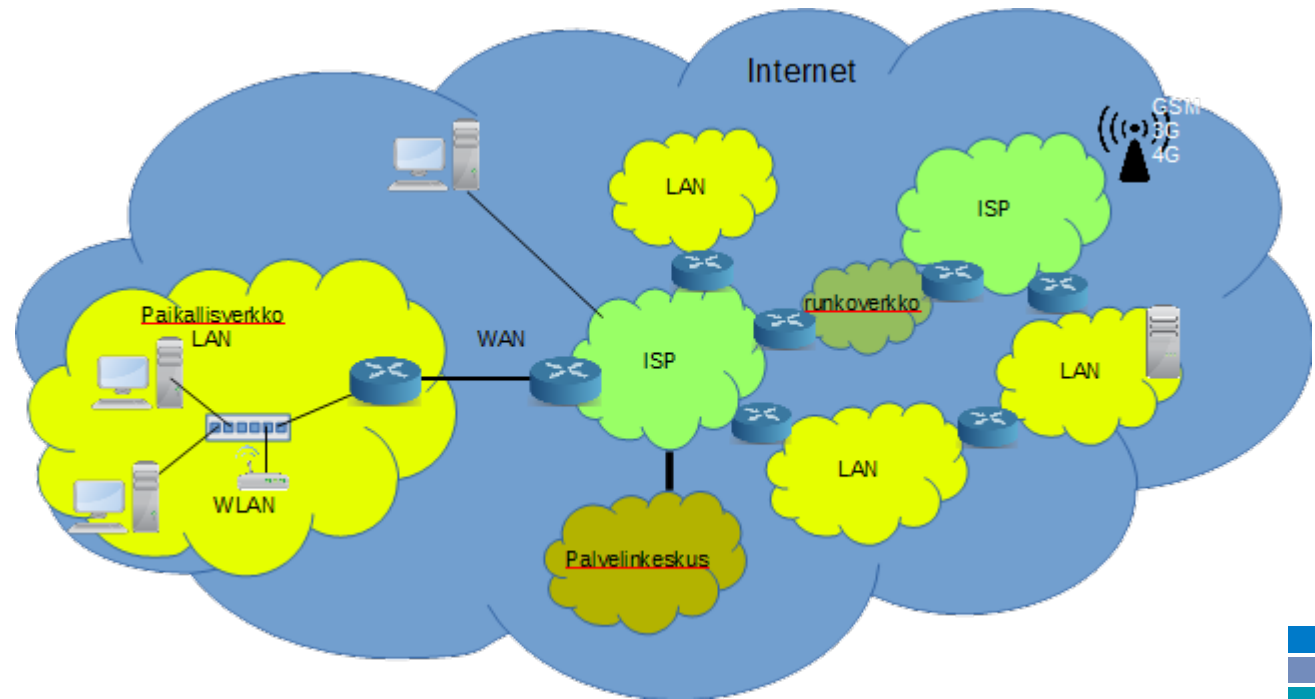


Communications Networks

Principle of network

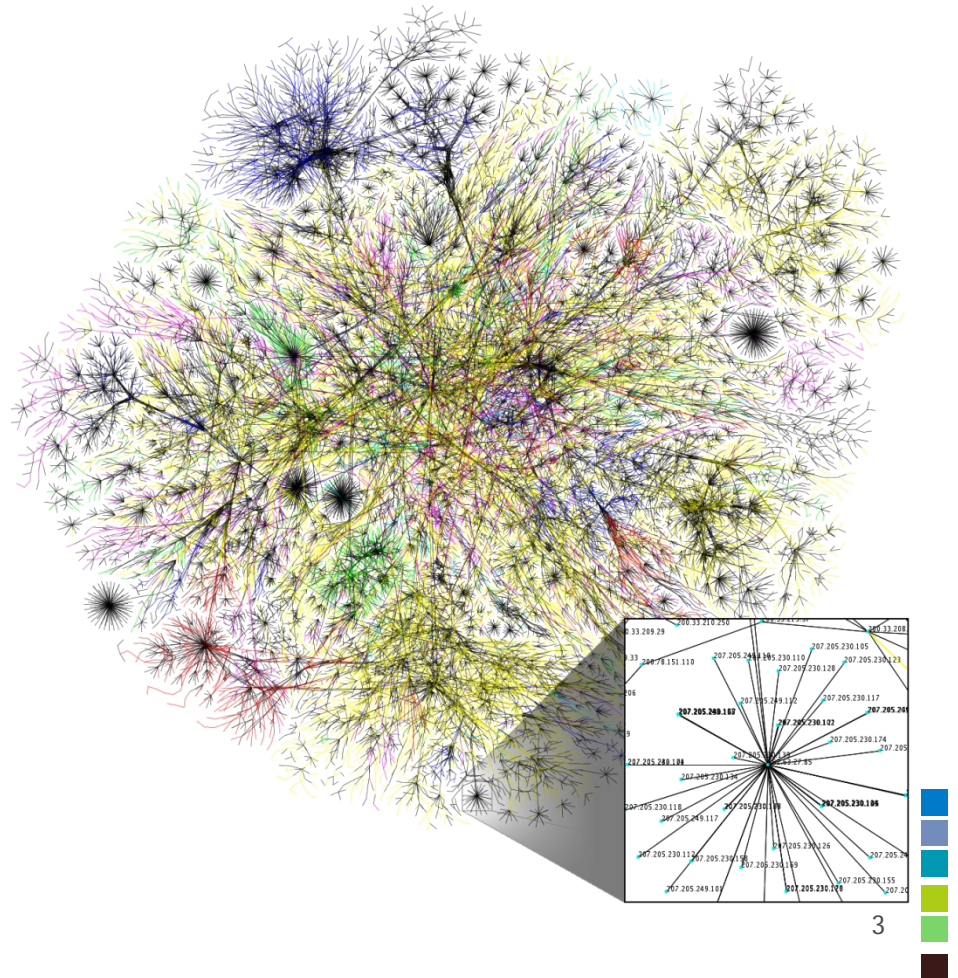


Structure of Internet

- Some of the routes of Internet
- <https://en.wikipedia.org/wiki/Opentelemetry>
- <http://www.cheswick.com/ches/map/gallery/isp-ss.gif> (this is from 1999)

Opentelemetry used to be in:

- (<http://www.opentelemetry.org/>)



History of Internet

- ARPANET 1960 (military use)
- Internet 1970 (ARPANET - > Universities)
- Universities in Finland connected to Internet 1988
- Home use really: 1993
- WWW = Graphical interface (1990)
- 2000... Smart phones

The first message sent via the Internet was as short as "LO". Between two universities attempts were made to send the message "LOGIN" but the data network was crashed with the letter "G". The story very well illustrates how "brittle" these networks were in the early stages, and they may not always work better this day.

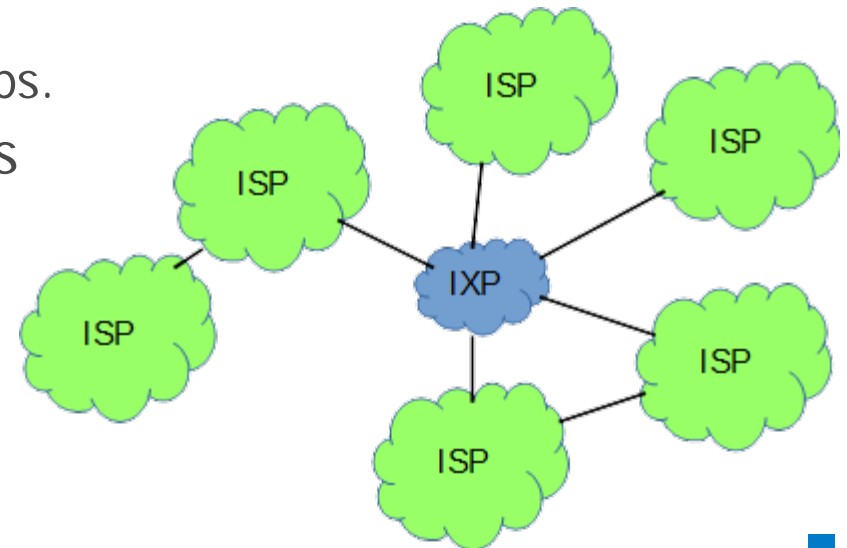
Usage of Internet

Please see:

- <https://www.internetworldstats.com/stats.htm>
- <http://www.internetlivestats.com/>

Internet Service Providers (ISP)

- ISPs provide:
 - Internet access, Internet transit, domain name registration, web hosting, Internet news groups.
- Corporate and private customers
- Some ISPs are Tier 2 service providers who get their own connection from the Tier 1 operators
- ISP:s are connected via IXP's (Internet Exchange Point)



IXP (Internet Exchange Point)/node

- An Internet exchange point (IX or IXP) is the physical infrastructure through which Internet service providers (ISPs) and content delivery networks (CDNs) exchange Internet traffic between their networks (autonomous systems)
- Traffic between Internet operators is mainly through these node points.
- There are also some direct links between operators.
- Four in Finland: provided by Ficix (2+1) and TREX (1)
- Some nodes are also connected to cloud computing companies.
- All traffic does not pass through these nodes, but traffic passing through them gives the picture of the traffic volume.

