Introduction

Network Hosts and Communication Links

- A **network host** is a computational device that is connected to a network.
- **Hosts** may work as a **server** offering **information resources, services, and applications** to users and other hosts.
- **Hosts** are assigned a unique **network address**.
- The **network edge** refers to the area where a **device or local network interfaces with a large network**.
- A **link** is a **communication channel** that connects two or more devices for the purpose of **data transmission**.
- **Bandwidth** refers to the **maximum rate data can be transmitted over a link**.

Packets and Packet Switching

- **Packet Switching** is a method of **grouping data into packets** that are transmitted over a network.
- A **network packet** is a formatted unit of data carried by a **packet-switched network**.
- **Packets** consist of **control information, and the payload**.

Network Devices

- A **modem** or a **modulator-demodulator** is a computer networking device that **converts data** between a **digital format, and an analog format** for the purpose of transmission.
- A **router** is a computer networking device that **creates and manages a local network**, and **manages the data entering and exiting the network**.
- A **switch** is a computer networking device that **connects devices via packet switching** to **receive and forward data**.
- **Routers use IP addresses** to route data, and **switches use MAC addresses** to route data.

Network Terminologies

- A **bit (binary digit)** is a single unit of information.
- A **physical link** is the physical **communication link** that **connects transmitters and receivers**.
- **Guided media** refers to signals that **propagate in a solid medium**.
- **Unguided media** refers to **signals that propagate freely**.
- **Routing** refers to the process of determining the **path a packet will take** to reach it's destination.
- **Forwarding** refers to the **process of receiving a packed, and sending it to the next node in the path**.

The Internet

The Internet

- **The Internet** is a **global computer network** that provides a variety of **information and communication facilities**.
- **The Internet** consists of **interconnected networks** using **standardized communication protocols**.
- A **communication protocol** is a **system of rules that allows two or more entities to communicate of the internet**.
- **Protocols** define the **rules, syntax, semantics, and synchronization** of the communication.
- The **internet network core** refers to the infrastructure (routers) that connect networks together.

Internet Service Providers and Access Networks

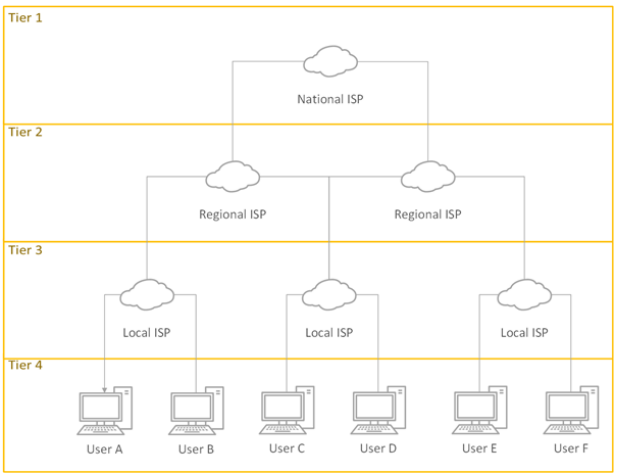
- An **Internet service provider** is an organization that **provides services for accessing, and using the internet**.
- One way an **ISP** can provide their customers with **internet access** is through **existing telephone lines (Digital Subscriber Lines or DLS)**.
- **DSL** was mainly used when the **internet was first created**, and is often referred to as **dial up**.
- The **problem** with **DLS** is that it only supports a single connection.
- A more-modern way **ISPs** provide their customers with **internet access** is with **cable-based access**.
- **Cable-based access** uses **frequency division multiplexing (FDM)** to **transmit data in different channels** allowing for several connections simultaneously.
- There are different types of **cables** such as **Hybrid Fiber Coax (HFC)**, and **Fiber Optic Cables**.
- Another way **ISPs** provide their customers with **internet access** is through **wireless access points (WAPs)**.
- **WAPs use electromagnetic radiation** to **transmit information** over different frequencies.

The Network Core

- **The Network Core** is a mesh of **interconnected routers** that use **packet-switching** to transmit data.
- **Transmission delay** refers to the amount of time it takes for a packet to transmit.
- **Transmission delay** can be **calculated** with the following formula Delay $= \frac{L}{R}$ where L is the **length of the packet**, and R is the **transmission rate of the link in bits per second**.
- **Routers** use the **store and forward principal**; before they can **forward packets**, they have to **wait until the entire packet has arrived**.
- If the **arrival rate** of a packet **exceeds the transmission rate of a link** the packet will be **placed into a queue** for a short period of time; If the queue **runs out of memory** unsent packets will be **overwritten, causing packet loss**.

