01 **Zero & One**

Unit 8: Networks

Programming & AI, 1st secondary (Introduction to ICT)



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8-1 Computer Networks

- **What is a network?**: An **information and communication network** is a web-like network that uses **communication lines** to carry information.
- **Types of networks and their devices**
  - **LAN (local area network):** connects devices in a limited place such as a school or a home
  - **WAN (wide area network):** connects a much wider area, such as a company's branches in different governorates.
  - **Internet:** a network that connects LANs and WANs **all over the world**.
  - **ISP (provider):** the company that connects you to the Internet
  - **Router:** relays and forwards data **between different networks**
- **Server and client**
  - **File server:** manages files.
  - **Printer server:** handles printing.
  - **Mail server:** sends and receives emails.
  - **Proxy server:** a go-between that accesses the Internet **on behalf of** the users.
- **Network usage patterns**
  - **Client-server system:** roles are split: one machine provides the service and the others request it.
  - **Peer-to-peer system:** all computers are **equal**
- **Communication methods**
  - **Circuit switching
  - **Circuit switching
  - **Packet switching
  - **Packet switching

LAN	A network that connects devices within a limited area such as a school or a home.
WAN	A network that connects devices over a wide area.
ISP (provider)	A company that connects users to the Internet under a contract.
Router	A device that relays and forwards data between different networks.
Hub	A central device that connects several cables in a network.
Server	A computer that provides services to other computers.
Client	A computer that requests services from a server.
Proxy server	A server that accesses the Internet on behalf of its users.
Circuit switching method	A method that sets up a path between sender and receiver before sending.
Packet switching method	A method that divides data into packets and sends them.

8-2 IP Addresses and Domain Names

- **IP address**: An **IP address** is a **unique** identification number given to every device on a network, just like a home address
- **The form of IPv4**
  - **IPv4:** represents the address with **32 bits** in binary.
  - The 32 bits are split into **4 blocks of 8 bits each**, separated by a **dot (.)**.
  - Each block is written in decimal **from 0 to 255** (because 8 bits = 256 values)
  - Conversion example: the block `11000000` in binary = **192** in decimal (128 + 64).
- **Global, private and running out**
  - **Global IP address:** used on the **Internet**, and it cannot be duplicated.
  - **Private IP address:** used **inside a local network** such as a home or school LAN.
  - **IP address exhaustion:** the Internet spread fast, and IPv4 has only about **4.3 billion** addresses (2^32)
- **Domain names and DNS**: A **domain name** is text used in place of the numbers of an IP address so that **people can understand and remember it**, like `moe.gov.eg` .

IP address	A unique identification number, like an address, given to each device on a network.
IPv4	An IP address format of 32 bits written as four decimal blocks from 0 to 255.
IPv6	An IP address format expanded to 128 bits to solve address exhaustion.
Global IP address	An IP address used on the Internet, unique with no duplicates.
Private IP address	An IP address used only inside a local network such as a LAN.
Domain name	A string of characters that makes a numeric IP address easy for people.
DNS	A system that maps domain names to IP addresses and back.
DNS server	The server that carries out the DNS job of matching names and IP addresses.

8-3 Communication Protocol

- **Packets and protocols**: A **packet** is a small chunk of data sent over the network, together with a **header** that holds the destination information.
- **Well-known protocols**
  - **TCP:** divides data into packets, **puts** the received packets **in order**, and **asks for any lost packet to be sent again**
  - **UDP:** focuses on sending data **in real time** (speed matters most) and does not guarantee order or completeness
  - **IP:** assigns **IP addresses** so that packets reach the right destination.
- **The four layers of TCP/IP**
  - **Layer 4
  - **Layer 3
  - **Layer 2
  - **Layer 1
- **How does data travel on the Internet?**
  - **1):** Divide the data you want to send **into packets**.

