



S-38.3180: Quality of Service in Internet

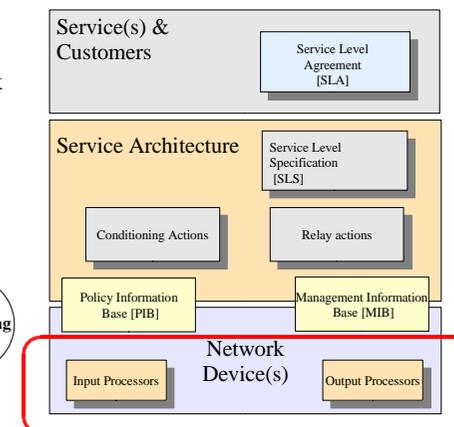
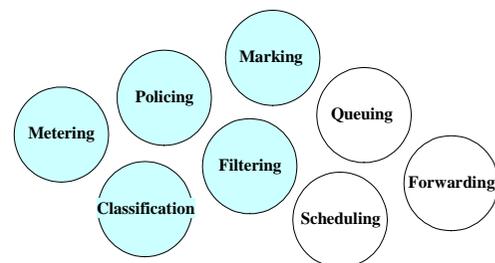
Lecture II: Ingress Traffic Processing

1.11.2006



Today's Topic

- This lecture is about functional mechanisms which can be found from the input processors of network devices



Terminology

- Connection:** is dynamically formed reservation of network resources for a period of time.
 - Connection requires a **state** to be formed inside the network
 - State is a filter defining packets which belong into particular connection and required reservation attributes
- Flow:** is formed from arbitrary packets which fall within predefined filter and temporal behavior.
 - Packets from one source to same destination arrive to investigation point with interarrival time less than t seconds.



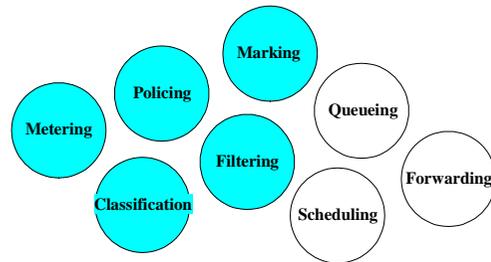
Terminology

- Aggregate:** is a group of flows which have same forwarding characteristics and share link resources.
- Class:** is a group of connections which share same forwarding characteristics.



Input processor

- Input processor of Internet router consists several mechanisms
 - Filtering
 - Classification
 - Metering
 - Policing
 - Marking
 - Shaping



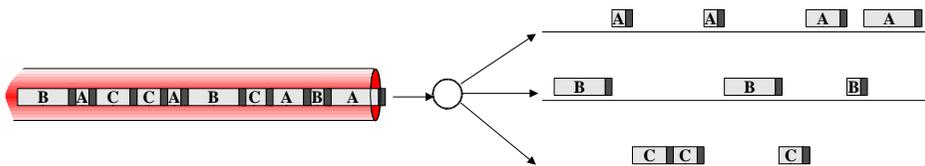
Classification

- Individual **connections** can be recognized by looking sufficient number of protocol fields.
- This is used in **Integrated Services** architecture.
- IntServ uses reservation protocol for informing the network about fields which should be examined.
- If per connection accuracy is not needed or can not be feasibly implemented is **aggregate** based operation the answer.
- This is used in **Differentiated Services** architecture.
- Aggregate is based on static filters covering broad range of different connections i.e. aggregating connections to one logical unit



Classification

- **Classification** is process where packets in the packets stream are separated into **n** logically separate packet streams.
- These streams are then treated as separate entities for which different actions are performed
- Separation is based on **filters** which match packet content to the filtering rules.



Filtering

- Commonly filters are based on IP packet / transport header information
 - IP addresses
 - Protocol information
 - DSCP-field
 - Port information
 - Length information

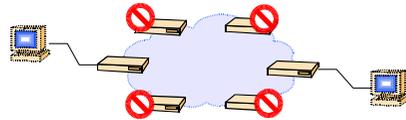
Version	IHL	ToS/DSCP	Length	
Identification		Flags	Offset	
TTL	Protocol		Checksum	
Source Address			Destination Address	
Options		Padding		
Source Port		Destination Port		

- Generally **any fixed block of bits** can be used as a filter
- Commonly used notion for filter ->Five tuple = (SourceIP, DestinationIP, Protocol, SourcePort, DestinationPort)



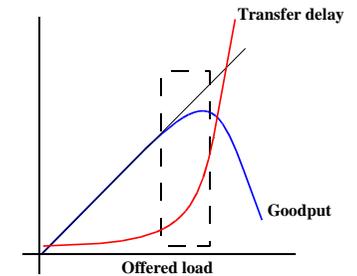
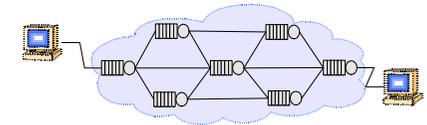
Service Level Management

