



Information Technology (9626) - A Level Notes

Computational complexity (University of Cambridge)

Emerging Technologies

3D Printing

- Used in medicine to create personalized casts for broken bones. Also used to make replacement organs and blood vessels using the patient's own cells.
- Can be used to manufacture houses using large-scale printers.
- Can be used to print specialized tools and car parts.

Advantages

- In the event of a natural disaster, temporary shelter can be quickly mass-produced.
- Organs can be printed on demand, so patients can quickly get replacements without any effects on their body.
- Specialized tools can be printed when necessary without complicated logistics.

Disadvantages

- 3D Printers can be used to create guns or weapon parts - this is very dangerous.
- Most 3D Printers use plastics to produce objects that cannot biodegrade.

4G and 5G Communications

- 4G and 5G are the new generations of mobile data transfer. They offer substantially higher download and upload speeds - this improves the experience of streaming online video and downloading large files.
- The increased speeds means that organisations can make use of mobile devices further, with large quantities of information being transmitted over large distances.

Artificial Intelligence

Artificial Intelligence is software that is meant to simulate human actions or decisions. These are very complex programs that must be trained using a lot of input data and repeated simulations. Artificial Intelligence is currently widely used in:

- Voice Assistants
- Self-Driving Vehicles
- Expert Systems
- Image Recognition

Augmented Reality

This is where technology overlays real-world images with computer-generated graphics. Typically, a camera is used to capture the image of the real world, and an output device (usually a screen) then outputs the same image but with an overlay added.

Biometrics

Biometrics is the use of technology to authenticate users by means of one of their physical biometric features. This includes fingerprints, retina, and

iris scanning. In the past, they were used for high-security storage facilities. Nowadays, biometrics can be found on many modern smartphones. This is extremely secure as physical features cannot be easily stolen and it will always authenticate a user properly. However, if the data is indeed stolen, it is practically impossible to change one's biometrical features, such as fingerprints. It is also a privacy concern since there are some people that are worried that law enforcement could force users into unlocking their personal devices - this isn't possible with passwords, since they are not physical properties.

Cloud Computing

This is where a collection of remote servers are used for storage or processing purposes. Through cloud computing, a user does not physically need any powerful devices - all they need is an internet connection, and the servers' power will be at their disposal.

Advantages

- Data can be accessed from anywhere, any time, using any device.
- Reduces need for hosting servers on-site. Reduces costs.
- Powerful servers can be rented on demand and only used for the period of time where they are necessary.

Disadvantages

- Privacy concerns; very sensitive data should not be stored on a cloud service as the cloud storage service will also have access to the data.
- Security concerns: the security of the data depends on the cloud storage service, so if the company isn't too reputable or its security isn't good enough, data could be stolen.

Computer-Aided Translation

Computer-Aided Translation software can extract text from images and translate it into the language of choice. This is especially useful when travelling in foreign countries; meanings can be conveyed in just the push of a button. However, they are usually only accurate when translating simple words and phrases, and cannot be relied on to translate long texts or webpages.

Holographic and Fourth Generation Optical Data Storage

Traditionally, optical data storage has relied upon flat surfaces, like a CD or a magnetic tape. Holographic data storage is capable of storing data in a 3D shape, with bits encoded layer upon layer. However, this is a technology in its very early stages, and is quite costly and still under development.

Holographic Imaging

Holographic imaging or holography is the ability to make holograms. A hologram is a 3D projection, which can be viewed from all angles and does not require a flat white surface to project upon.

Quantum Cryptography

Quantum cryptography is one of the safest ways to encrypt data. Instead of generating encryption keys using mathematics, quantum cryptography keys are generated using photons. Data encrypted using quantum cryptography will be corrupted if someone without the correct key attempts to read it -

this makes it very difficult for someone to intercept the message without being noticed.

Robotics

Robotics is the use of robots in complicated tasks or repetitive tasks that would benefit from less human intervention. This is usually used in manufacturing.

Advantages

- They can complete boring and repetitive tasks.
- They can be used for dangerous situations, such as in chemical factories or defusing bombs.
- They are becoming increasingly cheaper and can be used in our everyday lives.

Disadvantages

- Causes unemployment, especially for low-skill jobs.
- The rise of artificial intelligence is a concern.
- Robots follow a fixed set of rules and are incapable of adapting or changing the way in which they work.

QR Codes

QR codes are a type of barcode made up of black and white squares. These squares correspond to binary numbers, which can be interpreted by a QR scanner using a narrow beam of light. The three larger squares store alignment data, while the smaller squares stores the data itself, which can be encoded in a variety of ways. They are small in size and can contain a lot of information, making them extremely suitable for product packaging and advertising.

Wearable Computing

This usually includes fitness devices and smartwatches, and others. They can usually track a variety of health data, such as steps taken and calories burnt. Newer devices can also track other information such as heart rate and location, and can be connected to a smartphone. Other devices include Google Glass, and wearable cameras used by the police.

Ultra-High Definition Television

4K and 8K are new, high-definition technologies that display 4 times and 8 times the pixels of HD on a screen. They are still relatively new, and 4K and 8K capable screens and devices are still quite expensive. While many new televisions and monitors support these technologies, there is still a lack of 4K content being produced, and a lot of bandwidth is needed to stream content at such a high quality.

Vision Enhancement

This is a field of technology which aims to assist the visually impaired. This usually takes the form of glasses or lenses that amplify the light received by the eye. Other innovations include devices placed in the tongue that will send electrical impulses to the brain to simulate the function of eye neurons.

Virtual Reality

Virtual reality is where 3D space is processed and rendered by a computer. This usually involves the need of a VR headset so that the user is completely immersed in the experience. A considerable amount of

processing power is needed to render the image as the user moves around, in a stable manner so as to prevent motion sickness. VR is usually used for games, but recently, medical procedures and flight simulators have also started to use this technology in a variety of training programmes.

Role and Impact of IT in Society

E-Business

An e-business is one that performs either all or the majority of its commerce online. This includes companies like Amazon - even though they work with physical products, most, if not all, of their transactions take place online. The number of e-businesses is constantly increasing, as a result of lower overhead costs and the relative ease of opening one.

