**Internet Technology**
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**Lecture No. #02**
**Review of Network Technologies**

In today lecture we would be looking at some of the basic concepts and backgrounds from computer networks which would be useful for us in this subsequent discussion. So topic of discussion today is review of network technologies.

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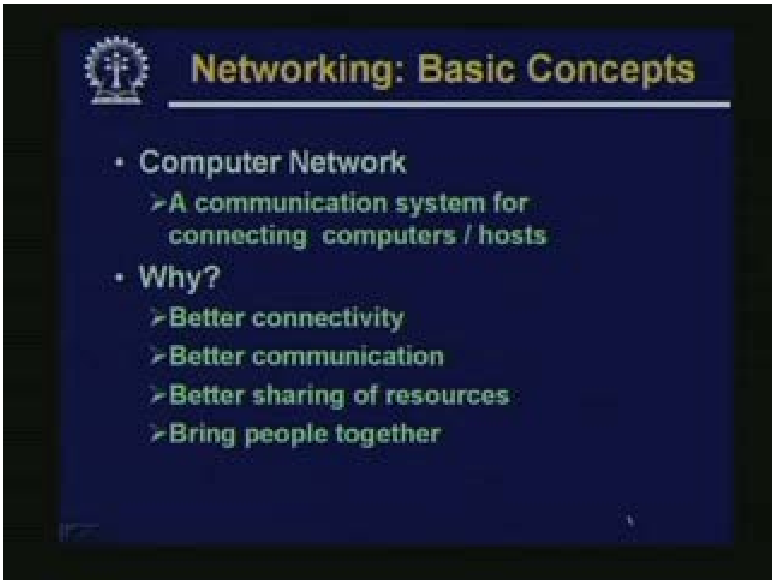


So let us start with some very basic concepts of networking. While you know a computer network is essentially a communication system for connecting computers. Now why we have computer networks? The need arise out of number of requirements of course better connectivity, better communication, were the main reasons. This also allows you to have better sharing of resources. Suppose you have a printer connected with one computer in the network, the others over the network can also have access to the printer. And to top it all network allows us to bring people together. It helps us in making the world really small place. These are some of the advantages that a network offers.

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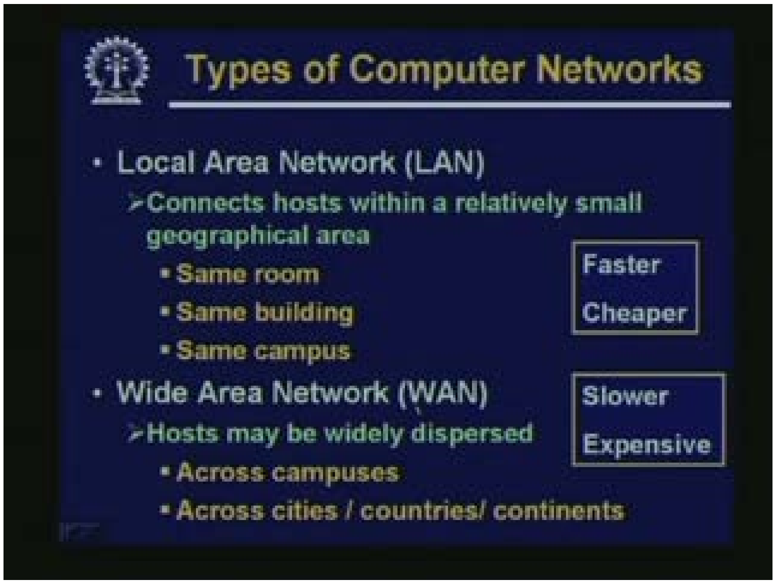


Now taking of the types of computer networks that we have, networks can be broadly categorized into either a Local Area Network or a LAN and a Wide Area Network or a WAN. Now let us try to see the basic differences between the two. Well in a LAN the idea is that the computers that are connected within a LAN, they are within a relatively small geographical span. Well when you say relatively small span they may be in the same room or laboratory same building or within the same campus. In contrast in a wide area network the hosts may be widely dispersed well. It can across buildings across cities across continents anything across counties anything so hosts are computers in a wide area network can be really widely dispersed across campuses across cities counties continents. Now if you want to compare a LAN or a WAN well in terms of economics, a LAN is cheaper than a WAN, a LAN is cheaper, WAN is expensive. In terms of performance a LAN is typically faster than a WAN.

There are other logistics differences also. LAN is under the control of a single organization. That means a LAN has a single ownership. Suppose in my organization I set up a LAN, I will be the owner of that LAN. It is my responsibility to manage, upgrade if necessary and to configure it in a way I want to. But in a WAN, in wide area network is not under the control of the single person. Say suppose I want to connect to my friend who is there in some other country I may have to go through a number of intermediate service providers and that may actually mean I am going through several you can say owners whose means in terms of WAN whose networks I am going through in order to reach my final destination. So this ownership is another big difference between a LAN and a WAN this is in terms of the logistics.

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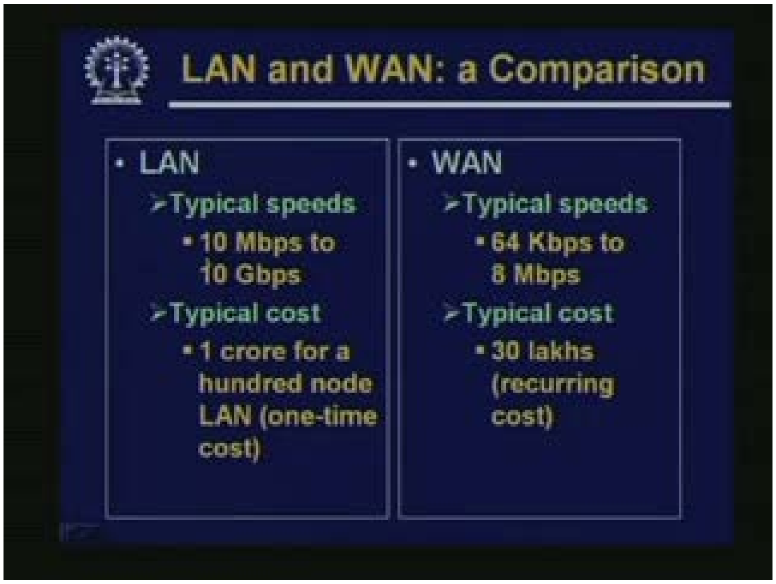


Just to compare in terms of some figures with respect to performance LAN can work at speeds from 10 Mbps up to 10 Gbps. Gb means 1 giga means 1000 mega. Now as we stand today typically LAN speed today range from 100 Mpbs to 1 giga per second, these are the typical speeds we have today. But in contrast in wide area networks speeds are as low as 64 Kbps to 8 Mbps. Cost was also for a LAN it is mostly a onetime cost of course. There are maintenance charges but a very rough estimate. You may have to pay about one crore for a 100 nodes state of art LAN. But in contrast in a WAN if you go for a 4 Mbps link or an 8 Mbps link, the typical cost will be of the order 30 lakhs per year. This cost will have to pay as an annual maintenance or we can say it recurring expense that is payable per year. So the long run a WAN will prove to be much more expensive.

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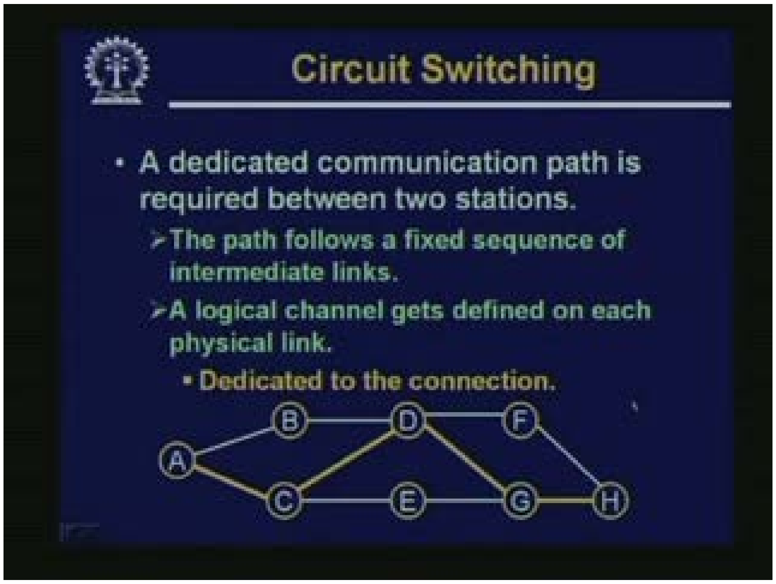


Now talking of the way data flows from one node to the other in a network, while one principle of data communication is called circuit switching. The basic concept behind circuit switching is that a dedicated communication path is established or required between two stations. The path that is established will follow a fixed sequence of intermediate nodes and links and on each link you define a logical channel and this logical channel gets dedicated to the connection. While what does logical channel, mean I will just explain this shortly with respect to this diagram. Suppose this node A is the source and this node H is the final destination. Suppose we choose to select this path through which all packets will flow through the intermediate nodes ACD and G so ACDGH will be the path.

