

Computer Networks

A computer network is a system in which multiple computers are connected to each other to share information and resources.

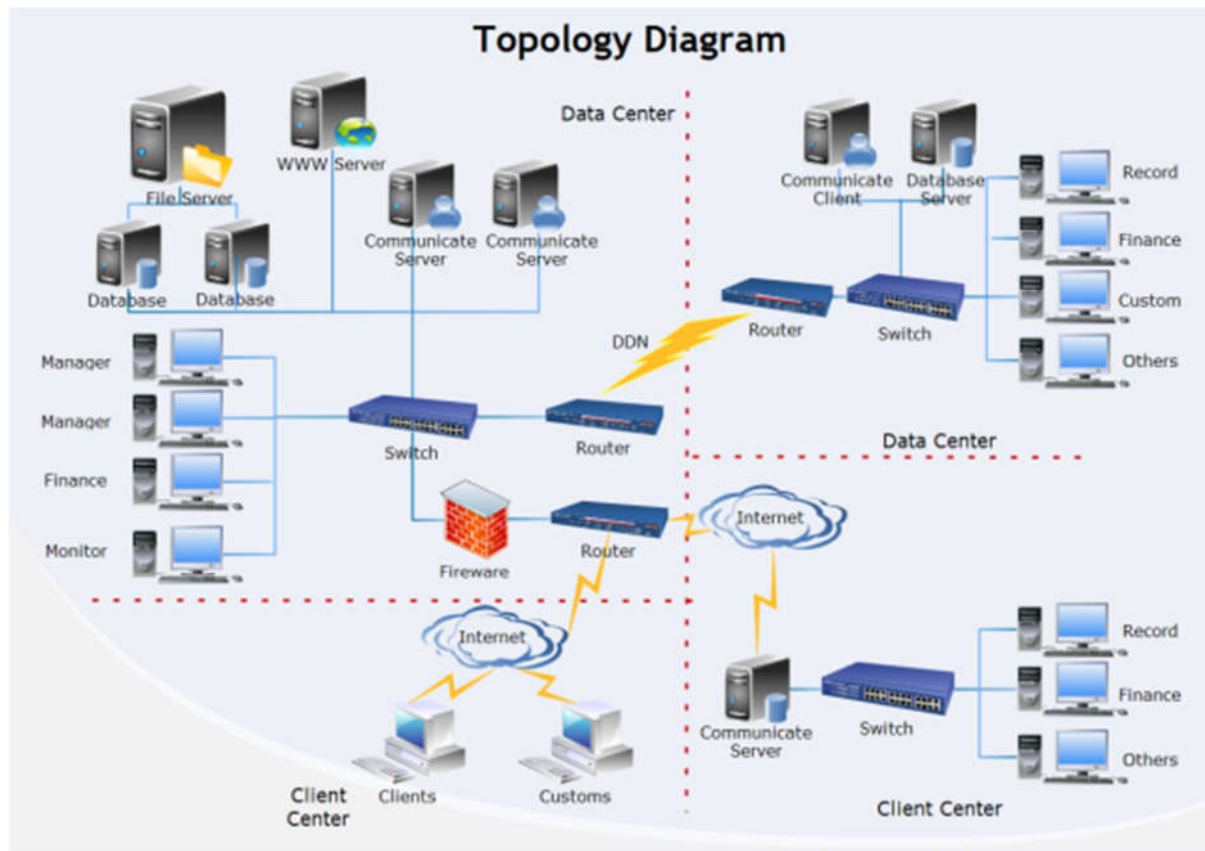


Figure 1: Example of the network layout (source: <http://www.edrawsoft.com/topology-diagram-example.php>)

Network Applications/Use

Business

- **Resource sharing** – printers, documents, storage space, Internet connections, Clouds
- **Communication** – email, IP telephony (VoIP), videoconferencing and videopresentations, business-oriented social networks (e.g. LinkedIn)
- **e-Commerce** – e-shops, e-banking

