QoS, CoS, BE

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Lecture topics

- Course organisation
- Why QoS
- Terms related to Quality of Service

Chapters from book:

- Chapter 1: The Big Picture

Course Objectives

- Quality of Service in Internet
  1. what is it
  2. why to bother
  3. how to provide
  - theory
  - tools
  - frameworks
  - practical issues
- *You* become *traffic engineers*

Course Information

Prerequisites: S-38.188 or equivalent knowledge of packet networks and Internet

Course home page at http://www.tct.hut.fi/opetus/s38180/

Announcements at news://news.tky.hut.fi/opinnot.sahko.s-38.tietoverkkotekniikka

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Course material assistant N.N.

How to complete the course

- Enrol with webtopi
- Exercises
  - *must* get at least 50 % of points for each to take part to exam
- Examination (first exam 2002-12-17T16/19 S4)

Course material

Book Wang, Zheng. "Internet QoS: architectures and mechanisms for Quality of Service". Morgan Kaufmann Publishers, San Francisco, USA 2001. ISBN 1-55860-608-4

Lecture slides In English. Available in PDF format from course home page and via Otatieto. *Printing with University printers **strictly** forbidden.*

Lectures In Finnish.

Extra material Articles for topics not covered by the book. Up-to-date information. Links from course home page and copies via Otatieto. *Printing with University printers **strictly** forbidden.*

What is BE?

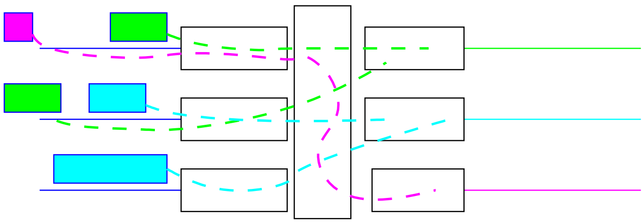
- BE: Best Effort[1]
- A network *does its best* to transport a packet to a right recipient
- Each packet is treated with the same policy
- A packet is forward if there is
  - processing capacity,
  - packet storage (buffer), and
  - capacity in outgoing link

  available

How a router works?

- Decides where a packet should go or should it be discarded Also (LAN) bridges and (ATM) switches may drop packets or forward to different routes. This is discussed with MPLS.
- FCFS: First Come, First Served

1. Packet is received by input line card
2. Routing table is consulted
3. Packet is transfered to outgoing interface
4. Packet is sent to wire



Current Internet

- Service provided is *best effort*
- Service differentiation is done with access speed
  - possibly foreign traffic bandwidth is limited
- Even if you want to pay for premium, you won't get better service, using Internet technology: you will have to revert to "traditional" circuit-switched technologies, especially if you need to cross operator boundaries.

[1] Paras yritys

Different needs

- I want only 13 kbit/s but delay may not exceed 100 ms and only 1 % of packet loss
- I need to transfer 1 GiB of data in next hour
- 95 % of my web pages should load in less than 10 s
- I want guaranteed 6 Mbit/s with maximum delay of 0,5 s, jitter of 100 ms and MPEG frame loss better than 10^{-4}

A packet network *can* support all of those, but it *needs* proper *mechanisms* and *policy*

What is a flow

- A flow is a series of packets travelling from one part of network to another part of network

  unidirectional A→B different from B→A

  bi-directional A→B same as B→A

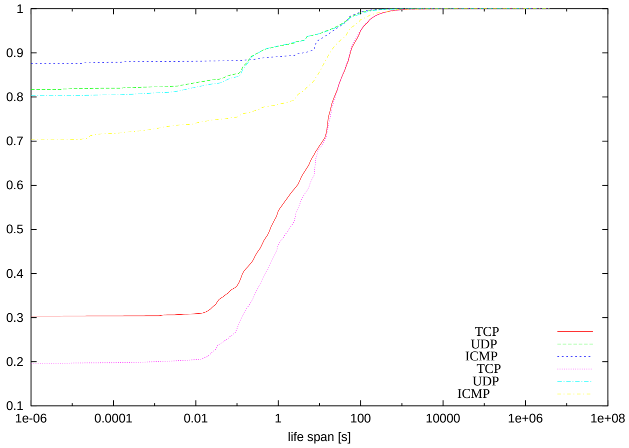
  It is not (always) possible to observe both directions at the same location, because of asymmetric routing.