Online Shopping

The rise of IT has also caused a rise in online shopping. Online shopping websites and applications are now extremely popular since customers can buy products easily and conveniently. Online shopping is usually beneficial to retail companies - there is no need to have a physical store, and the number of employees can be reduced. However, it is also very difficult for people to see the quality of products online or check the size of them. This is especially true for clothing - it is very hard to determine if a shirt will be a good fit from just looking at measurements.

Online Banking

Online banking is an online version of the majority of services that a normal bank would offer. Instead of having to visit a branch to open and manage an account, users can simply use a website or a mobile application to do so. Users can easily view their balance, make transfers, apply for loans from home, 24/7. Online Banking is especially popular with young people, who find visiting banks with limited opening hours too much of a hassle.

Electronic Funds Transfer

This is when money is transferred electronically. This includes POS (point-of-sale) transactions, where customers pay using their debit or credit card. This also includes direct debits, where customers set up their bank accounts to automatically pay for monthly utility bills. Even though transferring funds electronically has already become the norm, many people are still concerned about privacy issues and the danger of having fraudsters getting their hands on personal information to steal funds.

Automatic Stock Control

In the past, retail businesses had to manually inspect their inventory and record it every time a shipment arrived or a product was sold. This is very important since businesses need to manage their stock very carefully to avoid holding too much or too little. Nowadays, most stock control systems are electronic - as a shipment of goods arrive, they are scanned before they are stored in a warehouse. These systems are also connected to sales systems to automatically update the inventory every time a product is sold. Advanced systems can also automatically reorder products every time stock is running low.

Digital Currency

Digital currencies like Bitcoin and Ethereum are similar to physical currencies, but they are completely electronic. They can be used instantly, and are usually decentralized and deflationary in nature. This makes them extremely valuable to many people. Cryptocurrencies are also completely transparent and public, meaning that everyone can view all the transactions that have ever taken place. However, they are subject to much controversy, but they are increasingly becoming more popular and widely adopted by merchants.

Data Mining

Data mining is the process where companies process large sets of data to identify patterns and establish relationships. This is usually used by advertisers to determine the best advertisement that should be displayed by a user, and also used by companies to identify market trends. There are many ways to analyse data. These include:

- Anomaly detection - identifying unusual data that may require further investigation.
- Association - finding relationships. For example, if a user buys a mobile phone, it is very likely that they are also looking for a phone case and a screen protector.
- Cluster detection and classification - identifying groups and subgroups in data, and classifying them.
- Regression - creating predictive models based on collected data.

However, there are many privacy concerns regarding data mining - many people are worried that companies like Facebook and Google are collecting too much data through their monopoly of services. The data collected can be used for other purposes besides advertising - they could also be used to influence public opinion on certain issues and influence elections.

Social Networking

Social networking has developed a great deal in a very short period of time. Originally, this was just communicating via email and chat rooms. Nowadays, people communicate through those means, but also through instant messaging services and other platforms such as Facebook, Twitter and Instagram.

Benefits

- Extremely easy to communicate with friends and family.
- Can meet new people easily.
- Can share photos/videos of daily lives easily - makes people feel closer together by seeing glimpses of other people's lives.
- Can easily find discussion groups of a common interest.
- Improves sharing of information.

Drawbacks

- People spend less time physically together, since many rely on social media.
- Social media can become an addiction for some people.
- Makes it easier for criminals and fraudsters to scam people online.
- Danger of children becoming unable to socialize, and danger of being targeted by inappropriate content and child predators.
- Very easily for misconceptions/misleading news/propaganda to be spread.
- Concern over social media companies collecting too much information.

Video Conferencing

This is where computers are used to provide a video link between two or more people, usually over the internet. This simply requires a computer system, a camera, a microphone, speakers/headphones and a good

internet connection. In many cases, a smartphone can also be used as an alternative.

Advantages

- No need for employers to pay employees to travel abroad for meetings.
- No need for employees to travel around; they can spend more hours working.
- People can be seen and heard, so body language and facial expressions can also be seen.
- Documents can be easily shared.
- Video conferences can be set up for many people simultaneously; this is especially useful for multinational companies.

Disadvantages

- Buying and setting up a suitable video conferencing system can be costly.
- Employees in different time zones may have to work overtime to coordinate a meeting.
- Technical difficulties may cause delays.
- A stable internet connection is essential - this may not be available in some places, and will carry an extra cost.
- Staff may have to be trained to use the system, or technicians need to be employed.

Web Conferencing

Web conferencing is similar to video conferencing, but instead of being a many-to-many conference, it is a one-to-many conference. The system requirements are very similar for the ones setting up the conference, but the conference itself can be viewed by any internet-connected device. This is usually used to set up presentations, carry out training, or used by educational establishments to give online lessons.

Advantages

- The host controls the content on the screen, and a large quantity of people can view the conference without having to be in the same location.
- Saves costs for attendees since there is no need to travel to watch the conference.
- Pre-recorded content can be used, which saves time.
- Documentation and supporting files can be easily shared with the attendees.

Disadvantages

- It is virtually impossible for the host to ensure that attendees are actually paying attention.
- It is more time-consuming to set up than a regular presentation.
- The software can be costly.
- The host will have to be trained on how to use the software, and some attendees may be technically inept and may require extra assistance.
- Both the host and the attendees must have a good, stable internet connection.

Teleworking

Teleworking is the act of using IT to work remotely, away from an office. This can mean working from home, or from any other suitable location, such as a coffee shop. This gives employees the freedom to manage their own schedule, as long as the work is done. Giving employees the flexibility and freedom to work whenever they want could help motivate them.

This can also save time and money since employees don't have to travel to their place of work every day. If a company relies entirely on remote employees, this could mean that they don't even need an office. However, employers could feel like they have no control over employees since there

is no way to monitor them. Teleworking is also unsuitable for employees that have to handle sensitive and confidential documents.

