# UNIT 2   NETWORK DEVICES-II

**Structure**                                                             **Page Nos.**

## 2.0   INTRODUCTION

In the previous unit we have studied some of the network devices which are used at physical layer and data link layer.  In this unit we continue our discussion about devices/operating at a lower layers but also look at higher layer devices.  Routers and Gateways work at network layers and above, whereas modem work at a lower layer. We will also examine differences between bridges and routers.

## 2.1   OBJECTIVES

After going through this unit you should be able to define and differentiate the following:

1.    Routers
2.    Gateways
3.    Modems.

## 2.2   NETWORK DEVICES

### 2.2.1   ROUTERS

In an environment consisting of several network segments with different protocols and architecture, a bridge may not be adequate for ensuring fast communication among all of the segments. A complex network needs a device which not only knows the address of each segment, but also can determine the best path for sending data and filtering broadcast traffic to the local segment. Such a device is called a Router.

Routers are both hardware and software devices. They can be cards that plug into a collapsed backbone, stand-alone devices or software that would run on a file server.

**Purpose of Routers**

The purpose of a router is to connect nodes across an Internetwork, regardless of the Physical Layer and Data Link Layer protocol that is used. Routers are hardware and topology-independent. Routers are not aware of the type of medium or frame that is being used (Ethernet, Token Ring, FDDI, etc.). Routers are aware of the Network Layer protocol that's used (e.g., Novell's IPX, Unix's IP, XNS, Apple's DDP, and so on).

## Router OSI Operating Layer

Routers operate on the OSI Model's Network Layer. The Internetwork must use the same Network Layer protocol. Routers allow the transport of the Network Layer PDU through the Internetwork, even though the Physical and Data Link Frame size and addressing scheme may change.

Routers that only know Novell IPX (Internetwork Packet Exchange) will not forward Unix's IP (Internetwork Packet) PDUs, and vice versa. Routers only see the Network Layer protocol that they have been configured for. This means that a network can have multiple protocols running on it (e.g., SPX/IPX, TCP/IP, Appletalk, XNS, etc.).

For example a Novell SPX/IPX router; only sees the Network Layer protocol IPX. This means that any TCP/IP PDUs will not pass through: the router does not recognise the PDUs, and doesn't know what to do with them. Therefore, Routers allow network traffic to be isolated - or segmented - based on the Network Layer Protocol. This provides a functional segmentation of the network.

Routers that only can see one protocol are called Protocol Dependent Routers. Routers that can see many different protocols (two or more) are called Multi protocol Routers.

## Router Addressing

Routers combine the Network Number and the Node Address to make Source and Destination addresses (in routing Network Layer PDUs across a network). Routers have to know the name of the segment that they are on, and the segment name or number where the PDU is going. They also have to know the Node Address: MAC Address for Novell, and the IP address for TCP/IP.

For Novell's SPX/IPX (Sequential Packet eXchange/Internetwork Packet eXchange), the Network Layer PDU's address is composed of the Network Address (32 bit number) and the Host address (48 bit - MAC address).

## Routing Protocols

Routing Protocols are a "sub-protocol" of the Network Layer Protocol. They deal specifically with the routing of packets from the source to the destination (across an Internetwork). Examples of Routing Protocols are: RIP, IGRP and OSPF. Let us look at each of these protocols in some more detail.

## RIP - Routing Information Protocol

RIP was one of the first routing protocols to gain widespread acceptance. It is described in RFC1058, which is an Internet standard. Commercial NOS, such as Novell, Apple, Banyan Vines, and 3Com, use RIP as the base routing algorithm for their respective protocol suites.

RIP is a distance vector algorithm. Routers maintain a detailed view of locally-attached network segments, and a partial view of the remainder of the routing table. The routers contain information on the number of hop counts to each segment. A hop is considered to be one transverse through a router. Pass through a router, and the Hop count increases by 1.

The routers are updated every *30* seconds, when each router sends out a RIP broadcast. This advertisement process is what enables RIP routing to be dynamic. Dynamic routers can change routing tables on the fly (as the network configuration changes). By using the Hop Count information from their routing tables, routers can select the shortest path (the least number of hops) to the destination.

**Apple uses *RTMP* (routing table maintenance protocol)**: This adds a good, bad or suspect route status indicator, depending on the age of the route information.

**Novell adds ticks to the RIP algorithm**: *Ticks* are dynamically assigned values that represent the delay associated with a given route. Each tick is considered 1/18 of a second. LAN segments are typically assigned a value of 1 tick. A T1(1.544 Mbps) link may have a value of 5 to 6 ticks and a 56 Kbps line may have a value of 20 ticks. A larger number of ticks indicates a slower routing path.

