



OCR GCSE Computer Science



Your notes

Wired & Wireless Networks, Protocols & Layers

Contents

- * Modes of Connection
- * Encryption
- * IP Addressing & MAC Addressing
- * Standards in Computing
- * Network Protocols
- * The Concept of Layers



Your notes

Modes of Connection

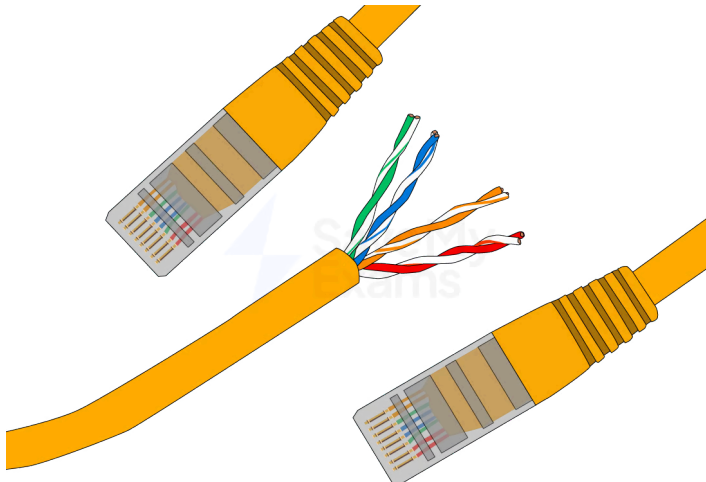
- To connect devices to a network, there are two main options:
 - **Wired**
 - **Wireless**
- There are advantages and disadvantages to each option which are explored below

Wired Networks

What is a wired network?

- A wired network is a network where **physical cables** are used to join devices together and **transmit data**
- Computers can be connected to networks using many different types of wires to transmit data
- The most common type of cable in a local area network (LAN) is **Ethernet**

What is Ethernet?

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- Ethernet is a wired networking **standard** to carry electrical signals between devices
- Ethernet is common in most offices and homes to connect devices such as **desktop computers & servers**
- Ethernet uses **twisted pair cables** to allow **duplex** communication



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Advantages	Disadvantages
Speed - Fast data transfer	Portability - Can't move easily, location is limited by physical cable
Security - Better physical security	Cost - Need more cables to add a new device
Range - High (up to 100m), less susceptible to interference	Safety - Cables can be trip hazards, need routing along walls, under floors



Worked Example

A school has a LAN (Local Area Network)

The LAN allows access by both wired and wireless devices.

The wired connection is an Ethernet connection. Ethernet is considered a standard.

Explain why Ethernet is a standard [2]

Answer

- Ethernet is used by (mostly) all manufacturers // Ethernet is used in many devices
- ...to allow compatibility with other devices
- Ethernet has a high bandwidth
- Ethernet has inbuilt security
- Ethernet is a proven/reliable connection
- Ethernet is low cost for purchase/installation/maintenance (compared to other wired connections)

Wireless Networks

What is a wireless network?

- A wireless network is a network where connections are made **using radio waves** to transmit data **through the air**
- The most common types of wireless connections are:
 - Wi-Fi
 - Bluetooth

What is Wi-Fi?



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- Wireless fidelity (**Wi-Fi**) is a common **standard** for wireless networks
- Wi-Fi is common in most homes and offices to connect devices such as **laptops, tablets & smart phones**
- Using Wi-Fi, devices communicate with a **wireless access point (WAP)**, which can be a standalone device or built into a **router** or **switch**

Advantages	Disadvantages
Portability - Easy to move around, location is only limited by range	Speed - Slower data transfer than Ethernet
Cost - Less expensive to setup and add new devices	Security - Less secure than Ethernet
Compatibility - Most devices are manufactured with a built in Wi-Fi adapter	Range - Relies on signal strength to the WAP, signals can be obstructed (up to 90m)



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What is Bluetooth?



