S-38.3180: Quality of Service in Internet

Lecture I: Differentiated Services

15.11.2007

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 miseries (uncontrolled delays and packet losses)
    - Ideology: network is used with good intent
    - Reality: as fast and soon as possible
  - Customer model
    - Access to the ‘Internet’
      - Possibility to use shared information resources

Best Effort Router

- Packets are forwarded based on their destination address
- Scheduling
  - FCFS
- Queue Management
  - RED
- Equal treatment of traffic
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)

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

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version</td>
<td>4</td>
</tr>
<tr>
<td>Type</td>
<td>4</td>
</tr>
<tr>
<td>Protocol</td>
<td>0</td>
</tr>
<tr>
<td>Length</td>
<td>20</td>
</tr>
<tr>
<td>Identification</td>
<td></td>
</tr>
<tr>
<td>TOS</td>
<td>DSCP</td>
</tr>
<tr>
<td>Flags</td>
<td></td>
</tr>
<tr>
<td>Offset</td>
<td></td>
</tr>
<tr>
<td>TTL</td>
<td></td>
</tr>
<tr>
<td>Source Addr</td>
<td></td>
</tr>
<tr>
<td>Destination Addr</td>
<td></td>
</tr>
<tr>
<td>Options</td>
<td></td>
</tr>
<tr>
<td>Checksum</td>
<td></td>
</tr>
<tr>
<td>PAR</td>
<td>PAR</td>
</tr>
</tbody>
</table>

DiffServ Router

- Packets are forwarded based on the destination address and class information (DSCP)
- Scheduling and queue management are done based on the class information
  - Each coded DSCP value has own resource policy

DiffServ Router

- DiffServ router has one additional element in forwarding path compared to basic Best Effort router:
  - Controller
- 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 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 PHB**

- Per hop behavior is block which contains queue management methods required to implement desired service:
  - Queues
  - Queue space management algorithms
  - Schedulers
- Black Box transfer function for individual device

---

**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).
  - Black Box transfer function of a domain
- 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

Core routers do nothing but forwarding of packets based on the extra information in DSCP field of packets.

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

- Service commitment is only assured
  - Resources inside EF class are shared
    - Amount of other EF traffic influences to the value of delay, jitter and loss
  - Path is freely chosen
    - Delay constraint can not be held as the delay of paths are inherently different
  - No reservation is done
    - Provisioning is in the key role
**EF**

- **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

- 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></th>
<th>Best-Effort Service</th>
<th>Differentiated Service</th>
<th>Integrated Service</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Connectionless</td>
<td>Aggregated state</td>
<td>Connection-oriented</td>
</tr>
<tr>
<td></td>
<td>Local session state</td>
<td>End2End session state</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Session signaling [RSVP]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Admission control</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leaky-bucket traffic control</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CoS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Per-flow QoS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Per-class WFQ(^1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Per-class and/or per-flow WFQ</td>
<td></td>
</tr>
</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.