- **2):** Put the sender's and receiver's **IP addresses** in the **header** of each packet.
- **3):** Choose the **best route** for each packet and deliver it
- **4):** On arrival: if a packet is missing, it is **requested again**, then the packets are **put in order** so the data is complete again.

Packet	A small unit that data is divided into to be sent over a network.
Header	The part of a packet that carries the destination information.
Communication protocol	A common agreement (set of rules) for communicating on a network.
TCP	A protocol that splits data into packets, reorders them and requests lost ones again.
UDP	A protocol that focuses on real-time sending, used for calls and video streaming.
IP	The protocol that uses IP addresses to deliver packets to the right destination.
TCP/IP	The set of protocols used on the Internet, organized in four layers.
Routing	Choosing the best route for each packet to reach its destination.
Transport layer	The TCP/IP layer for communication control, error detection and retransmission.
Application layer	The TCP/IP layer for communication between applications.

8-4 Mechanism of Web Pages and Emails

- **The Web in 3 words**
  - **WWW:** a system that links a huge number of contents on the Internet, used to browse web pages
  - **HTML:** the **language** used to write web pages.
  - **URL:** shows the **location** of a web page and the **method of communication** to reach it.
- **Parts of a URL**
  - `https` = **scheme name** (protocol name).
  - `www` = **host name** (server name).
  - `moe` = **name of organization**.
  - `gov` = **type of organization**: `gov` government agency, `co` company, `ac` university, `ed` / `edu` school.
  - `eg` = **country name**: `eg` Egypt, `jp` Japan, `kr` South Korea
- **Opening a web page step by step**
  - **1):** The browser **asks the DNS server** for the IP address of the domain name.
  - **2):** The DNS server **returns the IP address** of the web server.
  - **3):** The browser **reaches the web server** using that IP address.
  - **4):** The web server sends the page data and the browser **displays it**.
- **Email**
  - **SMTP:** the protocol for **sending** email to a mail server (from your device to the outgoing server, and from the outgoing to the incoming server).
  - **POP:** downloads the email from the server to your device **and deletes it from the server**.
  - **IMAP:** lets you view the email while it **stays stored on the server**, so you can open it from several devices.

WWW	A system linking countless contents on the Internet so users can browse web pages; the Web.

HTML	The language used to create web pages.
URL	An address showing where a web page is and how to communicate with it.
Scheme name	The first part of a URL, naming the protocol, such as https.
Host name	The part of a URL that names the server, such as www.
Username	The part of an email address before @ that identifies the recipient.
SMTP	A protocol for sending emails to a mail server.
POP	A protocol that downloads emails from the server and deletes them there.
IMAP	A protocol for accessing emails that stay stored on the mail server.

8-5 Network Transfer Speed

- **Transfer speed**
  - `1 kbps = 1,000 bps`
  - `1 Mbps = 1,000 kbps`
  - `1 Gbps = 1,000 Mbps`
  - Careful: small **b** = bit, capital **B** = byte, and **1 byte = 8 bits**.
- **The formula (one triangle)**
  - **Transfer speed [bps] = data volume [bits] ÷ transfer time [seconds]:**
  - **Transfer time [seconds] = data volume [bits] ÷ transfer speed [bps]:**
  - **Data volume [bits] = transfer speed [bps] × transfer time [seconds]:**
- **Worked example: convert units first**: In the exam: `1 KB = 1,000 B`, `1 MB = 1,000 KB` and `1 GB = 1,000 MB`.
- **Transfer efficiency**: **Transfer efficiency:** is the share of the communication speed that is really achieved.

Transfer speed	The number of bits of data transferred per second.
bps	Bits per second, the unit of transfer speed.
Mbps	Megabits per second; 1 Mbps = 1,000 kbps.
Transfer time	The time to send data: data volume in bits divided by transfer speed in bps.
Data volume	The amount of data in bits: transfer speed multiplied by transfer time.
Transfer efficiency	The ratio of the communication speed that is actually achieved.
Actual transfer speed	Communication speed multiplied by transfer efficiency.



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