- Bluetooth is another common **standard** for wireless networks
- Bluetooth is common in most homes and offices to connect devices such as **headphones, controllers, keyboards & mice**
- Bluetooth is used typically for a **direct connection** between **two devices**

Advantages	Disadvantages
Compatibility - Ideal for personal devices and ad-hoc connections	Speed - Very slow transfer speeds
Power - Very low power consumption	Security - Data can be intercepted by anyone in range
	Range - Very short range (10m)



Worked Example

Dave has set up a new travel agency and needs you to set up a network for the shop. There will be **four workstations** for staff to book new holidays and take payments from clients, and each member of staff will also be issued with a **tablet** so they can show customers different destinations and hotels. Staff will use their PCs to phone customers and suppliers using **headsets**.

Describe how different types of network connection could be set up to support the new business
[6]

Answer

- The workstations should be connected using **Ethernet [1]** because they **won't need to be moved**, this will allow for **fast transfer speeds** and it is **more secure** than Wi-Fi for sending customer data [1]
- The tablets should be connected using **Wi-Fi [1]** so they can be **moved around without cables** and the signals won't have to go through walls [1]
- The headsets should be connected through **Bluetooth [1]** so that staff don't get **tangled in wires** and they can connect just to **their own workstation** rather than needing full access to the network [1]



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Encryption

Encryption

What is encryption?

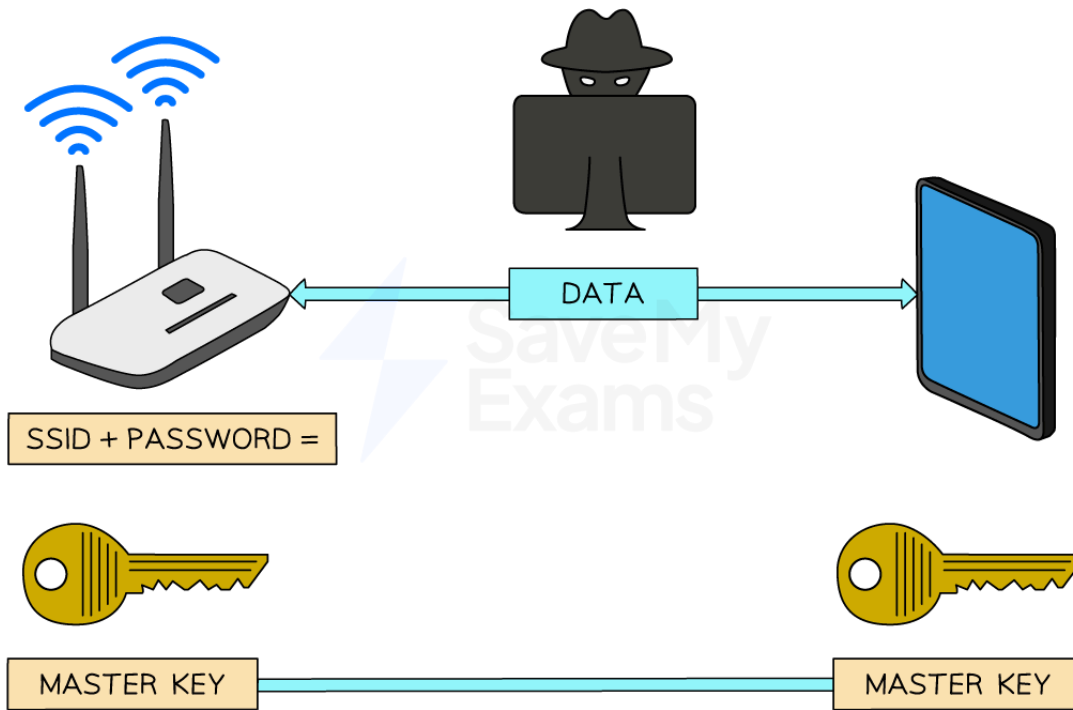
- Encryption is a method of **scrambling data** before being transmitted across a network in order to protect the contents from **unauthorised access**
- While encryption is important on both **wired** and **wireless** networks, it's even more critical on wireless networks due to the data being transmitted over radio waves, making it easy to **intercept**

How is wireless data encrypted?

- Wireless networks are identified by a 'Service Set Identifier' (**SSID**) which along with a password is used to create a '**master key**'
- When devices connect to the **same wireless network** using the SSID and password they are given a copy of the master key
- The master key is used to **encrypt** data into '**cipher text**', before being transmitted
- The receiver uses the same master key to **decrypt** the cipher text back to '**plain text**'
- To guarantee the security of data, the **master key is never transmitted**. Without it, any intercepted data is rendered useless
- Wireless networks use dedicated **protocols** like **WPA2** specifically designed for **Wi-Fi** security



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How is wired data encrypted?

