CSN-341

Computer Networks

Group-6

Tutorial 1

under

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Question 1: Describe the different wireless technologies you use during the day and their characteristics. If you have a choice between multiple technologies, why do you prefer one over another?

We use several wireless technologies during a day. Each one has its unique characteristics which helps us with our day-to-day life. Some of these are:

Wi-Fi

Wi-Fi is a daily staple for staying connected at home and work. Its ability to handle multiple devices with fast internet speeds makes it indispensable for streaming, working remotely, and connecting smart home devices.

- Operates on 2.4 GHz and 5GHz bands with a range of up to 100m and a maximum speed of 9.6Gbps.
- Operates under the IEEE 802.11 standards, which define the protocols for implementing wireless local area networks (WLANs).
- Uses the CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) mechanism to manage access to the shared medium and reduce collisions.
- Supports various encryption methods (WPA, WPA2, WPA3) to secure the data transmitted over the network.
- Preferred for high-speed internet access and for connecting multiple devices within a local area network.

Bluetooth

Bluetooth is ideal for short-range, low-power communication and is commonly used for peripheral device connections.

- Operates on 2.4 GHz ISM band with speeds up to 3Mbps.
- Supports short-range communication and is designed for low power consumption, making it ideal for connecting peripheral devices.
- Uses a master-slave architecture where the master device controls the communication and synchronization with slave devices.
- The Bluetooth protocol stack includes profiles that define specific applications and use cases, such as A2DP for audio streaming and HID for input devices.

Cellular networks (4G/5G)

Cellular networks are the go-to network for accessing internet and voice communication anywhere. It is well preferred because of its ability to provide high speed internet at places where Wi-Fi connections are not feasible.

- Operate on a hierarchical structure with multiple layers of cells, each served by a base station.
- 4G (LTE - Long Term Evolution) and 5G (New Radio) are the latest generations of cellular technology, offering high data rates and low latency.
- LTE uses OFDMA (Orthogonal Frequency Division Multiple Access) for efficient spectrum utilization and supports MIMO (Multiple Input Multiple Output) to improve throughput.
- 5G enhances these capabilities with additional frequency bands, beamforming, and network slicing.

NFC (Near Field Communication)

NFC is incredibly convenient for making quick, secure transactions and pairing devices with a simple tap. It's a technology that blends seamlessly into everyday life, enhancing the ease and speed of small interactions.

- Operates at 13.56 MHz and uses electromagnetic induction to enable communication between devices within close proximity (up to 4 cm).
- Supports both passive and active modes, where passive devices (tags) are powered by the electromagnetic field generated by active devices (readers).
- Supports three modes of operation: reader/writer mode, peer-to-peer mode, and card emulation mode.
- These modes enable NFC to be versatile for different applications, including contactless payments, data transfer, and access control.

Question 2: Suppose users share a 2 Mbps link. Also suppose each user transmits continuously at 1 Mbps when transmitting, but each user transmits only 20 percent of the time.

When circuit switching is used, how many users can be supported?

In circuit switching, each user requires 1 Mbps. With a 2 Mbps link:

$$\text{Number of users supported} = \frac{2\text{ Mbps}}{1\text{ Mbps}} = 2$$

For the remainder of this problem, suppose packet switching is used. Why will there be essentially no queuing delay before the link if two or fewer users transmit at the same time? Why will there be a queuing delay if three users transmit at the same time?

- No queuing delay with two or fewer users: If two users transmit at 1 Mbps each, the total is 2 Mbps, matching the link capacity, so no queuing delay.

- Queuing delay with three users: If three users transmit at 1 Mbps each, the total is 3 Mbps, exceeding the 2 Mbps link capacity, causing queuing delay.

Find the probability that a given user is transmitting.

Each user transmits 20% of the time:

$$P(\text{user is transmitting}) = 0.20$$

Suppose now there are three users. Find the probability that at any given time, all three users are transmitting simultaneously. Find the fraction of time during which the queue grows.

Probability that all three users are transmitting simultaneously:

$$P(\text{all three users are transmitting}) = 0.20 \times 0.20 \times 0.20 = 0.008$$

Fraction of time the queue grows: Queue grows only when all three users transmit simultaneously. So,

$$\text{Fraction of time the queue grows} = 0.008$$

So, the queue grows 0.8% of the time.

Question 3: Assume that we have created a packet-switched internet. Using the TCP/IP protocol suite, we need to transfer a huge file. What is the advantage and disadvantage of sending large packets?

Advantages of Large Packets

- **Reduced Overhead**: Each packet typically includes a header with control information (e.g., source and destination addresses). With large packets, the proportion of overhead to actual data is lower, meaning more of the transmitted data is useful payload rather than control information.
- **Processing Efficiency**: Each packet requires processing by network devices such as routers and switches. This processing includes examining the header, determining the next hop, and possibly performing error checking. Larger packets mean fewer packets need to be processed for the same amount of data, which reduces the processing burden on network devices and can lead to higher overall throughput.
  - **Example**: To transmit 10,000 bytes, a network would need to process 100 packets of 100 bytes each or just 10 packets of 1,000 bytes each. The latter scenario involves significantly less processing.
- **The Overall Throughput of the process increases.**

Disadvantages of Large Packets

- **Increased Impact of Packet Loss**: If a large packet is lost or corrupted, a larger chunk of data needs to be retransmitted compared to smaller packets. This can increase the time required for error recovery.
- **Higher Transmission Delay**: Larger packets can take longer to transmit over the network, which can increase the transmission delay for real-time applications (e.g., gaming).
  - For real-time applications like VoIP or online gaming, consistent transmission times (low jitter) are crucial. Larger packets can introduce more variability in delay (jitter) because they occupy the transmission medium for a longer period, causing more fluctuation in the timing of packet delivery.
- **Queueing Delay**: In network devices like routers and switches, packets may need to wait in a queue before being processed. Larger packets can contribute to longer queueing delays because they take more time to process and forward, potentially causing other packets to wait longer.
- **Fragmentation Issues**: Some networks or network segments might have a maximum transmission unit (MTU) limit. Large packets might need to be fragmented, adding complexity and potential inefficiencies.