Technology in Sport

Technology has been used in sports to help referees in making important decisions. It can be used to determine whether a ball has landed within a certain area, or whether a goal was scored when a player was offside. This usually involves the use of multiple cameras and motion tracking sensors which track the ball throughout the entire match.

Technology in Medicine

Recent innovations in medicine include the use of artificial limbs and nanotechnology. In the past, prosthetic limbs often had no practical use other than simply for aesthetics. Modern prosthetics can connect to the patient's nerves and function similarly to a regular limb. Nanotechnology is used to target the delivery of drugs in a very precise way. Smart devices are also being developed as implants in the body, in order to track a patient's health and identify diseases before they develop.

Technology in Manufacturing

Modern manufacturing relies heavily on the use of robotics. By using robotics in manufacturing, products are more consistent and accurate, since human error is eliminated. Robotic assembly lines will also be operative 24/7. However, this has raised the capital required to start a manufacturing business; robotics are very expensive, and small businesses cannot make use of these techniques.

Technology-Enhanced Learning

Teaching has not only been improved by technology, but now also involves subjects such as information technology and computer science. Students now have access to computers and interactive whiteboards.

One of the biggest online learning methods is through the use of massive open online courses (MOOC). These are courses that are open to everyone and are usually free, with filmed lectures, resources, and discussion forums. A wide range of subjects and topics are offered, and they can be accessed using computers and mobile applications.

Networks

Definitions

Network: A set of connected computers and devices that are capable of communicating and sharing resources.

Switch: A device which connects devices on a network.

Packet: A collection of bits grouped together for transmission.

Hub: Similar to a switch, but does not examine each packet of data to determine its destination; it simply forwards all the data to all connected devices.

Wireless Access Point: Connects Wi-Fi enabled devices to a network.

Wi-Fi: Wireless ethernet - allows devices on a LAN to connect wirelessly.

NIC: Network Interface Card. Connects motherboard of a device to a network cable.

WNIC: Wireless NIC. Allows a device to connect to Wi-Fi.

Router: A switch which can forward data to the correct location in the most efficient manner.

LAN: Local Area Network. Connects devices in a small area.

WAN: Wide Area Network. Connects devices across a large area.

Repeater: Device which amplifies the signal on a network cable. Also known as an active hub.

Gateway: Connects two different types of networks together.

Bridge: A type of gateway which connects two LANs.

Firewall: Prevents external devices from gaining unauthorised access to a network.

Server: A computer on a network which provides resources for client devices.

Bandwidth: Range of frequencies available for a communication method, which determines the transmission rate.

Bitrate: Number of bits that can be transferred per second.

Data Packets

Data packets are groups of bits. They will include header information and the data being sent. The header contains information about the source, destination, length, and verification data to allow packets to be reordered if they are fragmented during transmission. The internet uses **packet switching**, which is the transmission of data using packets.

Router

A router is a gateway to a network. In most cases, it connects a home LAN to the internet via an internet service provider (ISP). A router's job is to determine the most efficient route to use to transfer data to its destination. To do so, it will read the header information in each data packet and use its routing table to direct the data to the correct destination. Routing tables can be updated to reflect the most efficient paths to a destination. Routers will also record the number of times a packet has been forwarded; this is known as the number of 'hops'. If a packet has reached a maximum of 16 hops, it will be dropped and marked as undeliverable. This is 'packet loss'.

Servers

File Server: A file server makes files available users on a network. These may be personal files, or files shared between groups of users. Depending on the permissions given to each user or group, files can be created, read, modified and deleted.

Print Server: A print server deals with all the print jobs on a network. Every time a computer or device in a network sends a request for printing, it is queued in the server. The server will then deliver each print job to the

printer. Print servers can be connected to multiple printers, and some users may be given priority.

Mail Server: A mail server receives and sends all emails for an organisation. This can be part of a LAN or a WAN. Incoming emails are checked for viruses and spam, and then they are sent to the user's mailbox. When a user sends an email, the mail server will forward it to the appropriate destination.

Application Server: An application server delivers software to client computers. Applications can be hosted on the server and accessed from the clients, or it can manage the installation of software on each client computer.

Proxy Server: A proxy server deals with all requests to the internet, and sits between the LAN and the gateway. Web filters can be implemented to filter out inappropriate content. It can also store web page in a cache to speed up loading times. Proxy servers often also include firewall software.

Streaming

Streaming takes place when video or audio files are sent to a receiving device for viewing or listening without downloading any file. In video streaming, the first few seconds consisting of several frames will be sent to fill a buffer (a temporary area of storage) which can then be watched at the receiving device. As frames are viewed, they are removed from the buffer, and new frames are added. A buffer helps keep a video stream run smoothly - without a buffer, any data congestion would cause the video to pause, miss out frames, or pixelate. The buffer delays the stream for a few seconds, so that the stream won't be interrupted if frames aren't arriving quickly enough. Data congestion can be caused by devices using up too much bandwidth both at the sending end and the receiving end.

Switching

Circuit Switching

This method of data communication creates a physical network path from the sender to the receiver before any data is transferred. All of the data is then transmitted using this single path. While the path is open, no other devices can use it. Once transmission is complete, the path is released for other data transmissions. This was used in old telephone networks.

Packet Switching

This splits data into individual packets before forwarding them to its destination. Individual packets can take different routes to the destination. The receiving end will then order the packets to reassemble the data. This way, each packet takes the most optimized route, and if packets are dropped along the way, the sending device will only need to resend the lost packets, rather than starting the transmission all over again.

Message Switching

This transmits the whole set of data together from source to destination. The data is sent to one network node at a time before being forwarded to the next. However, this is quite slow, since each node needs to process and store the data before forwarding it. This makes it unsuitable for streaming real-time games or real-time communication.

Optical Communication Methods

Optical communications use light to transmit data. The speed of light is the fastest in the universe, which means that there is negligible latency when transferring data, making it suitable for real-time applications.

Infrared

This is usually used by remote control devices. It works by transmitting electromagnetic radiation that is invisible to the human eye. It does not have a very high bandwidth and is only suitable for transferring small amounts of data. It is also affected by sunlight, and requires direct line of sight between devices. It will only work for short distances.