Home

- **Communication and social networks** – chat, video-chat, [Facebook](#), [Twitter](#), [Linkedin](#) etc.
- **Online fun** – games, bets, online dating services, geocaching, online TV and radio, video-on-demand (Netflix, YouTube), audio-on-demand ([Deezer](#), [Spotify](#), [Google Music](#))
- **Online education and knowledge resources** – Wikipedia, dictionaries, online courses (Coursera, Udemy, Learn2Code.sk, various universities)
- **Apps for tablets, smartphones, and computers**
- **Data sharing** – P2P networks (Torrent, DirectConnect)

Government

- **e-Government** – online access to services provided by various offices

- Online legislation
- Online tax forms
- e-Health
- *and more and more and ... for each category!*

Problems Introduced by Networks

- Networks can be **expensive** to install, maintain and replace
- **Surveillance** and **eavesdropping** (governments, companies, criminals), loss of privacy
- Network-related **crime** – identity theft, data theft, phishing, pharming, misuse of computers for cyber-attacks (DDoS, password cracking ...)
- **Dependence** on the network-based services – some vital parts of the economics rely on working computer networks
- **Addiction** – people exhibit symptoms of net-addiction → they must have their smartphone nearby; often checking online statuses, news, messages; they cannot concentrate/focus on anything else; without their phones/laptops → very nervous, aggressive, or depressed
- A simple means of spreading **scams**, **hoaxes**, **propaganda**
- **Information overload** – people lose focus and cannot differentiate importance or reliability of information; a lot of people rely on the online content and let their cognitive and memory abilities deteriorate (yes, I also mean YOU, my dearest students :-/).

Categories of Computers Networks

Criterion #1: SCALE

- **The area covered by the network**
- It strongly influences other aspects of networking (hardware, protocols, topologies)

PAN – Personal Area Network

- **A computer network that is used for data transmission between different personal devices** – e.g. laptop + smartphone + tablet + printer + other personal devices (e.g. health monitoring sensors)
- Mostly wireless – Bluetooth, WiFi, IrDA; wired – USB
- Speed: from kbps to dozens of Mbps

LAN – Local Area Network

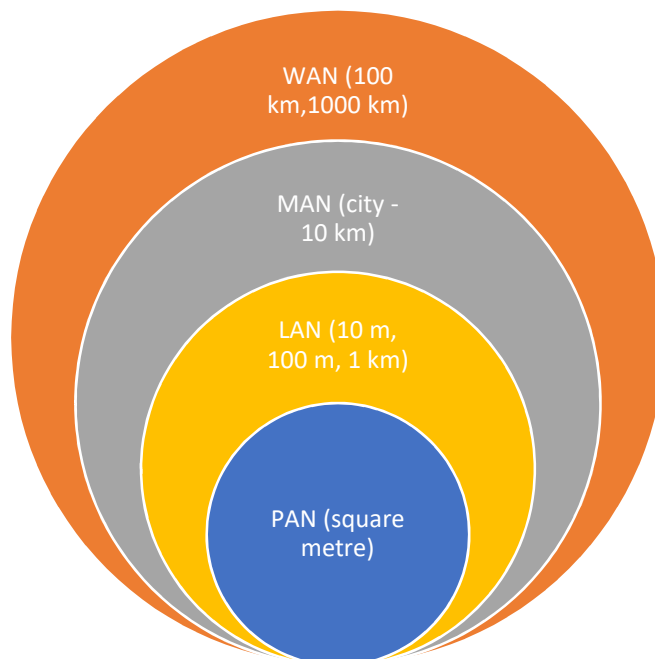
- **A LAN is a privately owned network that operates within and nearby a single building like a home, office or factory.**
- LANs are widely used to connect personal computers and consumer electronics to let them share resources and exchange information.
- When LANs are used by companies, they are called **enterprise networks**.
- Technologies typical of LANs:
 - **WiFi** – Access Points, WiFi routers
 - **Ethernet** – twisted pairs, optical fibres, switches, LAN routers
- Speed: 1 Gbps to tens of Gbps; 100 Mbps in older LANs

