Communication Networks

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Exercise 1 – Introduction

Internet Structure

## 1.1 Layer Model

Internet protocol stack	OSI reference model
Application	Application
	Presentation
	Session
Transport	Transport
Network	Network
Link	Link
Physical	Physical

Internet communication layers: Internet protocol stack and the OSI reference model.

Communication over the Internet can be decomposed into independent layers. In the lecture, we have discussed the Internet protocol stack which contains 5 layers. Another often used model is the OSI (Open Systems Interconnection) model with 7 layers. Find the best matching layer for the following operations/devices. You can use the already known 5-layer model. **Hint**: Some of the operations could be implemented in different layers.

a) Bit-to-bit transmission between two devices.

b) Encryption of a message.

c) A switch in a network.

d) Routing path search.

e) Adding a sequence number to each packet.

f) A router in a network.

g) A middlebox in a network performing deep packet inspection (DPI) to find malware in Web traffic.
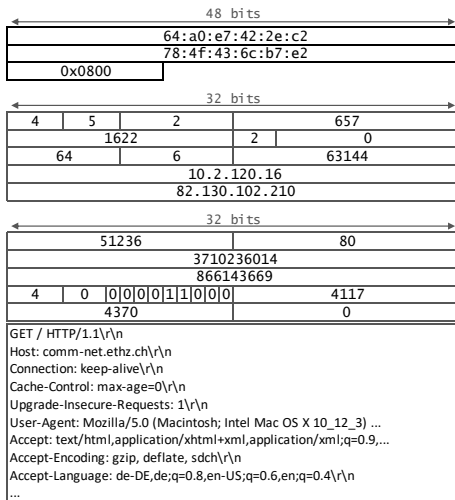
1.2 Internet Organization
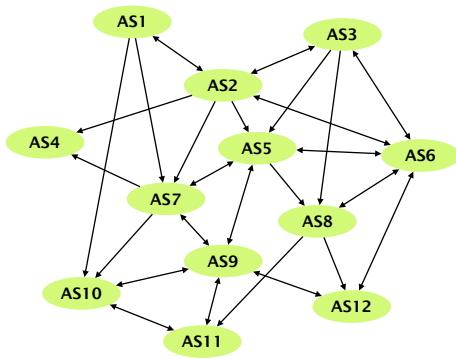
A network of multiple autonomous systems (AS).

The network on the left consists of multiple autonomous systems (AS). Single-headed arrows point from providers to their customers. Double-headed arrows represent peer connections.

a) For each AS, identify if it is a Tier-1, Tier-2 or Tier-3 ISP network or an IXP.

b) AS7 has two different providers (AS1 and AS2). How is this type of interconnection called? What are the advantages of multiple different providers for AS7? Can you see any disadvantages?

1.3 Internet Communication

48 bits

| 64:a0:e7:42:2e:c2 |
| 78:4f:43:6c:b7:e2 |
| 0x0800 |

32 bits

4	5	2		657
1622		2	0
64	6		63144
10.2.120.16
82.130.102.210

32 bits

| 51236 | | 80 |
| 3710236014 |
| 866143669 |
| 4 | 0 | 0 0 0 0 1 1 0 0 0 | 4117 |
| 4370 | | 0 |

GET / HTTP/1.1\r\n
Host: comm-net.ethz.ch\r\n
Connection: keep-alive\r\n
Cache-Control: max-age=0\r\n
Upgrade-Insecure-Requests: 1\r\n
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_12_3) ...
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,...
Accept-Encoding: gzip, deflate, sdch\r\n
Accept-Language: de-DE,de;q=0.8,en-US;q=0.6,en;q=0.4\r\n
...

Packet consisting of data in four layers (link, network, transport and application layer).

The figure on the left shows a (simplified version of a) packet that was recorded at your machine's network interface using `Wireshark`[a].
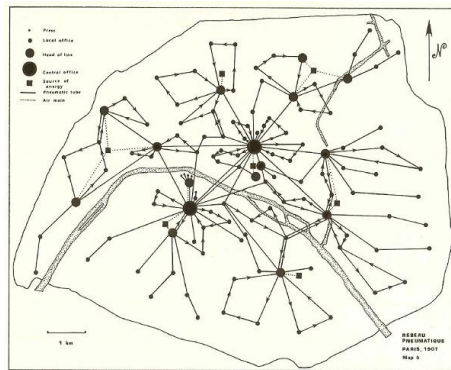
a) What kind of activity does this packet belong to?

b) From the lecture, you know that a packet is composed of data in different layers. The fields in the left-hand figure are already grouped to four blocks representing the link, network, transport and application layer. Do you know which protocol is used in each of the four layers? *Hint: You may want to have a look at the list of protocols on Wikipedia[b].*

c) After being sent out at your machine's network interface, the packet will traverse a switch which will forward it based on the destination address. On which layer does the switch operate and which is the destination address it will look at?

d) After leaving your local network, the packet will traverse a router. On which layer does the router operate and which is the destination address it will look at?