Fibre Optic

These are fine strands of glass that transmit data as light. They are very thin, and a large number can be fitted into a small space, so a lot of data can be transmitted at once. They are also flexible, meaning that they can be used in buildings and around corners. They are not susceptible to electrical interference, and they have very high bandwidth. Even though they are more costly to produce than copper cables and they are complicated to repair, they hardly suffer any degradation of signal, and they are suitable over long distances. Nowadays, many ISPs provide fibre connections directly to homes all around the world.

Laser

This is an intense beam of light that can be used to transmit data. Line of sight is necessary, but laser beams can cover large distances. It still travels at the speed of light, but it does not require a physical connection like fibre optics. They can be used to connect LANS between buildings, and they are suitable because there is very little interference under normal atmospheric conditions. However, bad weather will affect the quality of the signal. They are quick to set up and can be portable, and are secure because they are

narrow and are aimed directly from sender to receiver. This means that in order to intercept the data, interruption would be necessary, which would alert the sender and receiver.

Wireless Communication Methods

Bluetooth

This uses wireless frequencies between 2402 and 2480 MHz. Bluetooth splits data into packets which can be transmitted across 79 channels. It is typically used between mobile devices and a range of accessories and devices. It requires very little power to operate, doesn't require line of sight but has a limited range of about 10 metres.

Wi-Fi

It operates in the 2.4GHz and 5GHz frequencies. It is used in portable devices such as laptops, tablets, and mobile phones. The main advantage of Wi-Fi is that it enables connections to a LAN without needing cables, which can be costly to install and may be impractical in some situations. Connections speeds are not as fast as wired connections, but they are still very high. However, security is a concern, especially in public Wi-Fi hotspots, as hackers do not need a physical connection to infiltrate the network.

Radio

RFID (radio-frequency identification) uses electromagnetic fields to identify and track small RFID chips. These are usually used in shops and security tags. A more advanced form of RFID is NFC (near-field communication), used in wireless key cards and credit and debit cards for contactless payments. Modern smartphones can also read NFC tags, much like reading QR codes. Smartphones also contain NFC chips for contactless payments (Apple Pay, Samsung Pay, etc.)

Protocols

A protocol is a set of rules that ensure data is transferred correctly. A protocol defines the type of error checking, how sending devices will indicate the start and end of a message, how a receiving device confirms it has received a message, and any data compression methods to be used.

Abstraction Layers

The international framework for protocols sort them into seven different layers.

- Application Layer: Deals with specific applications, such as file transfer or email.
- Presentation Layer: Ensures that data is displayed in a recognisable format.
- Session Layer: Defines protocols between applications during a communication session.
- Transport Layer: Ensure data flows correctly without errors.
- Network Layer: Deals with how data is switched, routed and addressed.
- Data Link Layer: Deals with data packets.
- Physical Layer: Deals with electrical and mechanical applications.

POP

Post Office Protocol. Defines the rules for email client software to retrieve emails. POP is part of the application layer, and will connect to an email server, download the messages, and delete them from the server.

IMAP

Internet Message Access Protocol is another method for email client software to retrieve emails. It leaves the messages on the server and downloads a copy to the client. It also supports multiple folders on a server, and is also part of the application layer.

SMTP

Simple Mail Transfer Protocol is a protocol used for sending emails. It forwards the user's messages to its destination, and if the destination server is not available, will queue the messages until the destination server comes online again. It is also part of the application layer.

TCP/IP

Transmission Control Protocol/Internet Protocol is the basic communication protocol used on the internet. It consist of two layers - TCP splits data into data packets that are transmitted and reassembled at the receiving end. IP deals with locating the destination by using IP addresses.

FTP

The File Transfer Protocol is part of the TCP/IP suite and defines how files should be transferred from one location to another. Authentication using user accounts and anonymous connectivity are both possible. It is part of the application layer.

HTTP

The Hypertext transfer protocol is also part of the TCP/IP suite, and it is used by web browsers to send requests to a web server to view a webpage. When the request is received, the information is sent back to the web browser. HTTPS is a secure form of HTTP which encrypts the transmissions. It is part of the transport layer.

UDP

User Datagram Protocol. It is very similar to TCP, but it simply breaks up data into packets and sends it, without any reassembly. It includes a checksum to verify that data has arrived intact. Because of this, it has a lower bandwidth, but also lower latency, and is useful in real-time applications. It is part of the transport layer.

HDLC

High-Level Data Link Control. It is part of the transport layer and connects point-to-point serial devices and has built-in error correction.

Frame Relay

Frame relay forms part of the data link and network layer protocol. It puts data into packets of variable sizes, and is used in packet switching. However, it does not contain error correction and thus is quite unreliable.

BitTorrent

The BitTorrent protocol allows multiple downloads taking place from the same source file concurrently. Multiple clients (peers) download portions of the file, and they then share the portions they have with each other to build up the complete file. This reduces the bandwidth required by the original host, and can speed up file transfer, especially for very large files.

However, it is only useful if there are lots of peers. Once a peer has received the complete file, they can become a 'seeder' - a peer which continues to share the complete file with other peers.

Network Security

Unauthorised Access

Commonly known as hacking, it occurs when someone gains access to a network without permission. Hackers can bruteforce username and password to gain access to networks. Once they have access, they can read and even change data on the system.

Malware

Software that is designed to cause damage. Viruses, spyware and malware can easily spread through networks.

Denial of Service Attack

A denial of service (DoS) is where an attacker sends a large amount of request to a server, overloading it. These are easy to launch and difficult to track, and will cause severe disruption in an organisation and its services. Distributed denial of service (DDoS) attacks use multiple connections across the internet, usually using computers infected with viruses in a collection known as a 'botnet'. These are difficult to defend against since they come from many different locations.

Access Rights

When a user logs onto a network, they are given rights to access different parts of that network. These include permissions to create, read, update and delete files. In order to gain these access rights, a user must identify themselves - by entering a user ID and password, or using swipe cards, NFC cards, or even biometric methods.

