QoS Deployment Experiences

SANOG VII Mumbai, India 16-24Jan'06

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Agenda

- What is QoS?
- Why QoS?
- Benefits of QoS For Service Provider
- QoS Functional Components & Models
- QoS in MPLS Network
- QoS Deployment Experiences

What is QoS?

"Collection of technologies which allows applications/users to request and receive predictable service levels in terms of data throughput capacity (*bandwidth*), latency variations (*jitter*) and *delay*"

What is QoS? (cont…..)

- Measure of transmission quality and service availability of a network
- Transmission quality of the network is determined by the following factors: Latency, Jitter, and Loss.
- *QoS from User Perspective:* The network capability to provide the desired application performance for Voice,Video,and Data!
- *QoS from Service Provider Perspective:* Methods to utilize existing network capacity efficiently and meet performance requirements and achieve the maximum traffic throughput. “Managed unfairness”

What is QoS? (cont.....)

- ***Objectives of QoS***
  - Supporting dedicated bandwidth
  - Improving loss characteristics
  - Avoiding and managing n/w congestion
  - To give priority to certain mission critical applications in the n/w
  - To maximize the use of the current network investment in infrastructure
  - Better performance for delay sensitive applications such as Voice and Video
  - To respond to changes in n/w traffic flows

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Why QoS?

- ***Technological Reasons***
  - Real time applications are sensitive to delay, jitter and packet loss
  - Voice, Video, and Data application traffic demand varying service requirements
  - Over subscription of available bandwidth for multiple applications
  - Resultant congestion and ensuring of SLAs for priority traffic in networks
  - Optimization of bandwidth utilization

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Benefits of QoS For Service Provider

- B/W Management ➔ by congestion management and avoidance mechanism
- Better handling of N/W capacity for new applications / services
- Increase in revenue by selling multiple service classes over shared infrastructure like MPLS backbone
- Predictive behavior guarantee on the data IP / MPLS network (which are usually best effort).

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QoS Functional Components & Models

- **QoS Functional Components**
  - **Classification of packets on the basis of**
    - Layer 2 parameters (802.1Q CoS bits)
    - Layer 3 parameters (IP Precedence, DSCP, source MPLS EXP bits or destination IP)
    - Source port, destination port, or stateful inspection
  - **Policing / Shaping**
    - Both identify the traffic rate violations similarly
    - Policing-Dropping violating traffic or marking it with higher drop probability
    - Shaping-Delays the excess traffic by using buffer & shapes the flow to configured rate

QoS Functional Components & Models (cont.....)

➢ QoS Functional Components (cont...)

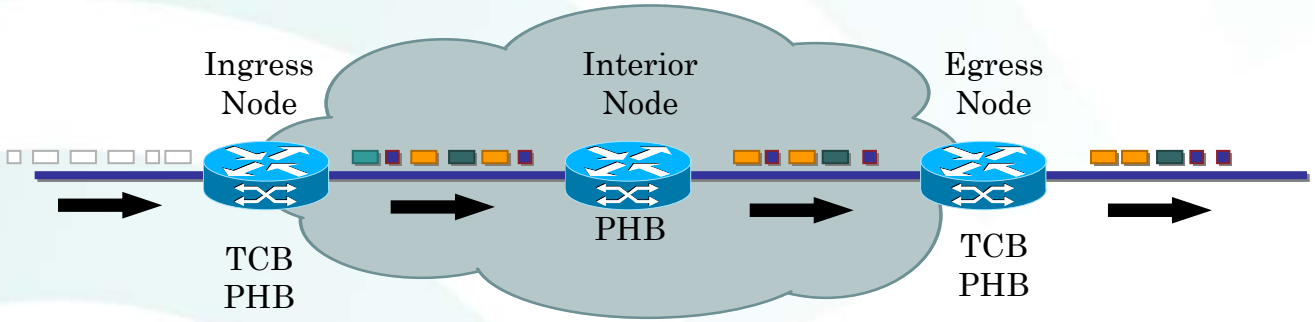
- **Marking / Rewriting**
  - ➢ Eases the classification in Service Provider's Core n/w
  - ➢ Carries packet's service class & drop probability information
  - ➢ Can be tied to policing
  - ➢ Layer 2 and layer 3 specific (e.g. FR DE, ATM CLP, 802.1p/q, IP DSCP, IP Precedence, MPLS Experimental field)
- **Scheduling (Congestion Management/Avoidance)**
  - ➢ ***Congestion Management (Queuing- CBWFQ, LLQ, MDRR)***
    - Creation of queues corresponding traffic classes
    - Managing the front end of queues by transmitting the packets from queues on the basis of priority & b/w share
  - ➢ ***Congestion Avoidance (Dropping-With RED)***
    - Monitoring network traffic loads to anticipate and avoid congestion at common network bottlenecks
    - Achieved by selective dropping of packets on the basis of drop probabilities

QoS Functional Components & Models (cont.....)

