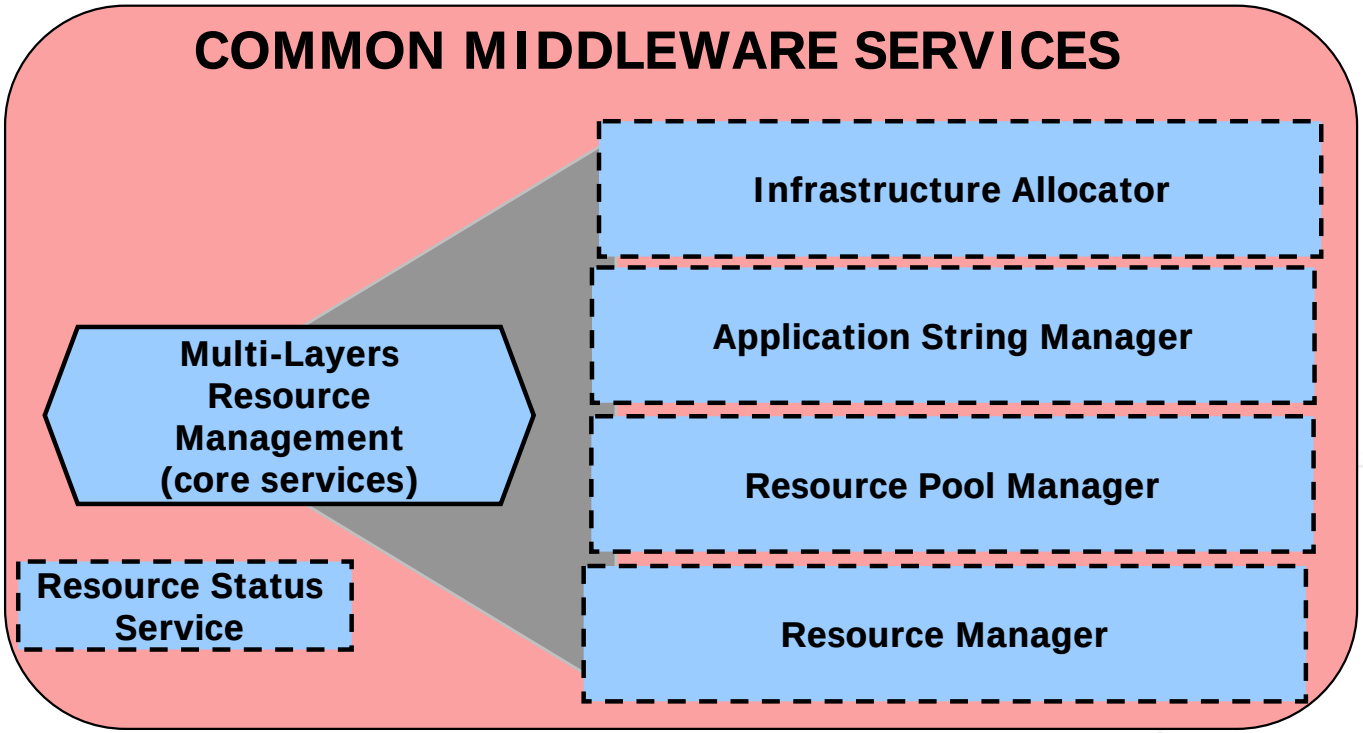
- DiffServ is a standards based architecture to provide QoS in IP networks.
  - Differentiated, but consistent per class traffic treatment throughout the network
    - Scheduling and buffer management same everywhere resulting in same per-hop behavior
      - Better predictability of delay, jitter, packet loss, etc.
  - Policing at the ingress
- CoS concepts for Layer 2 networks similar in spirit to DiffServ for Layer 3
  - CoS oriented toward fast hardware implementation
- DiffServ/CoS provided by standard network elements alone is not enough to assure QoS.