- Potential granularities [3, p. 60]
  - application, identified by
    * TCP or UDP port numbers
    * transport protocol
    * IPSec SPI [1]
    * IPv6 flow identifier
  - host, identified by
    * network layer address (IP address)
    * link layer address (e.g. MAC address)
    * hostname (e.g. DNS name)
  - network, identified by
    * address prefix
    * AS number
    * domain name
    * arbitrary group of hosts
  - traffic sharing a common path in the network, identified by
    * link (interface on router)
    * ATM or FR virtual channel identifier
    * MPLS path
    * AS path
- The most common granularities
  - (source address, source port, protocol, destination address, destination port)
  - (source network, destination network)
  - (destination network), this is how a routing takes place!
- Packets belonging to the same flow *should* receive similar performance, especially if granularity is high.
  - varying performance is bad for many protocols and applications

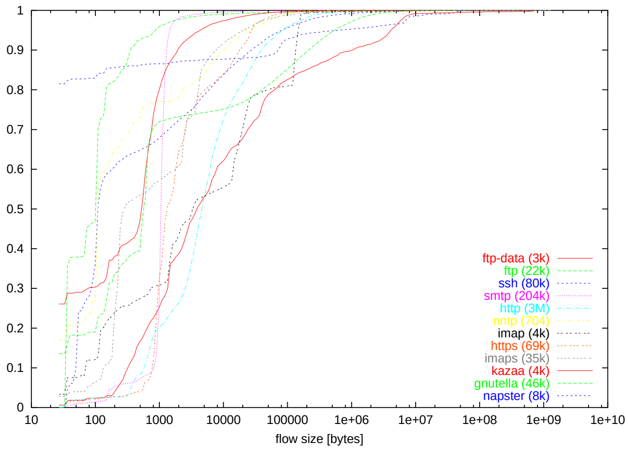
Flow lifetime

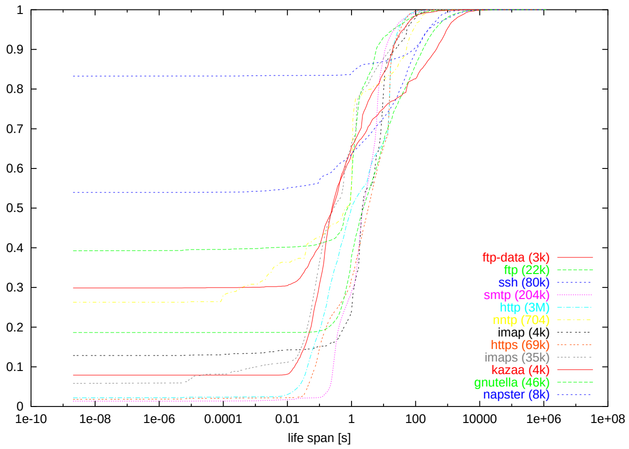
- Lifetimes vary
  - two packets exchanged in few milliseconds: one DNS query
  - millions of packets in a month: several TCP connections between two servers
- Flow timeout depends on application