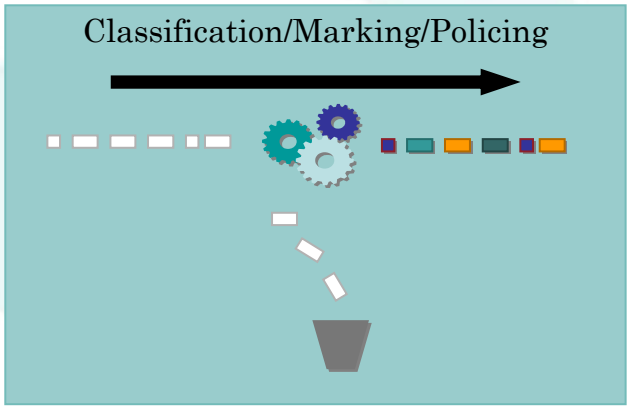
- ***QoS Models***
  - **Best Effort**
    - Traditional IP service with no state (no traffic classification)
  - **InteServ (Integrated Service) – RFC 2210,2211,2212,2215**
    - First effort towards IP QoS
    - Signaled QoS with per flow state
    - Resource/policy admission control
    - Not scalable over internet
  - **DiffServ (Differentiated Service) – RFC 2274,2275**
    - Provisioned QoS
    - Per flow aggregate QoS
    - No scalability issue–Better choice for Service Provider
    - No resource/policy admission control

QoS Functional Components & Models (cont.....)

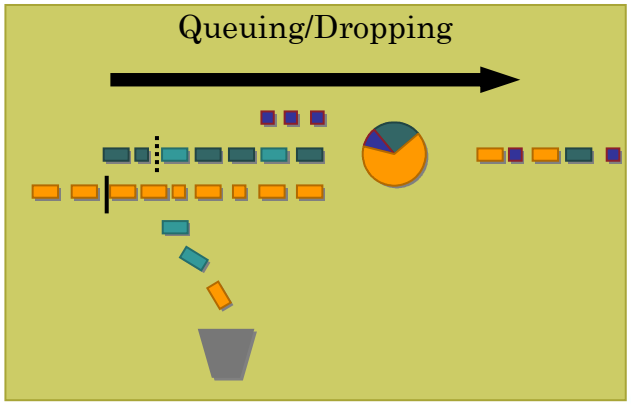
DiffServ – QoS Model



Traffic Classification and Conditioning



Per-Hop Behavior



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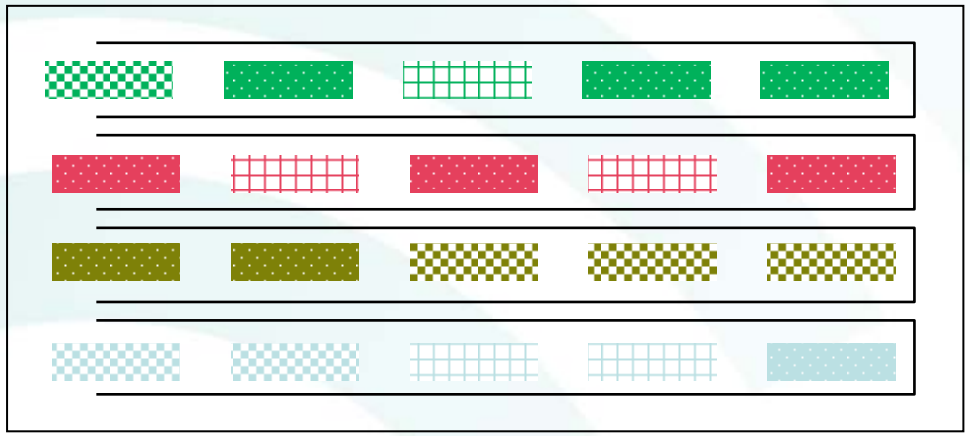
QoS Functional Components & Models (cont.....)

DiffServ – QoS Model

- **Per-Hop Behaviors (PHB)**
  - **Expedited Forwarding (EF): RFC2598**
    - Dedicated low delay queue
    - Comparable to Guaranteed B/W in IntServ
  - **Assured Forwarding (AF): RFC2597**
    - 4 queues × 3 drop preferences
    - Comparable to Controlled Load in IntServ
  - **Class Selector: Compatible with IP Precedence**
  - **Default (best effort)**

QoS Functional Components & Models (cont.....)