Our Integrated Bandwidth Broker (BB) and DiffServ/CoS-based solution at a Glance

- Admission control of application traffic to limit offered load
- Policing (and marking) of traffic at the network edge
- Class-based differentiated treatment in the network core
  - Same per-hop behavior leading to better predictability
- Efficient bandwidth utilization
- Ability to react dynamically to changing network conditions
  - Using high level policies
- Supports heterogeneous link layers and network technologies
- Provides a higher level abstraction so applications or middleware do not have to speak in network terms

ARMS Multi-Layer Resource Management (MLRM) Overview

- Common Middleware Services is a layer in software architecture.

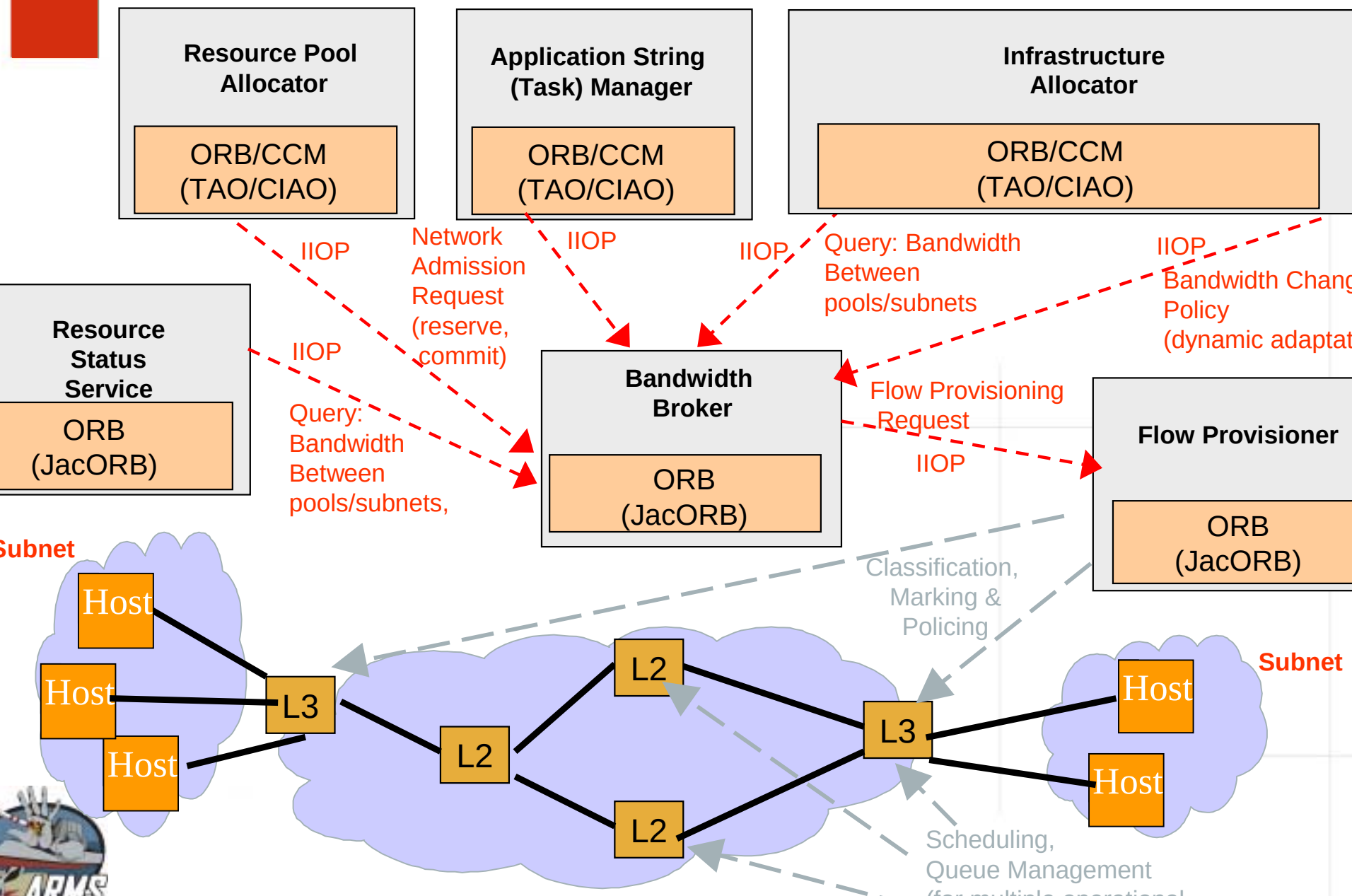


- Infrastructure Allocator: Divide and conquer; assigns applications to resource pools; considers coarse aggregate resource (CPU, network, security) availability
- Application String Manager: Sets up, monitors, control and adapts application strings application string is a sequence of applications, often known as a task in real-time computing)
