Unit-3: Network Layer

- Network Layer is a 3rd from bottom, which is responsible for handling the data(packets) transmission from source to destination.

- Its responsibilities/services are:

1. Route Addressing: Encapsulating the IP Addresses of source and destination machines to form a data packet, which can be sent at a time and independently.

If the size of data to be sent is larger than a fixed packet size, then the data is divided into multiple parts to form multiple packets and sent sequentially through different routing paths, simultaneously.

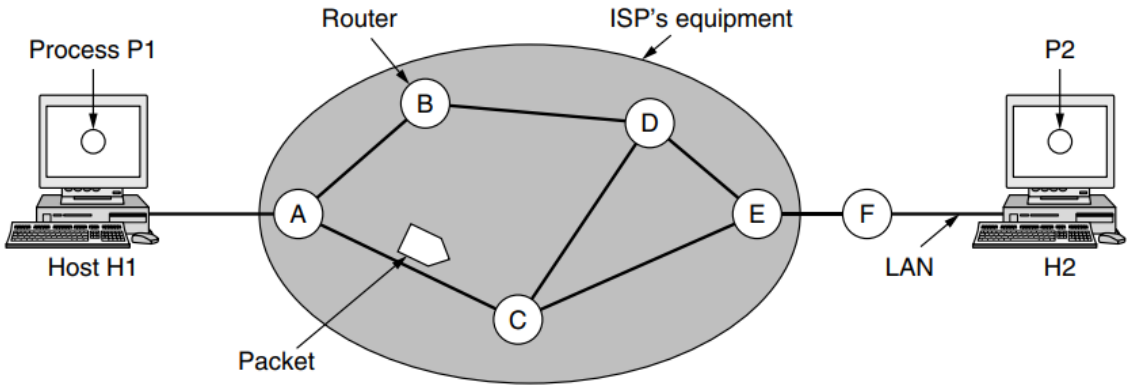
2. Path Determination: Determining a suitable and optimum path for the transmission of data packets, among multiple paths, through routers.

The path with the shortest distance in total from source to destination is known as an optimum path for data transmission.

Design Issues:

The design issues which must be avoided while designing a network layer are:

1. Store-and-Forward Packet Switching:



- It is a packet switching technique in which the packets to be sent are first stored into a router and examined for errors. After which, the packets are transmitted to the next suitable router.

- The Router/Switch first waits for the complete data packet and stores it into its buffer memory, and then checks for errors in the packet.

- If an error is detected, it rejects the packet. If there is no error, then it transmits the packet to the next suitable router.
- This Approach takes time to complete the whole data transmission through a network of routers, which delays the transmission. Due to which, this approach must not be used and avoided to ensure fast data transmission.

2. Services provided to transport layer:

The services to be provided to the transport layer (upper layer), must be chosen carefully.

The services to follow the below points:

- Independence of Router Technology: The services provided by the network layer should be independent of the specific technology employed by routers. This ensures that changes or upgrades in router technology do not affect the transport layer.
- Shielding Transport Layer: The transport layer should be shielded from the details of the number, type, and topology of routers in the network. This abstraction allows for easier adaptation and modification of the underlying network infrastructure without impacting the transport layer.
- Uniform Numbering Plan: Network addresses made available to the transport layer should follow a uniform numbering plan across both Local Area Networks (LANs) and Wide Area Networks (WANs). This uniformity simplifies address management and communication across diverse network environments.

3. Internal Design of Subnet:

- A subnet is a sub-part of a network of routers, through which the data is transmitted.

- A WAN consists of large no.of subnets. Hence, it is the responsibility of the Network layer to determine the suitable and optimum path for data transmission.

- The design of a subnet can be either connection-oriented or connection-less, which is chosen based on the application specific requirements.

- In connection-oriented network setup, the data is transmitted by first establishing the connection with the receiver machine and then transmitting data continuously, until the whole data is transmitted.

- In connection-less network setup, the data is encapsulated with destination address to form a data packet, which is sent independently without establishing any connection with the receiver machine. The receiving machine identifies the specified address and accepts the packet.

- For connection-oriented subnets, the Virtual Circuit (VC) setup is used.

- For connection-less subnets, the Datagram setup is used.

