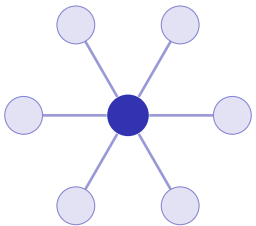
Communication

AS Computer Science ▪ Topic 2

A-Level Computer Science



What we will cover

1. Networks and the internet 2.1
2. Models, hardware, IDs 2.1.1
3. Cloud, media, Ethernet 2.1.2
4. URLs, DNS, IP 2.1.3
5. Recap



1 Networks and the internet

Sheet 2.1 – what you need to know

You must be able to:

- tell LAN from WAN and draw the main topologies
- check whether an address is IPv4, IPv6 or invalid
- describe how data crosses a star network and the cell network

What the exam asks

"Circle whether this IP address is IPv4, IPv6 or an invalid IP address. Justify your choice." **[2]**

"Explain how data is transmitted using the cell phone network." **[4]**

"Draw the topology for the main office network. Label all devices." **[4]**

Practise on exercise sheet 2.1, then try the real exam questions on past-paper sheet 2.1.

Why use a network?

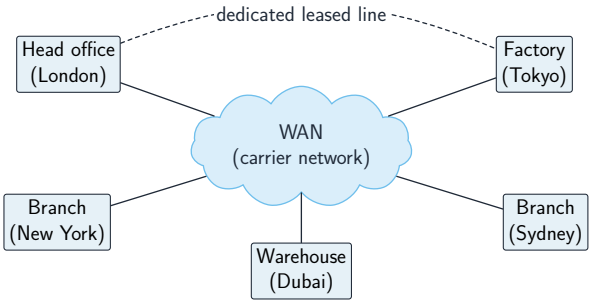
A **network** 网络 connects devices to communicate and share:

- share resources (printers, files, internet)
- central management & backup
- communication & remote access



An RJ45 Ethernet plug: a wired link into a network

LAN vs WAN

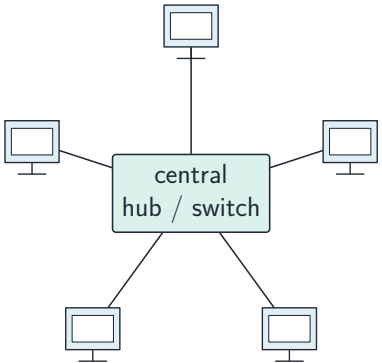


each site holds its own LAN

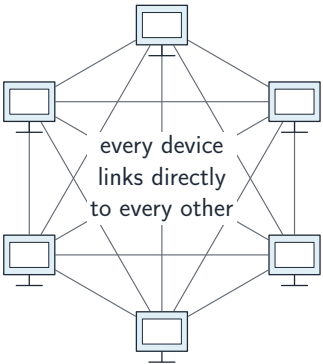
- **local area network** 局域网 (LAN) – small area, one owner, fast, low **latency** 延迟
- **wide area network** 广域网 (WAN) – large area, over **public switched telephone network** 公共交换电话网 links, telecom links, slower; joins LANs

A LAN is usually owned by the organisation itself; a WAN leases telecom links. The internet is the largest WAN.

Network topologies (1)



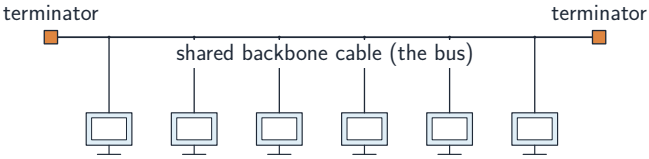
star 星形*: a central switch (most common)*



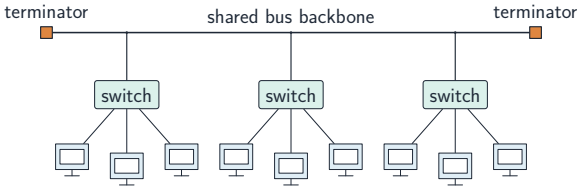
mesh 网状*: many paths,* ***fault-tolerant*** 容错

In a star one cable fault affects one device – but the switch is a single point of failure.

