

14. Communication and Internet Technologies

14.1 Protocols

Definitions and Purposes

- **Protocol:** A set of rules governing communication across a network; the rules are agreed by both the sender and the recipient.
- *Why Protocols are essential:*
 - Protocols set a **standard** for communication.
 - Protocols set the **formats** and **rules** of communication.
 - Protocols enable communication between devices from **different platforms**.
 - The communication is independent of the software/hardware used.
 - If two devices were sending messages to each other but using different protocols, they would not be able to communicate properly.
- *Types of protocols:*
 - **Push protocol:** Client opens a connection to the server and **keeps the connection active all the time**.
 - **Pull protocol:** Client **periodically** connects to a server, checks for updates, and closes the connection.

TCP/IP Protocol Suite

- Uses a set of **protocols** for **transmission of data**.
- A **stack**-like structure with four layers.
 1. **Application:** Handles **access to services** / Defines **protocols used**.
 2. **Transport:** Handles **forwarding of packets**.
 3. **Internet:** Handles **data routing**.
 4. **Data Link:** Handles how data is **physically sent**.
- **Sending:** Layers 1 → 4; **Receiving:** Layers 4 → 1.

1. Application Layer

- Messages are split up into groups of bits called **packets**.

Hypertext Transfer Protocol (HTTP)

- **Purpose:** Receiving and sending webpages / hypertext documents.
- **Use:** For browsing websites and web pages.

File Transfer Protocol (FTP)

- **Purpose:** To directly transfer data between two computers over a network.
- **Use:** Upload and download files over the Internet.

Simple Mail Transfer Protocol (SMTP)

- **Purpose:** protocol for **sending emails**.

- **Use:** Used by mail servers to forward email messages.

Post Office Protocol 3 (POP3)

- **Purpose:** Mail is held for you by a remote server until you download it; a **pull protocol**.
- **Use:** To receive **emails**.
- Doesn't keep the server and client in sync → When the client downloads the email, the original email on the mail server will be deleted.

Internet Message Access Protocol (IMAP)

- Used by email clients to **retrieve** email messages → a **pull protocol**.
- ... from a **mail server**.
- Keeps the server and client in **sync** → When a copy of the email is downloaded from the mail server, the original email on the mail server won't be deleted.

BitTorrent Protocol

- **Metadata:** The data that describes other data.
 - **Swarm:** A group of computers in a peer-to-peer network that has whole/part of the shared files.
 - **Leech:** A user who is downloading a file but is not actively sharing it with others.
 - **Lurker:** A user that only downloads files but does not **add new contents**.
 - Lurker will seed, as opposed to leeches.
 - **Tracker:** A server that keeps the information of all the computers in the swarm.
1. To share a file, the peer creates a small file called a **torrent**, which contains metadata about the file.
 2. The actual file is broken up into **pieces**.
 3. Other peers who wish to download this file must first obtain the torrent, load it into a **BitTorrent client**, and connect to a **tracker**.
 4. The tracker will pair the peers and help establish direct connections between.
 5. As each peer receives a piece of file they become a source for that piece of file, and they can **seed** the file.

2. Transport Layer

- Packets become **segments**.
- **Purposes:** Basically packet manipulations.
 - Performs **segmentation**.
 - **Sequences** the packets.
 - Sends the packets to the Network layer.
 - Controls the **flow of packets**.
 - Handles packet **loss/corruption**.
- **Protocol:** *Transmission Control Protocol (TCP)*.
 - Uses **positive acknowledgement with retransmission (PAR)** → a *three-way handshake process*.
 1. **SYN:** The client sends a synchronization request to the server.

2. **SYN-ACK:** The server acknowledges the request and responds with its own synchronization.
3. **ACK:** The client acknowledges the server's response, completing the handshake, and data transmission can begin.

3. Internet (Network) Layer

- Segments become **datagrams**.
- **Purposes:** Anything related to routing.
 - Identifies the intended network and host.
 - Transmits packets to the Link layer.
 - Routes the packets independently through the **optimum route**.
 - Addresses packets with their **source** and **destination** IP addresses.
 - Uses an **IP address** and **port number** to form a socket.
- **Protocol:** *Internet Protocol (IP)*.
 - Used for **routing** and **addressing packets** across networks.

4. Data Link Layer

- Datagrams become **frames**.
- **Ethernet:** Wired technology that controls the movement of frames between computers or devices to avoid simultaneous transmission by two or more devices, using techniques like **CSMA/CD**.
- **Wi-Fi:** A wireless technology that uses **CSMA/CA** to manage the transmission of frames over the air and prevent collisions between devices trying to send data simultaneously.
- **Bluetooth:** A technology designed for short-range wireless data transmission, primarily for connecting personal devices.

14.2 Circuit switching, packet switching

Circuit Switching

- **Process:**
 - A **dedicated physical circuit** is established between two communication ends (the sender and the receiver).
 - Circuit is established **before transmission starts**, and released after transmission ends.
 - Data is transferred using the **whole bandwidth**.
 - All data is transferred over the same route.
- **Use cases:**
 1. Where a **dedicated path** needs to be **sustained throughout the call**, and the **whole bandwidth** is required.
 2. A typical application is **standard voice communications / video streaming private data networks**.
- **Benefits:**
 1. **Whole** of bandwidth is available.
 2. Dedicated communication channel increases **quality** of transmission.

3. Data is transmitted with a **fixed data rate**.
 4. No **waiting time** at switches.
 5. Suitable for **long continuous communication**.
 6. **Fast** method of data transfer.
 7. Data arrives in the **same order** as it was sent.
 8. Data **can't get lost**.
 9. Data all follows the **same path**.
 10. Better for **real-time**.
 11. **Simple** method of data transfer.
- **Drawbacks:**
 1. A dedicated connection makes it impossible to transmit other data even if the channel is free → Not very **flexible**.
 2. No **alternative route** in case of **failure**.
 3. The time required to establish the **physical link** between the two stations can be too long.
 4. **Costly** to establish a dedicated line for each connection.
 5. Bandwidth can't be shared.

Packet Switching

- **Process:**
 - Data is split into **packet**.
 - The packet has a **header** and a **payload**.
 - **Header:** contains the source and destination IP addresses, the protocol used, and a sequence number.
 - Each packet follows its **own path**.
 - Routing selection depends on the **number of datagram packets waiting to be processed at each node**.
 - Depends on the *congestion*.
 - The **shortest path available** is selected.
 - Packets can reach their destination in a **different order** from that in which they are sent.
 - If packets are missing/corrupted, a re-transmission request is sent.
- **Use cases:**
 - Used on data networks to send **large files** that don't need to be live streamed.
 - Used when communication is **asynchronous** & Real-time transmission is not required.
 - When it is necessary to be able to **overcome faulty lines** by rerouting.
 - When it is necessary for the communication to be **more secured**.
 - Used for **high volume data transmission**.
 - When it is not necessary to use **all the bandwidth**.
 - Examples such as email, text messages, etc.
- **Benefits:**
 1. **Accuracy:** Ensures accurate delivery of the message.

2. **Completeness:** Missing packets can be easily detected and a re-send request sent so the message arrives complete.
3. **Resilience:** If a network changes, the router can detect this and send the data through another way to ensure it arrives.
4. Path also available to other users / Doesn't use whole bandwidth / Allows simultaneous use of channel by multiple users.
5. **Better Security** as packets are hashed and sent by different routes.

- **Drawbacks**

1. **Time delays** to correct errors.
2. **Time delays** at the destination to reassembled the packets.
3. **Complex protocols** required for delivery.
4. Unsuitable for **real time** transmission applications.