- Resource Pool Manager: Assigns applications to computing platforms and sub-networks in a resource pool

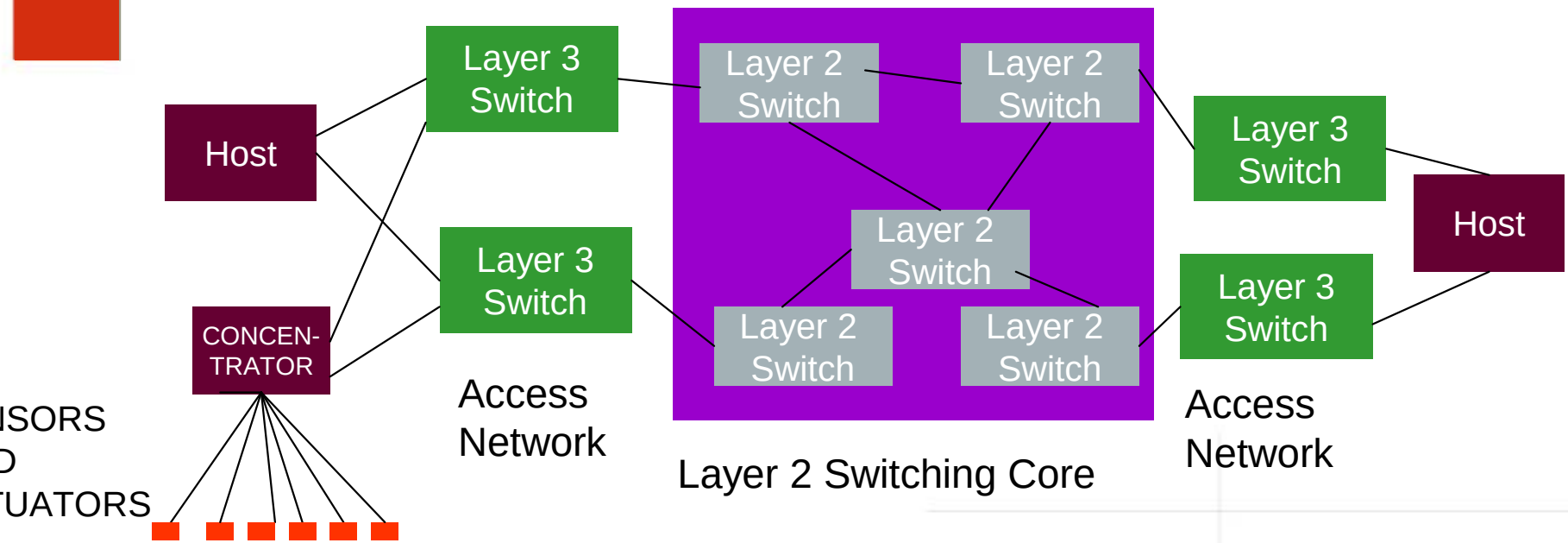
Bandwidth Broker Functionality

- Bandwidth Broker is a network resource pool manager. It supports
  - Flow Admission Functions
    - Reserve, commit, modify and delete flows
  - Queries
    - Bandwidth availability in different classes among pairs of pools and subnets
  - Bandwidth Allocation Policy Changes
    - In support of different mission modes
  - Feedback/Monitoring Services
    - Report on performance using metrics such average delay and packet loss

Bandwidth Broker Functionality in the Overall MLRM Context



Network Architecture



- High speed switched backbone
  - L2/L3 switches interconnect hosts/servers
- Edge network with L3 aware access switches
  - Policing, classification and marking functions
- Core network with L2 switches
  - Queuing and discard mechanisms for differentiated traffic classes

