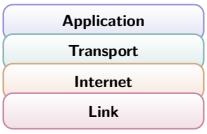
Communication & Internet Technologies

A-Level Computer Science ▪ Topic 14

A-Level Computer Science



What we will cover

1 Why protocols

A protocol is a shared language

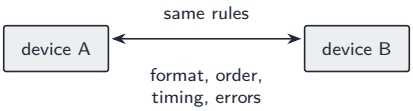
A **protocol** 协议 is a set of rules for how devices communicate. Both ends must follow the same rules, or the signals are meaningless.

format	order	timing	errors
where addresses and payload sit	who speaks first; when to acknowledge	timeouts and retransmits	what to do when something fails

> Without an agreed protocol two devices cannot understand each other – even on the same wire.

What a protocol fixes

Format, order and timing — agreed in advance, so two machines that have never met can talk.



2 Layers

Why split a network into layers?

Networking is complex, so it is split into **layers** 层. Each layer has one focused job and talks only to the layer above and below.

- **modularity** 模块化 – replace Ethernet with Wi-Fi without touching the rest
- standardisation – vendors interoperate
- **abstraction** 抽象 – you ignore details handled elsewhere

Application
Transport
Internet
Link

The internet uses the four-layer **TCP/IP suite** 协议栈.

The four TCP/IP layers

Application — what the user program does
HTTP, FTP, SMTP, IMAP

Transport — end-to-end delivery between processes
TCP, UDP

Internet — routing packets between networks
IP

Link — bits over the physical medium
Ethernet, Wi-Fi

The four layers

Each layer talks to its opposite number on the other machine and uses only the layer below.

sending: data goes down

Layer 4: Application — services for user programs — HTTP, FTP, SMTP, IMAP
Layer 3: Transport — end-to-end delivery between processes — TCP, UDP
Layer 2: Internet — routing packets between networks — IP
Layer 1: Link — sending bits over the physical medium — Ethernet, Wi-Fi

receiving: data goes up.

Transport – TCP vs UDP

The **transport layer** 传输层 delivers data end-to-end between processes, identified by **port numbers** 端口号.

TCP
传输控制协议
connection-oriented
sets up a connection; all data arrives *in order*; lost packets are retransmitted; flow control.
HTTP, HTTPS, SMTP, FTP

UDP
用户数据报协议
connectionless
sends and forgets – no acknowledgements, no ordering. Low overhead, no guarantees.
streaming, DNS, gaming

TCP against UDP

TCP acknowledges and retransmits; UDP just sends. Streaming prefers late-free to loss-free.

TCP
connection set up
all data arrives in order
reliable, more overhead

UDP
no connection
send and forget
fast, no guarantees

Internet layer and link layer

Internet layer

- **IP** 网际协议 carries packets between hosts
- each packet has a source and destination **IP address** IP 地址
- **routers** 路由器 forward it onward
- IP does not guarantee delivery – that is TCP's job

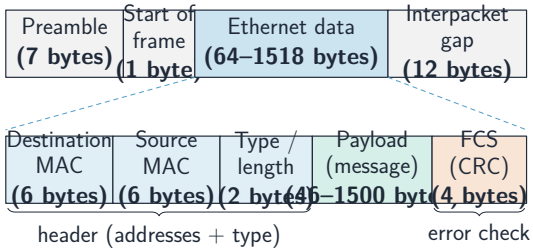
Link layer

- sends bits over one physical link
- frame header with **MAC addresses** MAC 地址
- Ethernet uses **CSMA/CD** 载波侦听多路访问/冲突检测
- a **switch** 交换机 forwards a frame only to the correct port

Copper, Wi-Fi or **fibre-optic** 光纤 (bits as flashes of light) are all link-layer media.

Inside an Ethernet frame

Addresses, payload and a check sequence — the link layer's envelope.



3 Application protocols

Common application-layer protocols

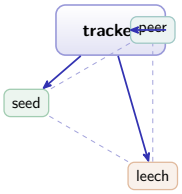
HTTP HTTPS	80 443	browsers fetch pages; HTTPS is HTTP over TLS
FTP	21	transfer files between client and server
SMTP	25	send email; receiving uses POP3 or IMAP
POP3 IMAP	110 143	POP3 downloads and usually deletes; IMAP syncs
DNS	53	names to IP addresses

BitTorrent – sharing without a single server

BitTorrent 比特洪流 is a **peer-to-peer** 对等网络 protocol.

