S-38.3180:Quality of Service in Internet

Lecture I: Quality and/or Differentiation

1.11.2006

Material

- **The course textbook**
  - Zheng Wang: "Internet Quality of Service: Architectures and Mechanisms "
    - ISBN: 1-55860-608-4
- **Lecture slides** to support the lectures
  - these are NOT to be taken as a standalone material or as a replacement for the book
- **Additional reading**
  - A selected set of related journal and conference papers and articles
- **Exercise material** to aid in completing the exercise and to provide background information

Exercises

- Selected topics from the course
  - **Simulations**
  - **Analysis**
- All exercises **must** be passed to get grade from the course
- Course grading is (tentatively)
  - 40% of exercises
  - 60% of exam
- Deadlines
  - **Each exercise has individual DL**
    - Usually week or two from the start
      - Late submission lowers the grade
    - Final DL is one week after last exercise
      - Late submissions are not graded

What is this course about

- We are going to try and try and try to get you to understand basics of
  - **Differentiation and Quality of Service**
    - What is the difference between these two
    - What have been standardized on these areas
    - Why to choose this or that for particular application
    - What is the big picture behind all of this
    - What are the small pieces that form the big picture
    - Are there any sense to make these things
      - Is there any sense to keep these lectures

Keep in mind through out the course

- **Money talks and bullshit walks**
  - There will be no quality without additional money
    - Providing quality has to be profitable business for network providers
      - Provisioning of QoS is expensive it requires
        - » Additional mechanisms into the routers – investments into equipments (CAPEX)
        - » A whole a lot engineering, monitoring and dimensioning – investments into manpower (OPEX)
  - Increase of revenue and profit boosts share value
    - Profit comes from
      - The lower OPEX
      - Higher value of the bit

Increasing the revenue

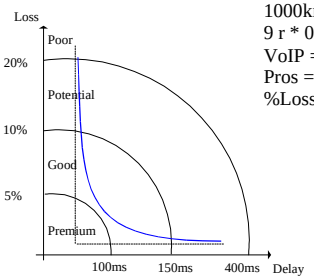
- Increase of the traffic
  - More customers to the existing infrastructure
    - Lower experienced quality for individual customer
      - Some customers are expected to leave
    - Revenue is increased by factor of new customers
    - Cost of bit is lower (fixed OPEX divided into larger amount of bits)
      - Increased profitability
- Differentiation of bits and packets
  - Customer population is split into different categories
    - Different quality for different customers
    - Different quality for different traffic
      - Cost per bit is higher
        - » Increased CAPEX and OPEX
      - Price for individual bit is higher
      - Profitability may not increase

Convergence

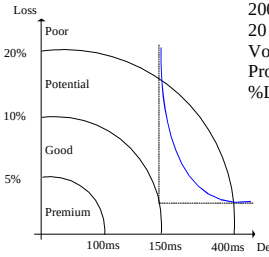
- **IP is the next try for ubiquitous integration platform**
  - All services are going to be delivered by using it (at least it is going to be tried)
  - Convergence means that different media streams share common forwarding plane (IP)
    - Different medias have different requirements but there is only one IP
      - Which suits basically for nothing but bulk datagram service

VoIP

- **With real-time conversational services delay (jitter) plays essential role**
  - 200ms one-way delay is absolute maximum for tolerable operation
  - Also they expect to have their packets on steady intervals



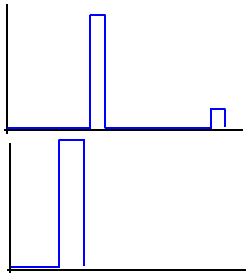
1000km * 5us = 5ms
9 r * 0.5ms/r = 4.5ms
VoIP = 20ms
Pros = 20 ms
%Loss = 1



20000km * 5us = 100ms
20 r * 0.5ms/r = 10ms
VoIP = 20ms
Pros = 20 ms
%Loss = 3

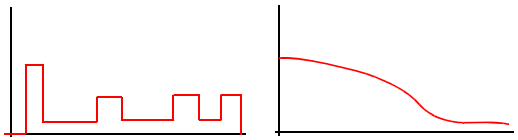
VoIP

- Way they send their information is controlled by the fact that information is generated from sampling of analog information
  - PCM-codec uses 125us samling interval with 7/8 -bit samples
  - VoIP software usually buffers these samples for 10-30ms to produce decent packages (100-300 bytes)
    - Therefore there is a peak in
      - Time spectrum due to framing period
      - Packet size spectrum due to almost non-existing compression
        - » Change in this has happened with certain new codecs which have been designed specially for Internet voice



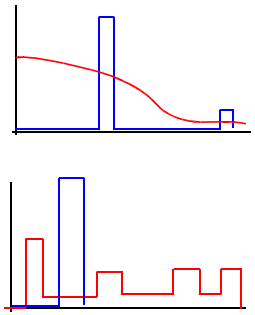
Data services

- **Data services are usually based on TCP-protocol, which by its nature tries to maximize network utilization while keeping packet losses on tolerable level**
- There is no clear expectation on service level as there are no easily measurable quantities
  - Other than throughput, latency and packet loss
- To maximize utilization one expects to see as large packets as possible with as high rate as possible