Three commonest problems that can occur with RIP are shown below:

1. **Routing loops** : The router indicates that the shortest path is back the way the packet came from.

2. **Slow Route Convergence**: Routers have delay timers that start counting after the RIP advertising packet is broadcasted. This gives the routers time to receive and formulate a proper routing table from the other routers. If the delay timer is too short, the routing table can be implemented with incomplete data causing routing loops.

3. **Hop Count Exceeded**: The maximum number of hop counts is 15 for RIP. A hop count of 15 is classified as unreachable which makes RIP unsuitable for large networks where hop counts of 15 and above are normal.

**EGRP - Exterior Gateway Routing Protocol**

EGRP was created to solve many of the problems with RIP, and has become the default routing protocol across the Internet. EGRP is an enhanced distance vectoring protocol; it uses up to 5 metrics (measures) to determine the best route as shown below:

1. Bandwidth
2. Hop Count (Delay) - maximum of 255
3. Maximum Packet size
4. Reliability
5. Traffic (Load).

These routing metrics are much more realistic indicators (of the best routes) than simple hop counts.

**OSPF - Open Shortest Path First**

**OSPF is a link state premise**: It has several states of routers that are linked together in a hierarchical routing model. This means that each router maintains link status information and this is exchanged between routers wishing to build routing tables. Unlike RIP OSPF uses IP directly, OSPF packets being identified by a special value in the IP datagram protocol field.

The top of the root is the Autonomous Router that connects to other autonomous systems (the Internet). The next is the Backbone Routers, the highest area in the OSPF system. Border routers are attached to multiple areas and they run multiple copies of the routing algorithm. Last are internal routers that run a single routing database for one area.

Basically, by dividing the network into a routing hierarchy, both substantial reduction of routing update traffic and faster route convergence -result on a local basis. Each level has a smaller routing table, and less to update.

### 2.2.2    Comparison of Bridges and Routers
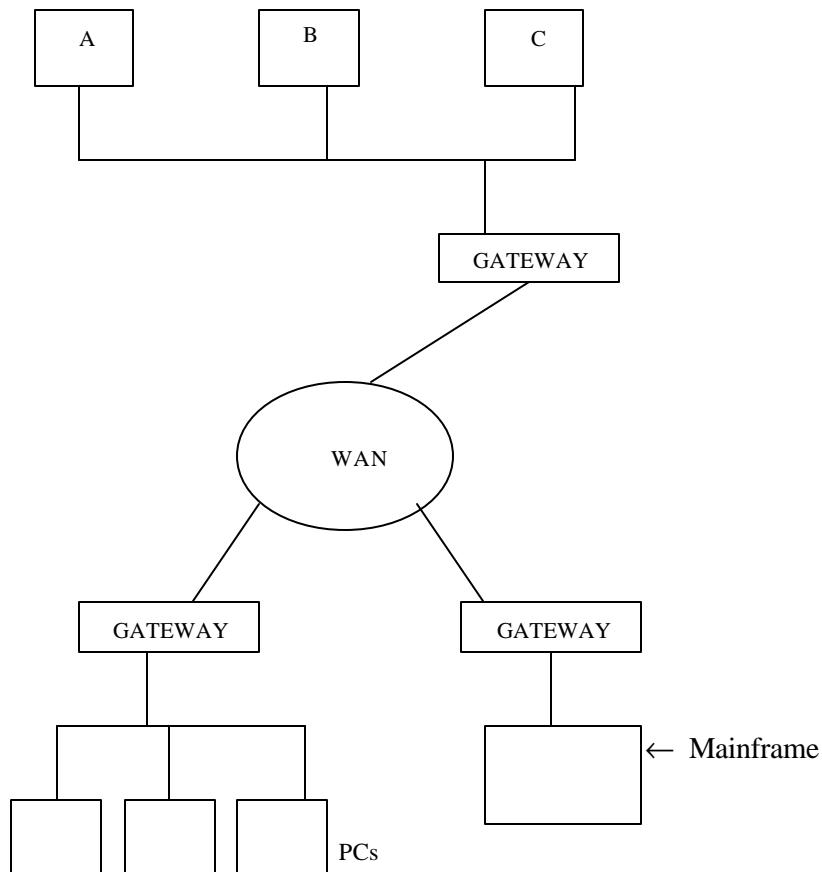
* Both are store-and forward devices, but Routers are Network Layer devices (examine network layer headers) and Bridges are Link Layer devices.
* Routers maintain routing tables (hierarchical, agrregatable addresses) and implement routing algorithms, bridges maintain filtering tables (flat addresses) and implement filtering, learning and spanning tree algorithms.