Network topologies (2)

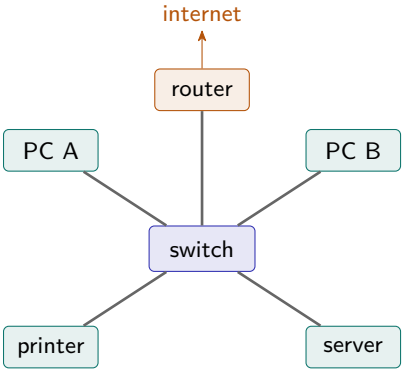


bus 总线*: one shared cable – cheap, but one break stops everyone*



each cluster is a star

A star network, labelled, and a packet's journey



1. PC A sends a frame holding the destination MAC address.
2. The switch looks the address up in its MAC address table.
3. It sends the frame out of that port only.
4. No other device receives it, so links do not collide.

> Draw every device on its own link to the central switch; the router joins the switch to the internet.

IPv4, IPv6 or invalid?

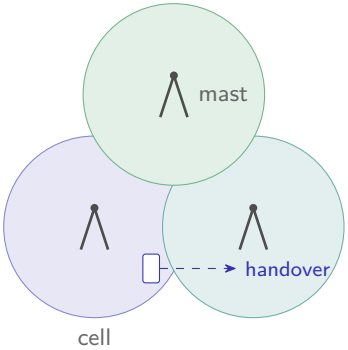
IPv4: four denary numbers, each 0–255, separated by dots (32 bits).

IPv6: eight groups of hexadecimal, separated by colons (128 bits).

> Justify with the rule broken: "300 is greater than 255", not "it looks wrong".

address	**verdict**
`172.16.4.12`	IPv4: four parts, all 0–255
`192.168.300.1`	invalid: $300 > 255$
`10.3A.5.6`	invalid: IPv4 uses denary only
`10.0.5`	invalid: only three parts
`2001:db8::ff00:42`	IPv6: hex groups, colons

How the cell phone network carries data



"Explain how data is transmitted using the cell phone network." [4]

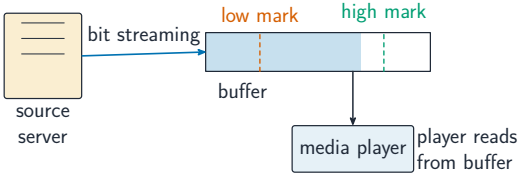
The area is divided into cells, each with a base station (mast).

The phone sends data in packets by radio waves to the nearest mast.

Masts are joined by cable or fibre to the network, and on to the internet.

Moving into a new cell, the call is handed over to that cell's mast.

Bit streaming



Bit streaming 流式传输: play media as it arrives.

- real-time (live): low latency, no rewind
- on-demand: **buffer** 缓冲 ahead, can pause

The pipeline: capture and sample → encode with **lossy** 有损 compression → send → the receiver buffers briefly and plays, dropping any late packet – a live stream cannot wait – the encoded stream must fit the available **bandwidth** 带宽.

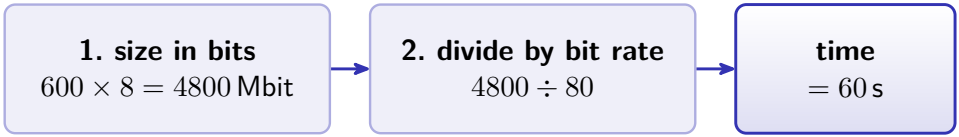
Bit streaming, and why it must be lossy

real-time streaming	live: the data is played as it arrives and not stored
on-demand streaming	the file exists on a server and is buffered as you watch
the buffer	a store filled ahead of the play point, so a brief slowdown does not stop playback
lossy 有損 compression	used here because moving pictures hide small losses, and the stream must be small enough to fit the bandwidth
the requirement	bit rate must be no greater than the available bandwidth, or the buffer empties
the trade	more compression means lower quality but fewer interruptions

> Everything here is bandwidth against quality. Naming the buffer and what it protects against is what the question is asking for.

