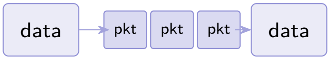
Data Transmission

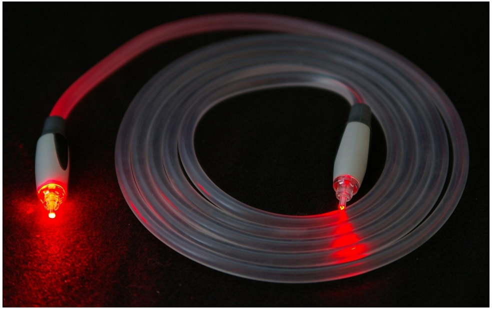
IGCSE Computer Science ▪ Topic 2

IGCSE Computer Science



What we will cover

1. Packets & packet switching
2. Serial, parallel & duplex
3. USB
4. Error detection
5. Encryption
6. Recap



Data often travels along a cable

Ethernet cable
Copper twisted pairs ending in an RJ45 plug – the usual wired cable inside a room or building.

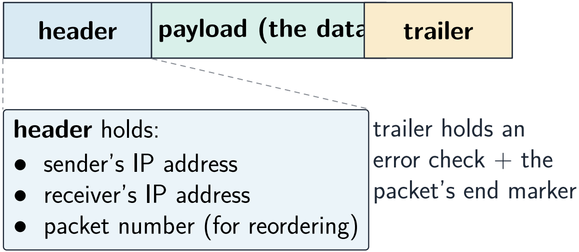
Fibre-optic cable
Thin glass fibres carrying data as *pulses of light*: much faster over long distances and unaffected by electrical interference.

Either way
Data transmission 数据传输 just means moving data from one place to another – computer to website, phone to printer.

Two cables, two jobs: copper for the last few metres, fibre for the distance between buildings and cities.

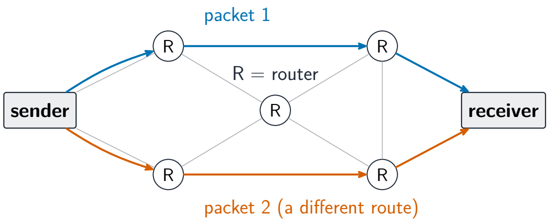
1 Packets

Packets



- the **packet header** 包头: the sender's IP address, the receiver's IP address and the packet number (so the parts can be reordered);
- the **payload** 有效载荷: the data itself;
- the **trailer** 尾部: shows where the packet ends, plus an error check.

Packet switching

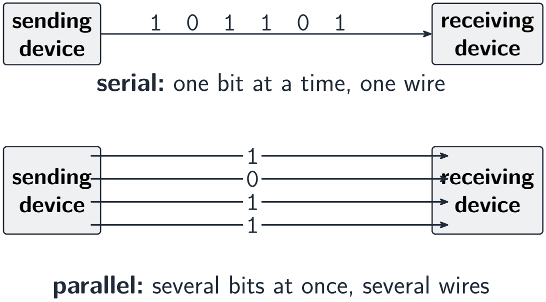


- **routers** 路由器 read each header and pick the best route
- each packet may take its own path
- so packets may arrive out of order
- the packet numbers put them back in order

> Different routes means a busy or broken link can be avoided, and many users share one connection.

2 Transmission methods

Serial vs parallel



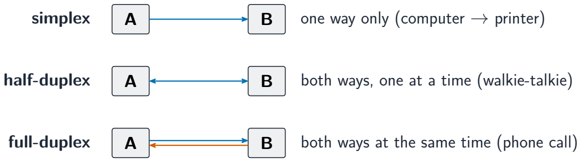
	serial 串行	parallel 并行
bits	one at a time	several at once
wires	one	many
distance	long	short only
cost	cheaper	dearer

> Over long parallel wires the bits arrive at slightly different times – which is why long links go serial (USB, the S is serial).

Choosing a method

The choice depends on the **distance**, the **speed** needed, the **cost**, and whether data must travel both ways at once.

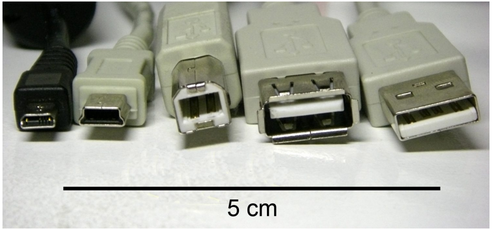
Direction: the three duplexes



- **simplex** 单工: one way only (PC → printer)
- **half-duplex** 半双工: both ways, one at a time (walkie-talkie)
- **full-duplex** 全双工: both ways at once (phone call)

> Choose by distance, speed, cost, and whether data must flow both ways at once.

USB



The **universal serial bus** 通用串行总线 is one standard **interface** 接口:

- one connector for many devices
- auto-detected; driver loaded
- carries power; fits only one way

> But: limited cable length, and older versions are slower.

USB: what you give up

Cable length	Only a few metres – beyond that the signal is unreliable, so USB cannot wire a building.
Older versions	An old USB port stays slow even with a new device: both ends must support the newer standard.
Transfer speed	Transfer speeds can be lower than some other connection types – Ethernet or Thunderbolt beat USB for large transfers.

> USB wins on convenience (one connector, auto-detected, carries power) and loses on **distance and top speed**.

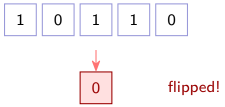
3 Error detection

Why check for errors?

Interference 干扰 in transit can cause:

- data loss – bits do not arrive
- data gain – extra bits appear
- data change – bits are flipped

So the receiver checks the data arrived correctly, using one of several methods.