- <u>VC Setup</u>:

- The logical (non-real, non-physical) representation of each subnet of routers of a WAN, used by Network layer to determine the suitable connection path before transmitting the data, is known as Virtual Circuit.
- Each VC is assigned a number when data is to be transmitted through multiple subnets, known as VC numbers.
- The process is:
    1. Establish a connection by sending a “call setup request”.
    2. Send data.
    3. Close the connection at the receiver end when data is accepted.

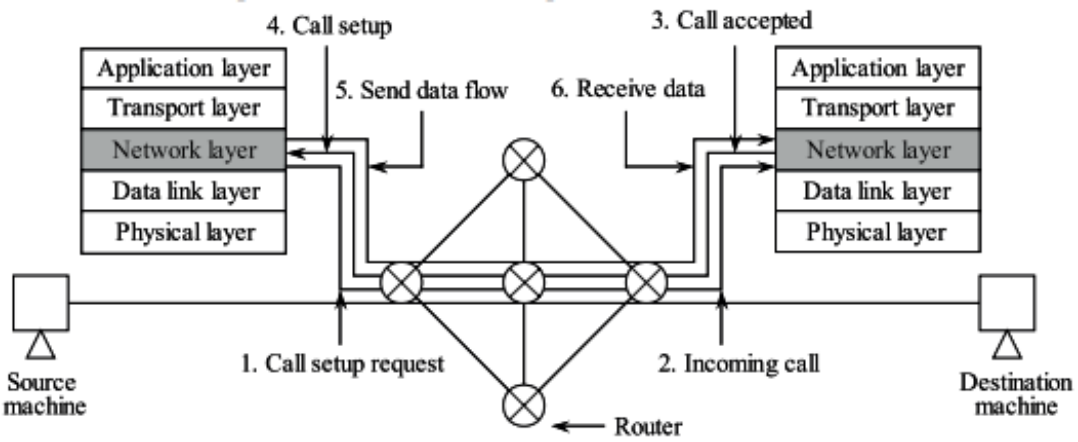


Figure (a): Virtual Circuit Network

- <u>Datagram Setup</u>:

- The data packet which is encapsulated with destination address and can be sent independently, is known as a datagram.
- If the size of data to be sent is larger than the fixed data packet size, then divide it into multiple data packets and send through different route paths, and then combine them in the same order.

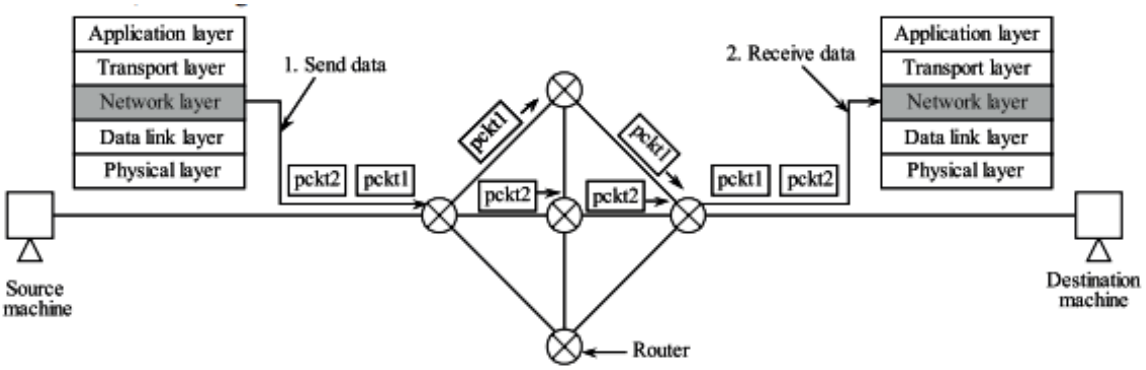


Figure (b): Datagram Network

Comparison of Virtual Circuit Subnet with Datagram Subnet

	Datagram Subnet		Virtual Circuit Subnet
1.	No route is established.	1.	A route is established before a packet is transmitted.
2.	It has only packet transmission delay.	2.	It has both call setup and packet transmission delay.
3.	Each packet is routed independently.	3.	All packets follow the same route which is chosen when the connection is established.
4.	Each packet header contains the full destination address.	4.	Each packet header contains a short VC (virtual circuit) number to identify destination.
5.	As each packet contains full address mapping is not required.	5.	Address mapping from VC number to a destination is required at each switch along the path before data is transmitted.
6.	The routers do not maintain a table for open VCs.	6.	Every router maintains a table with one entry for each open virtual circuit.
7.	The routing decision is made for each packet at each node.	7.	The routing decision is made only once for all packets using the same virtual circuit.
8.	When a router fails, the subsequent packets find the alternate route that bypasses the failed router.	8.	When a router fails, all the VCs that pass through these router are terminated.
9.	Congestion control is difficult.	9.	Congestion control is easy if enough resources are reserved in advance for each VC.
10.	Increase in packet delay due to overload.	10.	Increase in packet delay and blocking of call setup request due to overload.

