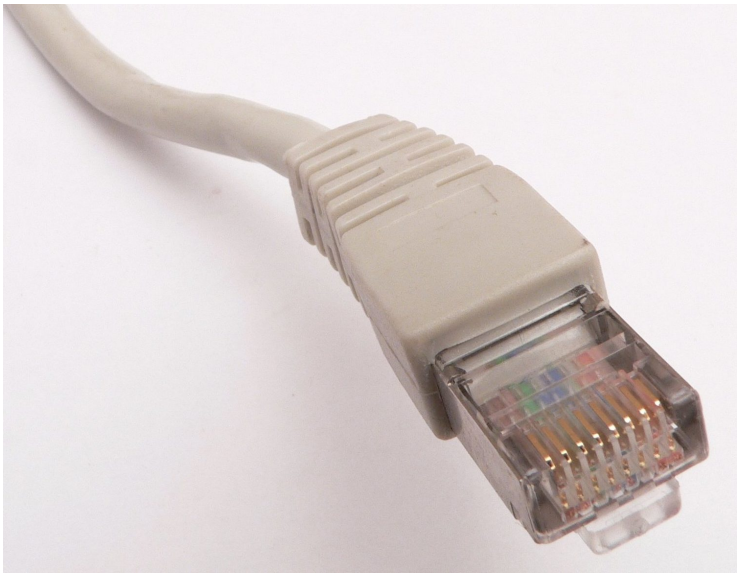
Computer Systems and Networks

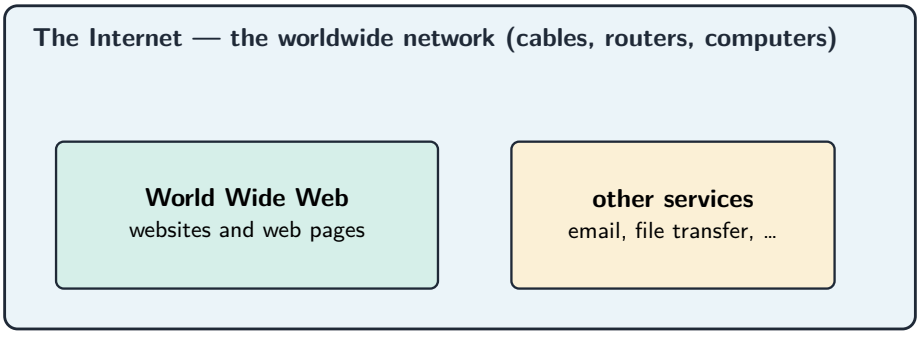
AP Computer Science Principles

The Internet



An RJ45 Ethernet connector — physical links carry packets across the Internet

The **Internet** 互联网 is a global network of networks. Data travels as **packets** 数据包 – small chunks that are sent separately and reassembled at the destination. Two ideas make it work at scale:



The internet is the worldwide network; the web is one service running on it

- **Protocols** 协议 are agreed rules for communication. **IP** (Internet Protocol) addresses and routes packets; **TCP** reassembles them in order and re-requests lost

ones; **HTTP** carries web pages; **DNS** translates a name like `example.com` into an IP address.

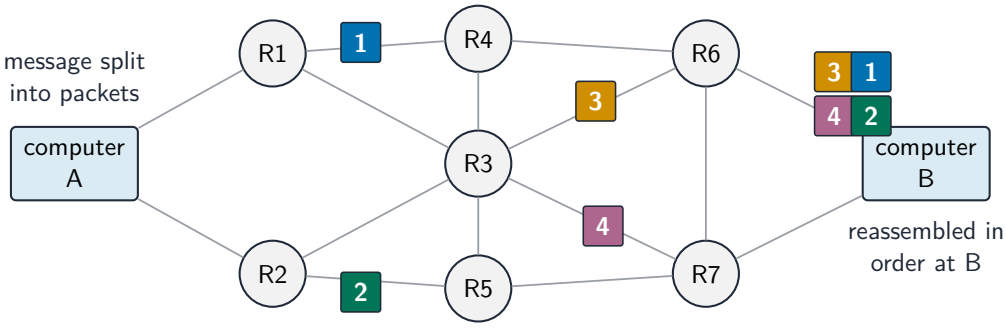
- **Redundancy** 冗余 and routing: there are **many** possible paths between two points, so if one path fails, packets take another. This makes the Internet **fault-tolerant** 容错.

