**S−38.180 Palvelunlaatu Internetissä**

S−38.180 Quality of Service in Internet

Luento 8: Differentiated Services

Lecture 8: Differentiated Services

Today's Topic

- This 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

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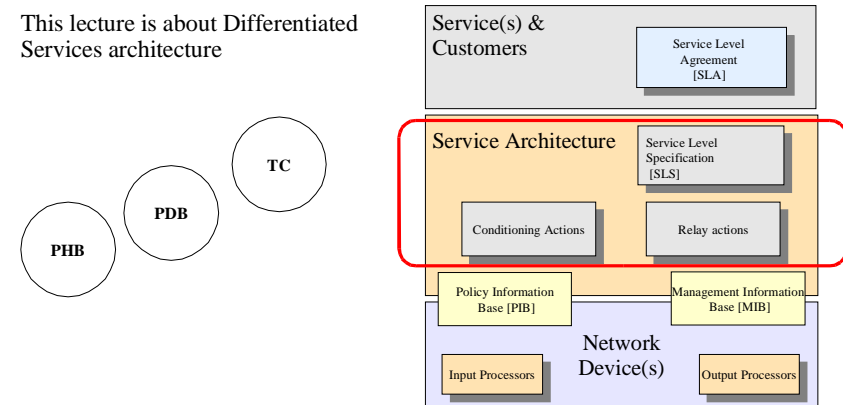
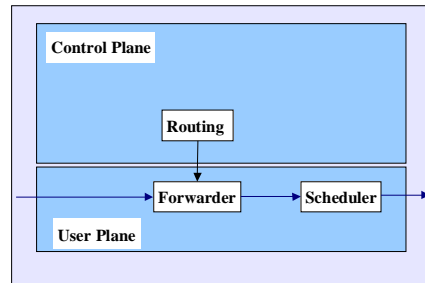# Best Effort Service

- 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
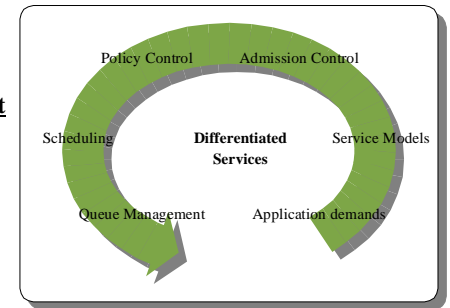 - Connectionless packet forwarding

Best Effort Router

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

Control Plane

Routing

Forwarder → Scheduler

User Plane
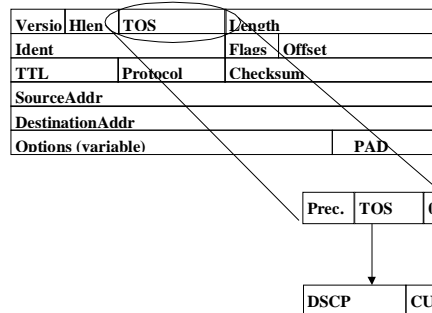
Differentiated Services

- Is combination of mechanisms presented in lectures 3, 4 and 5
- Physically, nothing more to 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)

Policy Control   Admission Control

Scheduling   **Differentiated Services**   Service Models

Queue Management   Application demands

Differentiated Services

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

Versio	Hlen	TOS	Length	
Ident			Flags	Offset
TTL		Protocol	Checksum	
SourceAddr				
DestinationAddr				
Options (variable)			PAD	

| Prec.	TOS	0

DSCP	CU

DiffServ Router

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

Control Plane

Policy Control

Routing

Classifier → Forwarder → Scheduler

User Plane
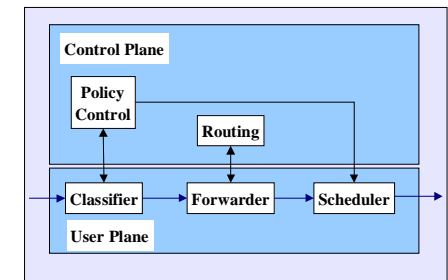
DiffServ Router

- DiffServ router has two additional elements in datapath compared to basic Best Effort router:
  - Traffic conditioner (TC)
  - Per hop behavior (PHB)
- Control plane of DiffServ router has one extra element ie policy controller, which is responsible of internal management and configuration of TC and PHB
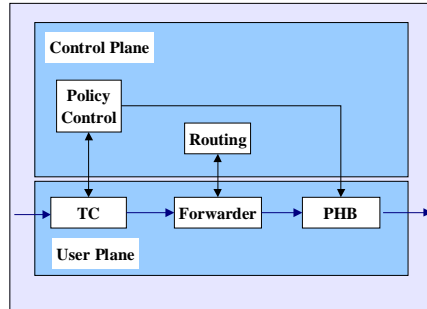
DiffServ Conditioner

- 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
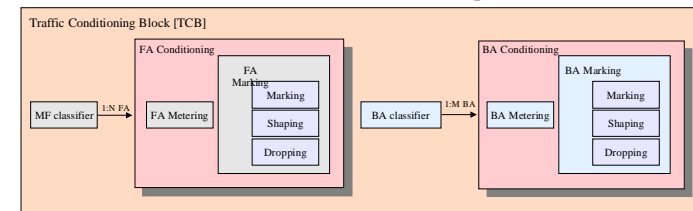
DiffServ PHB

