1.3.3 Internet Structure

Characteristics of Networks

A **network** is a collection of connected devices that can communicate and share data and resources.

Networks can vary in:

- **Size** – from a small network in a home to the entire Internet.
- **Geographical coverage** – devices may be located close together or across large distances.
- **Ownership** – a network may be privately owned or publicly accessible.
- **Purpose** – networks can be used to share data, resources and services

Protocols

A protocol is a set of rules that determines how data is communicated between devices on a network.

Protocols define things such as:

- how data is formatted
- how data is transmitted
- how devices communicate
- how errors are handled

Different protocols are used for different purposes.

Standards

A **standard** is an agreed set of rules or specifications that devices and software follow.

Standards are important because they allow devices and systems made by different manufacturers to communicate with each other.

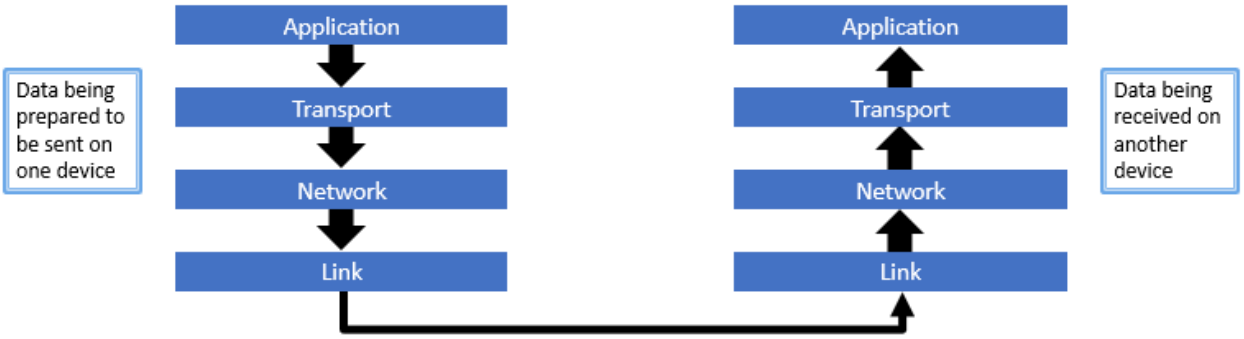
Without common standards, devices may use different methods of communication and be unable to communicate effectively.

TCP/IP – Transmission Control Protocol / Internet Protocol

The TCP/IP stack is the foundation of all internet and network communication.

It is organised into layers of protocols each of which have specific responsibility.

The four layers in the TCP/IP stack are: **Application**, **Transport, Network** and **Link** layers.



Packets travel along cables from router to router

Application Layer

The application layer:

- Chooses the appropriate protocol to provide network services to an application. (e.g. browser, email clients).
- Adds encryption to the data if necessary.

Examples of protocols that may be used in this layer:

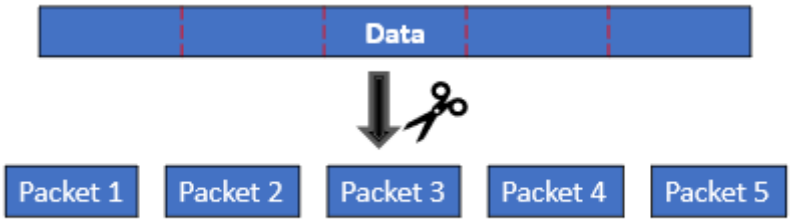
Protocol	Name	Used For
HTTP	Hypertext Transfer Protocol	Web communication
HTTPS	Hypertext Transfer Protocol Secure	Web communication with encryption
FTP	File Transfer Protocol	Transferring files between a server and client
SMTP / POP3	Simple Mail Transfer Protocol / Post Office Protocol v3	Email Services
SSH	Secure Shell	Remote access of a device over a network

Transport Layer

(Key protocol TCP)

The transport layer:

- Manages end-to-end communication between devices.
- Splits data into segments ready for transmission.
- Adds information to the segment header such as:
  - The total number of packets in the message
  - A sequence number to identify the packet's position in the data
  - The port number to identify the application that should deal with the packet
- Adds error detection information to the packets (e.g. checksum) and resend packets that are not successfully received.



The message is split into packets

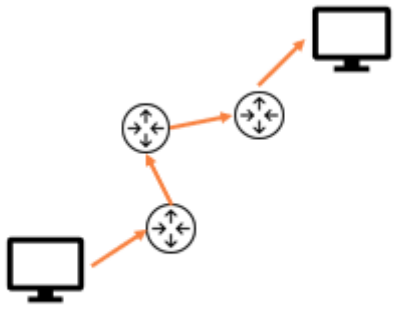
Network Layer

(Key protocol IP)

The network layer:

- Deals with routing packets across networks
- Adds the source and destination IP addresses to the packet headers
- Performs error detection on a packet header

A socket is formed which is an endpoint for network communication, identified by an IP address and port number



Packets use the IP address to hop from router to router until they reach their destination

Link Layer

(Key Protocols Ethernet/WiFi)

The link layer:

- Handles the physical connection on the network
- Adds MAC addresses to the packet header

Recall the MAC address is the address of the physical NIC (network interface card).