### 2.2.3    Gateways

This device *(Figure 1)* used to connect totally dissimilar networks.  They function at a high end of OSI model (typically network layer and above).  They can perform protocol conversion for all seven layers of the OSI model.  They are commonly used to connect a LAN and  a main frame computer.  Gateways handle conversions of messages, addresses and protocol to deliver a message from one network to another.  They offer greatest flexibility in internetworking communications. Gateway's decision making is more complex than Routers.  They are very costly and their implementation, maintenance and operations are also very complex.  They are slower than other devices.  They can recover e-mail messages in one format and convert them into another format.

Gateways provide an interface between IPX-based LANs and the IP protocols of the internet.  This provides a centralised and secure way to connect IPX-based  LANs to IP networks.  Because of this a single IP address can be used for entire network. Therefore, this eliminates configuration and maintenance problems.

Dual-homed Gateway are also present in the network.  It is a system that has two or more network interfaces.  It acts to block or filter some or all of the traffic trying to pass between the networks in firewall configuration, thus providing some security.

Gateway has its main memory and processor to perform protocol conversion. Typical corporate gateways connect the PC world of token Ring, Ethernet and apple talk LANs to IBM's mainframe SNA environment with x.25 packet switched networks or DECnet networks.

At the very lowest level gateway provides terminal emulation so all LAN workstations can emulate varies considerably depending on the gateway.

Second level of gateway functionality includes file sharing between LAN and host. Novell has developed a platform – independent version of netware that will run on several different platforms, including several traditional mini-computer platforms.

At the higher level of functionality, a gateway would provide peer to peer communications between micro computer programs running on the LAN and mainframe programs running on the host. These types of client/server relationships will become more and more important in the near future as programs are written to distribute databases among LAN's mini-computers and mainframes, with the machines users communicating with the programs using the same type of user interface.

**How do gateways link hosts and LANs**

Using gateways, micro-mainframe connection is much more cost effective than other type of connections like using coaxial cable via PC 3270 emulation card etc. The gateway board emulate a cluster controller so each network workstation is seen by the mainframe as a terminal linked to the cluster controller. The gateway's multiple mainframe sessions are split among the network's workstations, so the channel rarely sits idle. Only the gateway needs to have a circuit card and the software necessary for protocol conversion and terminal emulation.
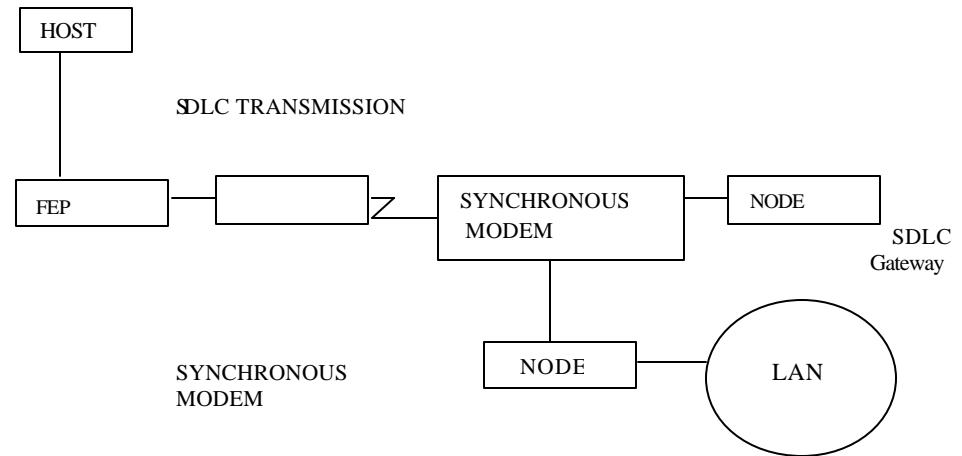
**Remote LAN Gateway**

These gateways *(Figure 2)* are becoming very common because of the evolution of enterprise networks and WAN. A PC on the remote site's LAN function as a gateway and runs gateway software. This gateway PC functions as a cluster controller and communications with a front end processor using IBM's synchronous data link control (SDLC) protocol via synchronous modems located at both sites.

The limitation of these gateways is speed. A synchronous modem can dial up a front end processor at speeds up to 64 Kbps. Companies with heavy micro-mainframe traffic might require multiple remote gateways to solve this congestion problem.

**X.25 gateways**

Remote LAN can also communicate with IBM mainframe e.g.., using X.25 gateway. A gateway PC with an adapter Card functions as a cluster controller and runs special gateway software that contains the QLLC protocol, an IBM defined protocol that runs over the X.25 suite. The other LAN workstations emulate IBM 3270 terminals. The IBM host simply assumes its communicating with the remote cluster controller.

