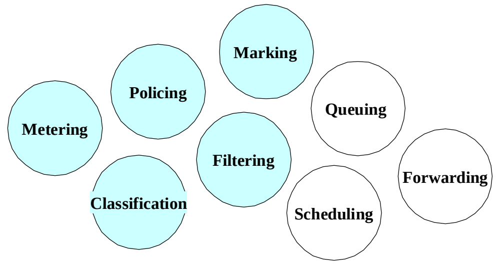
S−38.180: Quality of Service in Internet

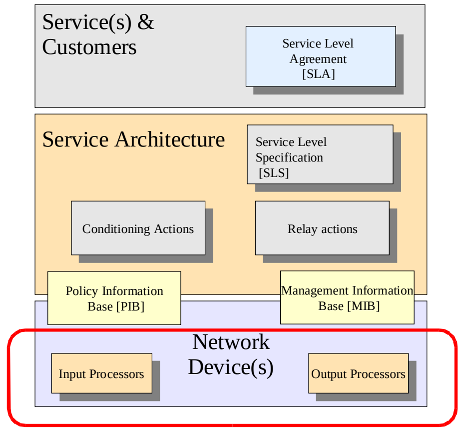
Lecture II: Ingress Traffic Processing

18.9.2003

Today's Topic

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





Terminology

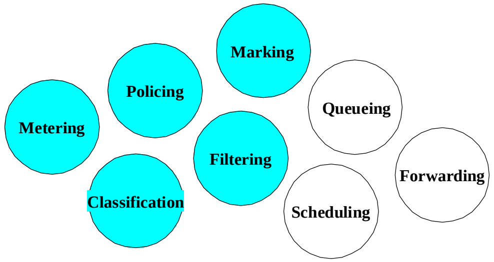
- **Connection**: is dynamically formed reservation of network resources for a period of time.
  - Connection requires a state to be formed inside the network
  - State is a filter defining packets which belong into particular connection and required reservation attributes
- **Flow**: is formed from 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

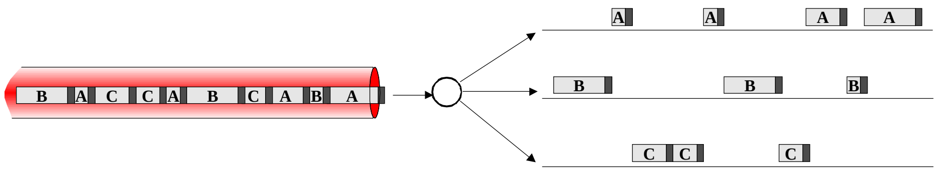


Classification

- 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

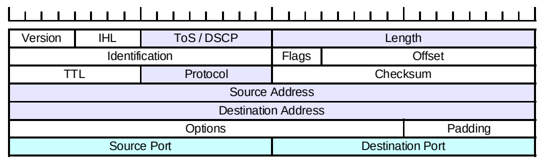
Classification

- 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

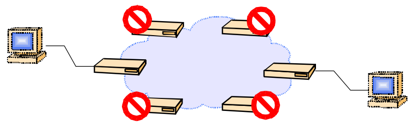
- Commonly filters are based on IP packet / transport header information
  - IP addresses
  - Protocol information
  - DSCP−field
  - Port information
  - Length information



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

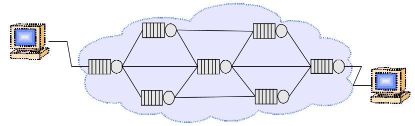
Service Level Management

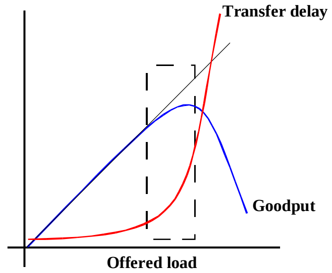
- QoS based networks need careful management
  - How to provision the network so that there will not be unnecessary queuing or packet loss
  - How to control the amount of traffic that gets into the network
- Network level
- Customer level / connection level
- Packet level



Service Level Management

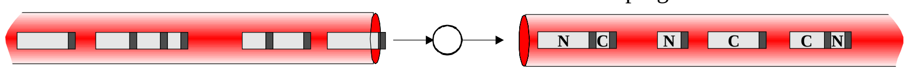
- Overall objective is to offer QoS and/or maximize network throughput
- This requires
  - Limiting user traffic to the level that individual links operate on optimal fashion
  - Individual links can not be fully utilized
    - Unequal capacities
    - Uncertainty of paths
    - Uncertainty of demands