Bandwidth Broker Highlights

- Bandwidth Broker tracks bandwidth (remaining) for each traffic class on each link.
  - If there is enough bandwidth on every link on the path for the flow, the flow is admitted; otherwise the admission for the flow is denied.
  - Once the flow is admitted, to get differential treatment, the ingress router is instructed to mark packets belonging to the flow with the right DiffServ (CoS) codepoint; if the flow is not admitted, the flow packets are treated/marked for best effort.
    - The Ingress router is also instructed to police the flow packet to ensure its rate does not exceed its limit
  - Based on the codepoint, packets get differentiated treatment; Per-hop behavior is achieved through pre-configuration of scheduling and buffer management attributes
- Bandwidth Broker needs to discover the path a flow will take to do admission control correctly
  - Routers/switches generally force paths
    - Traceroute for Layer 3 path discovery
    - Spanning tree discovery for Layer 2 leads to path discovery

Work in Progress: BB improves both performance and predictability (in a lab configuration using Layer 3 routers)

FTP transfer rates for downloading 10MB (80 Mbits) file over a 10Mbps connection with different levels of contention

Contention / FTP traffic	None	8 Mbps	16 Mbps	24 Mbps
Not admitted by BB; best effort; not policed	11.4 sec 911 KBps	70 sec 144 KBps	218 sec 46 KBps	> 5min
Admitted by BB and policed @ 2Mbps + nominal burst; high priority class	30.2 sec 336 KBps	30.5 sec 332 KBps	30.3 sec 335 KBps	30.3 sec 335 KBps

Layer 2 Quality of Service Considerations

- Layer 2 Transport supports a 3 bit field to carry CoS information
- More importantly, the number and type of queues is predefined based on hardware type and cannot be altered; typically,
  - 1 Strict priority queue
  - 1 or 2 priority queues with configurable drop thresholds
- L2 CoS value can only be carried in certain encapsulations
  - For instance, “vanilla” Ethernet frames cannot carry CoS values
- Bandwidth Broker adaptation layer for L2 CoS configuration
  - Build intelligent techniques to map demands of Layer 3 classes, such as EF, AF etc., to limited number of queues and drop thresholds.
  - Engineer policing and scheduling policies to achieve specified deadlines for real-time traffic.

Research Focus

- **Layer 2 QoS and integrating Layer 2 QoS with Layer 3 QoS**
- **Increasing the level of abstraction in specifying the network QoS**
  - Currently flow requirement is specified as a five-tuple (source address, source port, destination address, destination port, transport protocol) and the bandwidth (bps) required.
    - Generally bps is a blunt instrument
      - Deadline type requirements are both possible and needed.
    - In MLRM, often the five-tuple is not known at resource allocation time.
- **Adaptation**
  - Local adaptation (Modifying/Deleting flow)
    - e.g., Demoting flow traffic class to accommodate more important traffic; should be policy driven
  - Global adaptation
    - Changing bandwidth allocated to different classes throughout the network for operational mode changes
      - All routers/switches have to re-provisioned
      - Switchover can give rise to unstable operations

In comparison with State-of-the-Art Network QoS Approaches

- DiffServ Vs. IntServ (RSVP)
  - A good comparative paper at http://www.cisco.com/en/US/tech/tk543/tk766/technologies_white_paper09186a00800a3e2f.shtml
  - DiffServ scales better than IntServ
- Bandwidth Broker in the industry
  - Work in progress by QBone Architecture (Scalable QoS mechanisms) http://qos.internet2.edu/wg/; http://qbone.internet2.edu/bb/bboutline2.html
  - Grid Community http://www.globus.org/research/papers/QoSPolicy.pdf
    - Focuses on inter BB Service Level Agreements (SLA's)
- Telcordia has applied Bandwidth Broker technologies in other Government projects for different network technologies
  - In these projects,
    - No Layer 2 QoS and no unified Layer 2 & Layer 3 QoS treatment
    - No integration into middleware
    - No Higher level abstraction that is more readily usable in managing QoS for mission-critical applications