Now this is a dedicated path, so all the messages that A want to send to H will be following this path. But in terms of the intermediate link well these intermediate links can be absolutely dedicated like the first generation telephone network. When you have to dial, a piece of copper would be dedicated for the connection. So there will be intermediate stations, the exchanges where some delay switches will be set on and off and a continuous copper ware, a link would be established between the two parties. But in reality in a computer network the only links may not be dedicated may be we have in between a very fast or high speed link. You need only a part of the bandwidth of that link. So may be that link would be shared. But you will be guaranteed a particular bandwidth on that link. So for all practical purposes you are having a dedicated path for the kind of bandwidth you want, that is circuit switching.

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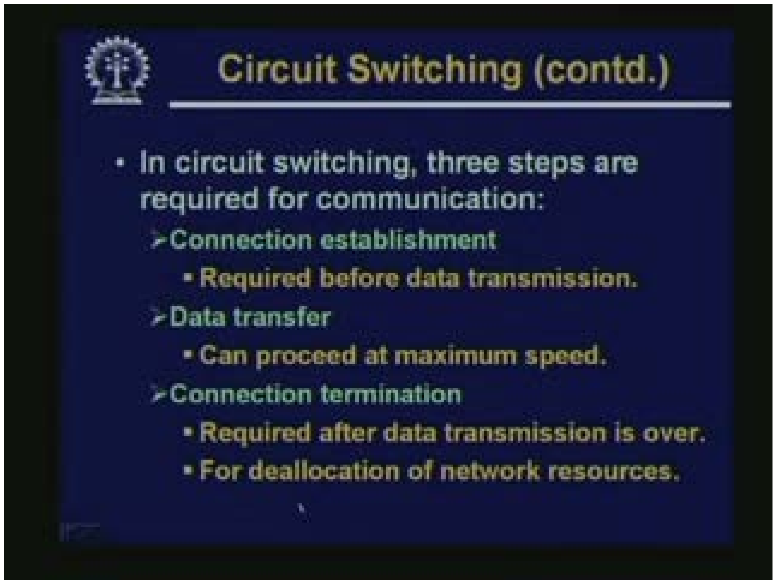


So for circuit switching there are three steps that need to be followed for communication. First is of course you have to establish a connection. This is most important and this connection has to be established before data transmission can begin. Following connection establishment you need the actual data transfer. Now since a connection has been established and a dedicated path is there, so data transfer can proceed at maximum speed without any other conjunction. So here the maximum speed of transmission which you want that will be guaranteed by the intermediate nodes and links. And finally when you are done you have to terminate the connection. This has to be done after data transmission is over. So here you will be actually de-allocating the network resources like links and the bandwidths that you had allocated during connection establishment these are the steps involved.

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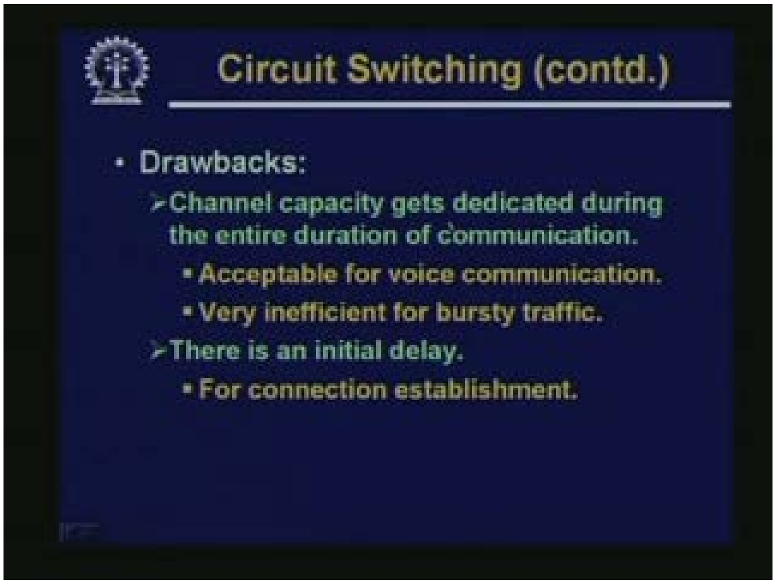


Drawbacks of circuit switching are that the channel capacity along the path gets dedicated along the entire duration of communication. If your communication goes on for 20 minutes. For example then for the entire 20 minutes the bandwidth will be dedicated along the path you are establishing the link. This may be alright for communication like voice because in voice well continuously you are speaking or receiving the line is very rarely free. But if you talk about computer traffic it is typically bursty in nature, sometimes you have lot of traffic. But sometimes there is no traffic. So for this kind of a scenario the link will be un-neutralized for most parts of the time. That is the drawback and secondly due to the initial connection set up there can be initial delay which for some applications you may not like or you may not want these are the drawbacks of circuit switching.

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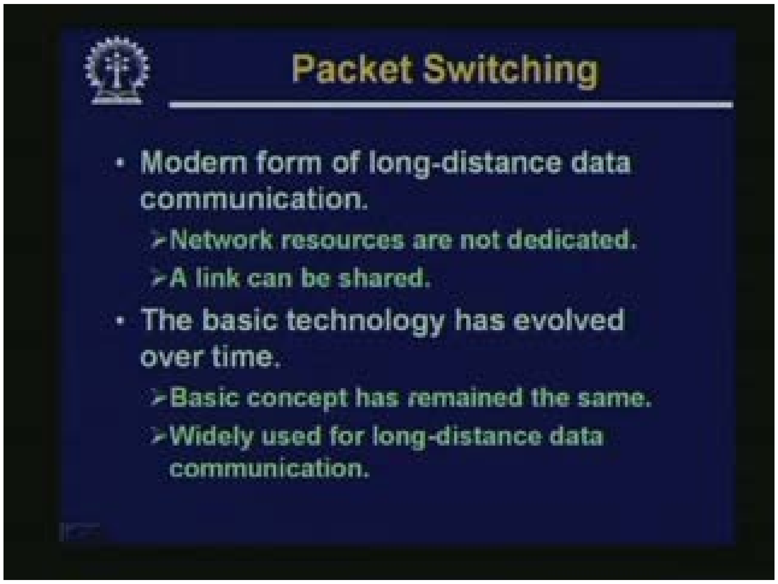


So to circumvent these drawbacks we actually use packet switching in modern day computer networks. Packet switching actually lays its foundation on the basic technology for long distance data communication. But today packet switching is used even in case of shortest distance communication with a LAN within local area network. So as packet switching as become some kind of defacto standard in most of the networks. So the characteristic feature of packet switching is that the network resources are not dedicated. A link or the bandwidth on the link can be shared. Depending upon the network load the actual performance you get, can vary. So the basic technology of packet switching has evolved. But the underlying concept has remained the same. This is widely used as I said for long distance communication.

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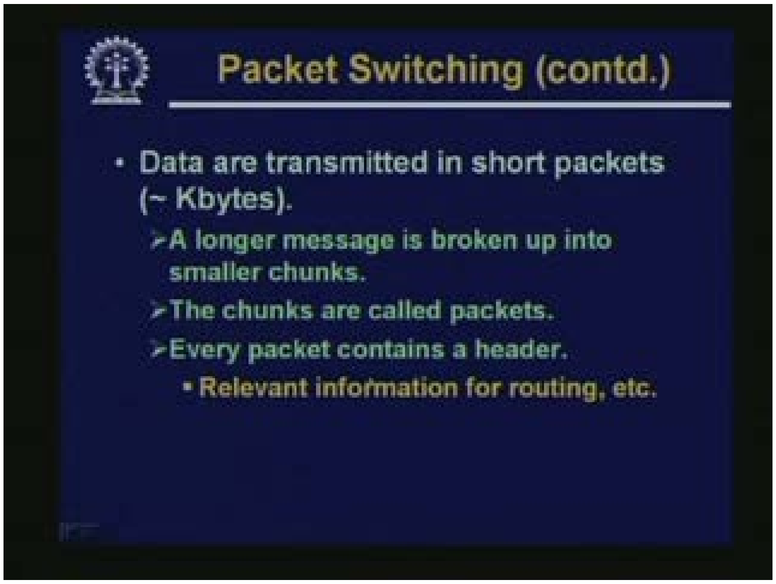


But also for LAN environment we use something like packet switching in many cases. Now the essential idea of packet switching is that when you have a big message to transmit, the message gets broken into smaller chunks or pieces these are called packets and this packets are sent in one at a time. So data transmitted in short packets typically few kilo bytes. Long message is broken up into chunks. These are called packets and each packet contains a header which will contain relevant information so that the packets can reach the destination correctly. So it will contain information the header in the packet which will be required for routing the packet in the proper way.