Passwords should be strong enough that they cannot be easily guessed and bruteforced, and they should be different for each account. However, this might make it difficult for users to remember their credentials.

When security is critical, two-factor authentication (2FA) can be used; aside from login credentials, users must also verify their identity using another method, usually by generating a code on their smartphone or using an NFC card.

Biometric Methods

Biometrics are biological characteristics that can be measured, and these can be used to identify a user's identity. This includes retina recognition, facial recognition, fingerprints and voice recognition. It can be used as a 2FA method alongside standard credentials, or it can be used as a standalone authentication method. Biometric authentication methods can now be commonly found in smartphones; some even support multiple methods.

Firewalls

Networks that have access to a WAN or the internet usually has a firewall in place to control what data can flow into and out of the network. It may be part of a router or it may be software installed on a server that is between the network and the gateway. Firewalls include an access control list (ACL) that uses a technique called packet filtering. An ACL will include a set of rules that determine which protocols, port numbers, source addresses and destination addresses are allowed and not allowed. If packets are not allowed, they will be dropped.

A firewall often includes a proxy server, which will make requests to the internet on behalf of client computers within the network. Proxy firewalls can then carefully inspect disguised data packets to check for any malicious data.

Backup

A backup is a copy of the original data, and in the event of a problem, the backup copy can be restored. This does not stop a hacker from gaining access to data, but it is essential when recovering from an attack. Backup processes should be set up to run automatically and regularly in a network.

Encryption

This is the process of changing data so that it will be unreadable to attackers. Although it can prevent data from being read, it does not stop hackers from destroying data and it does not stop malware. However, it is important for data to be encrypted whenever it passes through openm public networks.

Malware Security

Antiviruses and anti-malware software can be used to monitor a computer network for any malware, and it will prevent it from executing. They can also scan an existing system to find any existing malware.

Physical Security Methods

Buildings in which computers and servers are stored should also be protected. Security guards can be used to check for unauthorized users, and physical locks can be used to secure devices with sensitive data. Main servers should also be protected against electrical surges and power outages, usually through the use of an uninterruptible power supply (UPS). Server rooms should be located in areas protected from fires and floods.

Data Protection Act

A data protection act can be used to protect people and their data. In the UK, the Data Protection Act of 1998 states that personal data must be:

- Used fairly and lawfully
- Used for limited, specific purposes that the user is aware of
- Used in a way that is adequate, relevant and not excessive to what the user connected to
- Accurate
- Kept for no longer than is absolutely necessary
- Handled according to people's data protection rights
- Kept safe and secure
- Not transferred outside the European Economic Area without adequate protection.

These laws exist to protect data subjects and the information that is held about them. Users must be informed and their explicit consent must be sought after before their data is collected. The data must only be used for relevant purposes and not sold to third parties, and the data must be accurate and up to date. Data should also be destroyed once it is no longer needed.

Satellite Communication Systems

Satellite: An object in space that follows an orbital path.

GPS: Global Positioning System - uses satellites to determine the current location.

There are three different levels or orbit used by satellites:

- Low Earth Orbit (LEO) at 500-1500km from Earth.
- Medium Earth Orbit (MEO) at 5000-12500km from Earth.
- Geostationary Earth Orbit (GEO) at fixed points 35800km from Earth.

Data Transfer Systems

Satellite broadband is used in areas that are not covered by wireless or wired broadband connections. Satellite broadband uses GEOs and can offer modest speeds. However, GEOs are a long way from earth, which causes considerable latency, making satellite broadband unsuitable for real-time applications and streaming.

Satellites are also used for television and radio broadcasting. They can cover a large geographical area and there is no need to lay out cables. However, users must have a set-top box and a satellite dish. Satellite dishes must be configured by a technician to point directly at the satellite they wish to receive information from, and the signal can be affected by bad weather conditions.

Global Positioning System

Global Positioning Systems (GPS) use 24 LEO satellites that cover every point on earth to determine a receiver's location. A receiver must receive signals from three different satellites in order to determine its location in a process known as trilateration, where the time taken for the signals to be received is processed to determine its location. The signals received from the satellites contain information including the ID of the satellite, the current time as recorded by the satellite, and its status. Applications that use GPS include:

- Locating emergency vehicles.
- Finding nearby taxis and calculating taxi fares.
- Tracking people, objects and vehicles.
- Geotagging photographs.
- Satellite navigation systems.
- Treasure hunting games, such as Geocaching.
- Tracking cycling and running routes.
- Locating devices.
- Aeroplanes.

The increase in popularity of smartphones means that it is very hard to get lost in the present day. All smartphones have a built-in GPS, and users can locate themselves using mobile map applications.

Line of sight is required for GPS, so it can only be used outdoors and will be inaccurate in bad weather. They are also subject to interference, especially near heavily militarised areas. GPS can determine a 2D location (latitude and longitude) using 2 satellites, while 4 satellites are required for a 3D location (latitude, longitude and altitude).

Project Management

Stages

Conception and Initiation

In this stage, the initial ideas are identified and the goals are set. A feasibility study will be conducted, which will determine whether a project is beneficial to an organisation based on resources, time and finance. Requirements will be identified, and risks, budget and timescale and agreed with all stakeholders.

Planning

An in-depth budget and details of timescales will be formulated. Milestones will be set, and individual tasks will be identified and prioritised. A **Gantt chart** will be produced to show the tasks that must be completed and their order. Resources will be allocated to the tasks, ensuring that they are completed on time and no resources are overused or unused.

Execution

Once all plans are in place, the project can commence. The plan must be followed. Any delays to a task can delay the entire project, and the project manager is responsible for ensuring that the team stays on schedule.

Monitoring and Control

As the project is being executed, the project manager must manage the team and the resources allocated. Regular project review meetings should take place, and tasks must be adjusted accordingly if any problems arise.

Closure

Once the project is complete, it will be handed over to the client for review. If the requirements are satisfied, then the client will confirm the end of the project, and personnel and resources can be allocated elsewhere.