Protocol-level flows with 60-second timeout

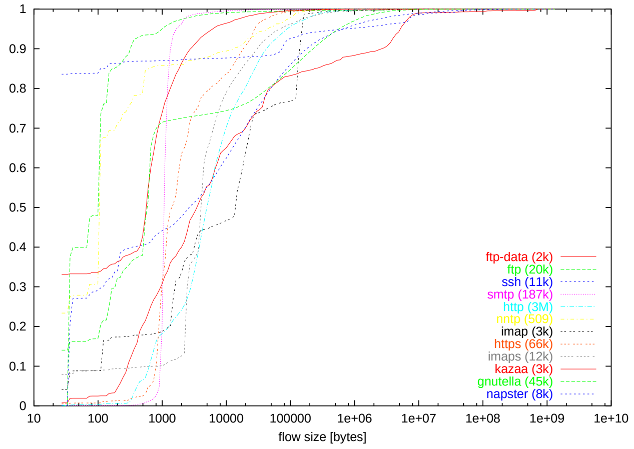


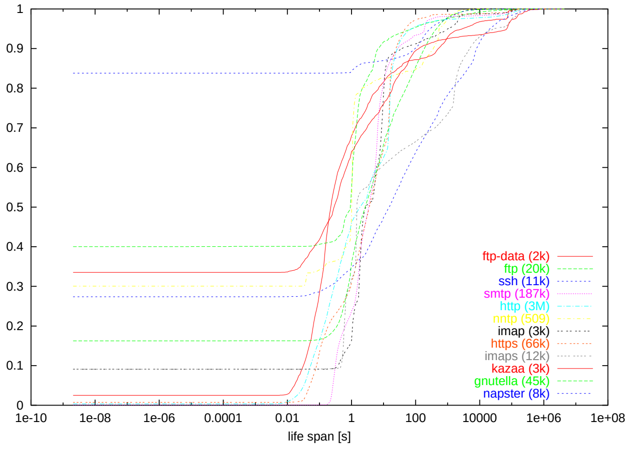
TCP, 60-second timeout, 5-tuple



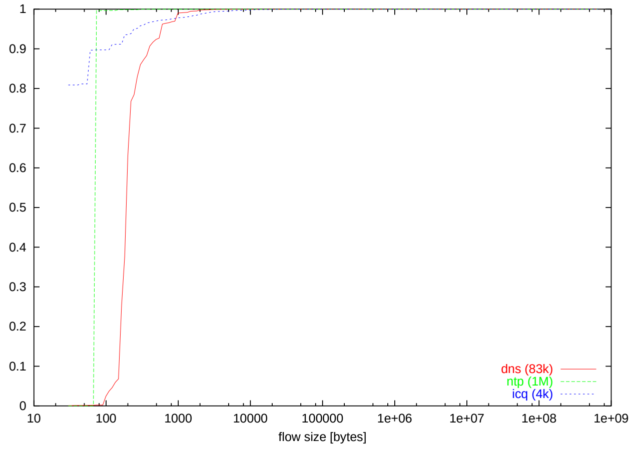


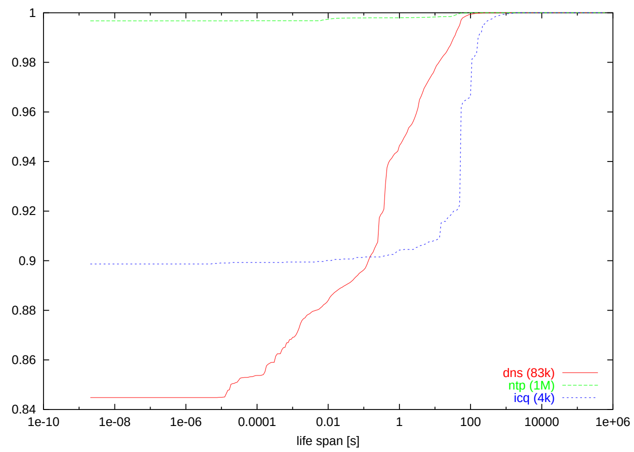
TCP, 48-hour timeout, 4-tuple





UDP, 60-second timeout, 5-tuple





To be or not to be TCP-friendly

- TCP is the most important transport protocol
  ⇒ network optimised for TCP: this includes buffer dimensioning and packet drop algorithms
- A protocol (application) can be TCP friendly
  - behaves similarly in event of congestion
  - uses *fair share* of resources
- Or not
  - gets more than fair share of bandwidth
  - causes fluctuations in network load
  - may result in *congestion collapse*
- "General public" should have some protection against misbehaving bandwidth pirates
  ⇒ Make 'em pay!

What is QoS?

- QoS: Quality of Service[2]
- User: No excess waiting, no distortion in voice or image, control timely
- Application: data is transfered over network so that application fidelity is maintained
- Network: packet delay, delay variation (jitter), loss and data throughput (bandwidth) is within acceptable region

QoS, definitions

> Quality of service is a concept based on the statement that not all applications need the same performance from the network over which they run. Thus, applications may indicate their specific requirements to the network, before they actually start transmitting information data. [2, p. 337]

> The collective effect of service performances which determine the degree of satisfaction of a user of the service. (ITU)

> QoS is the measure of how good a service is, as presented to the user. It is expressed in user understandable language and manifests itself in a number of parameters, all of which have either subjective or objective values. (RACE D510)

[2] Palvelunlaatu

QoS requirements

Hard requirements The network must either deliver requested performance or deny connection

statistical guarantees: average or most-of-time performance is declared

deterministic guarantees: hard limit is set for communication parameters.