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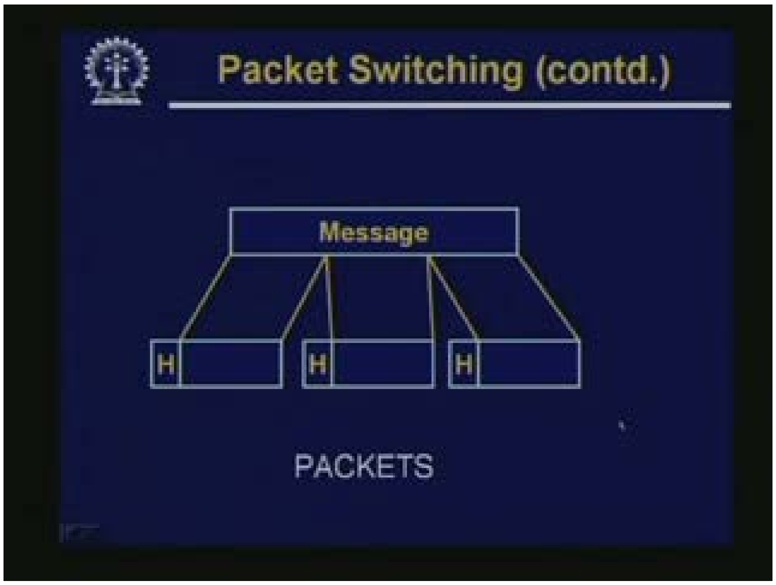

So this diagram shows how a message can be broken up into packets. A message gets broken up into 3 packets and each packet will be having its own header. This header will allow this packet to reach the destination and to have the intermediate nodes take the appropriate decision to route the packets accordingly.

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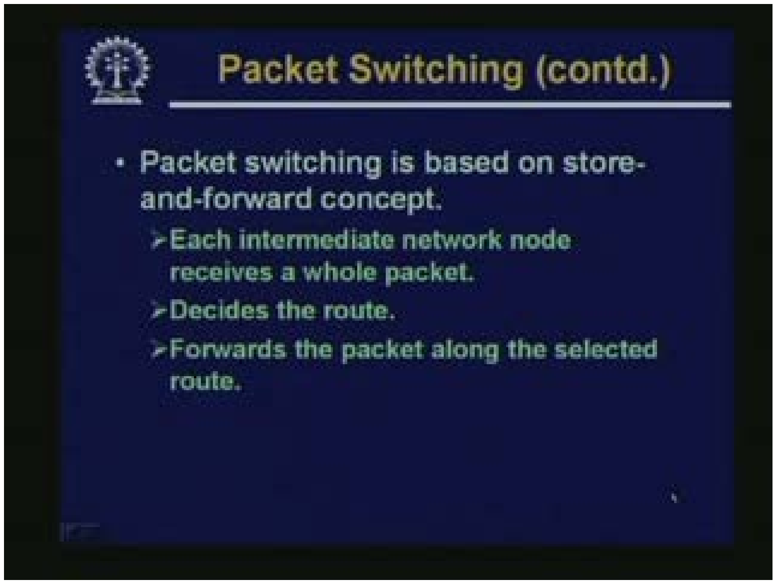


And another notable feature of packet switching is that, it is based on so called store and forward concept. The idea is that say you have a node here which want to send data through some intermediate nodes to a final destination out here. So idea is that when the first node sends out a packet, the packet has to be sent and received in its entirety by the next node. Each intermediate node network node will receive the whole packet. It will take a routing decision which route for because there can be a number of outgoing links. Which outgoing link to follow and finally it forwards the packet in the correct decision? This is called store and forward because etch intermediate node, suppose I am intermediate node well I will receive the packet in its entirety and I will store it in a buffer. I will not try to send the packet as it is being received. I will receive it fully, I will check the packet. If there are any transmission errors, there is check sums usually added to the header. Then I will take the decision depending upon this destination address. What to forward next. So then I will forward the packet to the next node. So store and forward, these are the two steps.

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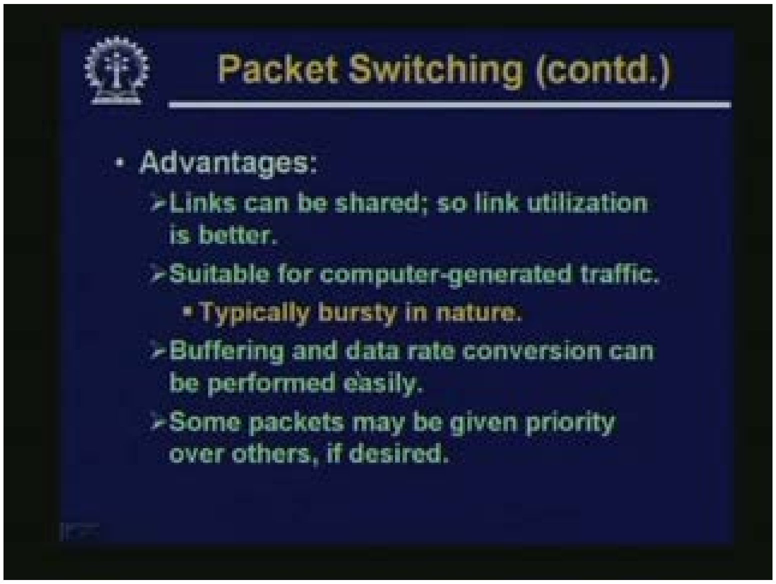


So advantages of packet switching are that since links can be shared, so link utilization is obviously better. This is suitable for computer generated traffic which I had mentioned is bursty in nature. Since we are doing packet buffering, you can perform data rate conversion. Like I will give examples suppose my incoming link is faster than my outgoing link, I can receive at a faster rate. So I can receive packets and storing in a buffer and I can take my time to send them over my outgoing link slowly. So some data rate conversion can take place here and also you can have the notion of packet priority for the high priority packets will be sent first. They will be incurring less delay.

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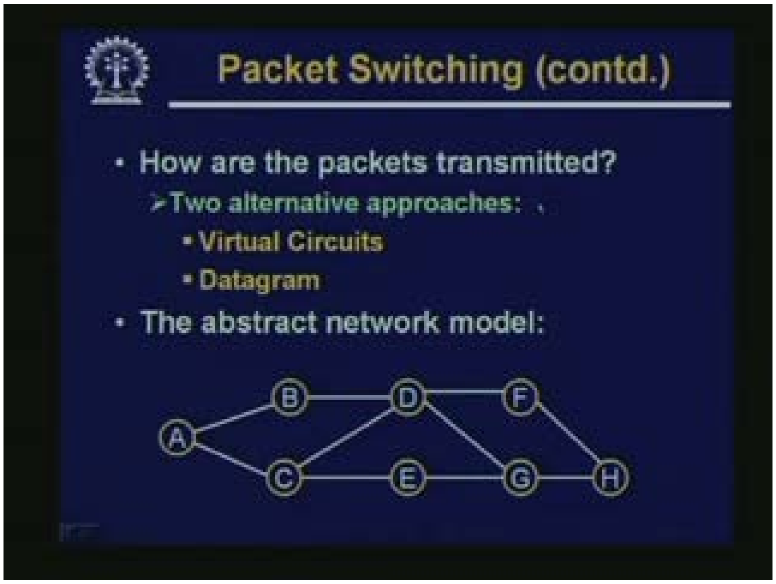

Now regarding the mode or the way the packets are transmitted, there are two alternate approaches. These are called virtual circuits and datagram. The abstract data model will be same as I had shown earlier. So there will be a number of nodes ABCDEFGH which will be connected by links and the main responsibility of the packet switching will be to send the data from some nodes, say A to a destination say H, this will be main responsibility.