Worked example: how long to download?

A 600 MB video over an 80 Mbit/s connection – how many seconds?



File sizes are in bytes (MB); connection speeds are in bits per second (Mbit/s). Multiply by 8 first – forgetting it is the classic exam slip.

2 Models, hardware, IDs

Sheet 2.1.1 – what you need to know

You must be able to:

- compare client–server with peer-to-peer, thin with thick clients
- give the job of a NIC, WNIC, switch, router, bridge and repeater
- split an IP address into network ID and host ID

What the exam asks

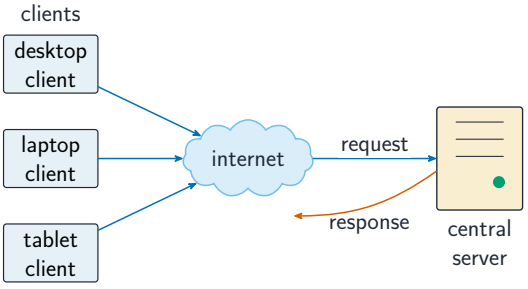
"Identify and describe the two parts of an IP address in a subnetwork." **[3]**

"Describe the functions of a Wireless Network Interface Card." **[4]**

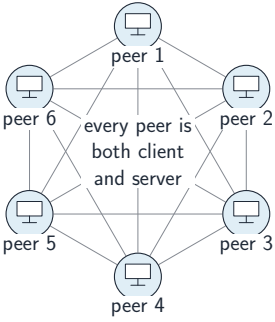
"Identify the following network ID and host ID." **[2]**

Practise on exercise sheet 2.1.1, then try the real exam questions on past-paper sheet 2.1.1.

Client-server and peer-to-peer



client-server 客户端-服务器: *central*



peer-to-peer 对等网络: *equal peers*

Server: easy to manage but a single point of failure. P2P: robust but harder to secure.

Thin vs thick clients

thin client 瘦客户端

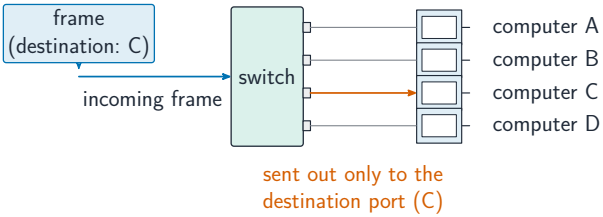
little local processing/storage
relies on a powerful server
(web terminal, remote desktop)

thick client 胖客户端

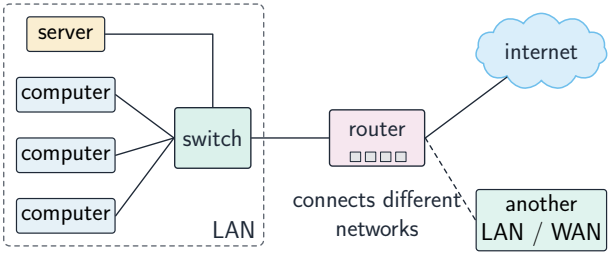
strong local processing/storage
runs full applications itself
(a normal desktop PC)

LAN hardware

- **network interface card** 网络接口卡 (NIC) – sends/receives; unique **MAC address** MAC 地址
- **switch** 交换机 – forwards a frame to the right port only
- **hub** 集线器 – copies to all ports (obsolete)
- **wireless access point** 无线接入点 (WAP) – joins **wireless network interface card** 无线网卡 clients to a wired LAN
- cabling – twisted-pair for short runs, fibre for longer ones



Routers



A **router** 路由器 connects different networks:

- forwards **packets** 数据包 by IP (routing table)
- **network address translation** 网络地址转换 (NAT), **DHCP** 动态主机配置协议, and a **firewall** 防火墙 to block unwanted incoming traffic