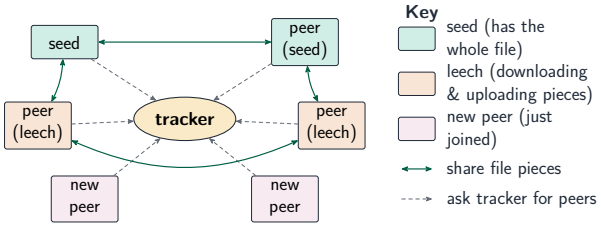
- a file is split into pieces
- a tracker helps peers find each other
- peers then share pieces directly
- no single server carries all the load

> Seeds have the whole file; leeches are still downloading.



A BitTorrent swarm

Every peer that has a piece can serve it, so popular files get faster as demand grows.

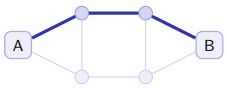


4 Switching

Circuit switching – one reserved path

Circuit switching 电路交换 sets up a dedicated path before any data is sent, reserved for the whole conversation, then released.

- reserved bandwidth, in-order delivery
- inefficient during silences
- slow to set up
- classic example: the traditional telephone network

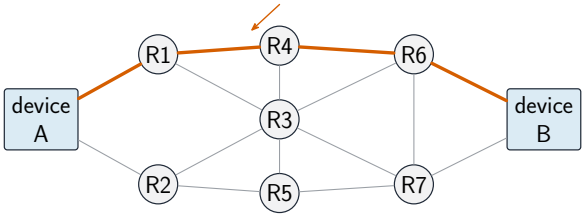


one path reserved

Circuit switching

A path is reserved for the whole call: guaranteed capacity, wasted when idle.

one dedicated path reserved for the whole call



Packet switching – independent packets

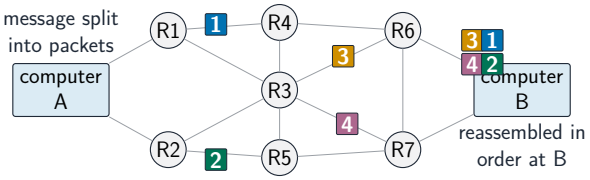
In **packet switching** 分组交换 the data is split into **packets** 数据包, each sent independently.

- each packet carries source, destination and a sequence number
- routers choose the next hop *per packet*
- packets may take different routes and arrive out of order
- the destination reassembles them

Efficient (links are **multiplexed** 多路复用) and robust (reroute around a failure). Variable **latency** 延迟; TCP handles loss.

Packet switching

Packets are routed independently and reassembled — resilient, shared, but variable in delay.



Circuit vs packet – the exam comparison

Aspect	Circuit	Packet
Path	dedicated, reserved	shared, per-packet
Setup	slow	none
Bandwidth	inefficient in silence	efficient
Order	in order	may be out of order
Failure	one cut kills the circuit	reroute around it
Suits	constant-rate voice	bursty web / email

Worked example – a call and a download

A phone call and a large file download share a network. Which switching method suits each, and why?

A phone call needs a steady stream with low delay – **circuit switching**: a dedicated path is reserved for the whole call.

A file download does not care about timing; the receiver reassembles it – **packet switching**: packets travel independently, each with addresses and a sequence number.

Name the *property of the traffic*: reserved capacity and low delay vs efficiency and resilience.

5 Recap

Topic 14 – key takeaways

1. **Protocols**
   format, order, timing, errors – a shared language
2. **TCP/IP**
   App / Transport / Internet / Link; TCP vs UDP
3. **Application**
   HTTP(S), FTP, SMTP, POP3/IMAP, DNS
4. **Switching**
   dedicated path vs independent packets

Check yourself

1. Which layer does IP sit in?
2. TCP or UDP for guaranteed, in-order delivery?
3. SMTP sends email – which protocols receive it?
4. One advantage of packet switching over circuit switching?

Answers **1.** Internet **2.** TCP **3.** POP3 or IMAP **4.** reroutes around failures / uses bandwidth efficiently