LANS & WANS

Local Area Network (LAN)

A **LAN** is a network that covers a **small geographical area**, such as a home, school or office.

Devices on a LAN are usually connected using cables or wireless connections.

Advantages of LANs

- High data transfer speeds
- Resources such as printers can be shared
- Data can be shared between connected devices
- Usually easier to manage than larger networks

Disadvantages of LANs

- The network only covers a relatively small area
- Setting up the network can be expensive
- A failure of network equipment can affect many devices

Wide Area Network (WAN)

A **WAN** is a network that covers a **large geographical area**.

It can connect LANs across cities, countries and continents with the **Internet** being the world's largest WAN.

WANs commonly use telecommunications infrastructure to connect networks over large distances.

Advantages of WANs

- Allows devices and networks over large distances to communicate
- Allows organisations with multiple locations to share resources and data
- Can connect multiple LANs together

Disadvantages of WANs

- More expensive and complicated to establish and maintain
- Generally has higher latency than a LAN
- More difficult to manage
- Data transmitted over larger networks can introduce additional security risks

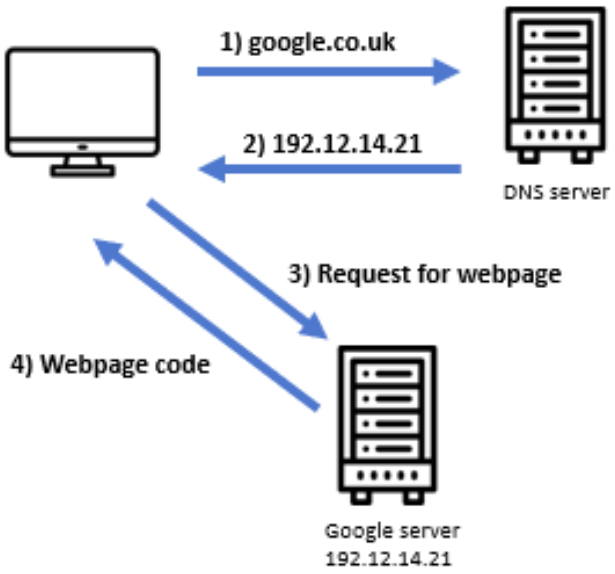
Domain Name System (DNS)

DNS (domain name system) servers are dedicated servers which store an index of fully qualified domain names with their corresponding IP addresses.

IP addresses are required to send requests to servers but are more difficult for humans to remember than domain names. You can think of it like a contacts list on a phone. It is much easier to remember names than the phone numbers themselves.

The steps to display a webpage

- When a domain name is typed into a browser…
- The browser makes a request for the corresponding IP address from a DNS server.
- The DNS server searches the index for the domain name and sends the IP address back. If the DNS server does not have that domain in its' index then it passes the request to another DNS server that could know.
- With the IP address the computer can make a request to the server holding the webpage.
- The server sends the webpage code so that the browser can display the webpage.



Packet & Circuit Switching

There are two ways that data can be transmitted across a network:

- **Packet switching**
- **Circuit switching**

Packet Switching

With **packet switching**, a message is divided into smaller units called **packets**.

Each packet contains:

- part of the data
- information such as its destination
- a sequence number so the packets can be put back into the correct order

The packets can travel through the network using **different routes**.

At the destination, the packets are reassembled to recreate the original message.

The Internet uses **packet switching**

Advantages of packet switching

- Network resources can be shared between many users.
- Packets can take different routes around network problems.
- If a route becomes unavailable, packets can be sent along another route.
- Efficient use of network capacity.

Disadvantages of packet switching

- Packets may arrive out of order.
- Packets may be delayed.
- Packets may be lost and need to be retransmitted.
- There is no guaranteed dedicated connection between the devices.

Circuit Switching

With **circuit switching**, a **dedicated communication path** is established between two devices before data is transmitted.

The path remains reserved for the duration of the communication.

All data travels along the same path.

Advantages of circuit switching

- A dedicated connection is established.
- Data arrives in the correct order.
- Consistent transmission once the circuit has been established.
- Suitable where a continuous connection is required.

Disadvantages of circuit switching

- Network capacity is reserved even when no data is being transmitted.
- Less efficient when the connection is not being continuously used.
- Establishing the circuit takes time.
- If part of the circuit fails, communication can be interrupted.