Wired and wireless connectivity and performance

4.1.4 · Networks · revision notes

How the characteristics of wired connections (copper and fibre-optic cable) and wireless connections (Wi-Fi) affect network performance: speed, range, latency and bandwidth. Questions ask you to define these terms, compare wired and wireless connections and recommend one for a situation, sometimes as a 6-mark 'Discuss'.

Key facts

- Copper (Ethernet) cable: electrical signals, about 100 m per cable run
- Wi-Fi: radio waves between devices and a wireless access point
- Latency: the delay between data being sent and being received
- Wireless: mobility, easy to add devices, no cabling; but slower, limited range, interference, shared bandwidth, less secure
- Fibre-optic cable: pulses of light, very high bandwidth, long distances, no electromagnetic interference
- Bandwidth: the maximum amount of data that can be sent per second
- Wired: faster, lower latency, more reliable, more secure
- Secure Wi-Fi with WPA2 or WPA3 encryption and a strong password

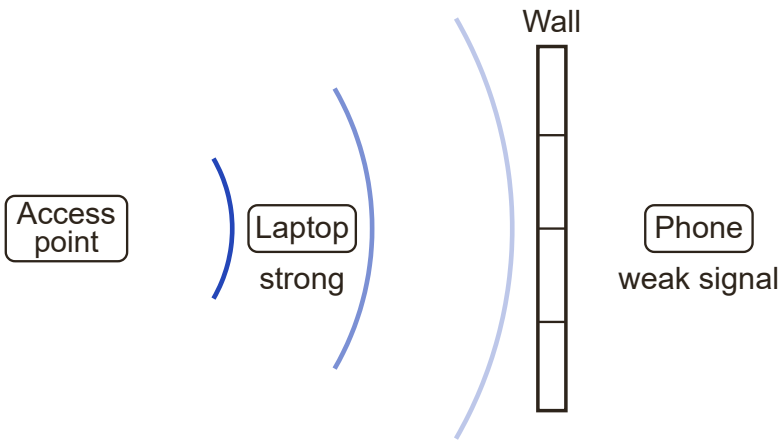
Notes

Wired connections

- **Copper cable** (e.g. twisted-pair Ethernet cable) carries data as electrical signals. It is cheap, but a single cable run is limited to about 100 m and it can suffer electromagnetic interference.
- **Fibre-optic cable** carries data as pulses of light. It has a very high bandwidth, works over many kilometres and is not affected by electromagnetic interference, but it costs more to buy and install.
- Wired connections give high, reliable speeds and low latency. They are more secure, because an attacker needs physical access to a cable or network socket.
- But cabling is costly to install, fixes devices in place and can be a trip hazard.

Wireless connections

- **Wi-Fi** sends data as radio waves between devices and a wireless access point (often built into a router).
- Users can move around while staying connected, and devices are easy and cheap to add because no cables are needed.
- The signal gets weaker with distance and when it passes through walls and floors, so the range is limited (typically tens of metres indoors).



The Wi-Fi signal weakens with distance and when it passes through walls, which limits the range.

- Other wireless networks and electrical devices cause interference, so data can be lost and have to be resent.
- An access point's bandwidth is shared between all its connected devices, so each gets less when many are connected.
- Signals can be picked up by anyone within range, so Wi-Fi must be protected with encryption (e.g. WPA2 or WPA3) and a strong password.

Measuring performance

- **Bandwidth**: the maximum amount of data that can be transmitted across a connection per second.
- **Speed** (transmission rate): the amount of data actually transferred per second, usually lower than the bandwidth.
- **Latency**: the time delay between data being sent and it being received. Low latency matters for video calls and online games.
- **Range**: how far the signal can travel before it becomes too weak to use.
- Overall, wired usually wins on speed, latency, reliability and security; wireless wins on mobility and ease of adding devices.

How to answer each type of question

Define bandwidth or latency

1 mark each | Grade 5

1. Give the precise definition, not just 'speed'.
2. Bandwidth is about the maximum amount of data per second; latency is about a time delay.

Example. (a) Define the term 'bandwidth'. (1)
(b) Define the term 'latency'. (1)

Model answer.

(a) The maximum amount of data that can be transmitted across a connection in a given time, e.g. per second (1)

(b) The time delay between data being sent and it being received (1)

Explain advantages or disadvantages of wired or wireless

2 to 4 marks | Grade 5

1. Pick points that fit the scenario (mobility, number of devices, cost of cabling, security, speed).
2. For each point, add a consequence with 'so' or 'because'.
3. Avoid vague answers such as 'it is better' or 'it is easier'.