The Backbone / Core of a Communications Network

- Partly cables are owned by the operators
- Some of the cables are owned by specialized companies.
 - They lease connections to operators and businesses.
- Long connections are nowadays implemented with fiber optic cables.
 - The customer can obtain the fiber connection ready or the so-called black fiber.
 - The Black fiber means that cable companies only supply cable. The customer manages the necessary equipment.

The cables

- Connections outside from Finland have been implemented with fiber optic cables running on the sea.
- Finland has connections to Sweden, Estonia, Russia and Germany.
- Information on Submarine Cables can be found at e.g.:
 - <http://www.submarinecablemap.com/>
 - The map also provides information about the features and owners of the cables.
- <http://submarine-cable-map-2014.telegeography.com/>

Standards

- What is standard?
 - Official
 - De facto
- In Finland, the definition of an officially recognized organization, is considered standard.
- In the strictest sense, official standards are only ISO standards.
- There is a lot of informal standards in the networks.

Standards, Organizations

	World wide	Europe	Finland
General	ISO	CEN	SFS
Telecom	ITU	ETSI	Finnish communications regulatory authority / Viestintävirasto
Electrical engineering	IEC	CENELEC	SESKO

- In the USA, the umbrella organization is ANSI, which works in partnership with ISO.
- IEEE is a co-operation organization for electrical and electronic engineers, which in practice operates under ANSI.
- EIA is an organization of electronics companies.

Standards, Internet

- Most of the definitions of the Internet are not official standards.
- ISOC, Umbrella organization (Internet society)
- IETF, Internet Engineering Task Force
 - A free-form organization whose activities can basically be attended by anyone.
 - Identify and troubleshoot problems on the Internet
- IESG, Internet Engineering Steering Group
 - Respond to the technical management of IETF's operations.
 - Accepts RFC documents.
- W3C
 - Develops WWW-services
- **ICANN/IANA**
 - IANA manages IP address (e.g. provides) and manages root servers.
 - IANA is an administrative organization. Practical activities are performed by ICANN

How IP Address is determined

- IANA / ICANN distributes addresses to regional organizations (mostly continental).
- Regional organizations share addresses with country organizations or **operators**.
- The country-specific organization (Finnish Communications Regulatory Authority) distributes addresses to operators.
- Operators distribute addresses to their customers.

Protocols

- **Protocols** define network activity and data to be transmitted in data transmission.
- There are always several protocols in use for data transfer at the same time. One protocol defines the **form** in which information is transmitted, other protocols: **How and Where**.
- The protocols in use form the so-called: **a protocol stack** and it is described with the OSI / ISO model

Services

- Client-server model
- LAN (local area network) services
- Internet services

Client-server model

- Most of the network services work according to the client-server model.
 - The customer contacts the server (with the exception of the so-called push function)
 - More specifically, the client program contacts the server program. For example, a web browser (Firefox, Opera,...) accesses the web server (IIS, Apache, ...)
- The client-server model option is Peer-to-peer or P2P.
 - Napster, BitTorrent, ...
 - Internet puhelin: Skype
 - Both sides are equal and the connection can be made whichever is the only one.

Services of Local area network (LAN)

- Fileserver
- Sharing devices
 - Printers
 - Mass storage (SAN, storage area network)
- Applications
- Databases (SQL)
- Centralized management, domains
- Backups
- Internet (connection) sharing

Services of Internet

- WWW
- Email
- DNS (domain name service)
- VoIP (Voice Over IP)

- sftp (file transfer protocol – secured)
- ssh
- IoT (Internet of Things)
- Intranet ("internal internet")
- Extranet (limited network)

WWW

- WWW is a service developed for document sharing (graphical interface originally). Today it is used for many different services: social media, webshop / e-commerce, file sharing, ...
- WWW uses the http protocol or its secure version of https.
- http is a simple protocol. It only has a few commands. Usually only GET and POST commands are used.
- The WWW is a stateless service.
 - The customer connects to the server and requests a web page. The server sends the page and the connection is disconnected. There is no information on the server that could later identify the customer or connection.
 - Several services, such as e-commerce and social media, require a session. We try to solve the problem in various ways, such as passwords, **cookies (Teamwork in Moodle)**, and codes to add to the page's address.