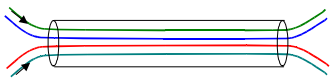
Convergence

- Mixing these two service types in a single network leads to certain problems
  - **Which is more important - small delay (required by real-time connections) or high utilization (starting point of TCP based dataservices)**
  - In packet level this shows out as differences
    - In sending process (frequency of packet sending is very different)
    - In quantity of information



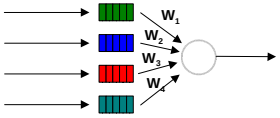
Convergence

- To overcome this we add quality and/or **differentiation**
  - **Network capacity is divided into fragments - one for each service type**
    - In connection based system this fragment is bitrate of the connection and number of parallel fragments is dependent on number of simultaneous connections
    - In connectionless system this fragment is bitrate of the aggregate and number of parallel fragments is dependent on number of service classes



Differentiation

- Dividing network into the fragments actually means that scheduling of network services is changed from First Come First Served (FCFS) to some other which can cope with **multiple parallel service requests**
  - Each request have weight that represents share of the network resources that are dedicated to individual request



So this course is about

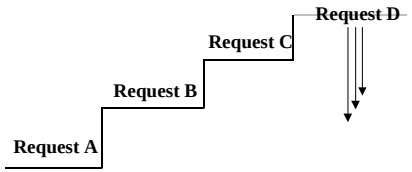
- How network resources can be targeted to individual users, applications
  - **Resources:**
    - **Network capacity**, bits that flow through the links and routers
    - **Buffer space**, memory that is used to store contending packets
    - **Forwarding capacity**, how many pps a router is capable of delivering

QoS - Differentiation

- Small but remarkable difference:
  - **QoS**
    - Pre-negotiated boundaries for the traffic and service which are used for individual packets over the time lifetime of the connection
  - **Differentiation**
    - Pre negotiated numerical boundaries for the traffic and service which are pursued over the lifetime of subscription

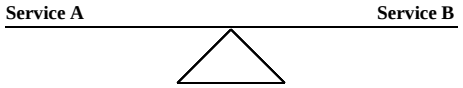
QoS

- **Goal is to device a service which could fulfill the demand**
  - Resources are connected to individual service requests
    - Numerical service descriptors of requests are used as basis for resource reservation
    - New service requests are blocked if there are no resources available



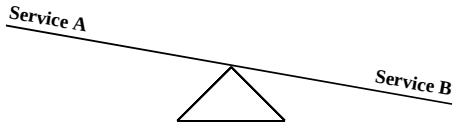
Differentiation

- **Current situation in Internet**
  - No differentiation
    - Equal opportunities -- equal misery
      - Depends on where are you looking ;-)



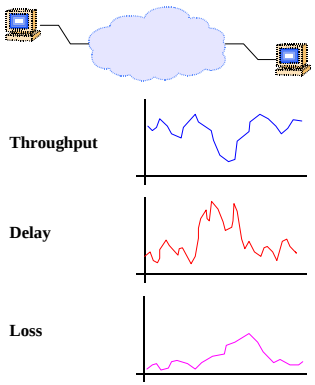
Differentiation

- **Differentiation means that resources are targeted to certain services or groups of users**
  - Overall resources do not increase
    - One gets better service than before
    - Other get worse service than before
  - Analogy: Try to bow someone without showing your ass to another



IP-service

- **Internet service is connectionless datagram service**
  - It roughly resembles normal snailmail
    - Each packet carries enough information to pass through the network
    - Each packet flows through independent path
      - Each packet experiences delay, loss and throughput which is dependent on network status and selected route



Differentiation

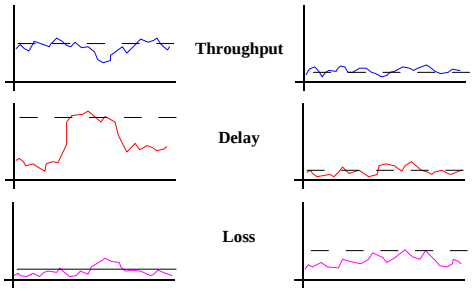
- **Snailmail has operated for years with differentiation based on money**
- Differentiation can change the
  - Speed of service
    - Delivery time
      - Express mail, normal mail
  - Quantity of service
    - Physical size of the letter
    - Weight of the letter

Differentiation

- **IP routers have two resources to differentiate with the effect on three measureable dimensions:**
  - **Capacity**
    - How many bits per second one can send into the net
  - **Delay**
    - What is the delay between sender and receiver
  - **Loss**
    - On what probability packets are delivered

Network Capacity

Buffer Space



QoS in IP networks

- **Not trendy at the moment**
  - QoS requires a lot from the network provider
    - Competence to run the network (strict provisioning)
      or
    - Lot of spare capacity (poor utilization)
- Used in marketing to increase revenue
  - Promising is cheap (differentiation)
    - Marginal increase in expenses
  - Guaranteeing is expensive (QoS)
    - Will this ever work economically ???