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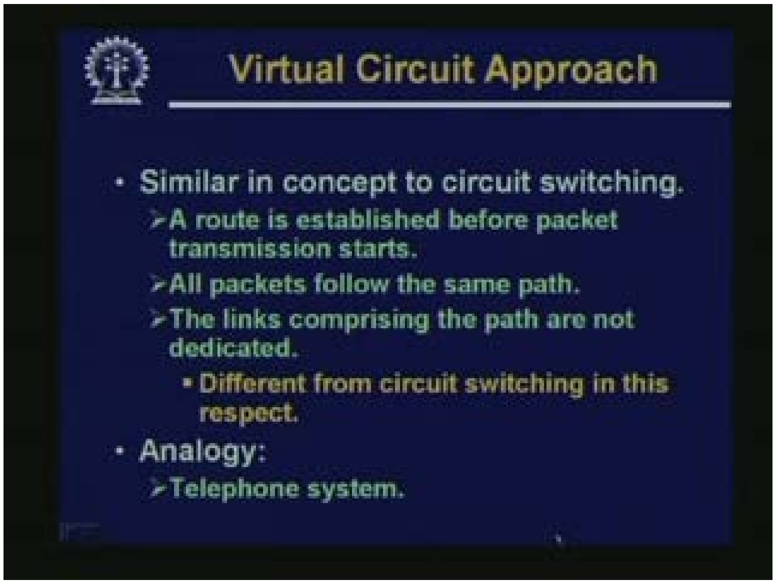


So let us now see what the virtual circuit approach actually is. Virtual circuit approach in a sense it is similar to circuit switching in the sense that all the packets will follow the same path. But it is different from circuit switching in the sense that resources along the path are not dedicated. If the router is congested the packets will take longer time. If the route is not congested the packets can move faster. So the path is fixed, but the quality of service or the bandwidth along the path is not guaranteed. So this is similar in concept to circuit switching. Here again the route has to established before the packet transmission starts. Because we told you all packets will follow the same path and the links comprising the path unlike circuit switching are not dedicated. And an analogy is the modern day telephone system where the exchanges are digital exchanges. None of the links are dedicated there are often shared and whenever you send a packet from your handset to a destination handset they typically the same path. But maybe you got a number of shared links in between.

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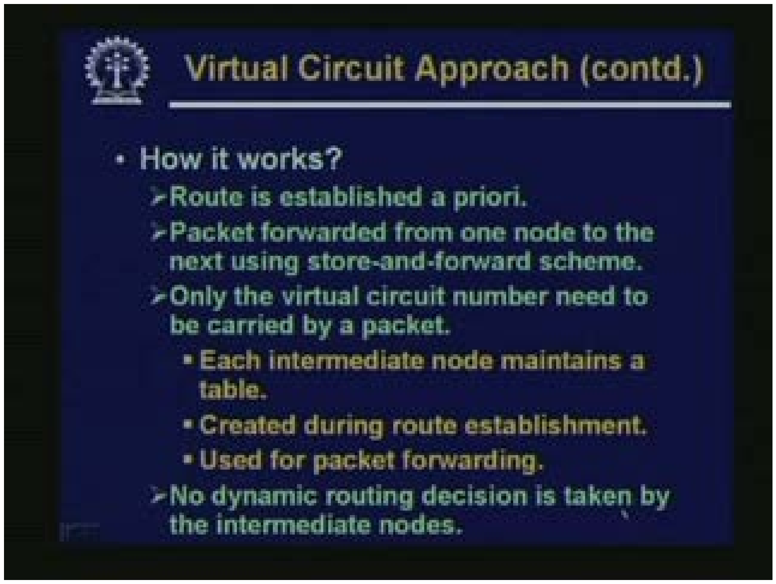


So in virtual circuit approach if you try to understand how it actually works, well as I said initially you need a connection establishment phase where the route is established a priori. Now once the route is established, along the route a packet will be forwarded from one node to the other using the same store and forward scheme. So here also all the though the same path is followed. But you cannot send the packets as the bits are received continuously. But you have receive a packet store and then forward to the next node. The next node will do the same thing; it will receive it store and then again forward it to the link that follows. In this way it will go on and one characteristic is that since root is established a priori so in the packet header you need not store the destination address explicitly. Rather you can only store a virtual circuit number which can be carried by each packet. And all the intermediate nodes can keep track of the virtual circuit number. For example so when the connection gets established, all intermediate nodes will have some entry made in the routing table.

That will this is a connection which is coming from that node, some virtual circuit number is assigned. Say I so if it is coming from virtual circuit number I then we will sending it over this outgoing link. So it only looks at the virtual circuit number of the incoming packet. It need not look at any address of the source or destination; only the virtual circuit number is required. So as I had said this requires each of the intermediate nodes to maintain a table. This table is created during the route establishment phase at the beginning and the table is consulted when the packets are forwarded to the correct outgoing link. Now here since at the time the packets are actually coming, the route is already fixed and already there in the routing table. Just the routing the intermediate node what they do? They are just looking at the virtual circuit number just doing a table look up and sending it to the output. So it is not trying to apply any intelligence. So there is no dynamic decision that is taken by the intermediate node. It is a blind table look up right.

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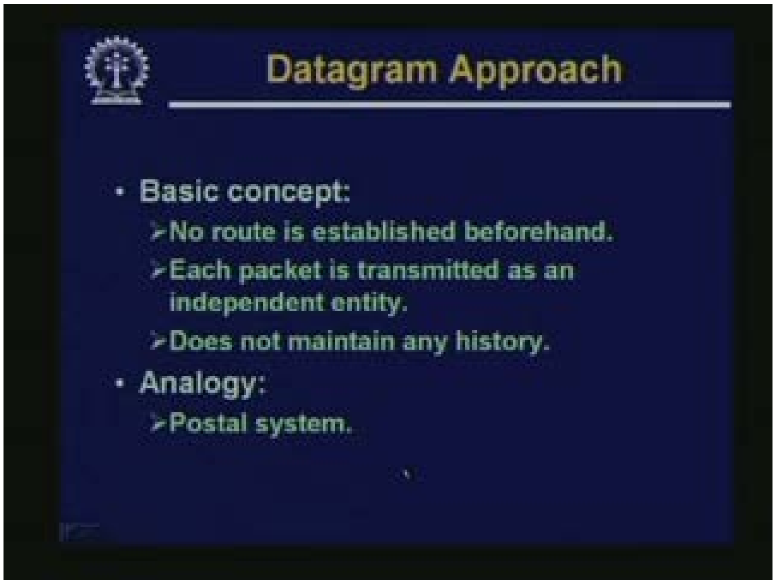


In contrast, datagram approach is different from virtual circuit in the sense that is no concept of route establishment. Since there is no route each packet is treated an independent entity and a transmitted separately. Suppose there are 5 packets they will be independently one by one. Now since they are independent, that is no history of the packets maintained anywhere. This is like the postal system just an analogy. Like in a postal system you recall for any postal letter we write the address of the destination and also we write the address of the person who is sending the letter and drop it in the mail box.

Now suppose I write five letters to the same person and I post them now as our mail system works there is no guarantee that the mails will receive the destination in the correct order. There is no guarantee as to the time limit exactly by what date the mail will be delivered and even some mail may not at all be delivered, some mail may lost. So all these characteristics are also true for the datagram. So datagram can be used in those applications where the application knows that, these kinds of errors can occurs unequal time delay out of delivery of packets, some packets may get lost. So if you need a recovery that has to be done by the application explicitly. But in general datagram packet switching is fast because it does not follow a fixed root. The root might get congested.

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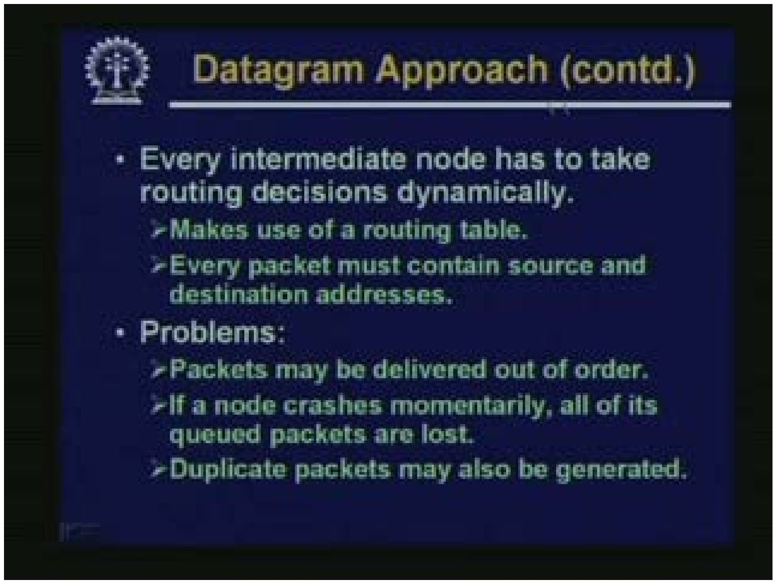


So and some other things is there. For the datagram approach since each datagram are sent independently. So every intermediate node has to take routing decision dynamically for every incoming packet. For every incoming packet you are taking decision where to forward it. So now the intermediate routing nodes have additional responsibility. They receive a packet look at the destination IP address and take a decision where to send it. These kinds of discussion have to be taken out. So they may use a routing table. But the need the source is not that much important. At least the destination address of the packet is important. So the intermediate node will take a decision dynamically based on the destination address.