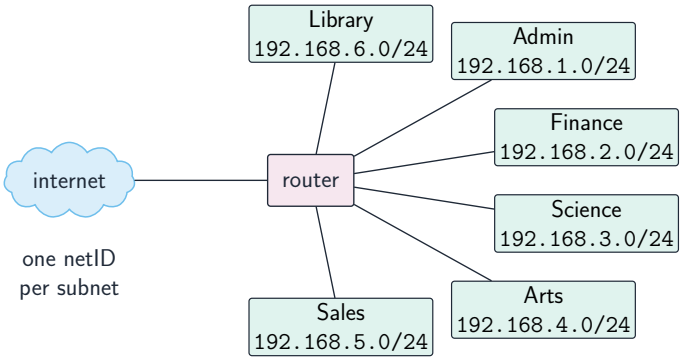
More hardware: what each device does

WNIC	connects a device to a wireless network; converts data to radio signals and back; has a unique MAC address; encrypts and decrypts the data
repeater	receives a weakened signal and regenerates it, so a cable can run further
bridge	joins two segments of a LAN that use the same protocol; forwards by MAC address
router	joins different networks; forwards packets by IP address. It does not resolve URLs (DNS does)

Webmail uses both: the WWW for the web page, the internet to carry it.

IP addresses and subnetting

- IPv4: 32-bit (`192.168.1.10`)
- IPv6: 128-bit, far more addresses
- **subnet** 子网: split by a **subnet mask** 子网掩码 (`255.255.255.0`)



Network ID and host ID

"Identify and describe the two parts of an IP address in a subnetwork." [3]

Network ID: identifies the network (subnet) the device is on.

Host ID: identifies the device on that network.

The subnet mask shows which bits are which.

mask	network ID	host ID
`10.45.3.7`		
`255.0.0.0`	`10`	`45.3.7`
`192.168.5.20`		
`255.255.255.0`	`192.168.5`	`20`

Each `255` keeps that octet in the network ID; each `0` gives it to the host.

Worked example – which subnet is this host on?

Host `192.168.10.130`, mask `255.255.255.192`: which network, and is `192.168.10.200` on it?

1. Last octet of the mask: $192 = 11000000$, so **26** network bits.
2. **Block size** $= 256 - 192 = 64$: subnets start at `.0`, `.64`, `.128`, `.192`.
3. 130 is in the `.128` block: network **`192.168.10.128/26`**, hosts `.129`–`.190`, broadcast `.191`.
4. 200 is in the *next* block: a **different subnet**, so traffic must pass a **router**.

Work in the last octet only: block $= 256 -$ mask value, and every subnet starts at a multiple of the block.

3 Cloud, media, Ethernet

Sheet 2.1.2 – what you need to know

You must be able to:

- define public and private cloud
- choose a transmission medium for a situation
- explain CSMA/CD; describe modems, PSTN and dedicated lines

What the exam asks

"Describe how CSMA/CD manages collisions during data transmission." **[3]**

"Describe the functions of a Wireless Network Interface Card." **[4]**

"Explain how data is transmitted using the cell phone network." **[4]**

Practise on exercise sheet 2.1.2, then try the real exam questions on past-paper sheet 2.1.

Cloud computing and wired vs wireless

Cloud computing 云计算: services over the internet, hosted by a third party.

- + **scalability** 可扩展性, low cost, anywhere
- − needs internet; data held by others

Wired (**Ethernet** 以太网 over **twisted-pair** 双绞线 or **fibre-optic** 光纤): faster, lower latency, fewer errors, more secure. **Wireless** (Wi-Fi, Bluetooth, cellular): mobile and cable-free, but slower and open to interference and eavesdropping.

wired: faster, safer, lower latency

wireless: mobile, no cables, but slower

Public or private cloud, and five transmission media

Public cloud

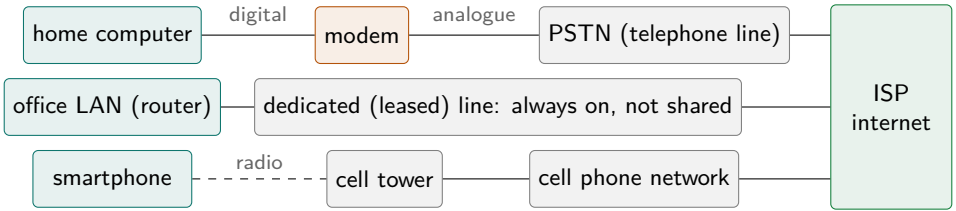
A provider's servers, shared by many customers over the internet.

