S−38.180:Quality of Service in Internet

Lecture I: History of Internet and QoS

18.9.2003

Important dates and locations

- **Lectures on Thursdays in S3**
  - Start on September 18th (today ;−)
  - Last lecture on October 23rd
- **Exercises on Wednesdays in Maari−C**
  - Presence not required but highly recommended
  - Start on September 24th
  - End on October 29th
  - All exercise reports must be returned on October 29nd by 4pm, expect the 6th exercise week later. We suggest you return the exercise reports before the next exercise begins.
- **Final examination on November 17th**

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

What is this course about

- We are going to try and try and ty 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
  - What are the small pieces that for the big picture
  - Are there any sense to make these things
  - Is there any sense to keep these lectures

Keep in mind

- Money talks and bullshit walks
  - ISPs are there for the money
    - They don't care about you
    - They don't care about your applications
    - They don't care what you are doing
    - They care about your money
      - Therefore,
        - » They care your opinions
        - » They care that you are satisfied

Increasing the revenue

- ISP want to increase their revenue
  - More money from the infrastructure
    - More customers to the current infrastructure
      - Lower quality for individual customer
      - Cost for the individual bit is lower
      - Price for the individual bit is same
  - Differentiation of bits
    - Same customer population with different categories
      - Different quality for individual customers
      - Cost per bit is higher
      - Price for individual bit is higher

Increasing the revenue

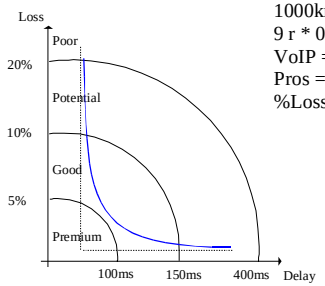
- Integration of networks
  - More services to the same network but with incremental charging
    - Cost per bit varies
    - Price per bit varies

Integration

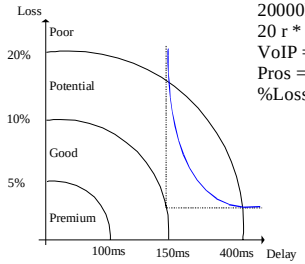
- Internet is becoming the next integration platfrom
  - All services are going to be delivered by using it (at least it is going to be tried)
  - Integration means that different media streams share common transmission system (IP)
    - Different medias have different requirements but there is only one IP

VoIP

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



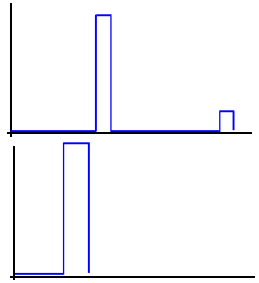
1000km * 5us = 5ms
9 r * 0.5ms/r = 4.5ms
VoIP = 20ms
Pros = 20 ms
%Loss = 1



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

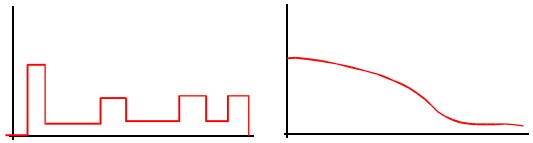
VoIP

- 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
      - Length spectrum due to fixed size of packet



Data services

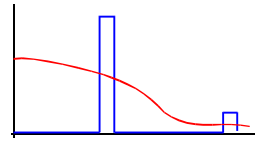
- Data service usually are based on TCP−protocol, which by its nature tries to maximize network utilization while keeping packet losses on minimal level
- There is no clear expectation on service level as there are no easily measurable quantities
  - Other than throughput and latency
- To maximize utilization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

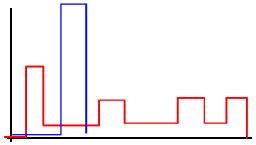


  - Large number of this kind of processes lead to high burstiness as individual connections come and go

Integration

- Mixing these two service types in 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