- QoS based networks need careful management
 - How to provision the network so that there will not be unnecessary queuing or packet loss
 - How to control the amount of traffic that gets into the network
- Network level
- Customer level / connection level
- Packet level



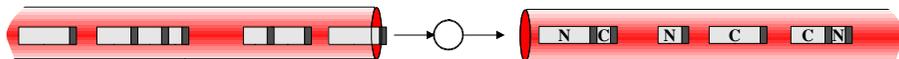
Service Level Management

- Overall objective is to offer QoS and/or maximize network throughput
- This requires
 - Limiting user traffic to the level that individual links operate on optimal fashion
 - Individual links can not be fully utilized
 - Unequal capacities
 - Uncertainty of paths
 - Uncertainty of demands



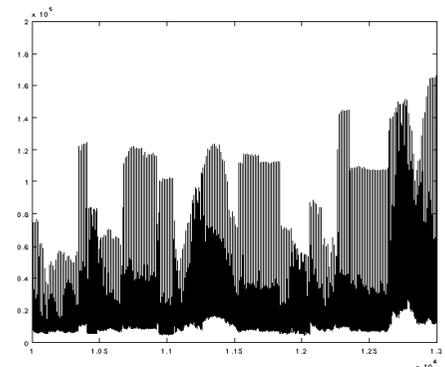
Rate Control

- Task is to decide which user packets should be **delivered** into the network and on what priority (**mark**)
 - They do not violate QoS management principles within the network by overloading the network
- Rate control operates in three levels
 - **Measures** the traffic
 - **Compares** the measured information to information in user / network policy
 - **Executes** policy based on comparison results
 - Marking
 - Dropping
 - Shaping



Rate Control

- User traffic process is largely dependent on application which is used.
 - Some applications produce constant traffic stream
 - Fixed size packets
 - Constant interarrival times
 - Other may produce bursts of packets
 - Variable size packets
 - Variable interarrival times





Rate Control

- **Objectives:**
 - **Simple**
 - Easy algorithm
 - Few parameters
 - **Accurate**
 - Actions are correct
 - Actions are transparent
 - Actions are immediate
 - **Predictable**
 - Action are consistent from time to time
- **Requires:**
 - Parametrization of user traffic
 - Either flow level
 - Or Aggregate level
 - This is bound to SLA made with the ISP



Metering

- Packet stream is measured to find out some of the following parameters:
 - *Peak rate* - maximum rate on which user is sending
 - *Sustained rate* - average rate on which user is sending
 - *Burst size* - maximum burst size which user sending on either with peak or average rate
- Actual measurement of information may be based on
 - Continuous time measurement
 - Discrete event analysis
 - Window based analysis

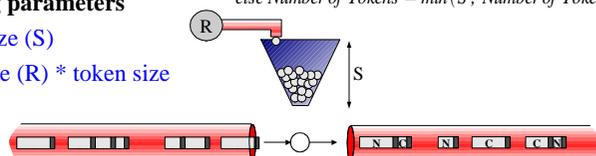


Token Bucket

- Produces information whether arrival rate is more or less than the threshold
- Algorithm is based on
 - Number of tokens in token bucket (in bytes)
 - Arrival time ($T_{Now}, T_{Last Arrival}$)
- **Two limiting parameters**
 - Bucket size (S)
 - Token rate (R) * token size

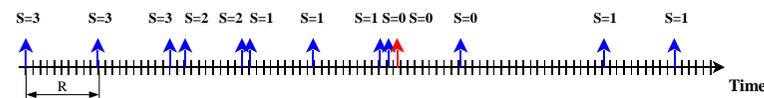
Initial condition:
 $Number\ of\ Tokens = S$

Upon each arrival:
 $Increment = TokenSize \cdot R \cdot (T_{Now} - T_{Last\ Arrival})$
 $Decrement = PacketLength$
 $Conformance = Number\ of\ Tokens + Increment - Decrement$
 if $Conformance \geq 0$
 then $Number\ of\ Tokens = \min(S, Conformance)$
 else $Number\ of\ Tokens = \min(S, Number\ of\ Tokens + Increment)$



Token Bucket

- **In ideal situation**
 - Packets arrive with intervals of token generation rate (R)
 - Packets are size of token
 - **Variation of arrivals is compensated with bucket size (S)**
 - **Allows bursting**
- Example:
 - R=10
 - S=3





Packet per packet EWMA meter

- Measures packet stream by using exponentially weighted moving average filter.

- Tunable by parameter

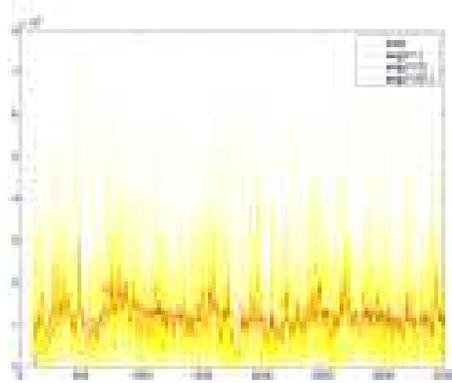
- Memory (ϵ)

Initial condition:

$$avg(0) = 0$$

After every packet arrival

$$avg(n+1) = (1-\epsilon) \cdot avg(n) + \epsilon \cdot \frac{PacketLength}{t_{n+1} - t_n}$$



Windowed EWMA meter

- Measures packet stream by using exponentially weighted moving average filter with sampling window.