Private cloud

Servers used by one organisation only: more control and security, more cost.

medium	**strengths, limits, typical use**
copper	cheap, easy to fit; interference, short runs: inside a LAN
fibre	fastest, long distance, no interference; costly: backbones
radio	no cables, devices move; short range: Wi-Fi
microwave	long hops between masts; needs line of sight
satellite	reaches anywhere; high latency, weather: remote sites

Getting onto the internet

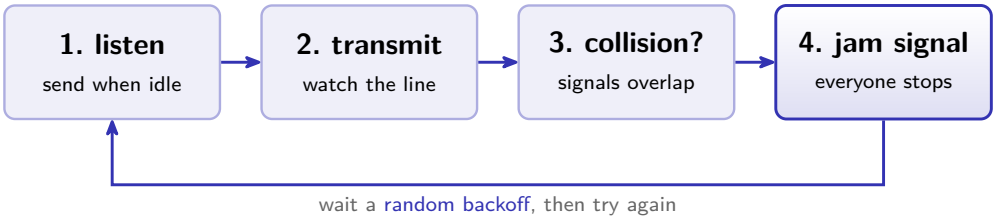


A modem converts digital data to an analogue signal for the telephone line (PSTN), and back.

A dedicated line is always on and not shared: fast and secure, but costly.

Ethernet and CSMA/CD

On shared media a **collision** 冲突 can happen – **CSMA/CD** 载波侦听多路访问:



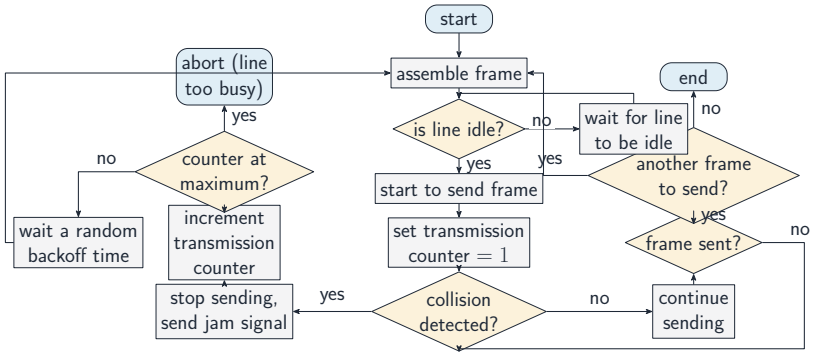
Modern **full-duplex** 全双工 switches avoid collisions altogether.

Wired against wireless, and how Ethernet shares a wire

for the same generation	wired wins on speed and reliability; wireless wins on convenience
1. carrier sense	listen first – if the medium is busy, wait
2. multiple access	any station may transmit when it hears silence
3. collision detection	keep listening while sending; a clash is a collision
4. back off	stop, wait a random time, and try again
why random	if both waited the same time they would collide again immediately

> Wireless cannot detect a collision while transmitting, which is why Wi-Fi uses collision *avoidance* instead of detection.

The CSMA/CD process for handling collisions



Listen first, and if two stations still transmit together, both stop and wait a random time before retrying – random, so they do not collide again.

4 URLs, DNS, IP

Sheet 2.1.3 – what you need to know

You must be able to:

- give the format of IPv4 and IPv6 addresses, with an example
- describe public, private, static and dynamic addresses
- explain how DNS turns a URL into an IP address

What the exam asks

"Describe, using an example, the format of an IPv6 address." **[4]**

"Draw one line from each term to its most appropriate description." **[4]**

"Describe how CSMA/CD manages collisions during data transmission." **[3]**

Practise on exercise sheet 2.1.3, then try the real exam questions on past-paper sheet 2.1.3.