Project Management Software

Project management software will include templates for projects for easier planning. They will also enable a project manager to create a Gantt Chart to clearly display the tasks that must be completed. They also include features to help a project manager allocate resources efficiently to individual tasks, with automatic systems that will calculate overall costs that can be exported. Calendars are also often included, and instant messaging and video conferencing features are often available.

Desktop

Desktop project management software requires installation to a specific computer or set of computers, and licenses are required. This will be highly responsive, but is limited in situations where collaboration is required.

Web-Based

Web-based software can be accessed through a browser. This main software can be installed on an intranet or in the cloud, making it accessible from everywhere and easy to collaborate. However, if a user has no internet connection, they will be unable to access the software.

Single-User

These are usually desktop systems and are usually used for small projects.

Personal

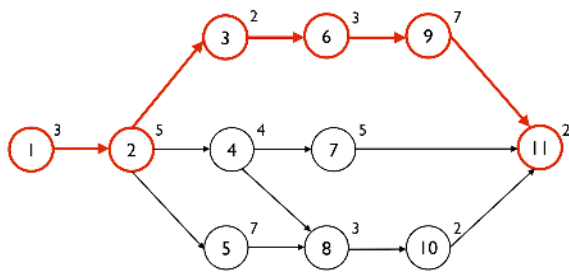
These are typically used by home users for simple projects such as planning a holiday. It will be single-user and include a very simple interface.

Collaborative

These are used by several users at once, with support for sub-projects. This type of software is usually web-based, with project and task information being stored on a central server.

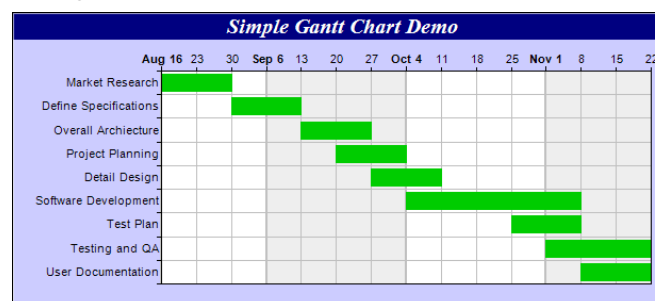
Critical Path Analysis

A critical path analysis (CPA) finds a project's critical path. The critical path identifies the tasks that must be completed on time in order for the whole project to be completed on time. This is done by adding up the length of all the sequential tasks and the longest of each of the parallel set of tasks. Some tasks are not critical and can be delayed - the time that they can be delayed is known as the float time.



Gantt Charts

A Gantt chart shows the start and finish dates of each task, the predecessors for each task, the progress of each task and the current position within the project. This is separated in bars.



Disaster Recovery Management

Risk Assessment

Risk assessment is the process of identifying potential risks to an organisation, its potential impact and the risk of it occurring. Risks include power outages, natural disasters, unauthorised access to data, data loss, and even loss of key personnel. This could cause a negative impact on revenue and reputation.

Securing the Risk

Once risks have been identified and prioritised, measures are put in place to protect against those risks. This includes proper cybersecurity and physical security measures, as well as backups.

Recovery Management

Detailed plans must be elaborated to prepare for disaster. This can include:

- Restoration of backups
- Replacement of Hardware
- Reinstallation of Software
- Replacement of key personnel

It is also very important to know how each recovery process will take - this should be as short as possible so as to avoid service disruption. Plans should also be tested before disasters actually occur.

Prototyping

A prototype is a 'mock-up' of a software solution in a primitive form, and it used to demonstrate how a system will look and work. This usually means that it is in the form of a user interface without any working features.

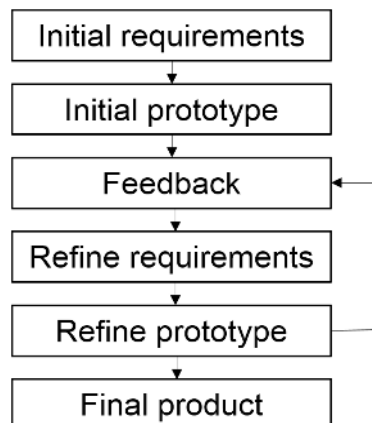
Advantages

- Problems can be identified early in the development process.
- Requirements can be clarified and refined based on prototypes.
- End-Users are more involved; valuable feedback collected.
- If it is evolutionary, users can get used to the system, reduces training required.
- Developers can get a clearer idea of what users want.

Disadvantages

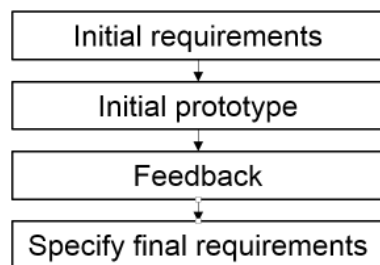
- Requirements analysis may be rushed, meaning that prototypes are inaccurate.
- In rapid prototyping, the process may be too quick and it may contain significant design flaws.
- When users see the prototype, they may suddenly request a lot more features that are impractical to implement.
- When users see a working prototype they assume that the project is close to completion when it is not the case.
- The initial costs of developing a prototype are high compared with traditional designs.

Evolutionary/Incremental Prototyping



This type of prototyping takes an iterative approach in that requirements are specified, an initial prototype is developed, it is reviewed and then improved based on feedback. Each prototype will be built upon the previous one and functionality will be gradually added.

Throwaway/Rapid Prototyping



In this type of prototyping, the prototype will never become part of the final delivered software; it will be discarded. This enables requirements to be fine-tuned early in the process, which is more cost-effective than making changes later on in the development.

Rapid Application Development

Rapid Application Development (RAD) uses prototyping to develop a system in a very short time frame, usually less than six months. Requirements are gathered through focus groups, and most emphasis is placed on the development phase. Strict deadlines are put in place to ensure the project stays on track.