**Netware Work Station running 3270
Terminal emulation Software**

**Figure 2:  Remote LAN Gateway**

## 2.2.4   Modem

It is device which is used to convert digital signals generated by the computer into analog signals to be carried by a public access telephone line.  It is also the device that converts the analog signal received over a phone line into digital signal usable by the computer. A  Modem  derives its meaning from a  modulation and demodulation is a composite word that refers to two functional units that make up device a signal modulator and a signal demodulator.  A demodulator converts analog signals into digital signals.

Modem can be classified into many categories to include the mode of transmission and their techniques as well as by the application features they contain and the type of lines they are built to service.

**Figure 3: Signal conversion by Modems i.e. Modulation and demodulation**

**Speed**

Modem speed range from 300 bps to 56 kbps. It normally transmit about 10 bits/character (each character has 8 bits); maximum rate of characters for a high speed modem is 2880 character/sec. For example, a compressed image of 20 KB (equivalent to 20,000 characters) will take nearly 6 seconds to load on the fastest modem.

The tasks which modem can perform are:

1) Automatically dial another modem using either touch-tone or pulse dialing.

2) Auto answer i.e., automatically answer another modem for making connection.

3) Disconnect a telephone connection when data transfer has completed or it an error occurs.

4) Automatic speed negotiation between two modems.

5) Convert bits into the form suitable for the line (Modulator).

6) Transfer data reliably with the correct type of handshaking.

7) Convert received signals back into bits (demodulator).

**Modem standards:** The CCIT (now known as ITU-T) has defined standards for modem communication. Each uses v.number to define their type.

| | | |
|---|---|---|
| V.22 bis | - | It operates at 1200 or 2400 bps |
| V.32 | - | Operates at 9600 bps |
| V.32 bis | - | Operates at 19,200 bps |
| V.33 | - | Operates at 14,400 bps |
| V.34 | - | Operates at 28,800 bps |

**Modem Commands**

They are provided by Hayes Company that pioneered Modems and defined the standard method of programming the mode of modem, which is the AT command language. A computer gets the attention of the modem by sending 'AT' command. For example, 'ATDT' is the touch-tone dial command. Initially, a modem is in the command mode and accepts commands from the computer. These commands are sent at either 300 bps or 1200 bps.

Most commands are send with AT prefix. Each command is followed by carriage return character; a command without these is ignored. More than one command can be placed in single line and spaces can be entered to improve readability, either character case can be used.

Modem can enter two states; the normal state and the command state. In the normal state the modem transmits or receives characters from the computer and in the command state, characters sent to the modem are interpreted as commands. Once a command is interpreted the modem goes into the normal state. Any character sent to the modem are then sent along with line. To interpret the modem or to end a connection so that it goes back into command mode, three consecutive '+' characters are sent i.e. '+++'.

**Example:** When a computer wants to make a connection using telephone no. 17325 it sends the command. 'ATCH 17325' using tone dialing. The modem then replies with an OK response i.e., 'O' value and it tries to make connection with remote modem. If it is not able to make connection it send message in a form of code as (3) for no

carrier, (7) for busy, (6) for no dial tone etc.  If it gets connected then it returns a connect code as it sends '+++' and then wait for a command from host computer.  In this case command is hang-up the connection (ATH).  The modem will then return an OK response when it has successfully cleared the connection.
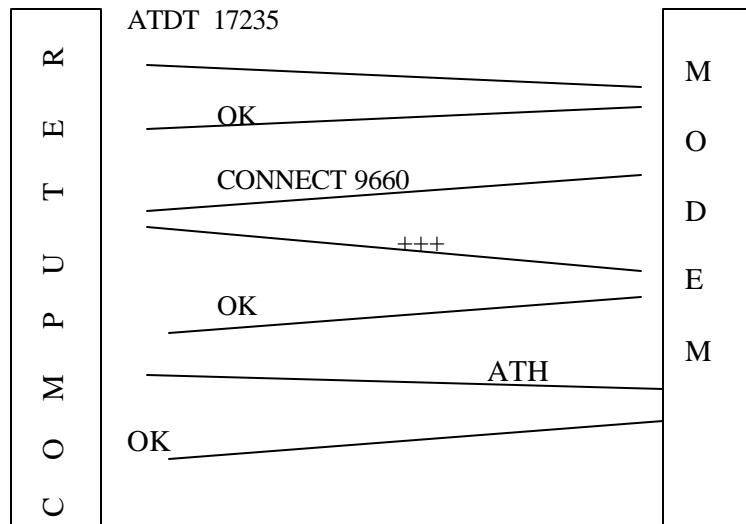


**Figure 4: Connection establish & release**

The modem contains various status registers called s-registers which store modem settings.