- Wired networks are encrypted in a very similar way to a wireless network, using a **master key to encrypt** data and the **same key to decrypt** data
- Encryption on a wired network differs slightly as it is often left to **individual applications to decide** how encryption is used, for example **HTTPS**



Worked Example

A bank does not use encryption when data is transmitted through the network.

Give two reasons why the bank should use encryption [2]

How to answer this question

- Answer must be 'why' the bank should use encryption and NOT just what encryption is. Give examples in your answer

Answer

- Customer data cannot be understood if intercepted // The data will be meaningless
- So that only authorised users can access the confidential material // protect confidential/personal/user/bank data
- To follow legislation/Data Protection Act



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IP Addressing & MAC Addressing

- Devices on a network send and receive data, a device needs an address to ensure it sends data to the correct place
- There are two types of network address systems:
 - IP Address
 - MAC Address

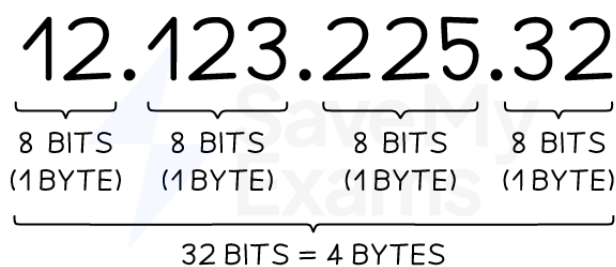
IP Addressing

What is an IP address?

- An IP (Internet Protocol) address is a **unique identifier** given to devices which communicate over the Internet (**WAN**)
- IP addresses are **dynamic**, they can change
- IP addresses make it possible to **deliver data to the right device**
- A device connecting to a network will be given an IP address, if it moves to a different network then the IP address will change

IPv4

- Internet Protocol version 4 is represented as **4 blocks of denary numbers** between **0** and **255**, separated by **full stops**
- Each block is **one byte** (8 bits), each address is **4 bytes** (32 bits)



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- IPv4 provides over **4 billion unique addresses** (2^{32}), however, with over **7 billion** people and **countless devices per person**, a solution was needed



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IPv6

- Internet Protocol version 6 is represented as **8 blocks of 4 hexadecimal digits**, separated by **colons**
- Each block is **2 bytes** (16 bits), each address is **16 bytes** (128 bits)

2001:0DB8:3333:4444:5555:6666:7777:8888

16 BITS:16 BITS:16 BITS:16 BITS:16 BITS:16 BITS:16 BITS:16 BITS

128 BITS

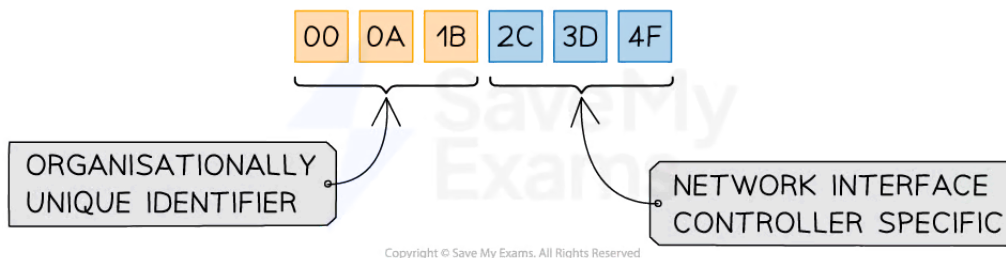
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- IPv6 could provide over **one billion unique addresses** for **every person** on the planet (2^{128})

MAC Addressing

What is a MAC address?

- A MAC (Media Access Control) address is a **unique identifier** given to devices which communicate over a local area network (**LAN**)
- MAC addresses are **static**, they can never change
- MAC addresses make it possible for **switches** to efficiently **forward data** to the intended **recipient**
- Any device that contains a **Network Interface Card (NIC)** has a MAC address **assigned during manufacturing**
- A device connecting to a local network already has a MAC address, if it moves to a different network then the MAC address will stay the same



- A MAC address is represented as **12 hexadecimal digits** (48 bits), usually **grouped in pairs**

- The first three pairs are the **manufacturer ID number** (OUI) and the last three pairs are the **serial number** of the network interface card (**NIC**)
- There are enough unique MAC addresses for roughly **281 trillion devices**



Worked Example

Computers in a network can be identified using both IP addresses and MAC addresses.