Parity check

data: 1 0 1 1 0 0 1

count the 1s: four (even)

parity bit $=$ 0 (keep it even)

sent: 1 0 1 1 0 0 1 **0**

> A parity bit is added to make the number of 1s even (or odd)

A parity block finds *which* bit is wrong

The problem	A single **parity bit** 奇偶校验位 tells you *that* an error happened, never *where*.
Parity block	Send several bytes together: each byte carries a row parity bit, and one extra **parity byte** at the end carries the column parities.
Finding it	The row that fails and the column that fails cross at the flipped bit – change it back and the data is repaired.

> Row parity plus a **parity byte** turns error *detection* into error *correction* for a single flipped bit.

Automatic Repeat reQuest (ARQ)

Automatic Repeat reQuest 自动重传请求 (ARQ) uses messages called **acknowledgements 确认**.

- The receiver sends a **positive acknowledgement** if a packet arrived correctly, or a **negative acknowledgement** if it did not.
- The sender starts a **timeout 超时** timer. If no positive acknowledgement comes back in time, the sender sends the packet again.

Worked example – the parity block

Even parity. One bit flipped in transit – find it.

	b1	b2	b3	b4	b5	par	
by1	1	0	1	1	0	1	
by2	0	1	1	0	1	1	
by3	1	1	1	1	0	1	row odd
by4	0	0	1	1	0	0	
par	0	0	1	1	1		col b3 odd

One parity bit only shows that an error happened. A parity block pinpoints it: the bad row $\times$ the bad column $=$ byte 3, bit b3.

Four more checks

checksum 校验和
a value from the data; re-computed and compared

echo check 回送校验
receiver sends the data back to compare

ARQ 自动重传
ack/timeout; re-send if none arrives

check digit 校验码
an extra digit on a typed number (barcodes, ISBN)

A check digit catches a mistyped, swapped (transposition), missing or extra digit.

What a check digit catches

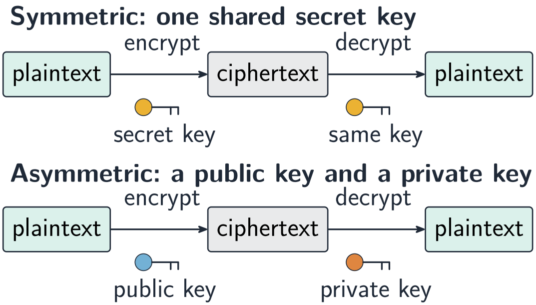
An incorrect digit	One digit typed wrongly – 7 for 1.
A transposition error	Two digits swapped: 21 typed as 12.
A missing or extra digit	A digit left out, or one typed twice.
A phonetic error	A digit that *sounds* similar – 13 heard and typed as 30.

The check digit is recalculated from the other digits when the number is entered and compared – which is why **barcodes** and ISBNs carry one.

4

Encryption

Encryption



- **symmetric** 对称: one shared key encrypts and decrypts
- **asymmetric** 非对称: a **public key** 公钥 encrypts, a **private key** 私钥 decrypts

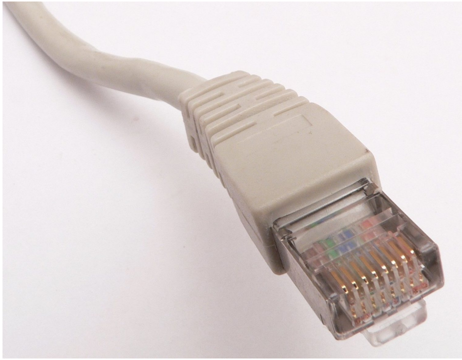
> Encryption does not stop interception – it stops the data being understood. Asymmetric never shares a secret key.

Plaintext, ciphertext, and what encryption really promises

Plaintext	**Plaintext** 明文 is the readable data before encryption – what a thief wants.
Ciphertext	After encryption it becomes **ciphertext** 密文: still readable as characters, but meaningless without the key.
Intercepted	Encryption does not stop data being **intercepted** 拦截; it stops the intercepted data being *understood*.

State the promise precisely in an exam: confidentiality, not delivery. The packet can still be caught – it just cannot be read.

An Ethernet cable with an RJ45 plug



An Ethernet cable with an RJ45 plug, often used to carry data on a wired network

Exam tips

- Data is sent in **packets** (a header with the addresses and packet number, a payload, and a trailer). Packets can take different routes and arrive out of order, then are reordered by their packet numbers.
- Match the transmission types: **serial** (one bit at a time, good over long distances) vs **parallel** (several bits at once, short distances); **simplex** / **half-duplex** / **full-duplex** describe the direction.
- A single **parity bit** only shows *that* an error happened; a **parity block** locates the exact wrong bit – the row and the column that both fail.
- Learn the error-detection methods and what each does: parity check, checksum, echo check, ARQ, and the check digit (for typed-in numbers).
- **Symmetric** encryption uses one shared key; **asymmetric** uses a public key to encrypt and a private key to decrypt, so no secret key is ever shared.

5 Recap

Topic 2 – key takeaways

1 Packets

header (addresses, number) + payload + trailer

2 Serial/parallel

serial one bit, long distance; parallel many, short

3 Errors

parity block locates the bit; checksum, echo, ARQ

4 Encryption

symmetric one key; asymmetric public + private

Check yourself

1. What puts out-of-order packets back in order?
2. Walkie-talkie: which duplex?
3. What does a parity block locate that one bit cannot?
4. Which key decrypts in asymmetric encryption?

Answers **1.** the packet numbers **2.** half-duplex **3.** the exact wrong bit **4.** the private key