**MODEM SETUP:**    The following *Figure 5* shows a sample window from the MS windows Terminal program. (in both MS Windows 3.x and Windows 95/98).  It shows the modem commands Window.  It can be seen that when the modem dials a number the prefix to the number dialed is 'ATDT'.  The hang-up command sequence is '+++'ATH.
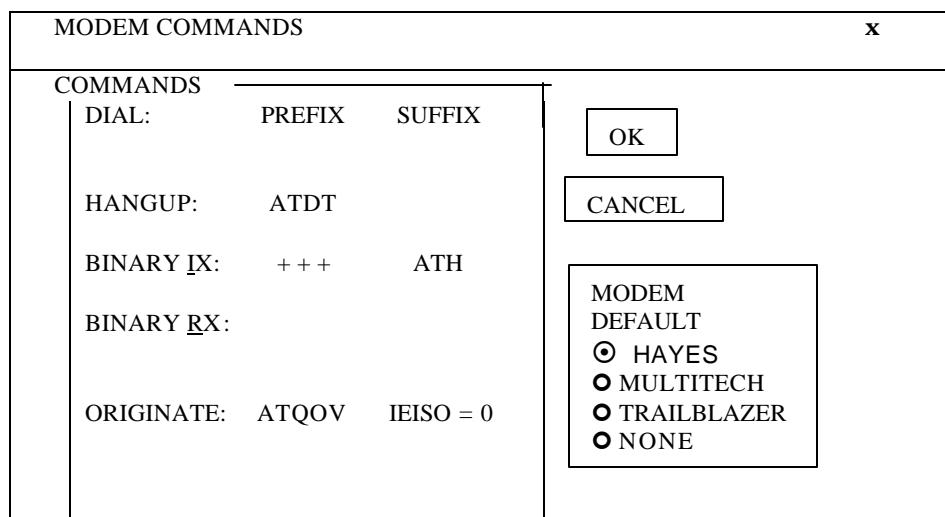


**Figure 5: Modem commands window**

**Modem Indicator**

These are used to inform the user about current status of a connection. Typically the indicator lights are:

- AA - ON when receiving call. OFF when not receiving calls, Flash when call is incoming.

- CD - ON when modem detects the remote modem's carrier else it is off.

- OH - ON when modem is on the hook else off.

- RD - Flashes when modem is getting data or a command from the computer.

- SD - Flashes when Modem is sending data.

- TR - Shows that DTR line is active i.e., computer is ready to send or receive data.

- MR - Shows that Modem is powered up.

The following Table illustrates widely used modems with bit rates and modulation techniques.

**Typical Modems:**

| ITU Recommendations | Bit rate (bps) | Modulation |
|---------------------|----------------|------------|
| V.21                | 300            | FSK        |
| V.22                | 1200           | PSK        |
| V.22 bis            | 2400           | ASK/PSK    |
| V.27 ter            | 4800           | PSK        |
| V.29                | 9600           | ASK/PSK    |
| V.32                | 9600           | ASK/PSK    |
| V.32 bis            | 14400          | ASK/PSK    |
| V.34                | 28800          | ASK/PSK    |

Most Modems operate with V.22 bis (2400 bps), V.32 (9600 bps), V.32 bis (14400 bps); The V.32 $ V.32 bis modems can be enhanced with echo cancellation. They also typically have built-in compression using either the V.42 bis standards or MNPC (Microcom networking Protocol) level 5.

☞ **Check Your Progress 1**

1) Which layer does the Router operate?

    (a)   Physical Layer    (b)   MAC Layer
    (d)   Network Layer    (c)   Session Layer

2) List few standards of modems.

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    ……………………………………………………………………………………
    ……………………………………………………………………………………

3)	List the name of routing protocols.

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## 2.3   SUMMARY

In this unit we have studied about some networking devices which are used at higher layers of OSI model.   The devices which were covered are following:

1.	**Router**	**:**	Used to connect two devices at the network layer of the OSI Model.

2.	**Gateways :**		Used to connect totally dissimilar networks because they can perform protocol conversion for all seven layers of the OSI Model.

3.	**Modem**	**:**	Used to connect the computer with the telephone lines.  A Modem can convert  digital signal of a computer to analog signals, so that it can be transferred through the telephone lines.

## 2.4   SOLUTIONS/ANSWERS

1.	Network Layers

2.	There are several standards and some of them are:

	V.32
	V.22
	V.27

3.	• RIP
	• IGRP
	• OSPF