Example. A hotel wants to give guests internet access in their rooms.
Explain **two** reasons why the hotel might choose wireless connections rather than wired connections. (4)

Model answer. Guests can use their laptops, phones and tablets anywhere in the room (1), because the devices do not need to be plugged into a network socket (1). The hotel does not need to install cables to every room (1), so it is cheaper and quicker to set up and causes less disruption (1).

Explain why a connection is performing poorly

2 to 4 marks | Grade 6

1. Look for clues in the scenario: distance, walls, the number of users, other devices nearby.
2. Name the cause (weak signal, interference, shared bandwidth).
3. Explain the effect: data is lost and resent, or each device gets less data per second.

Example. Students in a classroom at the far end of a school corridor say that the Wi-Fi is very slow when the whole class is online.
Explain **two** reasons why. (4)

Model answer. The classroom is a long way from the access point and the signal is weakened by walls (1), so data is lost and has to be resent and the transfer rate drops (1). The access point's bandwidth is shared between all the students' devices (1), so each device gets only a small share of it (1).

6-mark: Discuss whether to use wired, wireless or both 6 marks (levels-based) **Grade 8**

1. Consider each group of users in the scenario separately, e.g. fixed desktops and mobile devices.
2. Compare speed, latency, range, reliability, security, mobility and cost, linking each point to the scenario.
3. Include drawbacks of your choice as well as benefits.
4. Finish with a justified recommendation.

Example. A video-production company is moving into a new office. Editors work at desktop computers and open very large video files from a server. Managers move between meeting rooms with laptops. Discuss whether the office should use wired connections, wireless connections or both. (6)

Model answer. Marked by levels: the top band links developed points to the scenario and reaches a supported conclusion. Points could include: wired connections give the editors high, consistent speeds and low latency for opening huge files from the server; wired links are not shared with other devices or affected by interference, and they need physical access, so they are more secure; the editors' desktops do not move, so cables are not a drawback; Wi-Fi lets managers use laptops anywhere and move between rooms without plugging in; wireless is easy to extend to new devices, but its bandwidth is shared, its signal is weakened by walls and it must be encrypted (WPA2 or WPA3); cabling costs more to install. Conclusion: wired connections for the editors and the server, with Wi-Fi access points for the managers' laptops.

Don’t lose marks

- Defining bandwidth as 'the speed of the network'. It is the maximum amount of data that can be sent per second.
- Mixing up latency (a delay) with bandwidth (a capacity). A connection can have a high bandwidth and a high latency.
- Saying wireless is 'unsafe' without explaining why: its signals travel through the air and can be picked up by anyone within range.
- Saying fibre-optic cable carries electricity. It carries pulses of light.
- Recommending one type of connection without linking it to the needs in the question.

More tips

Memory tricks

- Wired wins the 'S' words: speed, stability, security. Wireless wins on mobility and convenience.
- Bandwidth is the width of a pipe (how much can flow each second); latency is how long the first drop takes to come out of the other end.
- Fibre = light = long distances and no interference.
- Wi-Fi problem checklist: distance, walls, interference, number of users sharing the bandwidth.

Exam technique

- Link every advantage or disadvantage to the people and devices in the scenario.
- Make comparison points two-sided, e.g. 'wired connections have lower latency than wireless connections'.
- Use the specification terms in your answers: speed, range, latency and bandwidth.
- In a 'Discuss' question, a mixture (wired for fixed devices, wireless for mobile ones) is often the best conclusion, but you must justify it.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **State how data travels in each medium**
Electrical signals in copper cable, pulses of light in fibre-optic cable and radio waves for Wi-Fi.

Grade 4 — **Give advantages and disadvantages of wireless**
Users can move around and devices are easy to add, but it is slower, has a shorter range and is less secure.

Grade 5 — **Define bandwidth and latency**
Bandwidth is the maximum amount of data sent per second; latency is the delay before data arrives.

Grade 5 — **Compare copper and fibre-optic cable**
Fibre is faster, works over longer distances and is not affected by electromagnetic interference, but costs more.

Grade 6 — **Explain why Wi-Fi performance falls**
Distance, walls, interference and sharing the bandwidth between many devices all reduce performance.

Grade 7 — **Recommend a connection type with justification**
Match speed, range, latency, mobility, security and cost to the needs of the users in the scenario.

Grade 8 — **Discuss wired versus wireless for a scenario**
Weigh up both types for each group of users and reach a justified recommendation, often a mixture of both.

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