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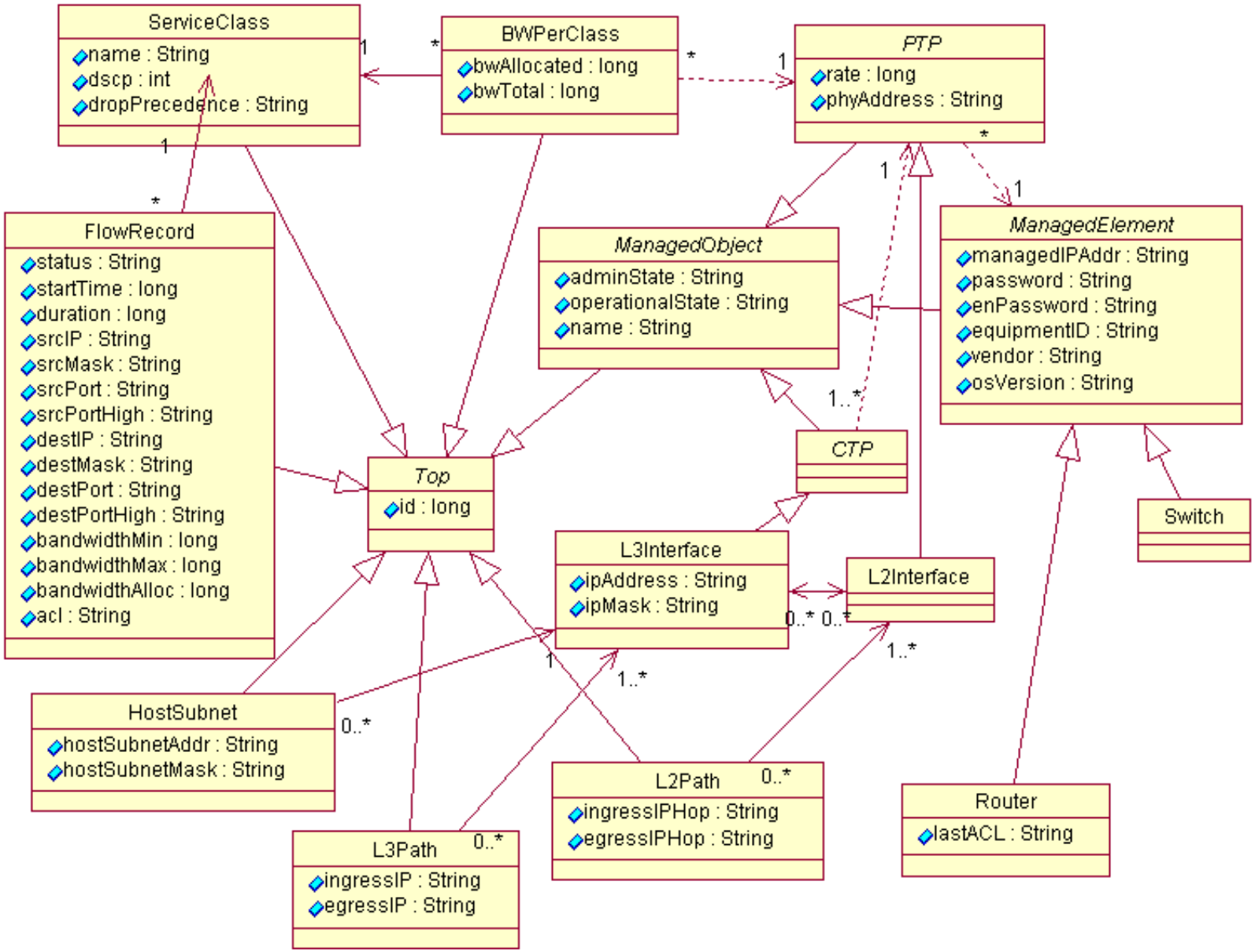
Backup slides

Bandwidth Broker: an Inside Look



Integrated Layer 3/Layer 2 QoS Treatment