Advantages

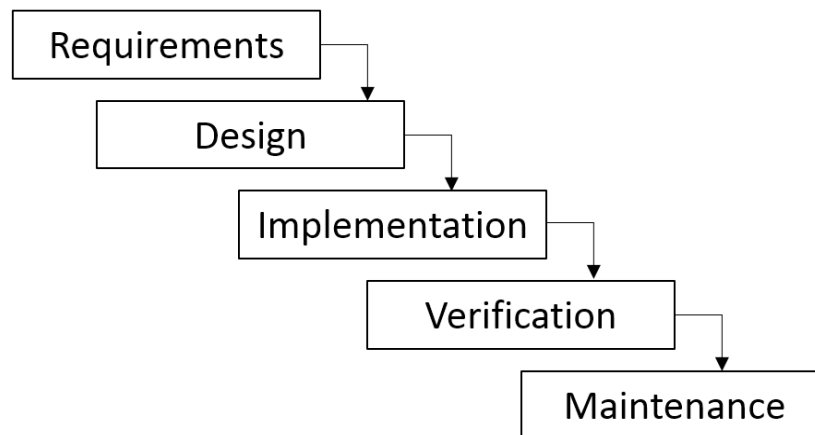
- High level of user involvement means that the product is more likely to be suited to the user's needs.
- Evolutionary approach enables requirements to evolve.
- Strict deadlines ensure that the project is completed on time.

- Prototyping with user input means that less time is spent on design and more on development, leading to a shorter completion time.

Disadvantages

- Requirements are not clearly specified from the start.
- Users are required throughout the whole process.
- Strict deadlines could mean that some parts of the project are rushed.
- Users that are not involved may feel disappointed and system may not meet their needs.

Waterfall Method



The waterfall method involves gathering all user requirements at the start of the project. Once this is completed, the process runs 'downhill' like a waterfall. However, this relies upon the requirements being clearly defined, which is impossible, making this method fundamentally flawed. The verification phase exists to ensure the system meets customer's requirements, and the maintenance phase exists to fine-tune the system so that it fits the user's needs completely.

Computer-Aided Design/Manufacturing

CAD: Computer-Aided Design

CAM: Computer-Aided Manufacturing

CAD uses vector graphics to create objects in both 2D and 3D. Objects can be stretched, resized and moved. Properties like material and colour can be changed. Object libraries will be available within CAD software so that the user can select standard objects to use in their design.

CAM involves the use of computers to manufacture physical products - this is usually through the use of robotics and/or 3D printing.

Advantages

- Expensive prototypes are not always necessary since 3D models can be viewed from many angles.
- CAD drawings can be easily modified without any manufacturing cost until a final version is completed.
- A list of required materials can be generated from CAD drawings.
- Components that have been designed once can be reused.
- CAD requires fewer designers, so it is cheaper for businesses.
- CAM enables products to be mass-produced consistently since it can deal with tiny measurements and is more precise.
- CAM removes the need for manual labour and reduces costs.

Disadvantages

- Both CAD and CAM has led to the loss of jobs.
- A prototype is always needed - testing using a model is inaccurate.
- CAD software is very complex and trained employees are needed.
- Initial costs of purchasing CAD software can be high.
- CAD designs may include errors made by the designer.
- Looking at a model is never the same as holding a real product.

System Life Cycle

Maintenance: Changes made to a system after its implementation

Requirements Specification: What a user needs a system to do.

System Specification: Hardware and software needed to run the system.

Design Specification: Illustration of how the system will look and work, and its data structures.

Analysis

Questionnaires

These are used when information is required from a large number of users. This also means that there is a large sample size. They are not suitable when the sample size is too small since it would be quicker to conduct interviews. Questions must be asked in a way that responses are not biased and can be analysed, often in the form of multiple choice responses.

Interviews

This involves direct conversations between analysts and clients. This is most suitable for small numbers of users, as detailed in-depth responses can be collected. However, interviews are time-consuming and this should be taken into account.

Observation

The analyst will watch the processes that take place within an organisation to find out how every task is completed. The information collected is usually used to develop the **requirements specification**. However, it is possible that users act or work differently from normal, which may lead to inaccurate data being collected.

Document Analysis

Existing documents can be analysed to determine the data being collected for input to a system, and processes that can take place can also be identified. This method should be used in conjunction with other methods.

Requirements Specification

A requirements specification is a contract between the developer and the client, and it will specify the exact needs a client wants for a system so that the developer can produce a system that satisfy them. This should usually include:

- Purpose of the system
- Main objectives of the system
- Data that must be output from the system
- Data that needs to be input to the system
- Validation and verification rules
- Deadlines for each milestone within the project.

System Specification

A system specification lists all the software and hardware needed for the new system. The software is dependant on the hardware, and thus must be identified first. The analyst must consider the storage space and processing power required for the system.

Design Specification




The design specification is produced by the designer and will illustrate how the system will look, what the data structures will be and how the system will work. It will often include:

- Flowcharts
- Data flow diagrams
- Data collection forms
- Screen layouts/mockups
- Data dictionary
- House style (logos, colours, fonts, etc.)

Design

Data Flow Diagram



A data flow diagram show how data flows throughout a system. The following symbols are used:


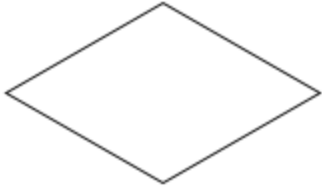

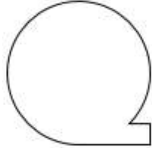

Data Flow	The data that is flowing throughout the system	
Process	An action that manipulates the data	
Data Store	Place where data is stored	
External entity	Where data originates or is destined	

DFDs exist at many levels. At level 0, or context level, the diagram will show the whole system and the data flows between the whole system and any external entities.

System Flowchart

A system flowchart shows the processes that take place within the system and the decisions that are made. It focuses on the logic of the system, rather than the data within the system. The following symbols are used:

Terminator	Start and end of the flowchart	
Arrow	Shows the direction of flow	

Process	Activity within a system	
Decision	Decision that has to be made with different output routes	
Input/Output	Input data or output data for the system	
Sequential Access Storage	Usually magnetic tape	
Data Storage	Data is written to a storage medium	

Data Collection Forms

These can include membership application forms, questionnaires, job applications or others. It is important for the form to be designed properly by:

- Avoid colour as the document may not be printed in colour
- Include clear instructions on how to complete the form
- Give clear instructions on how to return the form
- Identify which questions must be answered and which are optional
- Provide sufficient space for each answer
- Avoid cluttering the form with too many questions
- If scales are involved, clearly explain what they represent

Screen Layouts

A screen can be used for both inputs and outputs. Screen layouts should follow the following principles:

- Use colour sparingly and appropriately, only to differentiate values and not oversaturate the screen.
- Ensure all fonts are consistent.
- Avoid cluttering the screen with too much information, but make sure space is used as efficiently as possible.
- Ensure principles for designing a form are followed if user input is required.