The Internet is designed to be **open** and **scalable** – built on standards anyone can use, so it keeps working as billions of devices join. **Bandwidth** 带宽 is the amount of data a connection can carry per second.

Fault Tolerance

A Wi-Fi router: the local gateway that forwards packets toward the wider Internet

A system is **fault-tolerant** if it keeps working even when part of it fails. The Internet achieves this through **redundant** connections: because packets can be routed along multiple paths, the failure of one router or cable does not stop communication – traffic simply reroutes. Fault tolerance costs extra resources (the redundant paths) but greatly improves **reliability** 可靠性. A single path with no backup is not fault-tolerant.

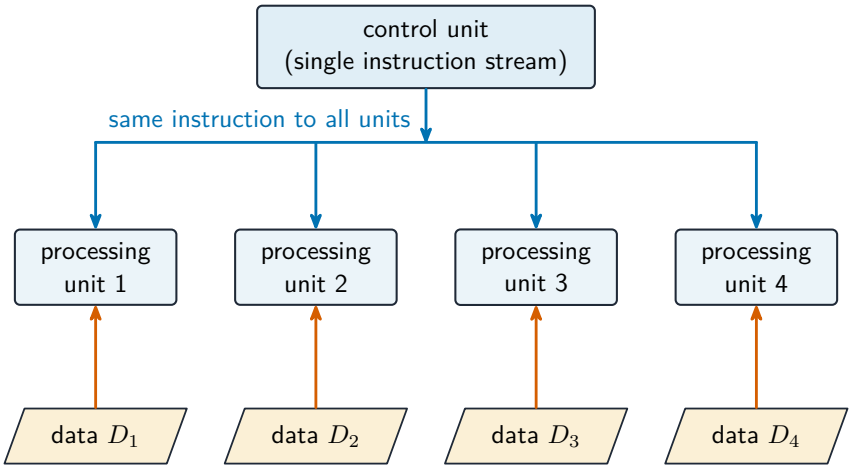


Packet switching sends packets by independent routes, so the network tolerates a failed link

Parallel and Distributed Computing

Data-centre server racks: distributed computing spreads work across many machines

- **Sequential computing** 顺序计算 runs one operation at a time.
- **Parallel computing** 并行计算 splits a task into parts that run **at the same time** on multiple processors, finishing faster.
- **Distributed computing** 分布式计算 uses **many computers** connected by a network to work on one problem – essential for problems too big for a single machine.



Parallel computing: many processors work at the same time

A parallel solution's **speedup** 加速比 is the sequential time divided by the parallel time. Speedup is limited: parts that **must** run in sequence cannot be sped up by adding processors, so doubling the processors rarely doubles the speed.

Worked example. A task has a part that **must** run sequentially, taking 40 seconds, plus a parallelizable part that takes 60 seconds on one processor – so on a single processor the whole task takes $40 + 60 = 100$ seconds. Spread the parallel part across 3 processors and it takes $\frac{60}{3} = 20$ seconds, so the total parallel time is $40 + 20 = 60$ seconds and the speedup is $\frac{100}{60} \approx 1.67$. The 40-second sequential part is a floor: even with infinitely many processors the task can never finish in under 40 seconds.

Exam skill: given the times for the sequential and parallel portions of a task, be able to calculate the total parallel time and the speedup.

Exam tips

- Describe how data travels in **packets** over a redundant, fault-tolerant network of independent routers.
- Know that **protocols** (IP, TCP, HTTP) are agreed rules, and that open standards let different systems interoperate.
- Explain **scalability** and how the Internet grows without central control.
- Contrast **bandwidth** (rate) with **latency** (delay), and describe the **DNS** name-to-address lookup.
- Discuss the **digital divide** and security basics (encryption, authentication) in plain terms.