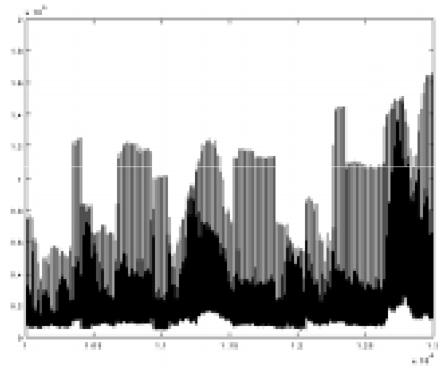
Rate Control

- 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:

$Increment = TokenSize \cdot R \cdot (T_{Now} - T_{Last\ Arrival})$

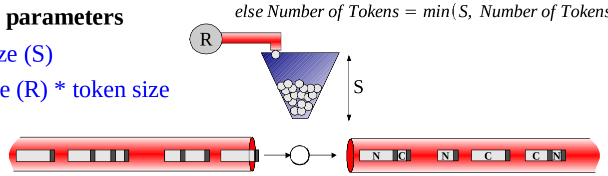
$Decrement = PacketLength$

$Conformance = Number\ of\ Tokens + Increment - Decrement$

$if\ Conformance \geq 0$

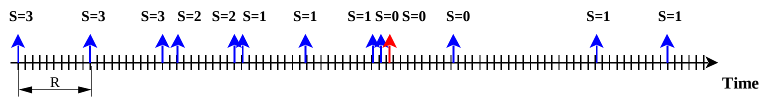
$then\ Number\ of\ Tokens = min(S,\ Conformance)$

$else\ Number\ of\ Tokens = min(S,\ Number\ of\ Tokens + Increment)$



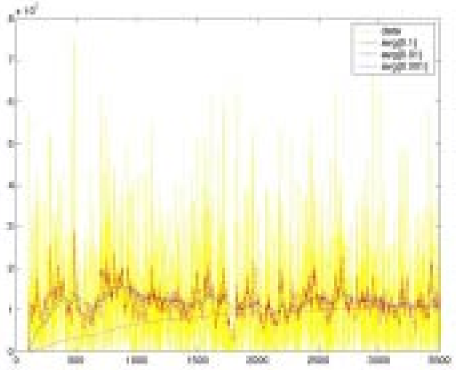
Token Bucket

- 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:

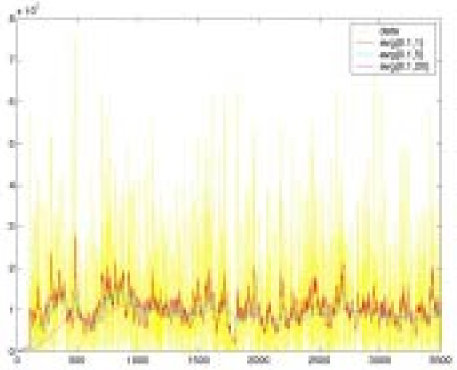
$avg(0) = 0$

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 (ϵ)
    - Sampling interval (ΔT)



Initial condition:

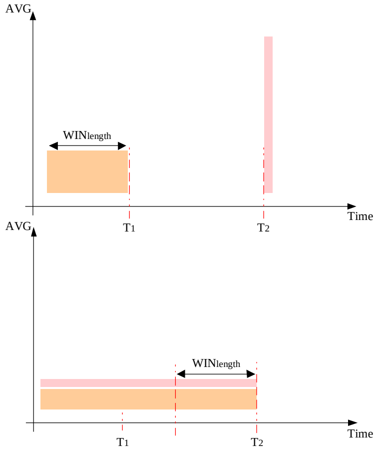
$avg(0) = 0$

After every ΔT time units

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

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:

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

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

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

$T_{front} = T_{now}$

Metering

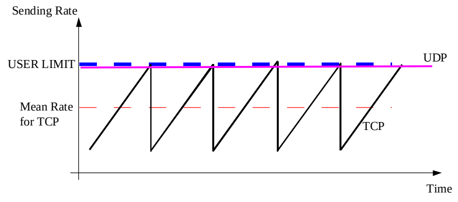
- Based on the measured information a conformance statement is declared
- **Conformance is the observation whether the measured variable is within predefined boundaries.**
  - Customer has contracted rate of ***X*** bps with variation of ***x*** bps
  - Customer has contract of average rate ***X*** bps 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