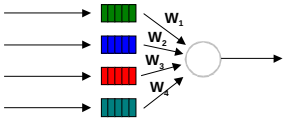


Integration

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

Integration

- 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

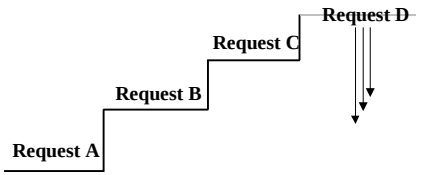
- How network resources can be connected to individual users, applications
  - **Resources:**
    - **Network capacity**, bits that flow through the links and routers
    - **Buffer space**, memory that is used to store contending packets

QoS − differentiation

- Small but remarkable difference:
  - **QoS**
    - Pre negotiated numerical boundaries which are used for individual packets over the time lifetime of the connection
  - **Differentiation**
    - Pre negotiated numerical boundaries 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 request are used as bases for resource reservation
    - New service requests are blocked if there are no resources available



Definitions

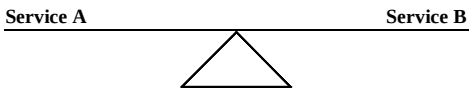
- (http://searchnetworking.techtarget.com/sDefinition/0,,sid7_gci213826,00.html)
- On the Internet and in other networks, QoS (Quality of Service) is the idea that transmission rates, error rates, and other characteristics can be measured, improved, and, to some extent, guaranteed in advance. QoS is of particular concern for the continuous transmission of high−bandwidth video and multimedia information. Transmitting this kind of content dependably is difficult in public networks using ordinary "best effort" protocols.
- Using the Internet's Resource Reservation Protocol (RSVP), packets passing through a gateway host can be expedited based on policy and reservation criteria arranged in advance. Using ATM, which also lets a company or user preselect a level of quality in terms of service, QoS can be measured and guaranteed in terms of the average delay at a gateway, the variation in delay in a group of cells (cells are 53-byte transmission units), cell losses, and the transmission error rate.

Definitions

- (http://www.webopedia.com/TERM/Q/QoS.html)
- Short for Quality of Service, a networking term that specifies a guaranteed throughput level. One of the biggest advantages of ATM over competing technologies such as Frame Relay and Fast Ethernet, is that it supports QoS levels. This allows ATM providers to guarantee to their customers that end−to−end latency will not exceed a specified level.

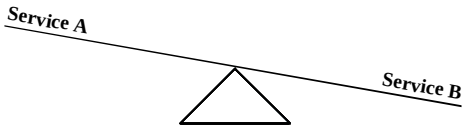
Differentiation

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



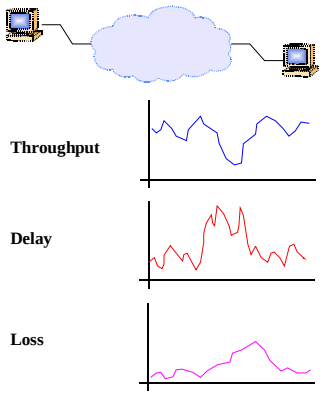
Differentiation

- **Differentiation means that resources are targeted to certain services or groups of users**
  - Overall resources do not increase
    - One gets better service
    - Other get worse service
  - Analogy: Try to shake hands with people both side of you − which gets first



IP−service

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



Differentiation

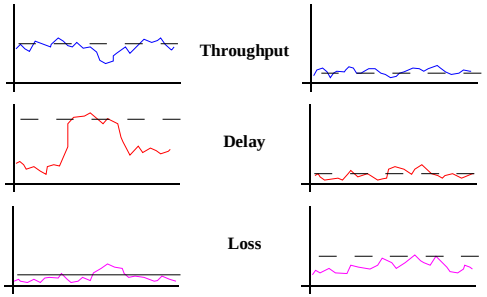
- **Snailmail has operated for years with differentiation based on money or status**
- Differentiation can change the
  - Speed of service
    - Delivery time
      - Express mail, normal mail
  - Quantity of service
    - Physical size of the letter
    - Weight of the letter

Differentiation

- **IP−nets can differentiate packets based on three 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 ISP
    - 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 ???