Question 4: What happens when you use cables longer than the prescribed length in a network?

When cables are too long, they can disrupt the flow of information, leading to weaker or distorted electrical signals. This can result in reduced speed, increased errors, and sometimes no data transfer at all. The prescribed length of cables refers to the maximum advisable length for optimal performance, which varies depending on the type of cable used.

Why the Prescribed Length is Important for Cables

- **Signal Strength**: Longer cables weaken and distort signals over greater distances as electricity must travel further, increasing the risk of data loss and errors.
- **Optimal Performance**: Cables are designed and certified to work within specific lengths for reliable data transmission and network speed. Exceeding these limits can degrade performance.

- **Resource Efficiency**: Using cables longer than necessary wastes network resources and power, as more energy is needed to transmit signals over extended lengths.
- **Compatibility**: The specified lengths are based on the type of cable and existing networking standards. Exceeding these limits can lead to compatibility issues, affecting connectivity between devices.

Adverse Effects of Using a Cable Longer than the Prescribed Length

- **Signal Weakness**: As electrical signals travel over a very long cable, they weaken, making it difficult for the receiving end to interpret the data, leading to errors or connection loss.
- **Slower Speeds**: The longer the cable, the more time it takes for a signal to travel, reducing the rate at which information flows between connected devices.
- **Data Loss**: In very long cables, parts of the data signal may weaken or become distorted, resulting in missing or corrupted packets by the time they reach their destination.
- **Signal Reduction**: The strength of the electric current diminishes as it travels over longer distances, making it more susceptible to interference and noise.
- **Delays**: Longer cables increase the time it takes for data to travel from one end to the other, causing cumulative delays that can make a network feel slow.
- **Protocol Problems**: Some network protocols have strict timing requirements, which can be violated when using cables that are too long, leading to malfunctions.
- **Interference**: Long cables can act as antennas, picking up electrical noise and radio interference, which mixes with the data signal.
- **Troubleshooting Difficulty**: Longer cables make it harder to pinpoint network issues, complicating troubleshooting efforts.
- **Higher Costs**: Longer cables require more material and labor, increasing installation and maintenance costs.
- **Reliability Problems**: Longer cables are more prone to accidental damage, such as being cut, crushed, or tampered with, leading to network downtime until repairs are made.

Question 5: Explain the difference between circuit switching and packet switching. Describe a scenario where packet switching would be more efficient than circuit switching and vice versa

Circuit Switching

- **Description**
  * Establishes a dedicated communication path between two endpoints for before the transmission even begins.
  * The communication path needs to be always available between the end systems. The switch can only make it active or inactive.
  * Offers fixed and guaranteed bandwidth.
  * Example: Traditional telephone networks.
- **Advantages**:
  * Predictable performance due to dedicated bandwidth.
  * Low latency once the circuit is established.
  * Reliable and consistent quality of service.
- **Disadvantages**:
  * Inefficient use of resources; the dedicated path remains reserved even if no data is being transmitted.

    * Efficient only when it is working at its full capacity; however, most of the time, it is inefficient because it is working at partial capacity.
    * Longer setup time due to the need to establish the circuit.

Packet Switching

- **Description**:
    * Communication happens by dividing data into small blocks called packets. The packets can travel independently through the network, taking different paths or reaching out-of-order.
    * A router in a packet-switched network has a queue that can store and forward packets.
    * Multiple users share the same network resources, making it more flexible and efficient.
- **Example**: The Internet and most modern data networks.
- **Advantages**:
    * Efficient use of network resources, as packets can be routed around congestion.
    * Flexible and scalable as it can handle varying traffic loads effectively.
    * No need to establish a dedicated path before communication starts.
- **Disadvantages**:
    * Potential for packet loss.
    * Generally higher latency than circuit-switched network due to potential delays.
    * More complex protocols and error handling mechanisms are required.

Scenarios when Packet Switching is More Efficient

- **Web Browsing and Email**: These applications involve bursts of data transmission with periods of inactivity. Packet switching efficiently utilizes the network by allowing multiple users to share the same resources.
- **Cloud Services**: Accessing and syncing data with cloud storage involves irregular data transfer patterns, making packet switching ideal for optimizing bandwidth and minimizing latency.
- **Streaming Services**: While streaming requires a steady flow of data, packet switching can adapt to varying network conditions, providing better overall performance and resource utilization.

When Circuit Switching is More Efficient

- **Voice Calls (Traditional Telephony)**: Circuit switching ensures a continuous, stable connection with guaranteed bandwidth.
- **Legacy Systems**: Older communication systems designed around circuit switched networks may still rely on their guaranteed quality of service.

In summary, packet switching is generally more efficient for most modern applications due to its flexibility and efficient resource utilization. However, circuit switching remains valuable for specific real-time applications requiring guaranteed and predictable performance.