DiffServ – QoS Model (AF PHB)



AF Class 1: 001dd0

AF Class 2: 010dd0

AF Class 3: 011dd0

AF Class 4: 100dd0

dd = drop preference

Eg. AF12 = Class 1, Drop 2, thus "001100"

- **4 independently-forwarded AF classes**
- **Within each AF class, 3 levels of drop priority! This is very useful to protect conforming to a purchased, guarantee rate, while increasing chances of packets exceeding contracted rate being dropped if congestion is experienced in the core.**

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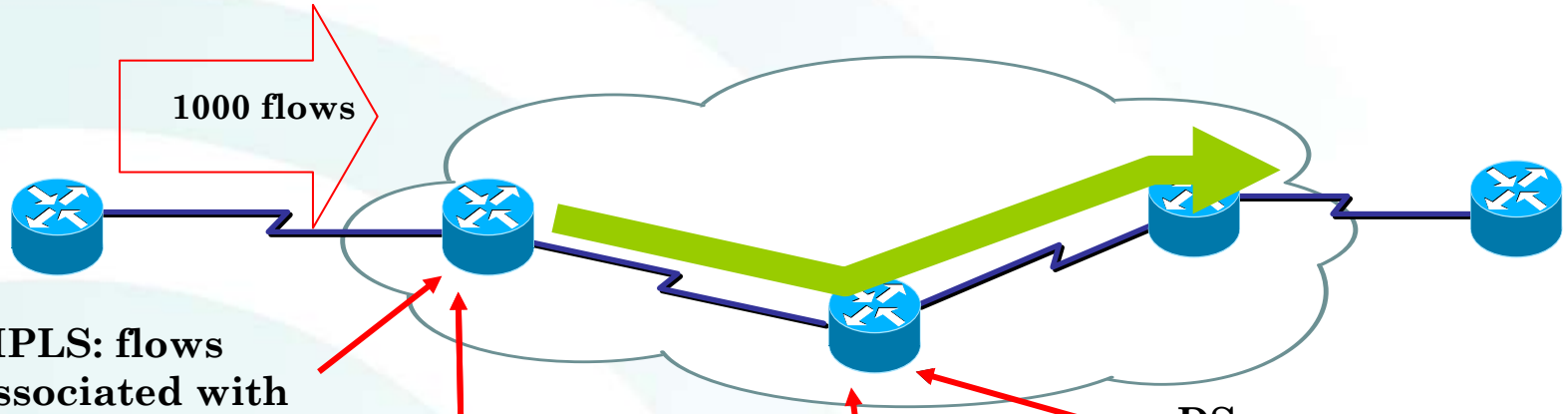
QoS in MPLS Network

- ***MPLS support for QoS***
  - MPLS can support both IntServ and DiffServ
  - MPLS support for DiffServ being standardized (draft-ietf-mpls-diff-ext)

QoS in MPLS Network (cont...)

Co-existence of MPLS & DiffServ is scalable



Co-existence of MPLS & Diff-Serv possible because of same scalability goals, both models do:
- aggregation of traffic on Edge & processing of Aggregate only in Core

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QoS in MPLS Network (cont…)

MPLS & DiffServ

Label Header for Packet Media

Label 20 bits

EXP Experimental Field, 3 bits

S Bottom of Stack, 1 Bit

TTL Time to Live, 8 Bits

- **Can be used over other layer-2 technologies**
- **Contains all information needed at forwarding time**
- **One 32-bit word per label**

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QoS in MPLS Network (cont…)

- ***DSCP & MPLS EXP Bits***
  - DSCP field is not directly visible to MPLS Label Switch Routers (except edge LSR)
  - Information on DiffServ must be made visible to LSR in MPLS Header (using EXP field / Label)

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QoS Deployment Experiences

QoS deployment in MPLS network

- ***Step 1:*** Identifying application requirements
- ***Step 2:*** Defining Policies
- ***Step 3:*** Testing policies
- ***Step 4:*** Implementing policies
- ***Step 5:*** Monitoring & adjusting

QoS Deployment Experiences (Cont....)

Step 1: Identifying Application Requirements

- Importance of an application to the customer
  - What applications are considered "mission critical"?
- Derived from application properties
  - Application performance/quality requirements
  - Properties of the underlying transport protocol stack
- Applications with different properties/requirements should be queued separately
- Interaction of SP's (Service Provider) business team with various enterprise customers (for understanding various service classes profiles in finalizing QoS products)

QoS Deployment Experiences (Cont....)