Describe two differences between IP addresses and MAC addresses [2]

Answer

- IP address is dynamic/can change // MAC address is static/cannot change
- IP address is used to communicate on a WAN/Internet // MAC address is used to communicate on a LAN



Your notes



Your notes

Standards in Computing

Standards in Computing

What is a standard?

- A computing standard is a **set of guidelines** that when used with different hardware and software allows them to work with each other (**compatibility**) and allow data exchange (**interoperability**)
- Standards give manufacturers and software developers the ability to create hardware and software that will **function together**
- Countries that use **different plug sockets** and devices that use **different charger cables** are examples of where standards are **not used**
- Examples of computer standards are:
 - **HTML** – A standard for creating websites that allows them to be viewed on the World Wide Web (WWW) using web browser software
 - **Ethernet** – A standard for wired network cables that allows the network to function
 - **USB** – A standard that defines the physical connector used for connecting **peripheral** devices to computers
 - **Wi-Fi** – A standard that allows wireless devices to communicate on a local area network (LAN)



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Network Protocols

- **Standards** exist in computing to allow **hardware and software to work together**
- **Standards** outline the broad guidelines and **protocols** focus on specific procedures

What is a protocol?

- A protocol is a **set of rules** that govern **communication** on a network
- There are protocols for different purposes, such as:
 - TCP/IP
 - HTTP & HTTPS
 - FTP
 - POP, IMAP & SMTP

TCP/IP

What is TCP/IP?

- TCP/IP is two protocols, transmission control protocol (**TCP**) and internet protocol (**IP**) that combined **allow communication over the internet** (WAN)
- TCP is responsible for making sure **communication** between two **routers** is **error free**
- IP is responsible for making sure **data is delivered** to the **right device** on a wide area network (WAN)

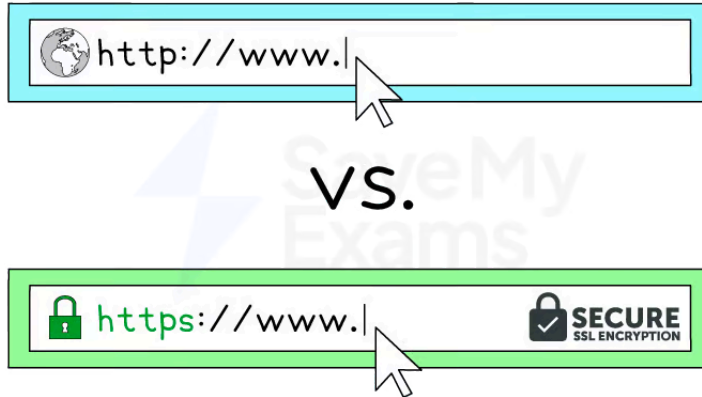
HTTP & HTTPS

What is HTTP & HTTPS?

- Hypertext Transfer Protocol (**HTTP**) allows communication between clients and servers for **website viewing**
- HTTP allows clients to **receive data** from the sever (fetching a webpage) and **send data** to the server (submitting a form, uploading a file)
- **HTTPS** works in the same way as HTTP but with an **added layer of security**. All data sent and received using HTTPS is **encrypted**
- HTTPS is used to **protect sensitive information** such as passwords, financial information and personal data



