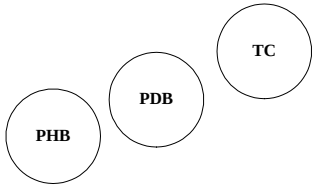
S-38.3180: Quality of Service in Internet

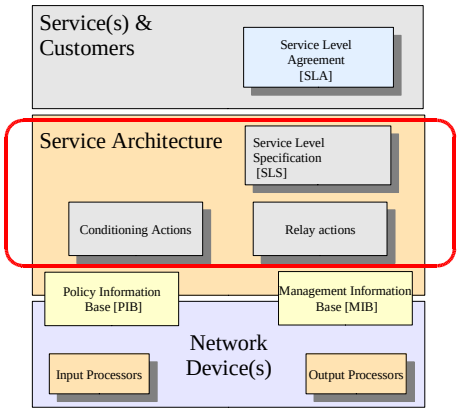
Lecture I: Differentiated Services

15.11.2007

Today's Topic

- This part of the lecture is about Differentiated Services architecture



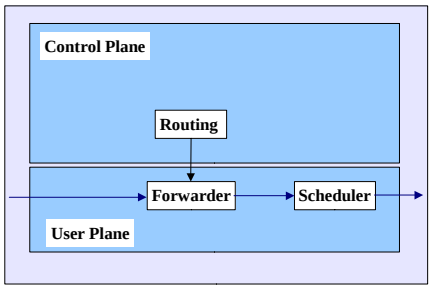


Internet today

- 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

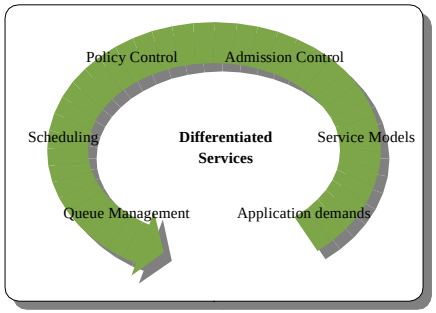
Best Effort Router

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



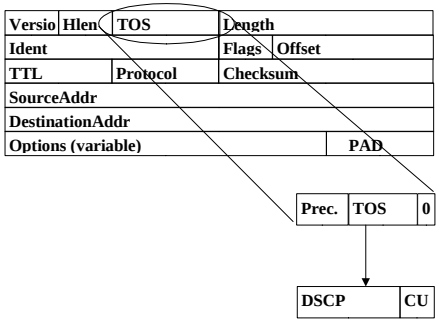
Differentiated Services

- 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 neccesarily)



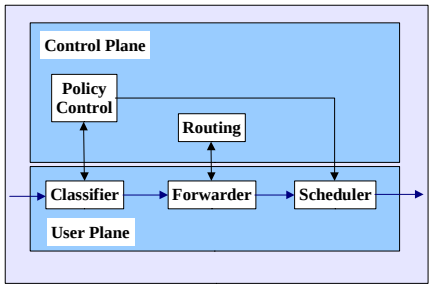
Differentiated Services

- 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



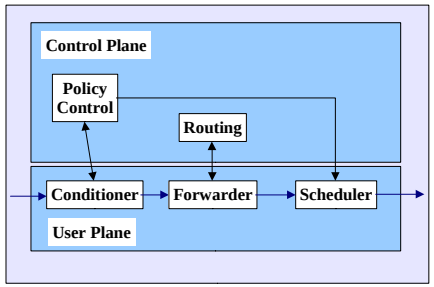
DiffServ Router

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



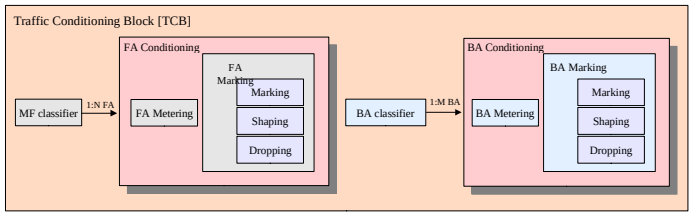
DiffServ Router

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



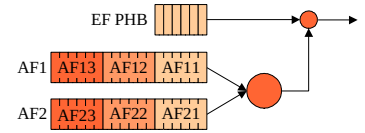
DiffServ Conditioner

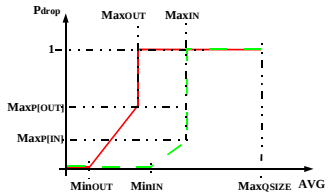
- Traffic Conditioner is constructed a set of
  - Classifiers
    - Responsible of logical separation of packet streams
  - Meters
    - Responsible of rate metering of logical streams
  - Markers
    - Responsible of actions based on metering results and predefined thresholds