The Internet Structure

- **Hosts** connect to the internet via **Access Internet Service Providers**.
- **ISPs are then interconnected**.
- There are different **tiers** of ISPs:



- The **ISP tiers** can have **peer-to-peer links** where they are **directly connected**, or they can have an **internet exchange point** which is an external network where **several networks can exchange data**.
- **Context network providers** (Google, Microsoft, etc) may also run **their own networks** that are connected to the **internet**.

Packet Delay

- **Packet delay** refers to the **amount of time** it takes for a packet to **reach it's destination**.
- There are **four sources of packet delay** at a given **router**:
  1. **Processing delay** - The amount of time it takes the **router to process the packet**.
  2. **Queuing delay** - The amount of time the **packet is queued for**.
  3. **Transmission delay** - The amount of time the **router takes to transmit the packet**.
  4. **Propagation delay** - The amount of time it takes the **link to transfer the packet**.

Network Throughput

- **Network Throughput** refers to the **rate of successful message deliveries** over a communication channel.
- **Network Throughput** is measured in **bits / time unit**.

Protocol Layers

- Most **network protocols** are structured as a **series of layers**, collectively referred to as a **protocol stack**.
- Each layer in a **protocol stack** is designed for a **specific purpose**.

The Internet Protocol Stack

- **The internet** uses the **Transmission Control Protocol / Internet Protocol (TCP/IP) stack**.
- **TCP/IP** is composed of **5 layers**:
  1. The **Physical Layer (Layer 1)** is the layer responsible for **moving data within a link**.
  2. The **Data-Link Layer (Layer 2)** is the layer responsible for **moving data in and out of the link**.
  3. The **Network Layer (Layer 3) controls the flow and routing traffic** to ensure data is sent efficiently and accurately.
  4. The **Transport Layer (Layer 4)** provides a **reliable data connection** over a network.
  5. The **Application Layer (Layer 5)** is the group of applications that **let the user access the network**.

TCP/IP Message Units

- At **each layer** the unit of data has a different name.
- At **Layer 1 (Physical)** each unit of data is called a **bit**.
- At **Layer 2 (Data-Link)** each unit of data is called a **frame**.
- At **Layer 3 (Network)** each unit of data is called a **packet**.
- At **Layer 4 (Transport)** each unit of data is called a **segment**.
- At **Layer 5 (Application)** each unit of data is called a **message**.

The Open Systems Interconnection Model (OSI Model)

- The **OSI model** is a **reference model** for how **applications communicate over a network**.
- The **OSI model** focuses on providing a **visual design** of how each **communication layer** is build **on top of the other**.
- The **OSI model** is composed of **7 layers**:
  1. The **Physical Layer (Layer 1)** is the layer responsible for **moving data within a link**.
  2. The **Data-Link Layer (Layer 2)** is the layer responsible for **moving data in and out of the link**.
  3. The **Network Layer (Layer 3) controls the flow and routing traffic** to ensure data is sent efficiently and accurately.
  4. The **Transport Layer (Layer 4)** provides a **reliable data connection** over a network.
  5. The **Session Layer (Layer 5) manages the conversations that occur between applications**.
  6. The **Presentation Layer (Layer 6) translates or formats data** for the **application layer**. This layer also handles **encrypting and decrypting** the data the application layer requires.
  7. The **Application Layer (Layer 7)** is the group of applications that **let the user access the network**.

Network Security

Network Security

- **Network Security** is a set of technologies that **protects** the **usability, and integrity of network infrastructure**.
- A **network security architecture** is composed of **tools that protect the network itself and the applications that rely on it**.

Types of Dangers on a Network

- **Malware (malicious software)** refers to **software** created by people with **bad intentions** that performs **malicious actions on the device / network**.
  - A **virus** is a **self-replicating program** that works by **executing malicious programs**.
  - A **worm** is a **self-replicating program** that that works by **passively receiving a program that is then executed**.
- **Spyware** is a **type of malware** that **tracks actions performed on the computer**.
- A **Denial of Service attack (DOS)** is an attack that sends **high volumes of traffic to it's target** to **overwhelm** the network.
- A **Distributed Denial of Service Attack (DDOS** is a **DOS attack** that uses **several devices to attack the target**.
- **Packet sniffing** is when a program **intercepts packets (stores them)** and then **forwards them as if nothing happened**.
- **IP Spoofing** is when **packets are sent with a false IP source address**.