- WWW page is provided as **URL-address** (Uniform Resource Locator).
 - URLs occur most commonly to reference web pages (http)

Syntax: <http://www.firma.fi:80/public/sivu.html>

http	A protocol: http tai https
www.firma.fi	The name of the server or ip-address.
80	The port. The default is 80 with http.
public	Directory path
sivu.html	The file which has the WWW-page

A port is a logical construct that identifies a type of network service (a specific process)

- See the list of the ports

email

- The email service includes two separate activities: sending a message and reading a message
 - The sender writes the message and sends it to the proxy server that sends the message to the recipient's mail server.
 - SMTP (Simple Mail Transfer Protocol) is used for sending. The recipient will read the message from the server. Normally POP3 or IMAP4 is used to read.
 - The message is not sent directly to the recipient's workstation.
 - Sometimes push-mail is used on mobile devices, which sends the message directly to the recipient's device.

DNS, domain name service

- The network needs IP addresses to work.
- IP addresses are difficult for people to remember. In addition, names can be guessed. It is easy to guess that the name of the Haaga-Helia WWW server is `www.haaga-helia.com`, but the ip address can not be guessed.
- For a user to use names, a service needs to be changed to convert the names to ip addresses.

Network types

Network types

- Main data network types are
 - Local Area Network (LAN, WLAN)
 - Wide Area Networks (WAN)
 - Mobile Data Networks
- Following additional network types can also be used
 - Metropolitan Area Network (MAN)
 - Home Area Network
 - Personal Area Network (PAN)
 - Campus area network (CAN)

Local Area Network (LAN)

- **LAN** is a managed data network that interconnects devices within a limited local area
- Today all LANs are using **Ethernet protocol**. LAN hardware is LAN switches.
- All endpoints connected to the same LAN communicate directly with each other via **the LAN switch**
- Traffic between endpoints connected to different LAN networks needs to be passed (**routed**) via a router. Router connects different LAN networks.

Local Area Network (cont.)

- Ethernet-protocol has regularly been updated and it's speed has continuously increased
 - initially Ethernet speed was 10Mbit/s
 - speed was then increased to 100Mbit/s
 - currently 1Gbit/s speeds are widely used in LAN networks and 10Gbit/s speeds are widely used in LAN trunk connections
 - Ethernet standard already has definitions for 40Gbit/s and 100Gbit/s speeds

Wireless Local Area Network (WLAN)

- Term Wi-Fi is also used for WLAN
- New versions of IEEE 802.11 standard have continuously increased WLAN network speed
 - (802.11 2 Mbit/s)
 - 802.11b 11 Mbit/s
 - 802.11a 54 Mbit/s
 - 802.11g 54 Mbit/s
 - 802.11n 600 Mbit/s
 - 802.11ac > 1Gbit/s
 - Newest (Updated 14.11.2018): 802.11ax > multiple Gbit/s



WLAN (cont.)

- Initially WLAN used only 2,4 GHz frequency
- New faster WLAN versions (802.11n, 802.11ac) work also on higher 5 Ghz frequency
- Security and encryption are very important since wireless traffic is easy to monitor
 - WEP - old technology, no longer secure
 - WPA,WPA2 – better technology, secure

Wide Area Network (WAN)

- WAN is a data network spanning regions, countries, or even the world.
- WAN is used to transmit data over long distances and between different LANs
- WAN connections are typically implemented in operator core networks
- Internet is basically a collection of all WAN networks (via different operator interconnections)

WAN (cont.)

- WAN connection for a LAN (WAN) can use various different technology
 - ADSL
 - VDSL/SHDSL^{*}
 - Cable modem
 - Ethernet^{*}
 - Fiber^{*} (valokuitu)
 - 3G/4G

^{*} This technology can provide a real quality WAN connection

Mobile Data Networks

- Mobile networks we initially designed for voice traffic
- New (4G) and future (5G) mobile networks are much better suited to carry data traffic
- Mobile network's radio frequency range is always limited and shared. This fact will limit individual mobile data transmission speeds, specially when there are many other users sharing the same network transmission capacity.

Mobile Data Networks (cont.)

- There are three mobile network generations used today. They all have different theoretical maximum data speeds
 - 2G (GSM) about 200 kbit/s
 - 3G 42 Mbit/s
 - 4G 150/300 Mbit/s

Theoretical maximum data speeds are possible if there is only one user using base stations data transmission and user has optimal connection to the base station. Real life speeds will be much smaller than Theoretical maximum speeds!