Switching

In computer networking, Switching is the process of transferring data packets from one device to another in a network, or from one network to another, using specific devices called switches. A computer user experiences switching all the time for example, accessing the Internet from your computer device, whenever a user requests a webpage to open, the request is processed through switching of data packets only.

What is a Network Switching?

A switch is a dedicated piece of computer hardware that facilitates the process of switching i.e., incoming data packets and transferring them to their destination. A switch works at the Data Link layer of the OSI Model. A switch primarily handles the incoming data packets from a source computer or network and decides the appropriate port through which the data packets will reach their target computer or network.

Process of Switching

The switching process involves the following steps:

Frame Reception: The switch receives a data frame or packet from a computer connected to its ports.

MAC Address Extraction: The switch reads the header of the data frame and collects the destination MAC Address from it.

MAC Address Table Lookup: Once the switch has retrieved the MAC Address, it performs a lookup in its Switching table to find a port that leads to the MAC Address of the data frame.

Forwarding Decision and Switching Table Update: If the switch matches the destination MAC Address of the frame to the MAC address in its switching table, it forwards the data frame to the respective port. However, if the destination MAC Address does not exist in its forwarding table, it follows the flooding process, in which it sends the data frame to all its ports except the one it came from and records all the MAC Addresses to which the frame was delivered. This way, the switch finds the new MAC Address and updates its forwarding table.

Frame Transition: Once the destination port is found, the switch sends the data frame to that port and forwards it to its target computer/network.

Types of Switching

There are three types of switching methods:

- Message Switching
- Circuit Switching
- Packet Switching
    1. Datagram Packet Switching
    2. Virtual Circuit Packet Switching

Message Switching -

Message switching was a technique developed as an alternative to circuit switching before packet switching was introduced. In message switching, end-users communicate by sending and receiving *messages* that included the entire data to be shared. Messages are the smallest individual unit.

Also, the sender and receiver are not directly connected. There are a number of intermediate nodes that transfer data and ensure that the message reaches its destination. Message switched data networks are hence called hop-by-hop systems.

They provide 2 distinct and important characteristics:

Store and forward - The intermediate nodes have the responsibility of transferring the entire message to the next node. Hence, each node must have storage capacity. A message will only be delivered if the next hop and the link connecting it are both available, otherwise, it'll be stored indefinitely. A store-and-forward switch forwards a message only if sufficient resources are available and the next hop is accepting data. This is called the store-and-forward property.

Message delivery - This implies wrapping the entire information in a single message and transferring it from the source to the destination node. Each message must have a header that contains the message routing information, including the source and destination.

Advantages of Message Switching -

Message switching has the following advantages:

- As message switching is able to store the message for which communication channel is not available, it helps in reducing the traffic congestion in the network.

- In message switching, the data channels are shared by the network devices.
- It makes traffic management efficient by assigning priorities to the messages.
- It allows for infinite message lengths.
- Unlike circuit switching, it does not necessitate the actual connection of source and destination devices.

Disadvantages of Message Switching –

Message switching has the following disadvantages:

- Message switching cannot be used for real-time applications as storing messages causes delay.
- In message switching, the message has to be stored for which every intermediate device in the network requires a large storing capacity.
- The type of message switching does not create a dedicated path between the devices. It is not dependable communication because there is no direct relationship between sender and receiver.

Applications –

The store-and-forward method was implemented in telegraph message switching centres. Today, although many major networks and systems are packet-switched or circuit-switched networks, their delivery processes can be based on message switching. For example, in most electronic mail systems the delivery process is based on message switching, while the network is in fact either circuit-switched or packet-switched.

In circuit switching network resources (bandwidth) are divided into pieces and bit delay is constant during a connection. The dedicated path/circuit established between sender and receiver provides a guaranteed data rate. Data can be transmitted without any delays once the circuit is established.

Telephone system network is one of the example of Circuit switching. **TDM (Time Division Multiplexing) and FDM (Frequency Division Multiplexing)** are two methods of multiplexing multiple signals into a single carrier.
drawbacks:

Inefficient use of resources: *Circuit switching requires the establishment of a dedicated communication path between two nodes, which means that the resources along that path, such as bandwidth and switch ports, are reserved for the duration of the communication. This can result in inefficient use of resources, as the resources may remain unused during periods of low or no communication.*

Limited scalability: *Circuit switching is not well-suited for large-scale networks with many nodes, as it requires a dedicated communication path between each pair of nodes. This can result in a high degree of complexity and difficulty in managing the network.*