Routing Algorithms:

In a network of multiple subnets, where each subnet represents a LAN network of a set of routers, there are multiple paths for a single destination.

Routing is the process of establishing the optimum routes (shortest transmission paths) that the data packets must follow to reach the destination, in less time.

In this process, a routing table is implemented at each router of a subnet, with which the suitable path is chosen at every hop.

(A hop is the movement of data from one router to another.)

Some of algorithms that are used for Routing Process are:

- Shortest-path routing
- Flooding
- Hierarchical Routing
- Broadcast
- Multicast
- Distance vector router

1) Shortest-path routing - [notes]

2) Flooding - [notes]

3) Hierarchical Routing - [notes]

4) Broadcast Routing:

- The process of sending a packet to all the nodes on the network at a single instance of time, is called broadcasting. And the algorithms used for broadcasting are called broadcast routing algorithms.

- i.e., a single sender transmits data to all the nodes in a network.

- It is commonly used in LAN networks. [ex: chatting groups]

Characteristics:

- The sender addresses the message to all devices in the network.
- All devices in the network receive a broadcast message.
- It's a one-to-all communication method.
- Broadcast messages can create network congestion, especially as the network grows.

Various methods of broadcast routing are:

A) Distinct point-to-point routing
B) Flooding
C) Multi-destination routing
D) Use of spanning tree

A) Distinct point-to-point routing: In this method, a sender establishes individual communication channels with each recipient (receiver) in the network.

- i.e., a sender sends a distinct packet to all the nodes in the network.

- each recipient receives a unique copy of the broadcast message through its dedicated communication channel.

- It is efficient for a small number of recipients, but it may become impractical as the number of recipients increases.

B) Flooding: in this method, a sender transmits the broadcast message to all its neighboring nodes, and each receiving nodes and each receiving node forwards the message to all its neighbors except the sender (the line through which it was received from)

C) Multicast-destination routing: It involves sending a single copy of a broadcast message to multiple recipients using a predetermined path or set of paths.

- It reduces redundancy compared to flooding but requires some knowledge of network topology.

D) Spanning Trees: A message is broadcasted into a tree structured network where no loop exists. Hence preventing the duplicate message generations.

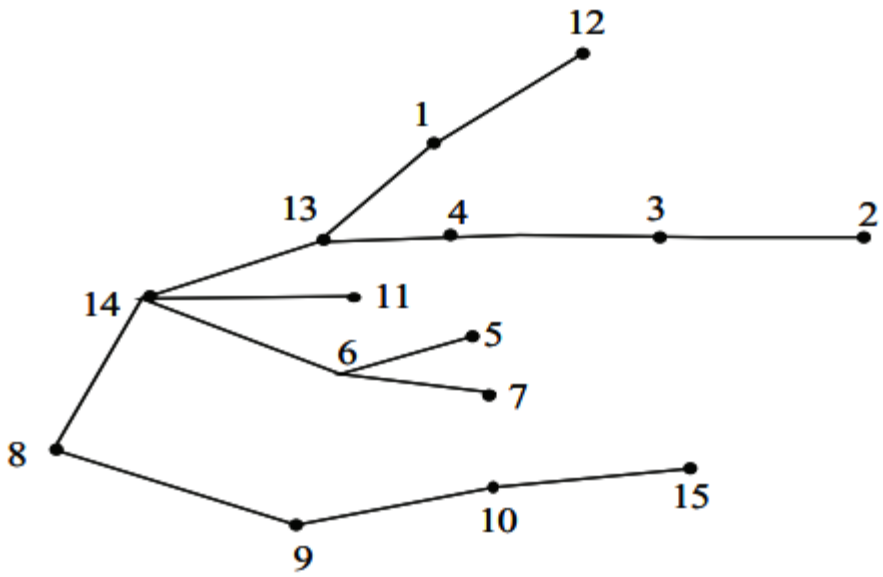


Figure (b): Spanning Tree for Subnet