S-38.3180: Quality of Service in Internet

Lecture I: Differentiated Services

16.11.2006

Today's Topic

- This part of the lecture is about Differentiated Services architecture

Internet today

- Current Internet:
  - 'Best Effort'-service
    - Equal opportunities (competitive resource sharing)
    - Equal missouries (uncontrolled delays and packet losses)
- Trend:
  - Internet is becoming commercial network with services leveling the commercial incentives

Best Effort Service

- Ideological background
  - Network is used only with good intent and need
- Turned to battle field
  - As fast and soon as possible
- Customer model
  - Access to the 'Internet'
    - Possibility to use shared information resources
- Basis
  - Connectionless packet forwarding
Best Effort Router

- Packets are forwarded based on their destination address
- Scheduling and queuing
  - FCFS
- Equal treatment

Differentiated Services

- Identification of which parallel best effort network packet is destined, is coded in each packet
  - IPv4 ToS field is reformatted
    - No routing nor precedence
    - Generic class identifier

DiffServ Router

- Packets are forwarded based on the destination address and class information
- Scheduling and queuing are done based on the class information

Differentiated Services

- Is combination of mechanisms presented in earlier lectures
- Physically, nothing more than Best Effort
- Logically, number of parallel Best Effort networks
- Packet is destined to one of the parallel networks
  - Packet per packet processed quality of service
  - Connectionless architecture is still preserved
- Each parallel network uses same routing topology (not necessarily)

DiffServ Router

- Packets are forwarded based on the destination address and class information
- Scheduling and queuing are done based on the class information

Control Plane

Policy Control

Scheduler

Classifier

Forwarder

User Plane

DiffServ Router

Policy Control

Scheduler

Classifier

Forwarder

User Plane

Best Effort Router

Control Plane

Routing

Forwarder

Scheduler

User Plane
**DiffServ Router**

- DiffServ router has one additional element in datapath compared to basic Best Effort router:
  - **Conditioner**
- Control plane of a DiffServ router has one extra element ie policy controller, which is responsible of internal management and configuration of conditioner and scheduler.

**DiffServ PHB**

- Per hop behavior is block which contains queue management methods required to implement desired service
  - Queues
  - Queue space management algorithms
  - Schedulers

**DiffServ Conditioner**

- Traffic Conditioner is constructed a set of
  - Classifiers
    - Responsible of logical separation of packet streams
  - Meters
    - Responsible of rate metering of logical streams
  - Markers
    - Responsible of actions based on metering results and predefined thresholds

**DiffServ terminology**

- Workload in DiffServ is divided between two inherently different types of routers
  - Edge routes
  - Core routers
- Edge routers are on the domain edge interfacing
  - Customer
  - Other ISP
- **Edge routers** are responsible of conditioning actions which eventually determine the logical network where packet is to be forwarded.
**DiffServ terminology**

- **Logical network is concatenation of PHBs which interact together.**
- These logical networks have target service called **per domain behavior (PDB).**
- Target service is loose definition for the goal of the logical network when it is provisioned and configured in a predefined way.
- Edge router chooses PDB for each packet which comes from the customer
  - Marks packet with DSCP of PHB used to implement PDB

**DiffServ**

- Service decision in edge router can be based on:
  - **Metering result**
    - Rate based
  - **Predefined set of filters**
    - IP address ie customer
    - TCP/UDP port ie application
  - **User request**
    - Precoded DSCP
    - RSVP signaling

- Core routers do nothing but forwarding of packets based on the extra information in DSCP field of packets
- Requires
  - Classifier to detect DSCP fields
  - PHB to implement forwarding behaviors

**Service classes**

- Differentiated Services is aligned between Best Effort and IntServ
- There is counterpart for each IntServ service class in DiffServ
  - Guaranteed Service <-> Expedited Service
  - Controlled Load <-> Assured Forwarding

**Expedited Forwarding (EF) [RFC2598]**

- Leased line emulation
  - From destined ingress point to destined egress point
  - End-to-end service with
    - Low loss
    - Low latency
    - Low jitter
    - Assured bandwidth
Assured Forwarding (AF) [RFC2597]

- **Four** independent service classes
  - All packets of a flow are destined to one of the classes
  - No association of service level between the classes
- **Three** precedences in each class
  - Flow can have packets with different precedences
  - Order of packets in all flow is not allowed to change
  - Precedence can not be used to scheduling decisions inside the class

<table>
<thead>
<tr>
<th>Precedence</th>
<th>Class</th>
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<tbody>
<tr>
<td>AF13</td>
<td>AF13</td>
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<td>AF23</td>
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<td>AF33</td>
<td>AF33</td>
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<td>AF43</td>
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</tbody>
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- **Leased Line**
  - Dedicated resources
  - Full isolation
  - No room for overflow
- **Virtual Leased Line**
  - Shared resources
  - Partial isolation
  - From other than leased line traffic
  - Can accommodate overflow
  - Vague service guarantee

- **Control of service guarantee**
  - Access control
  - Rate control
  - User control
  - Provisioning
  - At least sum of contracted rates is allocated to EF traffic
  - High priority in the network
  - Scheduled ahead of other traffic
  - Starvation of lower priorities?
  - Only small fraction of total link capacity (10-30%)
AF

- **Class differentiation**
  - Associate timing
    - Real-time to Bulk
  - Associate money
    - First class to cattle class
  - Associate user
    - CEO to laundry man
  - Associate protocol
    - TCP / UDP
  - Associate application
    - Clustering of similar application types

- **Precende differentiation**
  - Associate rate
    - Under/over subscription
  - The rest same as class based except timing can not be used

AF

- Construct services based on previous aspects
  - Many dimensions of freedom
  - How to make sure that system can not be manipulated
    - User control vs Network control

<table>
<thead>
<tr>
<th>Best-Effort Service</th>
<th>Differentiated Service</th>
<th>Integrated Service</th>
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<tbody>
<tr>
<td>Connectionless</td>
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<td>Connection-oriented</td>
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<tr>
<td>Aggregated state</td>
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<td>End2End session state</td>
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<td>Local session state</td>
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<td>Session signaling [RSVP]</td>
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<td>Admission control</td>
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<td>Leaky-bucket traffic control</td>
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<tr>
<td>CoS</td>
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<td>Per-flow QoS</td>
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<tr>
<td>Per-class WFQ¹</td>
<td></td>
<td>Per-class and/or per-flow WFQ</td>
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</tbody>
</table>

¹ Border routers may keep track individual sessions if required by policing or multifield classification.
² Scheduling depends on per hop behavior [PHB]. Minimum requirement is FIFO with multilevel RED.