Now the problems that I had mentioned by due to unequal delays packets may be delivered out of order. Why because since we are not fixing a path two packets may follow two different routes and they may arrive at the destination in a different order. It is always possible and if there is a problem that is a node crash say a node becomes down momentarily. Then all the packets that were queued on that node will also get lost. And in some systems if you do not get acknowledgement a packet is retransmitted. So in such systems even duplicate packets may get generated the sent packet may be delivered more than once.

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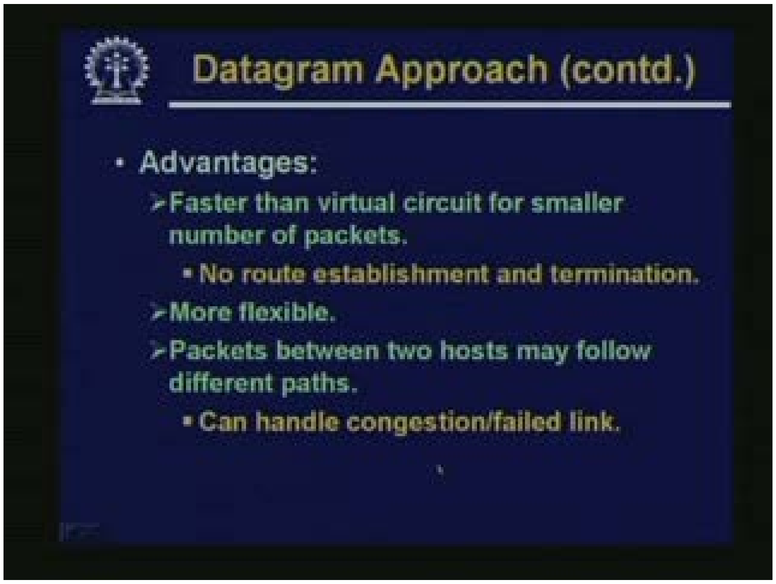


But datagram approach, in spite of the problem has some advantages. First thing is that it is faster than virtual circuit for smaller number of packets. Because you do not need to have a route establishment and termination phase. It is more flexible because depending on the network traffic you can choose the best route. In virtual circuit once you have fixed the route, all packets are bound to follow that route. But now if a link is down or it choked you can choose an alternate path these options are available to you. Packets between two hosts may follow different paths so it can handle congestion or failed link situations.

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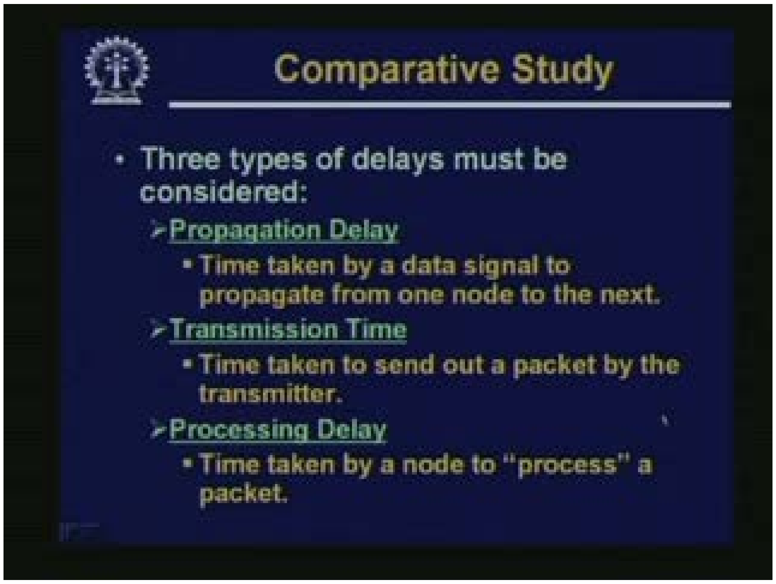

If you want to compare the different approach circuit switching, virtual circuit packet switching and datagram packet switching, then we will have to estimate delays. The total delay that you encounter now, there are three types of delays you can talk about. The first type is propagation delay. This is the time taken where data signal to propagate from one node to the next. Suppose I am try to send a data signal through a satellite link, now the ground link satellite link may take as large as 250 milli seconds. So here my propagation delay will be 250 milli seconds propagation as nothing to do with the speed of the link. It is just a delay. Transmission time depends on the speed of transmission. Say here I can have a link which is working at 64 kilobits per second. I can have a link which is working at 10 mega bit per second, 1 giga bit per second. These figures tell me how fast I can send out the bits on the link.

So if I have a packet of particular size the speed of the link will determine that how many milliseconds or microseconds will be required to send out the whole packet. This is the so called transmission time and finally each of the nodes is doing the store and forward. So there can be processing delay in each of the nodes. Because after storing it can check whether the packet is correct or not, it may have to compute a check sum. Then it may have to consult the routing table where to send it next and if there are multiple packets in the queue, some queuing delay that is encountered. These are the additional processing delay. Now in case of circuit switching here after initial circuit establishment data bits can be sent continuously without any delay. Well when you say continuously what I am saying is that bit by bit continuous well in circuit switching there is no concept of a packet.

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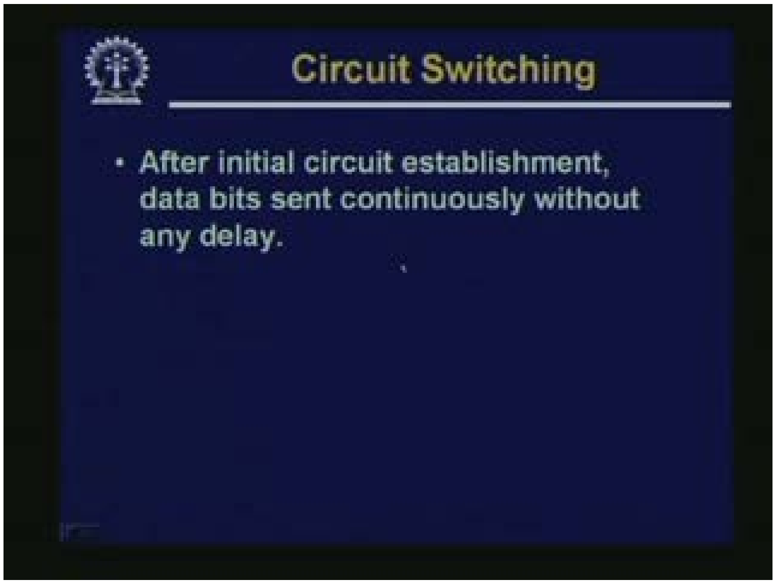


Once the circuit is established it may total message comprises of one million bits the one million bits flow continuously, so the entire link will get choked during the whole period and it will be hundred percent utilized.

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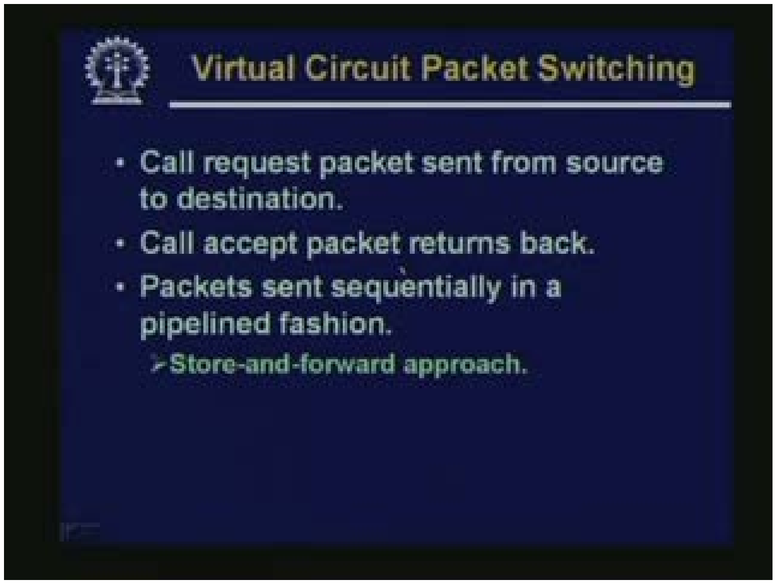


In contrast, virtual circuit packet switching will require, so called call request packets at the beginning for establishing the connection. So for one node to the other this call request packets will go. And finally it will reach the destination and from the destination there will be an acknowledgement or call accept packet which will follow back through the same route up to this source. So this forward and backward packet will serve the purpose of two things. Number one it will conform the root has been established. Number two it will allow the intermediate nodes to update the routing table with the virtual circuit number in a proper way appropriately. So call request packet goes and call accepts packet, return back. And after the packet switching is established, this link is established.