Network optimisation Based on requested load, the network optimises its internal routing

Accepting communication A communication is accepted only iff quality existing communication is not reduced below agreed level and the network can deliver requested performance

QoS classes

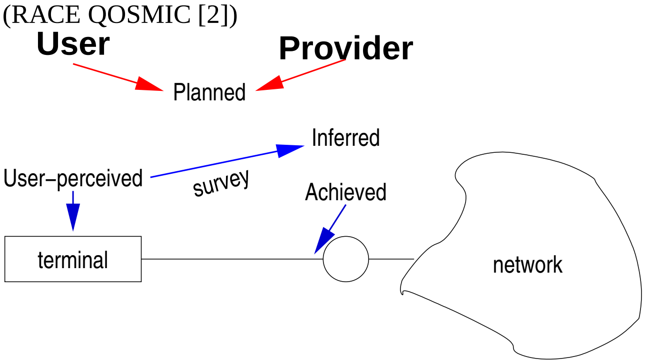
Planned QoS provider intends to offer and the user expects to receive

Achieved QoS actually delivered QoS measured by service provider

User-perceived QoS QoS perceived by human user

Inferred QoS QoS determined by provider based on user surveys

(RACE QOSMIC [2])



What is GoS

- GoS: Grade of Service[3]
- Network performance from user's perspective
- In telephone network:
  - Pre Selection Delay
  - Answer Signal Delay
  - Call Blocking probability

What is CoS?

- CoS: Class of Service[4]
- User: some traffic more important than other
- No strict bounds for delay and loss
- Each class receives *relative* performance compared to other classes
- Class is identified by some field(s) in packet

[3] Palvelutaso
[4] Palveluluokka

Different classes

IPv4 A bit mask TOS (Type of Service)

Precedence 3-bit (8 levels)

111 network control
110 internetwork control
101 CRITIC/ECP
100 flash override
011 flash
010 immediate
001 priority
000 routine

Delay normal / low

Throughput normal / high

Reliability normal / high

Only two of delay/throughput/reliability bits may be set for a packet.

IPv6 priority for real-time (8-15) and elastic (0-7) traffic

15 high-fidelity realtime media

8 lo-fi realtime media

7 network management (SNMP, routing, . . .)

6 interactive use (telnet, HTTP)

4 interactive transfer (HTTP, FTP)

2 unattended transfer (SMTP, FTP background)

1 filler traffic (NNTP server-server)

ATM CLP (Cell Loss Priority) to mark lower-priority traffic (e.g. non-conforming or UBR (Unspecified Bit Rate))

IEEE 802.1p user priority (3-bit) with service mapping

0 default (best effort)

1 less-then-best-effort

4 delay sensitive (no bound defined)

5 delay sensitive: 100 ms

6 delay sensitive: $<$10 ms

7 network control

Service mapping is changeable within network.

Both IPv4 TOS and IPv6 priority are replaced with *DS byte* (Differentiated Service)

Resource allocation

- Flow-based resource allocation
  - resource reservation
  - fixed path
  - traffic policing

  ⇒"circuit-switched approach"
- Packet-based prioritisation
  - edge policing

- provisioning
- traffic prioritisation

⇒"stateless approach"

- Flow-based differentiation
  - overlay network for different paths
  - traffic engineering using virtual paths (LSP: label switched paths)
  - network optimisation to cope with demand

⇒"virtual network approach"

Why different approaches?

- In core network scalability is needed
  - millions of simultaneous flows
  - tens of thousands flows are established each second
  - one flow uses only small fraction of total bandwidth

⇒wholesale approach

- In edge networks accuracy is essential
  - only few flows
  - link speeds low, especially in wireless environment
  - one flow may use most of bandwidth

⇒accurate bookkeeping needed

What is the problem, then?

- Frameworks for resource allocation
- Service models for operators
- Languages for describing resources
- Mechanisms for enforcing, including methods to charge users

Summary

- Enrol with webtopi
- Understand current status
- Understand {Q,G,C}oS

References

[1] L. Berger and T. O'Malley. RSVP Extensions for IPSEC Data Flows. Request for Comments RFC 2207, Internet Engineering Task Force, September 1997. (Internet Proposed Standard). URL:`http://www.ietf.org/rfc/rfc2207.txt`.

[2] F. Fluckiger. *Understanding Networked Multimedia*. Prentice Hall, London, 1995.

[3] Markus Peuhkuri. Internet traffic measurements – aims, methodology, and discoveries. Licentiate thesis, Helsinki University of Technology, Finland, May 2002.