Step 1: Identify Application Requirements (cont..) - QoS Requirements of Applications example:

	Bandwidth	Delay	Jitter	Loss
Voice Payload	Low	Low	Low	Low
Video Payload - Interactive (2-Way)	High	Low	Low	Low
Video Payload - Streaming (1-Way)	High	High	High	Low
Video Signaling	Low	Low	Medium	Medium
Voice Signaling	Low	Low	Medium	Medium
Data: Interactive,Mission Critical	Variable,typical medium	Medium	Medium	Medium
Data: Not Interactive,Mission Critical	Variable,typically high	High	High	Medium
Data: Interactive,Not Critical	Variable,typical medium	High	High	Medium
Data: Not Interactive,Not Critical	Variable,typically high	High	High	High

QoS Deployment Experiences (Cont….)

Step 2: Defining Policies

- Understanding network topology and traffic flow
- Assessing capacity of network devices (CPU, software, hardware etc.) and network links (speeds, overhead, congestion, etc.)
- Identifying bottleneck and non-bottleneck links
- Trusted and untrusted sources for QoS markings
- Layer 2 vs. Layer 3 service model
- Study & Research by SP's business team to design QoS product profiles (Interactions with various enterprise customers to understand their business application's priorities)
- Co-ordination among SP's business team & technical team till the completion of QoS deployment

QoS Deployment Experiences (Cont….)

Step 2: Defining Policies (cont….) –

- Defining SP's aggregate service class model (Keep minimum number of classes)
- Mapping of customer's service class model to SP's one
- Internet traffic is to be classified as Best Effort
- Defining SLA for customer service classes
- QoS mechanisms to be implemented at network edge & core
- QoS Transparency with MPLS DiffServ Tunneling Modes (Handing of customer's IPP/DSCP bits settings)

QoS Deployment Experiences (Cont....)

Step 2: Defining Policies (cont....) –

Example: QoS Standard Classification and Marking Rule Recommendations

Application	*L3 Classification*			*L2 CoS/MPLS EXP*
	IPP	*PHB*	*DSCP*	
Routing	6	CS6	48	6
Voice	5	EF	46	5
Interactive-Video	4	AF41	34	4
Streaming Video	4	CS4	32	4
Mission-Critical Data	3	—	25	3
Call Signaling	3	AF31/CS3	26/24	3
Transactional Data	2	AF21	18	2
Network Management	2	CS2	16	2
Bulk Data	1	AF11	10	1
Scavenger	1	CS1	8	1
Best Effort	0	0	0	0

QoS Deployment Experiences (Cont….)

Step 3: Testing Policies

- QoS policies function of customer requirement (provided by SP's business team) & SP's n/w's scalability, functionality

- ***Test QoS policies in the lab first***
  - ✓ Testing feasibility of QoS product profiles provided by business team
  - ✓ Testing these profiles under simulation of customer's application traffic entering the SP's n/w stochastically (under L2/L3 MPLS VPN scenario)

QoS Deployment Experiences (Cont….)

Step 3: Testing Policies (cont….)

- ***Test QoS policies in the lab first (cont….)***
  - ✓ Testing SP's vendors QoS implementation for it's routers'/switches' hardware/software (currently functional in SP's n/w) under different L2 encapsulations/markings & L3 protocol (IP)/markings
  - ✓ Testing SP's vendor's n/w OS for whether classification & marking rules are obeyed under default as well as user-defined conditions or not as well as scheduling tools are functioning as expected or not

QoS Deployment Experiences (Cont….)

Step 3: Testing Policies (cont….)

- ***Test QoS policies in the lab first (cont….)***
  - ✓ Testing of QoS service profiles' actual behavior vs. exhibited behavior (both should match)
  - ✓ Testing of QoS profiles for whether there is flexibility in allocation of n/w resources among different service classes
  - ✓ Testing of SLA probing feature available in routers'/switches' software for SLA monitoring & Capacity Planning purpose

QoS Deployment Experiences (Cont….)

Step 3: Testing Policies (cont….)

- ***Test QoS policies in the lab first (cont….)***
  - ✓ Testing integration of this SLA probing feature with SP's current NMS/OSS
  - ✓ Test policy in a small portion of the production network
  - ✓ Run baseline tests with and without QoS under congestion conditions

QoS Deployment Experiences (Cont....)

Step 4: Implementing Policies

- Perform Classification on MPLS PE routers
- Perform policing and marking on MPLS PE routers
- Work toward core applying inbound/outbound policies
- Phased deployment—apply your policies incrementally

QoS Deployment Experiences (Cont….)

Step 5: Monitoring and Adjusting

- Measure delay and loss for different service classes
- Monitor application performance
- Adjust policies where necessary

Thank You

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