Packets are sent sequentially in a pipelined fashion. But you remember that here you are not sending the packet continuously on a bit by bit basis. This is on a store and forward basis. The path has been established. I send the first packet to the next node, and then I send the next packet. Well if you think of the next node, the next node will receive the first packet totally. Then it will send it back so there will be a delay. So you can say that each stage will be having a delay equal to the propagation time plus the transmission time. So it is like more like a pipeline system which is working the packets are moving in a pipelined fashion. It is not continuous, it is packet by packet it is moving from one hop to the other; one node to the other. This is the basic difference.

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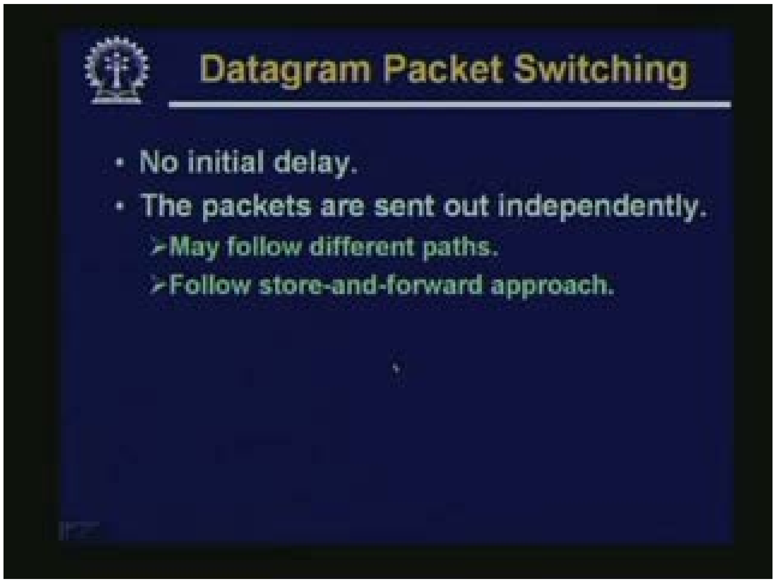


And in case of the datagram packet switching, there is no initial call establishment are call termination delay the packets are sent out independently may follow different path. But once a path is followed again it will follow store and forward approach. So for both virtual circuit and the datagram the packets are forwarded using the store and forward approach which will always be there. So when you try to calculate the total delay that is encountered by a packet will have to calculate all the things. The packet transmission delay, the propagation delay and also take care of the fact that the packet is going to the next node or the next hop. Then only the next hop will be sending it back to the next one. So it will have to wait till the whole packet is received before it can send it to the next.

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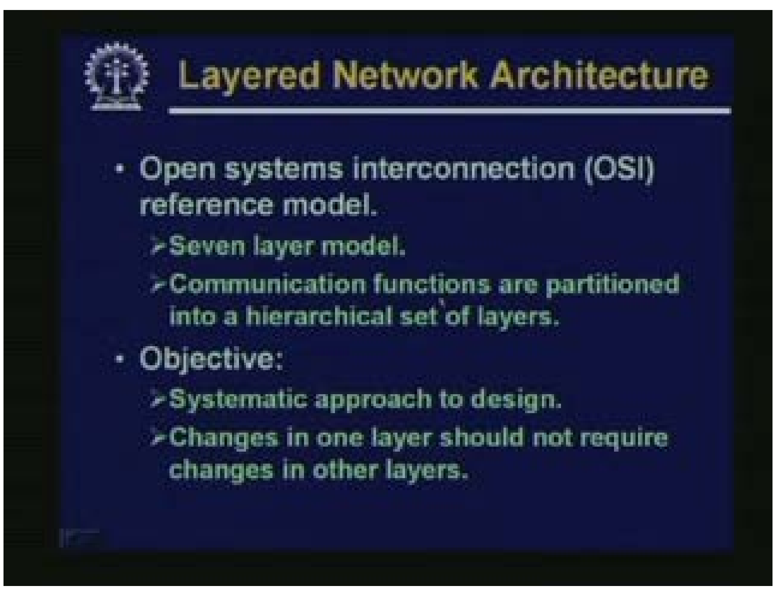

Now let us have a quick look at the so called layered network architecture which as become so popular in the design of networking systems. Well the open system interconnection; OSI reference model, this has become some kind of a model against which is to other networking protocols are compared. Now strictly speaking there is no implementation of this seven-layer model per say. But there are other implementations which are correlated with the seven layer model and they are evaluated. Now the OSI model comprise of seven layers as you see shortly. The purpose of these layers is that the network or communication functions are partitioned in a well-defined way into a hierarchical set of layers. The basic objective is that we are trying to having a systematic approach to design, instead of designing the whole thing at a one go. We are trying to divide up into smaller sub tasks and try to address a design the sub tasks independently. And another objective is that if you want to change one layer, this may not require you to change the other layers. If you have the design in different layers this is one advantage you will have.

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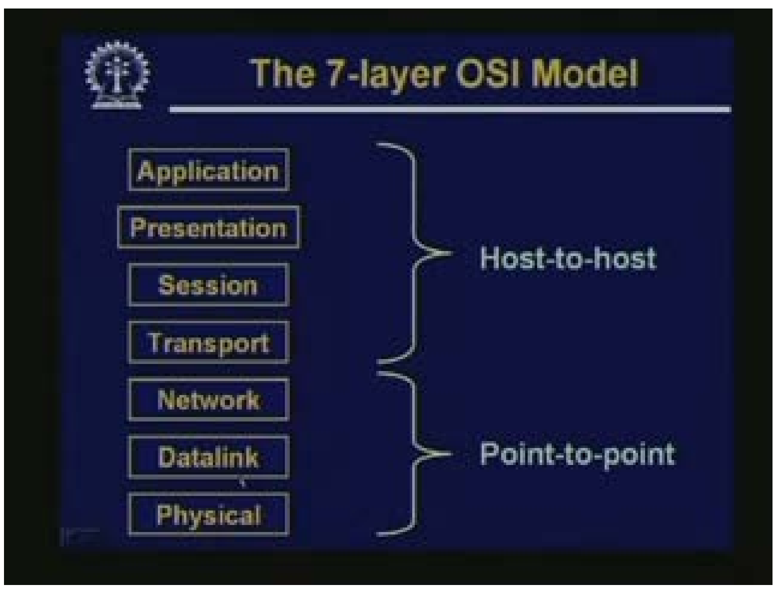


So the seven layers of the OSI model are these. From the bottom, physical, data link, network, transport, session, presentation and application. Now as we will see in a slide little later the lower three layers are called point to point layers. Because these layers or these you can say protocols and software are active in all the nodes through which a packet passes. Suppose this was the source from here, the packet is going here, from here it is coming here, from there it is coming to the final destination. So these are the intermediate links. So there are three point-to-point links through which the communication passes or the packet passes. So the lower three layers are active in all these 4 nodes. But the upper four layers these are called host to host layers. These are active only between the end-nodes, not between the others. This is the main difference. Now let us try to see what are the basic functions of these seven layers?