QoS

- **IP QoS is Russian roulette**
  - IP is connectionless and does not control the delivery
    - Sudden increase in number of packet to be delivered
      −> more processing −> more delay
    - Sudden link overload
      −> buffering −> more delay
    - Long term link overload
      −> overflowing buffers −> packet loss

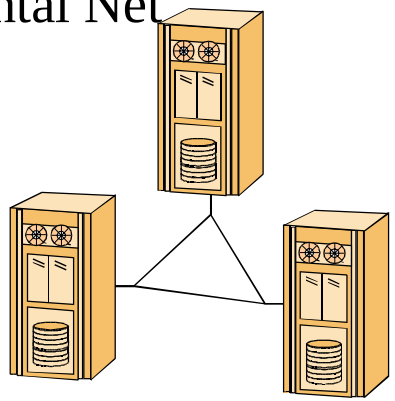
Once up on the time there was ...

"In the Beginning, ARPA created the ARPANET. And the ARPANET was without form and void. And darkness was upon the deep. And the spirit of ARPA moved upon the face of the network and ARPA said, 'Let there be a protocol,' and there was a protocol. And ARPA saw that it was good. And ARPA said, 'Let there be more protocols,' and it was so. And ARPA saw that it was good. And ARPA said, 'Let there be more networks,' and it was so."

-- Danny Cohen

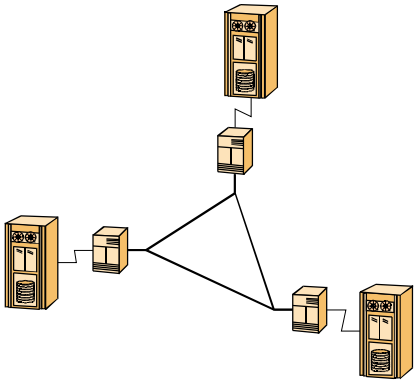
Experimental Net

- Background: development of computer hardware and software had been tremendous. New powerful processors were developed to index databases and raw data. Mass memory of computers and media to transfer information between them was tape reels.
- Idea: What if information could be transferred electronically between computers. And perhaps only need to know bases.
- Network = Terminals



Research Net

- Background: Means to interconnect computers were stabilized Need for interconnecting expensive supercomputers was urgent as their processing time was expensive.
- Idea: Need for new devises ’data exchange’ to carry out networking.
- Network and terminals were separated
- Users were socially responsible for their network usage (limited user group with high moral and self control)

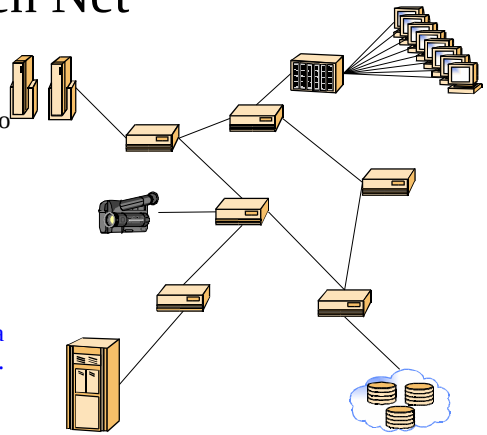


Open Net

Background: Telcos offered data services to companies on similar bases than research networks were build − two islands of users. HyperText produced a new media which had general interest over the borders of user groups.