MAN – Metropolitan Area Network

- **A network, which operates within the range of a city/town**
- TV cable network, WiMAX, fibre optics
- Speed: hundreds of Mbps to tens of Gbps
- Relatively rare

WAN – Wide Area Network

- **Any network larger than MAN – intercity, interstate, intercontinental, world-wide**
- 2 distinct components
 1. **LINES** – copper wires (originally for telephony), optical fibres, radio – usually belong to one company and others (various **Internet Service Providers – ISP**) have to lease their use.
 2. **SWITCHING ELEMENTS** – WAN routers



- Speed: greatly varies depending on the location – from kbps (old dial-up links in poorly developed areas of Africa, basic GSM network connection) to hundreds of Tbps (transatlantic optical fibre links).

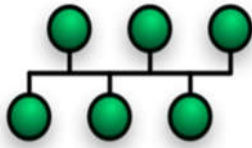
Criterion #2: TOPOLOGY

Network topology is the **arrangement of connections** among **nodes** of the network (**nodes** – computers, smartphones, switches, routers etc.)

The topology can be

- **Physical** – arrangement of real connections
- **Logical** – how data flows in the network – it may differ from the actual physical arrangement

Bus



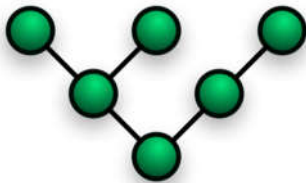
- Each node is connected to one medium (e.g. the same cable)
- Inexpensive
- Prone to problems:
 - if the medium fails, the whole network is down
 - the medium can be easily overloaded by data
 - difficult addition of new nodes

Star



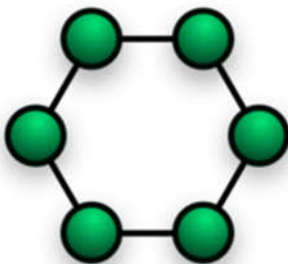
- All nodes are connected to one interconnecting node (in LANs – a switch)
- Simple
- Reliable unless the switch fails
- Expensive, if cables are used for links

Tree



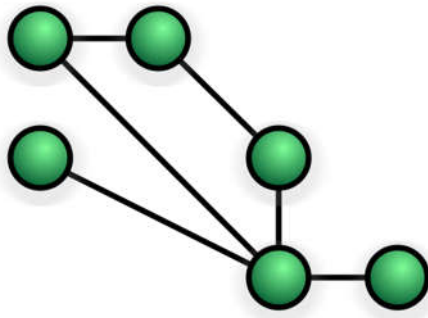
- Usually represents a hierarchy
 - **Root** – the most important node
 - **Intermediate nodes** – connectors
 - **Leaves** – client computers, smartphones etc.
- If a node fails, remaining segments of the network can cooperate
- Simple addition of new nodes
- Slower communication – data have to travel across multiple links and nodes

Ring



- Circular connection of nodes
- If any node fails, the network is off.

Mesh



- nodes of the network have no strict arrangement
- they may connect to as many other nodes as possible; extreme – **full mesh** – each node has an independent link to all other nodes
- its dynamic nature and non-hierarchical structure make it resistant to failures, which would prevent other network topologies from work
- there is no standard – implementation depends on the technology vendor (e.g. Mikrotik mesh is not compatible with CISCO mesh).

Hybrid

- A combination of any previous topologies

Criterion #3: MEDIA

- What means of connection are dominant in the network

Wired

- Metallic – twisted pairs, copper telephone lines
- Optical fibres

Wireless

- Microwaves – WiFi, Bluetooth, satellite
- Laser
- Infrared light
- Pigeons (in RFC 1149 and RFC 2549) 😊

Criterion #4: PROTOCOLS

A network protocol is a set of rules that governs the communications between computers on a network.