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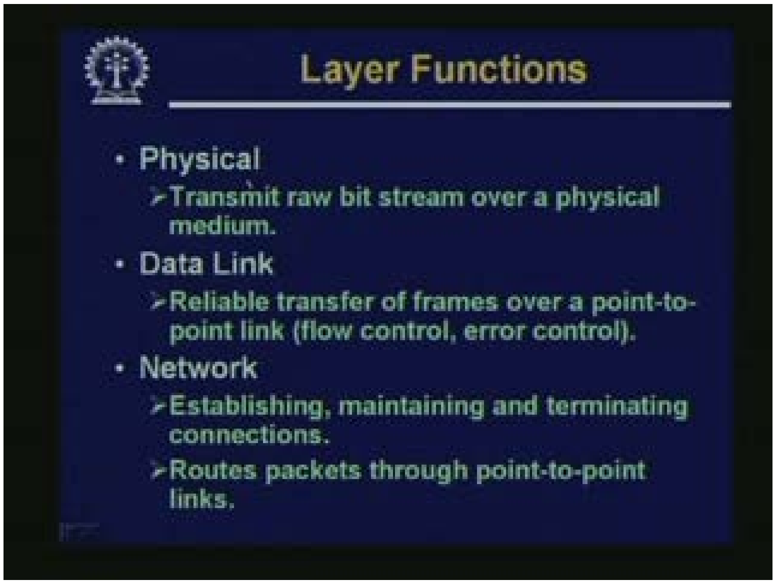


The function of the physical layer is to actually transmit the data in terms of raw bit stream. Transmit raw bit stream over a physical medium. Now why do you say physical medium? It can be a copper wire where bits are sent as voltages. It can be wireless links through the bits are sent using some kind of frequency modulation. It can be an optical fiber for bits are sent by switching on or off some light beams. So this is how it is done, it can also do some kind of encoding. For example instead of sending the bits in a straight, for example the user encoding called differential Manchester. So this kind of encoding is done before you are actually transmitting the data over the physical link. Now this encoding gives us advantages like receive can easily decode the data or you can have possible better utilization of the link and so on. Data link layer the next layer above physical, this tries to ensure reliable transfer of frames.

So at this layer the units of transmission or chunks are called frames. So it ensures reliable transfer of frames over a point to point link. So the data link layer takes care of two things flow control and error control. Flow control means if the senders and the receivers their speeds do not match. Then the data link layer will try to tell the faster person at well. You do not try to send or receive so fast go with my speed otherwise I cannot keep phase with you. And error control is that if some frame is at error the data link layer protocols can explicitly send back a request to the sender. That well this frame this either I have not received or I have received with an error. You please send the frame again. So in this way the errors can be recovered. Network layer it establishes maintains and terminates connection. So it is the network layer which is responsible for routing packets through point to point links.

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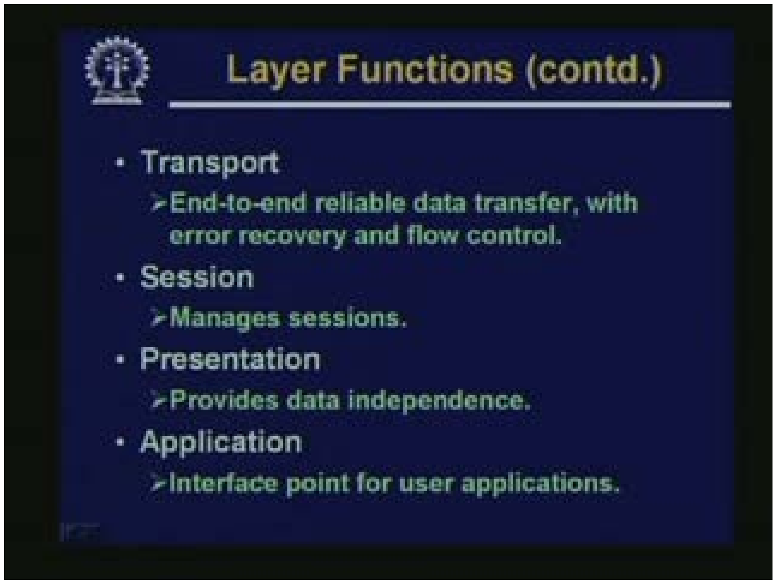


Then comes the transport layer. This is an end to end layer in the sense that all intermediate nodes are not visible to the transport layer. The transport layer views the intermediate network as the black box. Only the source and the destination are there as if they are connected by a direct virtual link. Transport is as view is like this and at this virtual link level this transport layer also tries to ensure reliable data transfer with again error recovery and flow control at the higher level. Session layer which manages a session presentation it can provide data independence; it can provide some sort of data encryption, conversion into a common format and so on. An application is the user application which is interfaced here. Now in practice, the session presentation application you may not very clearly distinguish among these three. They can be merged into one single block. But these seven layers have been defined with an eye towards distributing the functionality across the layer. So that if we have an application or an environment, all these seven functionality is required. Then you can basically separate them out in the different layers.

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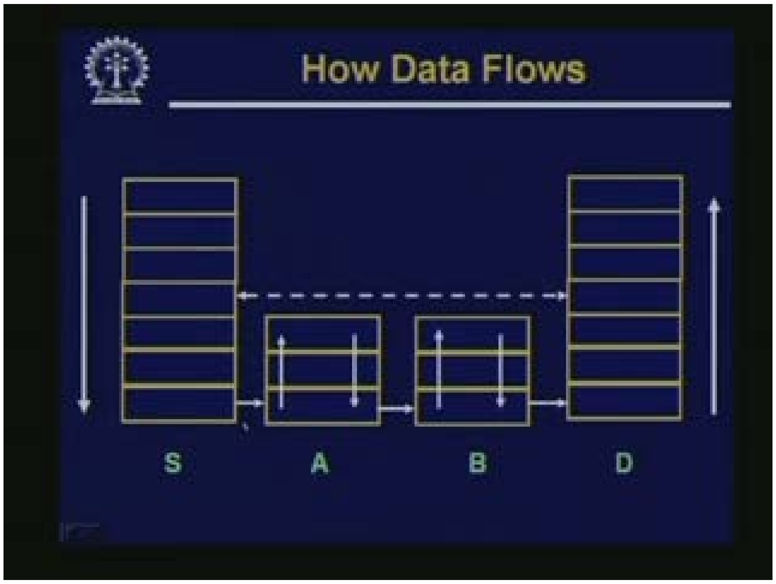


Just a diagram to show how data flows in the seven layer model. Suppose this is the source, this is the destination and these are two intermediate nodes A and B. Data flows from S to A, A to B and B to D. This S and D is the final source and destinations A and B are intermediate nodes. Just as I said that the lower three layers, they must be running on all the nodes including intermediate nodes. So the lower three layers are running on all the nodes. And the upper four layers they are providing some kind of a virtual link. As you can see that the transport layer out here and the transport layer out here, they are having a direct communication link. These are virtual link but when the actual data transmission is concerned say the application layer which is out here. This will send a data along this path. The data packets will successively flow down the seven layer hierarchy. It will go down to the physical layer level, it will actually reach the node A's physical layer.

It will go up to node A's network layer out here. So the network layer it can take a decision for because from there can be again more than one outgoing links. So from here again it will choose one of the outgoing links send it to B. In B again it will go up to the network layer, again coming down to the physical layer. Then it goes to C to D and here to the destination and again follows the reverse path and moves all the way up the ladder up to the application layer. So you can see that in this seven layer model the data packets flow down the hierarchy up down, up down and again at the final destination up to the application layer. This is how the actual message transmission takes place across the hierarchy of the layers. And another point note is that the intermediate nodes through which the packets are sent, they did not have any functionality above the third layer. The lower three layers are essential.

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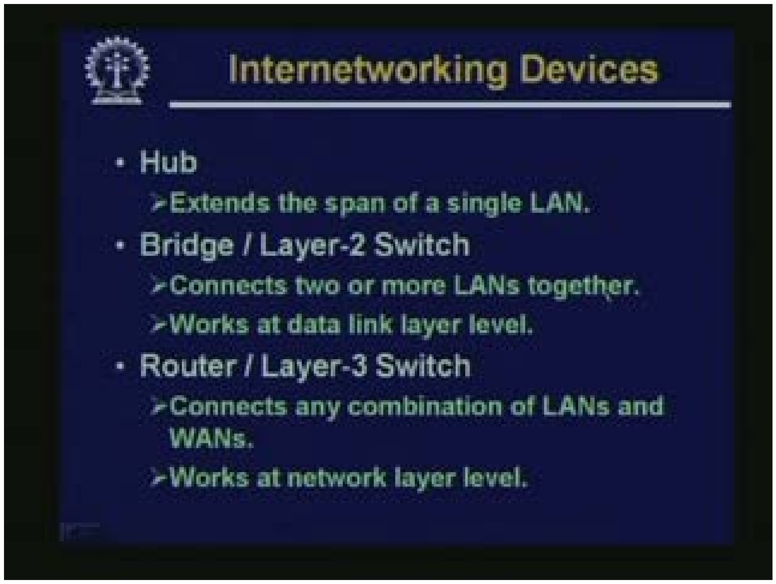


Now we just have a look at the different kinds of internetworking devices which we use in practice by. Internetworking is a general term; internetworking means through which we can connect several networks together. So when you talk about internetworking devices we are actually trying to talk about devices using which we can connect two or more networks together. So let us see what are the main kinds of internetworking devices we have? Well there is something called a hub. Well hub can extend the span of a single LAN. Well hub is a box in which there are several ports and in each of this ports you can connect a computer or you can connect another hub. So in this way you can extend this span of the LAN. A hub is used within a single LAN and hub can be used to extend the size or the capacity of LAN. At the next higher level you can have something called a bridge which is also called a layer two switch.