Data Dictionary

A data dictionary is a document or file that describes the structure of the data held within the database. It will include information about field names, data types, field size, default values, primary keys and validation rules.

Development and Testing

Test Data

When a system has been developed, it needs to be tested. Test data should be used. Each field should be tested using the following test data:

Valid/Normal Data	Data that will be accepted by the validation rule.
Abnormal Data	Data that will not be accepted by the validation rule.
Extreme Data	Data that will be accepted by the validation rule since it is just on the limits.

Alpha and Beta Testing

Alpha Testing is carried out by the developers or a specialized team of testers before a system is delivered to the user. This takes place close to

the end of the development stage. Alpha testing can take a long time, and errors that are found can affect other parts of the system.

Beta Testing is used when software is made available to a larger number of customers. Beta testers are usually real customers that have been chosen to test an early release of an application or some new features. Beta testing usually means that multiple versions of the software is released before the version is final.

Black Box/White Box Testing

Black box testing involves selecting input data and checking the expected output data matches the actual output data, with no knowledge or understanding of what actually happens, which is why it is called the 'black box'. This usually involves testing the whole system, and can be carried out by specialists or the users themselves.

White box testing involves the same process of input and output, but the internal structure and logic of the program is known to the tester. This is usually carried out with small program modules by the software developers, to ensure the software is working as intended.

Test Plans

A test plan identifies what is being tested, the type of test, the input data that should be used to test it, the expected result and space to record the actual result. Testing is necessary because no developer is perfect and errors will occur. A test plan will identify all the tests needed for every element of a system, and will include different test data.

Installation

Parallel Running

This is when a new system and an old system are run at the same time. On a certain date, the new system will be implemented but the old system will continue to run. This will continue until the organisation is confident and comfortable with the new system. This provides redundancy and a backup plan in case the new systems fails. However, this will incur additional costs as two systems have to be operative at the same time.

Direct Changeover

Direct changeover is when a date is chosen for the old system to completely stop running for the new system to take over. The systems do not run at the same time and data will need to be transferred from the old system to the new system. This reduces costs since there is no need to run two systems at the same time, but in case of failure, there will be extended downtime.

Phased Implementation

In phased implementation, parts of the new system will be introduced one at a time. This often takes place in large systems. The old system is slowly retired, until the new system is fully running. This reduces training time since people can slowly become accustomed to the new system.

Pilot Implementation

This takes place when part of an organisation starts to use a new system while the rest of the organisation continues to use the old system. The group chosen to use the new system is known as the 'pilot group'. If there are any errors, they will only affect the pilot group and their feedback can be collected before the system is implemented across the whole organisation.

Documentation

Technical Documentation

This is an overview of the structure of the system, how it was put together and how it works. Programming code or macros will be annotated to explain their purpose, and validation rules will be explained with their criteria and the error messages displayed. Flow charts will be included to show how different parts of the system work. There will also be an installation guide in case the system needs to be reinstalled in the future. Backup routines will be detailed to show where files are stored, how the routines were configured and how to restore from a backup. Security settings and software and hardware requirements will also be listed.

User Documentation

This is a user guide giving instructions to the user - this can be in an electronic or printed format. A contents page should be included, with the main part being instructions on how to use the system. Screenshots and photographs will also be included to aid the user's understanding. Glossaries and definitions can also be found to help the user. Troubleshooting steps and symptoms will also be included.

Evaluation and Maintenance

Evaluation

Once a system has been developed and installed, the process will be evaluated. Users will be given questionnaires to find out their opinion on the new system. However, the main point is figuring out if the systems meets user requirements, and its efficiency. There will also be opportunity for users to make suggestions.

Maintenance

There are four reasons why maintenance may be necessary.

Perfective	This is where the system is always looked to be improved. There may not be anything wrong with the system, but new technologies can be incorporated to keep the system up-to-date.
Adaptive	Systems need to adapt to changes, whether they are internal procedures or external changes. Adaptation is necessary to ensure the system continues to work effectively.
Preventative	Preventative maintenance is required to prevent problems arising within a system. Hardware should be regularly cleaned and data should be checked for consistency.
Corrective	When errors or bugs are found, they must be corrected to ensure the system continues to run smoothly.

Graphics Creation

Bitmap	Vector
Large file size, especially for high-resolution images	Small file size
Suitable for photographs	Suitable for computer illustrations/designs
Pixelation	No Pixelation
Individual pixels have a colour	Lines and curves design a shape

Animation

Object: An image, or combination of images, that is manipulated as one item.

Layer: An object or image given its own timeline for independent manipulation.

Animation: A series of images that are played one after another to simulate movement.

Key Frame: A fixed frame that indicates the start and end of an animation. Frames in between are automatically generated by tweening.

Tween: An animation where the start and end points are set. The computer generates the actual images to make the animation change.

Morphing: Another term for shape tweening. One image changes into another image.

FPS: Frames per second. The number of animation frames rendered per second. A higher FPS means that the animation will be smoother.

Motion Tween

This only deals with the movements of an object, including rotation. In a motion tween, an object is positioned in the key frames, and the computer fills in the gaps in movement.

Shape Tween

This allows a shape to be changed into a new shape, with the computer generating each step of the transformation. A shape tween can also include morphing.

Mail Merge

Advantages:

- Only one template needs to be created
- The template can be used multiple times
- Can easily display different text for different criteria
- Easier to proofread one letter

Disadvantages:

- Data source must be kept up-to-date
- Letter can feel very generic
- Errors may not be identified until letter is merged