Overview

- QoS Problem
- QoS Problem
- DiffServ Architecture
- Per hop behaviors
Problem: QoS

- Billing for service
- Providing of service
  Enforcement of contracts (policing)
- Definition of available services
- Indication of desired service
- Providing of service
- Billing for service

Issues to be resolved

Need a mechanism for QoS in the Internet
Existing Mechanisms

- State still a problem
- Still requires E2E signaling
- Doesn't work with existing apps
- Provides some aggregation
  - ATM VC's

- ATM VC's
  - What will happen
  - Billing and network provisioning hard - ISP doesn't know
  - Defines only a small set of simple services
  - Must be set by clients - doesn't work with existing apps

Current IP TOS/Precedence Bits

Existing Mechanisms
Existing Mechanisms

- Existing apps must be changed (even OSI)
- Useless path state if no reservations exist
- Message overload - RSVP signaling bad
- Link bandwidth
- No way to aggregate - number of reservations scales with
- End to end nature makes billing really hard - bilateral
- No billing denied - useless without

RSVP
Di/BerentiatedServices
Provide a level of QoS between RSVP and current best effort

Key Requirements

- Separate service primitives from implementation
- Flexibility for a wide range of services
- Aggregation between domains
- Core behavior based on aggregates
- Simple, well specified behaviors in core
- Move intelligence and service provisioning to edge
- Must work with existing applications
- No end to end signaling

Differentiated Services
Differentiated Service Architecture

- Markings are in the DS field of IP header (formerly TOS byte)
  - based on markings they have received
- Within the core of the network, routers treat packets solely
  - At the edge of network, boundary router takes packets and
  - Customers can be people or other ISP's or network providers
  - Potentially complex Service Level Agreements (SLA's)
- Services are negotiated with customers in the form of
  - Service Providers (ISP) define services

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Lots of flexibility and innovation in defining services •

- Customer identity
  - Traffic contracts - leaky bucket
  - Application based
  - Locality - per source, per destination
  - Time of day

- Service constraints
  - Absolute/relative throughput
  - Absolute/relative delay
  - Absolute/relative loss

- Quantitative performance metrics

Service Level Agreement comprises

Defining SLAs
Scope of Services

- Services are not defined end to end
- Services are bilateral agreements between peers
  - End user to local ISP
  - Local ISP to Backbone ISP
  - Campus Network to Backbone provider
- Simplifies billing issues
- Provides a clean architecture for provisioning and implementation
Instantiating SLA’s

TwokindsofSLA’s
- StaticSLA’sarepre-provisioned,dynamicaresignalledwhenneeded
- DynamicGeneralpolicymeetsrequirements
  - Well
  - COPSIntegrateswithRSVP
  - LDAPComplexdescriptionspossible,replicationsupported
  - SNMPLacksasynchronousnotification,replicationofdata
  - DIAMETERIntegrateswithRSVPwell

Instanitatieng a dynamic SLA is hard - RSVP

Manyways to instantiate a static SLA in a DS Edge Router
**DiffServ Functional Elements**

- **Domain**: Set of routers under a single policy authority.
- **Interior Router**: Router inside core of network.
- **Edge Router**: Connects to an edge router in a neighboring domain.
- **Region**: Set of contiguous DS Domains.
BORDER ROUTER MARKS PACKETS BASED ON SLA

CUSTOMER SHAPES TRAFFIC TO CONFORM TO PROFILE

CORE ROUTER TREATS PACKETS BASED ON MARKING

BORDER ROUTER MARKS PACKETS BASED ON SLA WITH NEIGHBOR ISP

DS REGION

CUSTOMER
Di/Dg/ErServEdgeRouters

EdgeRouter contains a number of elements

Shaper Shapes traffic based on meter and classifier
Markers Sets DS field in packets based on meter and classifier
Meter Determines traffic characteristics of classified packets
Bandwidth Aggregate Classifier Based only on DS field
Micro Flow Classifier Based on 5-tuple
SLA Treatment to given them
Classifier Looks at fields in the packets to determine what

Differ/Er Edge Routers
DiffServ Edge Router

EDGE ROUTER ARCHITECTURE

SLA DATABASE

CLASSIFIER → METER

MARKER

SHAPER
Likely there will be a small number of PHB’s

- Group PHB’s that only have meaning relative to others form a PHB

- Some PHB’s will be standard, others experimental/proprietary

- Codepoints mapped to PHB’s via a lookup table
  - Not dependent on bits in 5-tuple
  - Should be easily implementable

- Service
  - Does not specify an implementation, just characteristics of
  - Defines low level service treatment the packet should get

\[ \text{Behavior (PHB)} \]

DS field consists of a 6-bit codepoint, identifies a Per Hop

Per Hop Behaviors
Per Hop Behaviors

Best Effort

Current best effort service

Assured

Two PHB’s in this group - high drop priority and low drop priority

Premium

Packets should experience almost no delays. Easily implemented with priority queuing

Services are created by intelligently classifying, metering, and then assigning packets to a small number of PHB’s

Example PHBs and PHB Groups
Receiver Based

- Exception - receiver policies for access links
- Requires co-operating sources
- Requires reverse congestion notification
- Receiver oriented is much harder
- DS mechanisms sender oriented

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The DS Field

TOS BYTE IN IPV4 HEADER

DSCP: Differentiated Services Code Point

CU: Currently Unused

X0: Standardized
11: Experimental, not standards tracked
01: Experimental, used in standards if needed
Interoperability with IntServ

Three modes:

- IntServ aggregation - use IntServ, but aggregate at edges.
- IntServ over DiffServ - DiffServ agreements purchase tunnels over which RSVP can be used to finely manage bandwidth.
- Parallel - both exist, no interaction.
Example SLAs with a single PHB

SLA 1:
- Single PHB 1: packets receive almost no delay or loss

SLA 2:
- Toll quality IP telephony
  - Toll quality IP telephony
  - Implementation: Classifier selects customers' packets. On Saturdays, traffic is leaky bucket shaped to 100 kbps. On weekdays, traffic is leaky bucket shaped to 50 kbps. Packets leaving shaper have PHB 1.

User can send up to 100 kbps with no loss on Saturdays, 50 kbps during week.

Classified traffic is marked with PHB 1, else PHB 0 (best effort)

Traffic based on port/protocol held in headers. All telephony

Implementation: Classifier detects customers' IP telephony

- Toll quality IP telephony

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