Internet vs World Wide Web

Internet 互联网

the global network of networks (TCP/IP)

World Wide Web 万维网

one service on it: linked pages via HTTP

The Internet is the physical network – cables, routers, addresses. The Web is one service running on top of it. Email and file transfer are other internet services, and are not part of the Web.

Address kinds

private vs public

private: inside a LAN; public: globally routable (from **ISP** 互联网服务提供商)

static vs dynamic

static: fixed (servers); dynamic: from **DHCP** 动态主机配置协议, may change

NAT protection

devices behind NAT are not directly reachable from the internet

IP addresses, subnets and the URL

IPv4	32-bit, four denary numbers 0–255 – about 4.3×10^9 addresses, now exhausted
IPv6	128-bit, eight hexadecimal groups – effectively unlimited
a subnet 子网	the mask splits the address into a network part and a host part
the mask	255.255.255.192 keeps 26 network bits, leaving 6 for hosts – 64 addresses per subnet
a URL 统一资源定位符	locates a resource on the WWW: protocol, domain name, then the path to the file
DNS	resolves the domain name to an IP address, asking successively higher name servers until one answers

AND the address with the mask to get the network. `192.168.10.130` and `192.168.10.200` under /26 are on different subnets – 128 and 192.

Writing an IPv6 address

"Describe, using an example, the format of an IPv6 address." [4]

128 bits, written as eight groups of four hexadecimal digits, separated by colons:

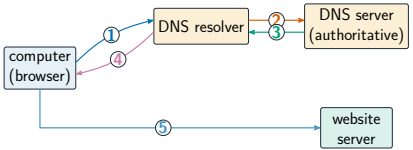
`2001:0db8:0000:0000:0000:ff00:0042:8329`

Leading zeros in a group may be dropped, and one run of all-zero groups may become `::`

`2001:db8::ff00:42:8329`

`::` can appear only once, or nobody could tell how many zero groups each one stands for.

URL and DNS



1 computer asks the resolver for the IP **2** resolver queries a DNS server
3 server returns the IP address **4** resolver passes the IP back to the computer
5 browser connects to that IP and requests the page

A **URL** 统一资源定位符 names one resource:

`protocol://domain/path`

- `https` – the **protocol** 协议
- `example.com` – the **domain name** 域名
- `/notes/1` – the path on that server

The **domain name system** 域名系统 (DNS) turns the domain name into an IP address before the browser connects.

When the name server has no record

1. The browser checks its own cache, then the operating system's.
2. It asks the DNS server (usually the ISP's).
3. No record? That server forwards the request to a higher-level name server, and so on up.
4. The IP address comes back and is cached on the way, so the next lookup is quicker.
5. The browser connects to that IP address.

Why is a private address safer?

It is not routable on the internet, so outside devices cannot reach it directly; the router uses NAT on its behalf.

Static: never changes (servers).
Dynamic: given by DHCP each time, may change.

5 Recap

Exam tips

- Distinguish **LAN vs WAN** and **client-server vs peer-to-peer** by who stores and controls the resources.
- Match each **topology** (bus, star, mesh) to its advantages and drawbacks (cost, reliability, collisions).
- Know the job of each device: a **switch** directs within a LAN by MAC address, a **router** routes between networks by IP.
- Explain **bit streaming** and why buffering is needed (data arrives at a different rate from playback).
- Distinguish **IPv4 vs IPv6** and public vs private addresses; DNS turns a URL into an IP address.

Topic 2 – key takeaways

1 Types

LAN vs WAN; client-server vs peer-to-peer

2 Topologies

bus, star, mesh, hybrid

3 Hardware

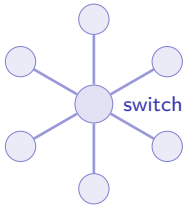
switch forwards by MAC; router by IP

4 Internet

Web is a service on it; DNS maps name to IP

Check yourself

1. Which device forwards frames by MAC address?
2. In a star topology, what fails if the switch fails?
3. What does DNS convert?
4. Internet or Web: which is the service?



Answers **1.** a switch **2.** the whole network **3.** domain name → IP address **4.** the Web