- Tunable by parameters

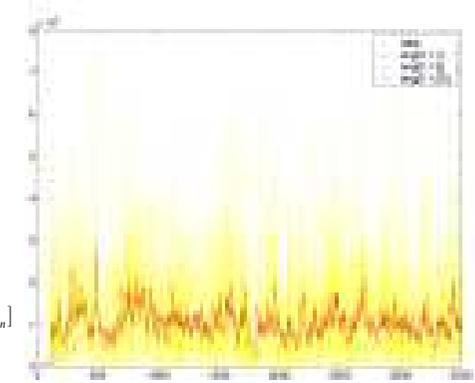
- Memory ()
- Sampling interval (ΔT)

Initial condition:

$$avg(0) = 0$$

After every ΔT time units

$$avg(t_{n+1}) = (1-\epsilon) \cdot avg(t_n) + \epsilon \cdot \text{bytes during } [t_{n+1}, t_n]$$



Time Sliding Window Meter

- TSW is memory based, windowed average rate estimator
- Tunable by parameter
 - Window length

Initial condition:

$$avg(0) = 0$$

$$Win_{length} = C$$

$$T_{front} = 0$$

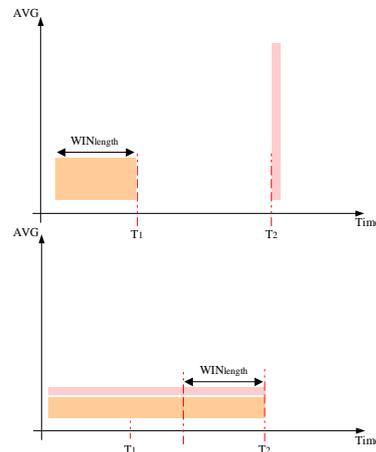
After every packet arrival:

$$Bytes_{TSW} = avg(n) \cdot Win_{length}$$

$$New_{bytes} = Bytes_{TSW} + PacketLength$$

$$avg(n+1) = \frac{New_{bytes}}{T_{now} - T_{front} + Win_{length}}$$

$$T_{front} = T_{now}$$



Metering

- Based on the measured information a conformance statement is declared
- Conformance is the observation whether the measured variable is within predefined boundaries.**
 - Customer has contracted rate of X bps with variation of x bps
 - Customer has contract of average rate X bps and peak of Y bps. He is allowed to send bursts of Z kB in peak rate.



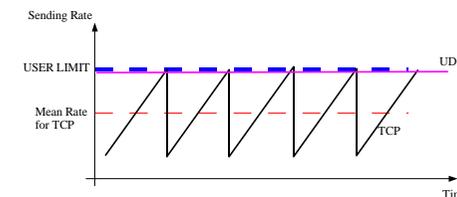
Conformance algorithms

- **Strict conformance**
 - Packets exceeding contracted rate are marked **immediately** as non-conforming
- **TSW conformance**
 - Packets exceeding **1.33 times** contracted rate are marked as non-conforming
- **Probability conformance**
 - Packets exceeding contracted rate are marked as non-conforming with **increasing probability**



Rate Control Problems

- Two parallel transport protocols with contradicting control:
 - UDP - with no control
 - TCP - with additive increase exponential decrease rate control
- **Problem:** Metering system cannot easily offer fair service to both TCP and UDP clients in the same system.



Marking

- Marker is used to attach conformance / class information to every packet.
- Marker uses IPv4 TOS/DSCP field to convey information for other processing elements in the network.
 - TOS
 - Prec: 3 bit priority
 - TOS: user preference for routing
 - DSCP
 - Class and precedence

Version	Header	TOS	Length	
Ident		Flags	Offset	
TTL	Protocol	Checksum		
SourceAddr				
DestinationAddr				
Options (variable)				PAD
		Prec.	TOS	0



Shaping

- Shaping is a functionality where incoming traffic is put into finite input buffer. This buffer is served by Token Bucket scheduler leading to fixed rate influx of traffic into forwarding process.
 - Packets are served
 - Immediately: if actual input rate is lower than service rate
 - Empty server
 - Delayed: if actual input rate is occasionally higher than service rate
 - Queued packet
 - Never: if actual input rate is constantly higher than service rate
 - Buffer overflow



Shaping

- Shaping of the traffic is important when there are
 - Large differences on link speeds
 - Speed of the transmission network is lower than speed of the IP interface
 - Bursts of packets from router interface will overflow transmission systems
 - Bounded capacity services with high reliability demands
 - There are lower probability of overflow if traffic is shaped well below link rate