

1.3 Computer Networks, connections and protocols

A computer network is two or more computers or devices that are linked together, either using cables or wirelessly. This means that they can communicate with one another and can share resources.

LAN – Local Area Network - consists of devices connected together in a single building or site, such as a school, using ethernet and wireless connections.

WAN – Wide Area Network - is formed by connecting together LANs. Spread across a wide geographic area and use third party telecommunications. The largest WAN is the internet.

Bandwidth, measured in (Mbps), refers to how much data can be transmitted over a network in a given period of time.

Factors that can affect performance:

the number of users - available bandwidth is shared between all of the users on a network. A large number of users can cause network congestion

the transmission media being used - Within a LAN it is usual for copper network cables or Wi-Fi to be used. Copper network cables have a bandwidth of up to 1000Mbps whereas Wi-Fi only has a bandwidth of up to 300Mbps.

Error Rate - When there is a lot of traffic on a network, it can result in transmission errors due to data packets colliding.

Client Server – all computers (clients) are connected to a main server. + All backups, file stored centrally, activities can be managed centrally. - If server stops, all is stopped, servers are expensive.

Peer to peer – all computers have equal status and are connected directly. Computers store their own programs and files. + no single point of failure. - no central management or maintenance

Network interface controller (NIC) - to allow a device to communicate with a network. Each NIC has a unique MAC address that allows it to be identified on the LAN.

Transmission media to allow devices to connect together; Copper wires, fibre-optic cables, radio waves for wireless.

Copper Cables - The bandwidth is generally between 100Mb and 1Gb per second, for a distance of up to about 100 metres. Copper wires are cost effective.

Fibre-optic cables have very high bandwidth (up to 100TB per second) and capable of transmitting data over 100km or more distances, hence why there are often used to connect WANs across large areas.

Radio Waves - Wireless networking technologies, such as Wi-Fi and Bluetooth, use radio waves to connect devices. The most commonly used frequencies for data transmission are 2.4GHz and 5GHz. The strength of a radio wave decreases as it moves further away from its transmission source, and so radio waves at 2.4GHz and 5GHz are only suitable for relatively short distances of up to 100 metres. Radio waves are also subject to interference from other radio signals of the same or similar frequencies, and are partially blocked by physical objects such as walls

Wireless access points (WAPs) is a piece of hardware that connects to a network switch and allows Wi-Fi devices to connect to a network. WAPs broadcast a Service Set Identifier (SSID) so that WIFI devices can connect to it. The WAP is usually connected to a network switch via a cable. However, WAPs can also be used to extend the range of a wireless network.

Switches is the piece of hardware that allows multiple devices to connect together to form a wired network. A switch stores the MAC address of every device connected to it in a table. When the switch receives a packet of data it looks at the destination address and forwards it on to the intended device. It is possible to connect multiple switches together to increase the number of devices on a network.

Routers is the piece of hardware that connects networks of different types together and commonly used to connect a LAN to the internet. Routers receive and check the destination IP address of a data packet to determine whether it is located on the local network. Routers collect data about all of the available routes to transmit data and then determine the most appropriate route for each individual data packet.

Protocols are rules or standards that must be followed when data is sent between devices on a network.

Ethernet is the protocol used to connect devices in a wired LAN.

Wi-Fi is a set of protocols that defines how network devices can communicate wirelessly using radio waves. Wi-Fi can transmit at the 2.4GHz frequency, which has a greater range but lower transmission speeds compared to transmission at the 5GHz frequency. Bluetooth is another form of wireless protocol, which can be used over short distances using ultra high frequency (UHF) radio waves.

Protocol Name	Function
HTTP - Hypertext Transfer Protocol	defines how web browsers work
HTTPS - Hypertext Transfer Protocol Secure	is the same as HTTP but S stands for secure, eg used for banking
FTP - File Transfer Protocol	used to transfer computer files between a client and a server
POP - Post Office Protocol	used to retrieve and download emails from an email server

IMAP - Internet message access protocol	alternative protocol for accessing email messages. However, the messages are read rather than downloaded (POP)
SMTP - Simple Mail Transfer Protocol	used to send email to an email server
TCP - Transmission Control Protocol	splits the data from applications into smaller data packets that can be sent across a network

Protocols are assigned to layers, each of which has a specific purpose to enable communication to take place. When data is being sent, it passes through each layer in turn and is encapsulated with more information. When a data packet is received each layer of information is read and decoded in reverse order

Benefits of Layers - one layer can be developed or changed without affecting other layers, enables hardware and software manufacturers to develop different products that will all work together. It is easier to identify and correct networking errors and problems

Every device connecting to the internet is assigned an IP address to enable it to be located. IPv4 addresses use a 32-bit number, broken down into four 8-bit sections each representing a number between 0 and 255 and written in denary. IPv6 addresses use a 128-bit number, which is broken down into eight 16-bit sections and written in hexadecimal.

A MAC address is made up of 48 bits, shown as six groups of two hexadecimal digits separated by colons, and it can never be changed. MAC addresses are used to identify specific devices on a LAN.

The domain name server (DNS) enables websites to be accessed via their domain name, for example www.google.co.uk. The DNS links the domain name to its Internet Protocol (IP) address. Websites are hosted on web servers. Client computers request files from a server. When you visit a website, the browser on your device requests the web pages from a web server and they are downloaded to your device.

The Cloud is a network of servers that store data. Files and applications can be accessed from any internet-connected location.

- + files can be accessed from anywhere
- + users will have most up to date version and don't have to update anything which reduces the need for technical staff
- + The amount of storage is flexible; they can buy more if they need it
- internet connection is required
- users have little control over security of the data
- cloud providers can change their terms and prices with little notice

The way in which devices in a network are arranged and connected together is called its topology.

Star network topology - each computer is connected to a central point, which can be a switch or a server.

- + fast and reliable because each client has its own connection to the central node
- + data is only directed to the intended computer, it helps to keep network traffic to a minimum, and in turn this reduces data collisions.
- + easy to add new devices as they simply need to be connected to the switch.
- + If the connection to one device on the network fails, the rest of the network will be unaffected.
- require a lot of cabling, as every computer is connected individually, which can be expensive.
- If the central server or switch fails then so will the entire network.

Star networks tend to be found in large organisations such as schools and businesses. They are also found in home networks, especially those that are wireless, with all of the devices connecting to a central router with a built-in wireless access point.

It is important to note that star network diagrams can appear to look the same as client-server networks. However, the devices in a star network could run applications in either a client-server or peer-to-peer model.

Mesh network topology - every device is connected to every other device, commonly used for wireless networks

- + no single point of failure, and so are used where the reliability of network communication is very important, e.g. the military and the emergency services
- + If any component fails, data can simply be sent down a different route.
- + Data can also be transmitted from different devices simultaneously allowing high volumes of data traffic to be handled.
- too impractical and too expensive to set up, and require a lot of maintenance owing to the many connections.

Mesh network diagrams can look similar to peer-to-peer networks. However, a mesh topology network can also support a client-server model where one of the devices is the server.