[a]https://www.wireshark.org/
[b]https://en.wikipedia.org/wiki/Internet_protocol_suite

Bandwidth and Delay

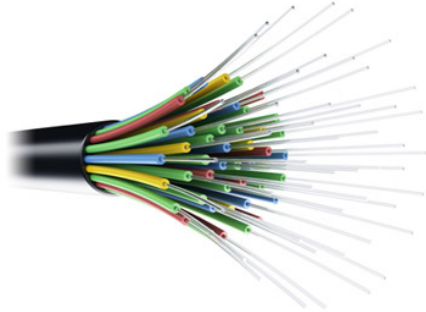## 1.4 Network Characterization

Calculate and compare the bandwidth and the delay for different communication methods. (For this task, assume that the delay only consists of propagation delay.)

The pneumatic tube network of Paris in 1907.

a) Pigeon post: Pigeons can be used as messengers. They are trained to transport messages from one location to another. Assuming you want to send a USB flash drive with 16 GB[a] from Zürich to a friend in Paris (500 km) (only in one direction). Calculate the bandwidth and the delay for one pigeon carrying the USB drive and traveling at an average speed of 80 km/h.

b) Pneumatic tube: These systems were introduced in the late 19th century to transport small, urgent items within buildings or even within cities. The capsules travel at an average speed of 8 meters per second. Assuming you send an external hard drive with 2 TB of storage through a tube from ETZ to the main building (distance 400 m), calculate the bandwidth and delay.

c) AWS Snowmobile: Amazon uses a truck to move data from its customers to their data center. The truck houses a container which can store 100 PB of data.[b] Assuming the truck is transporting data from New York to an AWS data center in San Francisco (distance 4700 km) at an average speed of 100 km per hour, calculate the bandwidth and the delay.

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[a]1 GB = 10^9 bytes, 1 TB = 10^{12} bytes, 1 PB = 10^{15} bytes
[b]https://techcrunch.com/2016/11/30/amazon-will-truck-your-massive-piles-of-data-to-the-cloud-with-an-18-wheeler/

## 1.5 Types of Delay

Optical fiber cable.

When accessing a website your data has to travel from your computer through different networks to the server on which the website resides and back.

a) You want to load a website from Sydney (`sydney.com`). How long does it take for a data packet to travel to the server and back (straight-line distance Zürich-Sydney $16'600\,\mathrm{km}$) assuming your data packet travels at the speed of light ($3 \times 10^8\,\mathrm{m/s}$)?

b) Measure the time it actually takes for a packet to travel to the server and back by issuing a `ping sydney.com` in a terminal[a]. If you don't have a computer available you can use our measurement:

`PING sydney.com (54.252.93.212):`
`time=284.405 ms`

The calculated and measured times are not even close. Why do we observe such a difference?
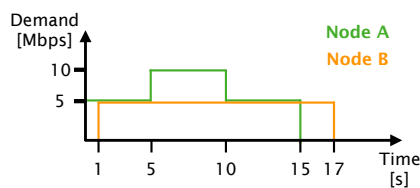
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[a]https://linux.die.net/man/8/ping

Sharing

1.6 Packet vs. Circuit Switching
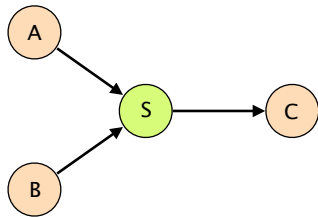
Network with a shared link.

Demand distributions for node A and B.

Consider the network on the left. A and B are sending data towards C over a switch S and a shared link. All the links in the network have a bandwidth of 10 Mbps and you can assume that the propagation and switch processing time are negligible. For circuit switching, assume that circuit establishment and teardown each take 50 ms. For packet switching, you can assume that switch S already knows how to reach C.

a) How long does it take if node A is sending a 50 Mbit file to C using packet switching? B sends nothing.

b) How long does it take if node B is sending a 50 Mbit file to C using circuit switching? A sends nothing.

Assume now that A and B are using packet switching and are each sending a 50 Mbit file to C at the same time.

c) What will happen if the switch has no buffer?

d) How large has the buffer to be (in Mbit) such that both senders can successfully transmit their files to C when they are simultaneously sending at full speed?

e) For obvious reasons, switch buffers cannot be of unlimited size. How is it possible to successfully send data over the Internet even if some packets are dropped due to full buffers?

Finally, assume that A and B have to send data with a demand according to the diagram on the left.

f) How long does it take to send all data if A and B use circuit switching (reserving for the peak demand)?

g) How long does it take to send all data if A and B use packet switching (you can assume an unlimited buffer size on S)?