Vulnerability to failures: *Circuit switching relies on a dedicated communication path, which can make the network vulnerable to failures, such as cable cuts or switch failures. In the event of a failure, the communication path must be re-established, which can result in delays or loss of data.*

Delay and latency: *Circuit switching requires the establishment of a dedicated communication path, which can result in delay and latency in establishing the path and transmitting data. This can impact the real-time performance of applications, such as voice and video.*

High cost: *Circuit switching requires the reservation of resources, which can result in a high cost, particularly in large-scale networks. This can make circuit switching less practical for some applications.*

Lack of flexibility: *Circuit switching is not flexible as it only allows one type of communication at a time, such as voice or data. This can limit the ability of users to perform multiple tasks simultaneously.*

Limited mobility: *Circuit switching is not well-suited for mobile devices or nodes that move frequently, as it requires the establishment of a dedicated communication path. This can result in communication disruptions or dropped calls.*

Limited capacity: *Circuit switching can have limited capacity as it requires the establishment of a dedicated communication path between two nodes. This can limit the number of simultaneous communications that can occur.*

High setup time: *Circuit switching requires a significant setup time to establish the dedicated communication path between two nodes. This can result in delays in initiating communication.*

No prioritization: Circuit switching does not provide any mechanism for prioritizing certain types of traffic over others. This can result in delays or poor performance for time-critical applications, such as voice or video.

Advantages of Circuit Switching:

It has the following advantages :

The main advantage of circuit switching is that a committed transmission channel is established between the computers which give a guaranteed data rate.

In-circuit switching, there is no delay in data flow because of the dedicated transmission path.

Reliability: Circuit switching provides a high level of reliability since the dedicated communication path is reserved for the entire duration of the communication. This ensures that the data will be transmitted without any loss or corruption.

Quality of service: Circuit switching provides a guaranteed quality of service, which means that the network can prioritize certain types of traffic, such as voice and video, over other types of traffic, such as email and web browsing.

Security: Circuit switching provides a higher level of security compared to packet switching since the dedicated communication path is only accessible to the two communicating parties. This can help prevent unauthorized access and data breaches.

Ease of management: Circuit switching is relatively easy to manage since the communication path is pre-established and dedicated to a specific communication. This can help simplify network management and reduce the risk of errors.

Compatibility: Circuit switching is compatible with a wide range of devices and protocols, which means that it can be used with different types of networks and applications. This makes it a versatile technology for various industries and use cases.

Disadvantages of Circuit Switching:

It has the following disadvantages :

- It takes a long time to establish a connection.
- More bandwidth is required in setting up dedicated channels.

- It cannot be used to transmit any other data even if the channel is free as the connection is dedicated to circuit switching.
- **Waste of Resources:** Circuit switching reserves the bandwidth and network resources for the duration of the communication, even if there is no data being transmitted. This results in the wastage of resources and inefficient use of the network.
- **Expensive:** Circuit switching is an expensive technology as it requires dedicated communication paths, which can be costly to set up and maintain. This makes it less feasible for small-scale networks and applications.
- **Susceptible to Failure:** Circuit switching is susceptible to failure as it relies on a dedicated communication path. If the path fails, the entire communication is disrupted. This makes it less reliable than other networking technologies, such as packet switching.
- **Not suitable for bursty traffic:** Circuit switching is not suitable for bursty traffic, where data is transmitted intermittently at irregular intervals. This is because a dedicated circuit needs to be established for each communication, which can result in delays and inefficient use of resources.

Packet Switching :

Packet Switching in computer networks is a method of transferring data to a network in the form of packets. In order to transfer the file fast and efficiently manner over the network and minimize the transmission latency, the data is broken into small pieces of variable length, called Packet. At the destination, all these small parts (packets) have to be reassembled, belonging to the same file. A packet is composed of a payload and various control information. No pre-setup or reservation of resources is needed.

Advantages of Packet Switching over Circuit Switching

- More efficient in terms of bandwidth, since the concept of reserving a circuit is not there.
- Minimal transmission latency.
- More reliable as a destination can detect the missing packet.
- More fault tolerant because packets may follow a different path in case any link is down, Unlike Circuit Switching.
- Cost-effective and comparatively cheaper to implement.

Disadvantage of Packet Switching over Circuit Switching

- Packet Switching doesn't give packets in order, whereas Circuit Switching provides ordered delivery of packets because all the packets follow the same path.
- Since the packets are unordered, we need to provide sequence numbers for each packet.
- Complexity is more at each node because of the facility to follow multiple paths.
- Transmission delay is more because of rerouting.
- Packet Switching is beneficial only for small messages, but for bursty data (large messages) Circuit Switching is better.

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