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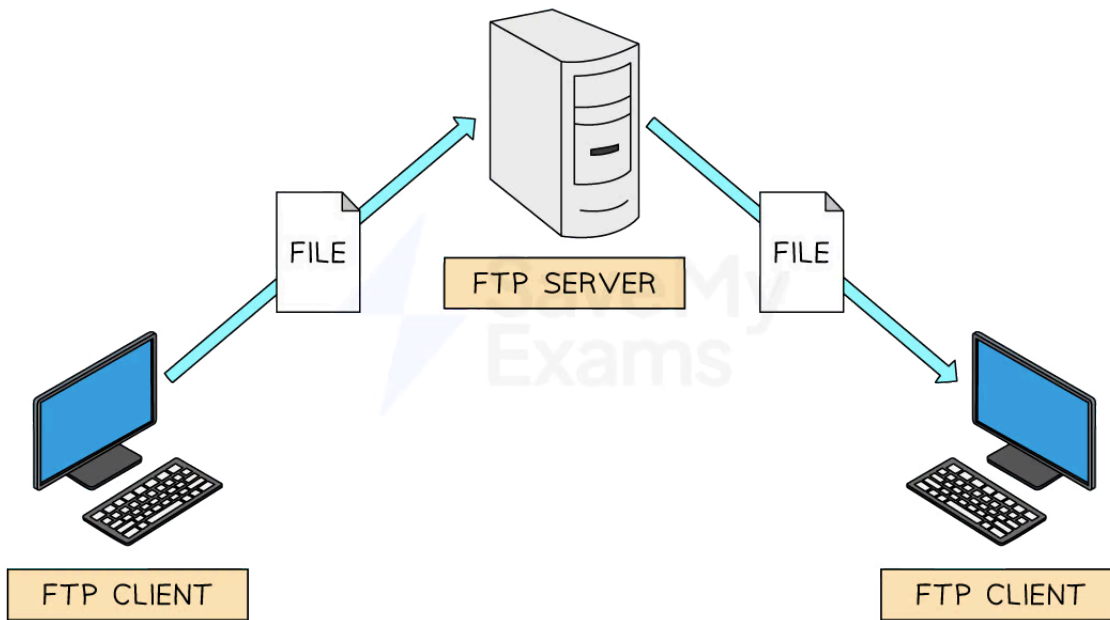
FTP

What is FTP?

- File Transfer Protocol (**FTP**) allows sending and receiving files between computers
- Uploading and downloading files to/from a web server is often completed using FTP
- FTP offers greater efficiency and support for bulk transfers and large files such as resuming interrupted transfers
- FTP clients are software applications that use the FTP protocol to make the process easier for users



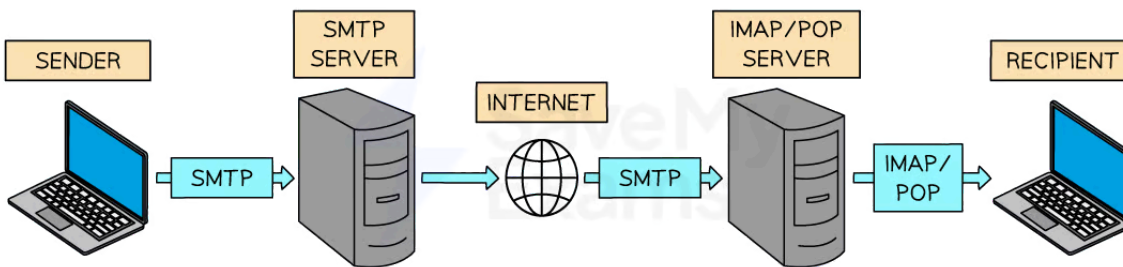
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POP, IMAP & SMTP

- A family of protocols that handle sending and receiving of email across the internet (WAN)



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What is SMTP?

- Simple Mail Transfer Protocol (**SMTP**) is a protocol that allows **communication** between an **email sender** and the **email server**, and between different email servers using the internet
- In the diagram above, **SMTP** is used to transfer the sender's email to their email provider's server and **SMTP** is used to transfer the email to the recipient's email server



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What is POP?

- Post Office Protocol (**POP**) is a protocol for downloading emails to a device from an email server
- Once the email has been retrieved it is removed from the server

What is IMAP?

- Internet Message Access Protocol (**IMAP**) is a protocol for downloading emails to a device from an email server
- Once the email has been retrieved, a copy is retained on the mail server

Advantages & disadvantages of POP/IMAP

	Advantages	Disadvantages
POP	<ul style="list-style-type: none">▪ Frees up storage space on email servers▪ Faster on slow connections	<ul style="list-style-type: none">▪ Only access emails from the device they're downloaded to▪ Emails deleted on the server once downloaded
IMAP	<ul style="list-style-type: none">▪ View and manage emails from any device with internet access▪ Changes made on one device are synchronised on all connected devices	<ul style="list-style-type: none">▪ Server storage space can limit amount of retained emails▪ Requires internet access to view emails



Worked Example

Protocols are used to transmit data through the network and over the internet.