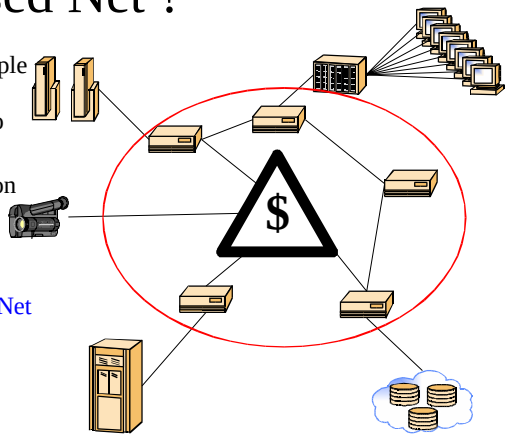
Idea: Commercial access for individual persons

Terminals get smarter and information becomes asset. Network is only a media which is used to achieve personal goals.



Closed Net ?

- Background: New media takes place. People demand more and more information on various formats. Technology is not able to meet demand. People get unsatisfied...
- Idea: Usage of the net is restricted based on economical incentives Multiple classes of users − first class vs cattle class.
- Information and service are charged individually to control the user behavior. Net becomes more and more intelligent.



Standardization of Internet QoS

- First attempt: IPv5
- Second generation: Internet Integrated Services (IIS)
- Third generation: Differentiated Services (DS)
- Fourth generation:

Internet QoS

- Common nominator
  - Separate control path
    - Router is divided into layers
      - Data path (Forwarding)
      - Control path (Path & connection control)
      - Management path (Device management)
  - More/less processing
    - More than BE
    - Less than per packet per device processing

IPv5

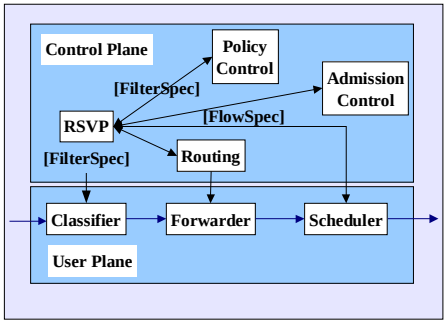
- RFC 1819
  - Internet Stream Protocol Version 2 (ST2)
  - Connection−oriented Internet protocol
- Two stacks in hosts and routers
  - One for conventional data services (IPv4)
  - One for real−time services (IPv5)
    - Different control and data path
      - ST−II control agents in routers decide whether there is room for additional real−time connections

IIS − IntServ

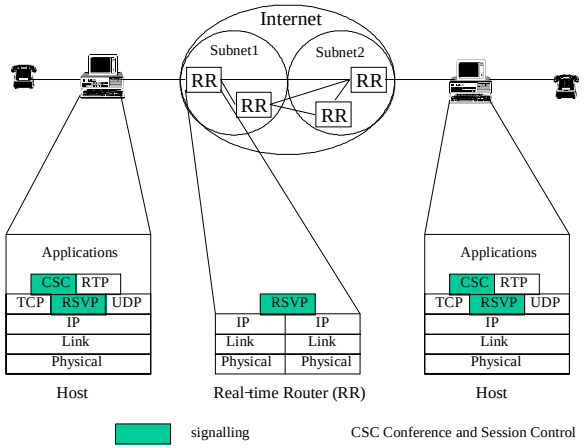
- Restructured ST−II within IPv4
  - Connection oriented nature on top of connectionless IP
  - Control path build as separate messaging sequence with the help of reservation protocol and agents
    - RSVP protocol is responsible to do actual messaging and book keeping
    - CAC agent checks to see if there is free capacity to accommodate new real−time connections

IIS − IntServ

- Connection oriented nature of IntServ requires that there is book keeping between
  - Connection identifier (FilterSpec)
  - Resources (FlowSpec)
  - Path (Route)



IIS − IntServ



DS − DiffServ

- Connectionless class based differentiation policy build on top of IPv4
  - There is no connection control as the operation is based on the aggregates
    - Control can be build as a outside functionality with brokering functionality
      - RSVP signaling between end user and network broker to produce provisioning that resembles IntServ

DS − DiffServ

- Connectionless nature does not require per flow book keeping
  - Aggregates must be kept but they are rather static
  - Per user information is stored on the edge of the network