If 2 networks use different protocols, they cannot communicate directly - a translating machine must be used (e.g. *ADSL router or modem* translates LAN protocols (Ethernet) to WAN protocols (ATM, PTM)).

Examples

- **IP protocol** – the primary network protocol used on the Internet; it organises data into packets, it also defines addresses of computers
- **HTTP/HTTPS** - a standard for the mutual communication of web browsers and servers
- **DHCP** - a protocol that assigns unique IP addresses to devices – a user does not have to configure it manually
- **802.11** – a protocol for wireless networks

The number of various protocols is enormous, and they are related to different levels of the ISO OSI model – the most important protocols will be mentioned in that part.

Just a short preview:

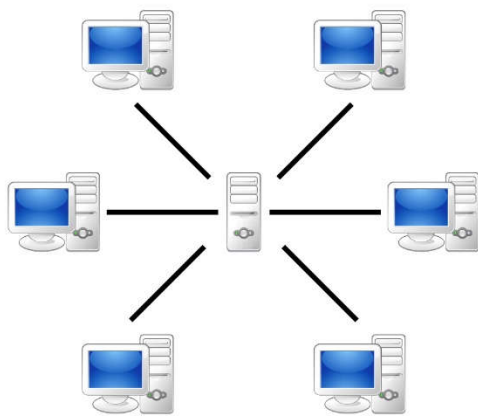
- 1st layer of OSI: DSL, USB, Bluetooth, 802.11 (WiFi)
- 2nd layer of OSI: Ethernet, VLAN, 802.11 (WiFi – yes, again)
- 3rd layer of OSI: IP, ARP, X.25
- 4th layer of OSI: TCP, UDP
- 7th layer: HTTP, HTTPS, FTP, SMTP, IMAP, BitTorrent, DHCP, DNS

Criterion #5: Architecture

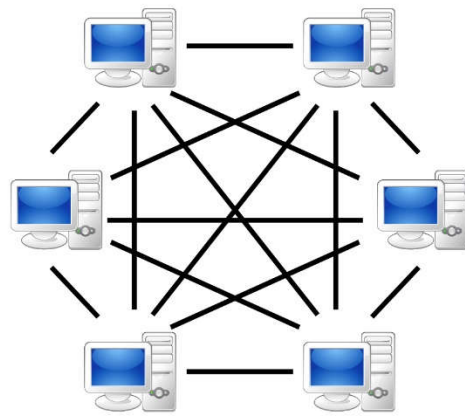
Roles assigned to computers in the network.

Client-Server

- Centralized system
- There are 2 roles
 - **Server** – **provides** useful **services** (computing power, storage, software etc.) to clients
 - **Client** – **initiates** the **communication** with server in order to obtain the required service
- Examples: majority of services nowadays: email, web, internet banking, online TV ...



Server-based



P2P-network

P2P – Peer-to-peer

- **Decentralized system**
- **All members have equal roles in the system** (i.e. they can act as both client and server for other members); in some versions there are infrastructure nodes with extra coordinating functions
 - Data sharing – Torrent
 - Exchange of goods – Bitcoin (digital currency), TradePal
 - Communication – Skype

- Sometimes used in combinations with client/server services – e.g. in Spotify, Windows 10 updates, VISA

Criterion #6: Network Paradigm

- philosophy of how data is transmitted

Circuit Switching

- between the connected locations is established dedicated connection with guaranteed speed and time delay
- such connections are paid for time (even when not in use) – e.g. a circuit with 1 Gbps costs 5000 to 15000 €/month in Slovakia (1000 to 1500 €/month in Czech Republic)

Packet Switching

- There is no dedicated path that connects the locations – data is split into small portions (**datagrams**)
- The speed and time of communication may vary
- There are 2 versions:
 - **Datagram switching** - connectionless – data of the same data exchange may be delivered across different links
 - **Virtual circuit switching** – there is first created a route in the network (dynamic, unlike in circuit switching – the path can be different for different connections), then the data is exchanged over this route.