Define what is meant by a 'network protocol'. [1]

Answer

- A set of rules for communication





Your notes

Worked Example

TCP/IP is one example of a protocol.

Give the name of one appropriate protocol for each task in the table [3]

Task	Protocol for this task
Viewing a website using a web browser	
Downloading an email to your computer	
Securely log into a bank's website	

Answer

Task	Protocol for this task
Viewing a website using a web browser	HTTP
Downloading an email to your computer	POP/IMAP
Securely log into a bank's website	HTTPS



Your notes

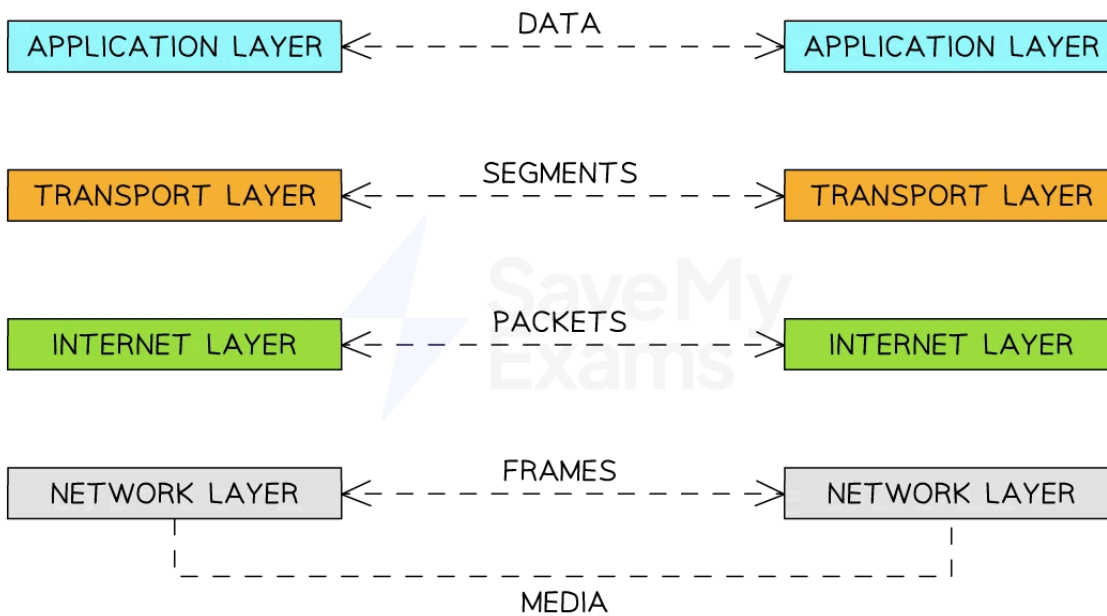
The Concept of Layers

The Concept of Layers

- Networks rely on many complex parts all working together at the same time, from different types of network, the different operating models, the internet, wired and wireless to encryption, addressing and protocols
- Managing the complexity of networks is helped with the use of **layers**

What is a layer?

- A layer is a **sub part of a more complex task**
- Dividing network tasks into layers **reduces the complexity** and makes each layer **more manageable**
- An example of layers can be seen in the **TCP/IP** protocol which uses a **4-layer model** known as a '**stack**'



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Examiner Tips and Tricks

In the exam you are required to understand the concept of layers but you are not expected to remember the names of the layers!



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What are the advantages of layers?

- Layers are **self-contained** which makes managing, repairing and upgrading easier as each layer can be worked on **independent of other layers**
- Layers allow for **focus** on specific parts of a protocol **without affecting other layers**
- Promotes data exchange (**interoperability**) between hardware and software



Worked Example

TCP/IP is a set of protocols based on layers.

1. With regards to network protocols, define what is meant by a 'layer' [1]
2. Describe one advantage of using layers to construct network protocols [2]

Answers

- Breaking up a complex task into more manageable sub tasks
- Self-contained
- ...it allows different developers to concentrate on one aspect of the network
- A layer can be taken out and edited without affecting other layers...
- ...it promotes interoperability between vendors and systems