DiffServ PHB

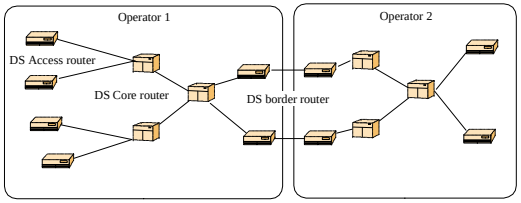
- Per hop behavior is block which contains queue management methods required to implement desired service
  - Queues
  - Queue space management algorithms
  - Schedulers
- Black Box transfer function for individual device





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

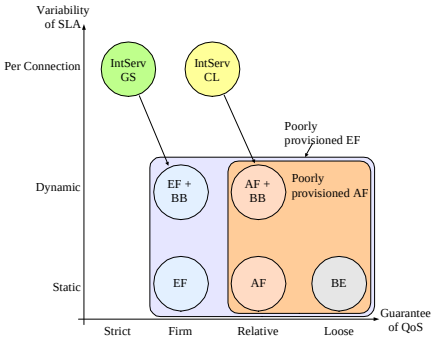
- **Logical network is concatenation of PHBs which interact together.**
- These logical networks have target service called **per domain behavior** (PDB).
  - Black Box transfer function of a domain
- Target service is loose definition for the goal of the logical network when it is provisioned and configured 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 decission 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

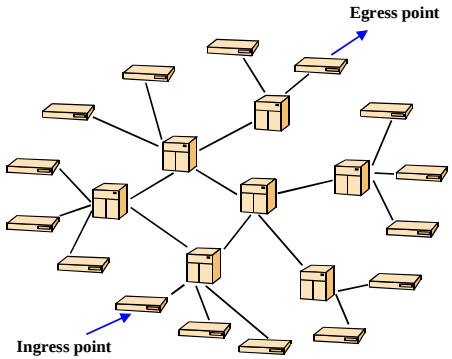
Service classes

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



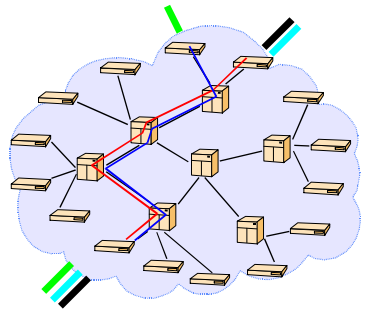
Expedited Forwarding (EF) [RFC2598]

- **Leased line emulation**
  - From destined ingress point to destined egress point
  - End-to-end service with
    - Low loss
    - Low latency
    - Low jitter
    - Assured bandwidth



EF

- 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**

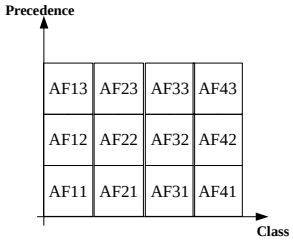


EF

- **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%)

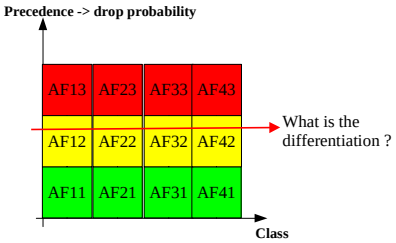
Assured Forwarding (AF) [RFC2597]

- **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 a flow is not allowed to change
    - Precedence can not be used to scheduling decissions inside the class



AF

- No end-to-end semantics
  - Service can be deployed as any to any service
    - Like today
  - Uncontrollable resource usage inside the network
    - Very vague QoS
  - Class / precedence in contrast to service guarantee ???

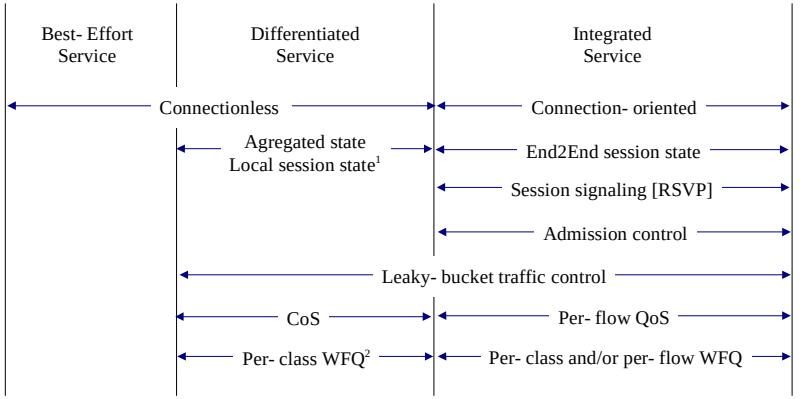


AF

- **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 exept 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



[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.