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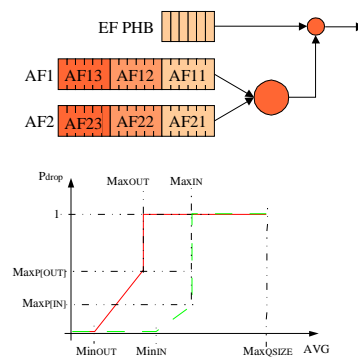
DiffServ terminology

- 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 logical network where packet is to be forwarded
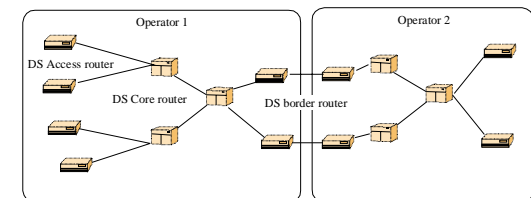
DiffServ terminology

- 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 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
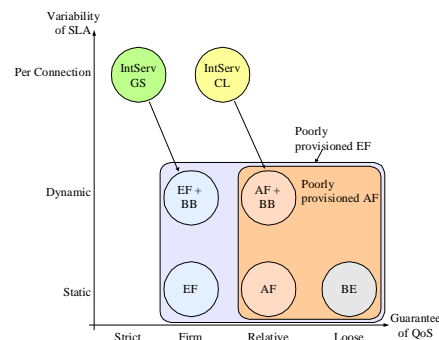
Expedited Forwarding (EF) [RFC2598]

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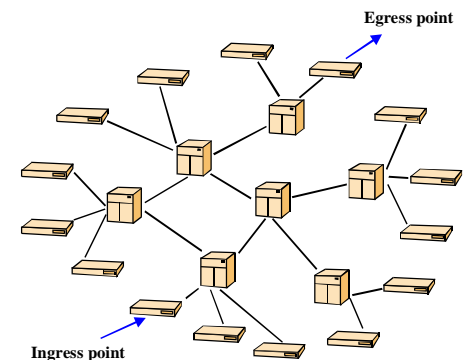
EF

- Service commitment is <u>only</u> 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
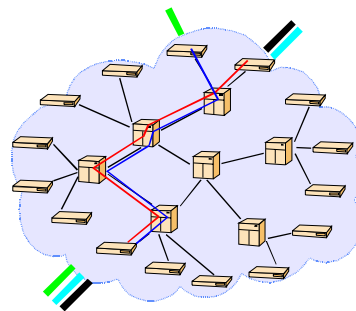
EF

- 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
    - <u>At least</u> sum of contracted rates is allocated to EF traffic
    - High priority in the network
      - Scheduled ahead of other traffic
      - Starvation of lower priorities ?
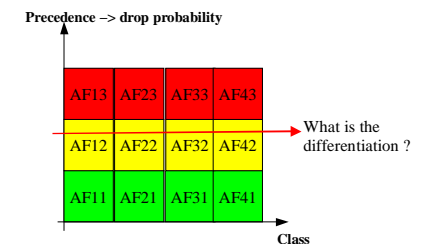   - » Only small fraction of total link capacity (10–30%)

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

Precedence

AF13	AF23	AF33	AF43
AF12	AF22	AF32	AF42
AF11	AF21	AF31	AF41
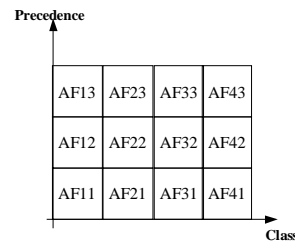
Class

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
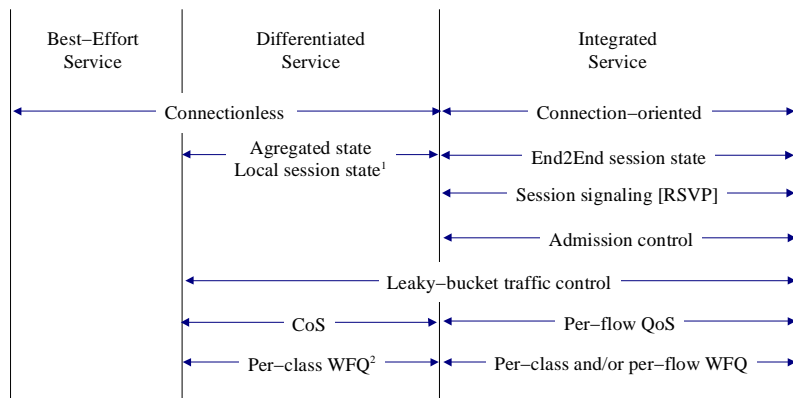 - Class / precedence in contrast to service guarantee ???

Precedence –> drop probability

AF13	AF23	AF33	AF43
AF12	AF22	AF32	AF42
AF11	AF21	AF31	AF41

What is the differentiation ?

Class

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

Best–Effort Service	Differentiated Service	Integrated Service
Connectionless		Connection–oriented
	Agregated state Local session state[1]	End2End session state
		Session signaling [RSVP]
		Admission control
Leaky–bucket traffic control		
CoS		Per–flow QoS
Per–class WFQ[2]		Per–class and/or per–flow WFQ

[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.