Transmission Media

There are three main types of transmission media used for digital communication:

- Wireless — uses radio waves or microwaves to transmit data through the air or space eg wifi, cellular networks(eg 5G) or satellites.
- Twisted Pair — uses electrical signals to transmit data through copper cables
- Optical Fibre — uses pulses of light to transmit data through glass or plastic fibres

Network engineers need to make informed decisions when designing networks. Which transmission media would be the most suitable. Factors to consider include:

- bandwidth
- cost (of implementing/installing/upgrading)
- range
- reliability
- security
- attenuation
- susceptibility to interference

Let's start by taking a look at **optical fibre**.

Open the submarine cable map.

1. Search for Grace Hopper transatlantic cable. Do some research and answer the following questions:

How long is the Grace Hopper cable?	
Who owns it?	
Which 2 countries does Grace Hopper connect America to?	
What is its bandwidth[1]?	
How much did it cost to install?	
How susceptible is optical fibre to interference eg electromagnetic interference?	

[1] Bandwidth is the maximum rate of data that can be transferred at once along a given path/channel/cable, usually measure in Bits Per Second.

Hopefully the answers to these questions give you an appreciation of Fibre Optic cable as a transmission medium.

The only obvious downside is the cost of installation and maintenance. Of course, the Grace Hopper scenario is extreme, but relative to Wireless technologies and Twisted Pair, optical fibre would be the most costly.

Twisted Pair vs Wireless

Twisted pair is just a pair of copper wires twisted together, allowing the transmission of electromagnetic signals. It is the hardware that the Ethernet standard mostly uses. The signals are of course trapped inside a cable and difficult to access during transmission.

Wireless signals use radio waves that travel through the air, making them easier to intercept than signals sent through twisted pair cables

TASK 1

Without researching, think practically and attempt to answer the following questions.

Which transmission medium is usually cheaper to install and maintain in a school or office network: twisted pair cable or wireless? Explain why.
Why is twisted pair cabling generally considered more secure than wireless communication?
Compare the reliability of twisted pair and wireless connections in environments with interference or physical obstacles.
How does the range of twisted pair cables compare with the range of wireless networks?
Which medium typically provides higher bandwidth and lower attenuation[2]: twisted pair or wireless? Explain your answer using practical examples.

Suggested answers are at the back of this worksheet.

[2] Attenuation refers to the gradual weakening or loss of signal strength as data travels through a transmission medium, for example wireless signals lose strength the further they travel, and if they encounter obstacles such as walls or floors.

We can appreciate that the designers of trans-continent communication systems were never going to solve the problem using wifi signals or twisted pair. But why invest so much money in a fibre-optic solution, involving hundreds of thousands of kilometers of physical cables, when a satellite-based solution would work, given the ease of sending satellites into orbit (eg Starlink).

Task 2

Do some research and find out why a fibre-optic solution was chosen.

A set of suggested reasons can be found at the back of this worksheet.

TASK 1 - Suggested answers

Without researching, think practically and attempt to answer the following questions.

Which transmission medium is usually cheaper to install and maintain in a school or office network: twisted pair cable or wireless? Explain why.
Wireless networks are usually cheaper and faster to install because fewer cables are required. Twisted pair networks may have higher installation costs because cables must be run through walls, ceilings, or floors.
Why is twisted pair cabling generally considered more secure than wireless communication?
Twisted pair is more secure because data travels through a physical cable, making interception more difficult. Wireless signals travel through the air and can potentially be accessed by unauthorized users if security settings are weak.
Compare the reliability of twisted pair and wireless connections in environments with interference or physical obstacles.
Twisted pair connections are generally more reliable because they are less affected by walls, weather, or electromagnetic interference. Wireless signals can weaken or disconnect when obstacles or interference are present.
How does the range of twisted pair cables compare with the range of wireless networks?
Standard twisted pair Ethernet cables are usually limited to about 100 meters before signal quality decreases. Wireless networks can cover larger areas without cables, but signal strength decreases over distance and through obstacles.
Which medium typically provides higher bandwidth and lower attenuation[3]: twisted pair or wireless? Explain your answer using practical examples.
Twisted pair generally provides higher bandwidth and lower attenuation than wireless. For example, a wired Ethernet connection often supports faster and more stable speeds for gaming or video editing, while wireless speeds may fluctuate depending on signal strength and network congestion.

[3] Attenuation refers to the gradual weakening or loss of signal strength as data travels through a transmission medium, for example wireless signals lose strength the further they travel, and if they encounter obstacles such as walls or floors.

Task 2 - Suggested Answers

Much higher bandwidth
Fibre-optic cables can carry enormous amounts of data simultaneously — far more than satellites.

Lower latency
Even low-Earth-orbit satellites still send signals thousands of kilometres into space and back. Light travelling through fibre across the ocean is often faster overall for internet communication.

Greater reliability and consistency
Weather, atmospheric conditions, and orbital congestion can affect satellite systems.

Lower cost per bit of data
Satellites are extremely expensive to launch, maintain, and replace. Fibre is expensive to install initially, but once deployed it can carry huge amounts of traffic very efficiently.

Global internet traffic volume is enormous
Most international internet traffic already travels through submarine fibre-optic cables because satellites alone could not currently handle the world's data demands.