A bridge or a switch can be used to connect two or more LANs together. And this works at the data link layer or sometimes it is called the medium access control layer level MAC layer level. So bridge or layer two switches they use not the IP address. But something like the Ethernet or the mac address for taking decisions that how to forward the frames from one LAN to the other right. And the next higher level you have the routers or the so called layer three switches. These can connect any combination of LANs and WANs. They work at the network layer level in particular in the internet they use the IP address; they use the IP protocol and the IP address for taking the decision. So a hub can connect several computers inside a single LAN a bride can connect several LANs together. A router can connect LANs with WANs which is most general.

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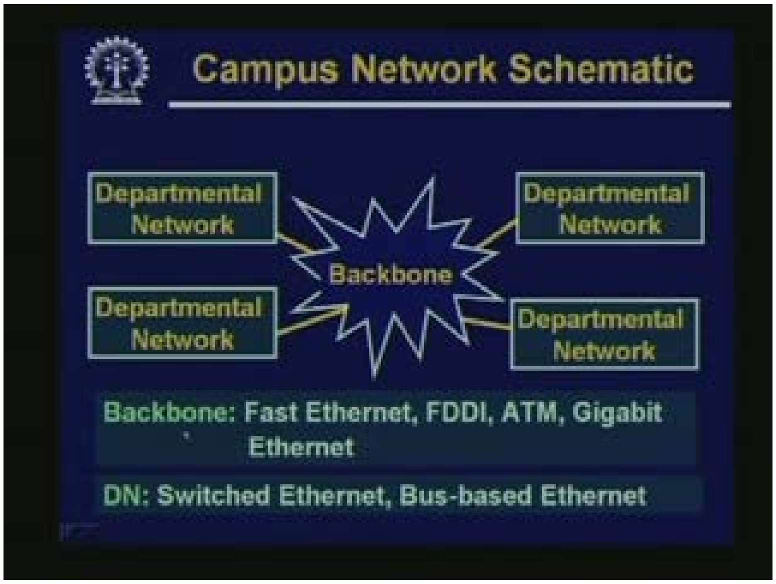


Now a quick look at some of the typical pictures, say in a typical campus wide network. Some is suppose you have an organization network. There are several departments, so a typical network will look like this. There will be several departmental networks and there will be a central backbone which will be connecting all the departmental networks together. Now if you think of an educational institution, here also we have the notion of several departments, several buildings. Buildings are connected together by a network which is called the backbone network. Now the entire thing is a LAN. But in terms of the way they are actually deployed and used. Typically the speed of the backbone network is higher as compared to the speed of the departmental network. Because it is expected that the backbone network will be carrying more traffic as compared to the individual departmental networks.

Just to look at some of the alternate technologies that are available, for the backbone network you can have fast Ethernet. You can have fiber distributed data interface, both of which work at 100 Mbps. You can have ATM. ATM stands for Asynchronous Transfer Mode. It works at about 500 Mbps you can have giga bit Ethernet which works at 100 Mbps or 1 Gbps for the department network you can have switched Ethernet you can have bus based Ethernet. Now if you try to look at a state of art solution, the state of the art solution will comprise of a backbone network which can work at 1 Gbps. You can have a department network which can work at 100 Mbps switched Ethernet LAN. That is some sort of a say state of the art network.

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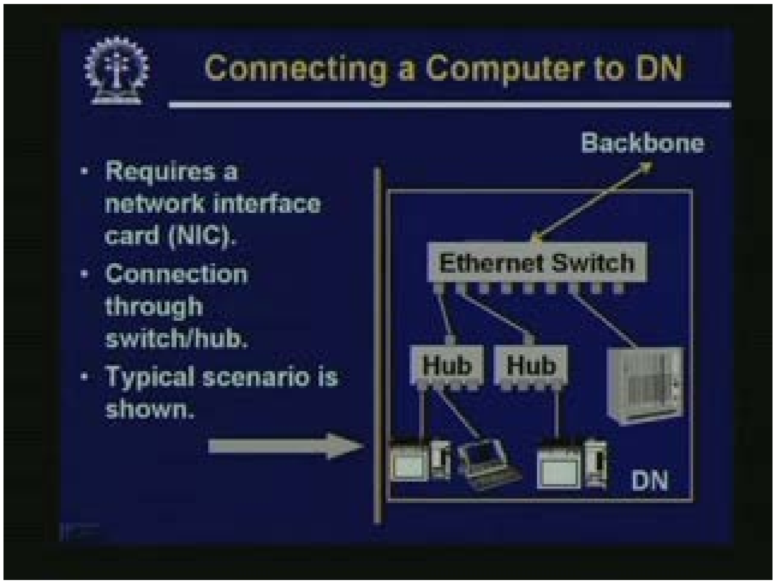


Now just we look at a department network. This is very rough picture of a departmental network. For one side you are connected to a backbone by a very fast link, this can be a giga bit Ethernet link. Now inside the department you can have a main Ethernet switch. There can be several hubs, you can have your computers servers all connected to them. This is as one level I have shown; there can be multiple levels of switches and hubs. So this is how the network the different machines and the servers can be connected together inside a network. We have a main switch in the department under which there can be hubs. There can be other switches and all the computers are connected below that. This is how it is done and for connection to the outside world you can have a scenario like this where suppose this is your institute network. You can have a number of outside connections like you can have a router through which you can have multiple links.

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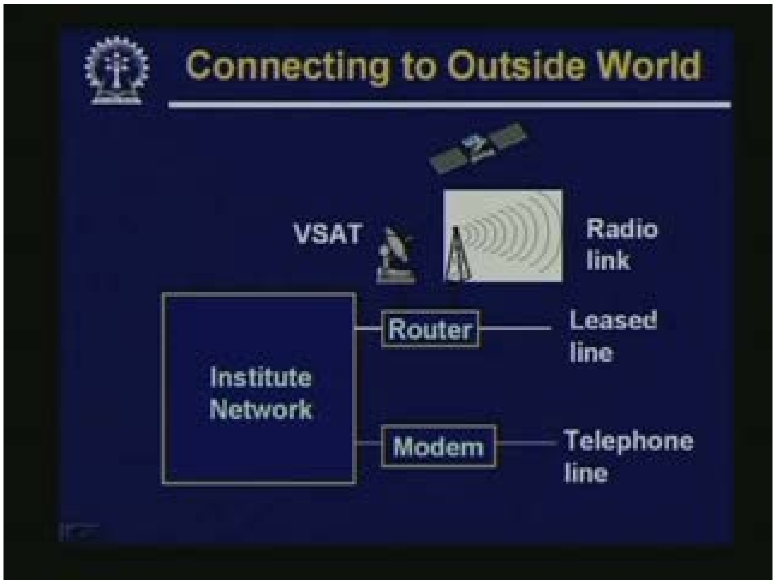


You can have a link with a satellite connection. You can have a link with a wireless link. You can have a leased line link; you can have a telephone line link through a modem. So if you have a link through a telephone line, typically it is done through a modem. But if you have a either leased line radio link or you can have a satellite link also. A satellite can in the sky you can have a satellite link. So all these links can be through a router. So these are the alternate technologies I am just try to mention without going into the detail. So if we have an organization network we will have to solve the problem of connecting the computers inside. And also we have to solve the problem of how to connect this computer to the outside world. Means how links to the outside world are made. Because ultimately your task will be to have these machines connected to the internet? And for internet you will have to rely on some internet service provider which will be providing you a connection from your LAN to the outside world.

So this brings me to the end of today's lecture. But what I would be following in this lecture as well as the lecture is followed is that at the end of very lecture I would try to give you some suggestive questions or some quiz questions which you can try to solve and also I have try to give you the solution of the questions that are posed in the previous classes. Now since in the previous class I did not pose any question, it was an introductory class. So in this class I will only state the quiz questions for today's lectures. Now just one thing I also want to say that whatever is been covered here and whatever quiz questions are being posed at the end of the lecture. These are just suggestive questions. You are strongly urged to look into reference material. To look into text books to work out some more exercises and problems to get much better felling of the subject. So that you can be much more confident about solving a problem once it is given to you. Now let us look at the quiz questions on today's lectures.

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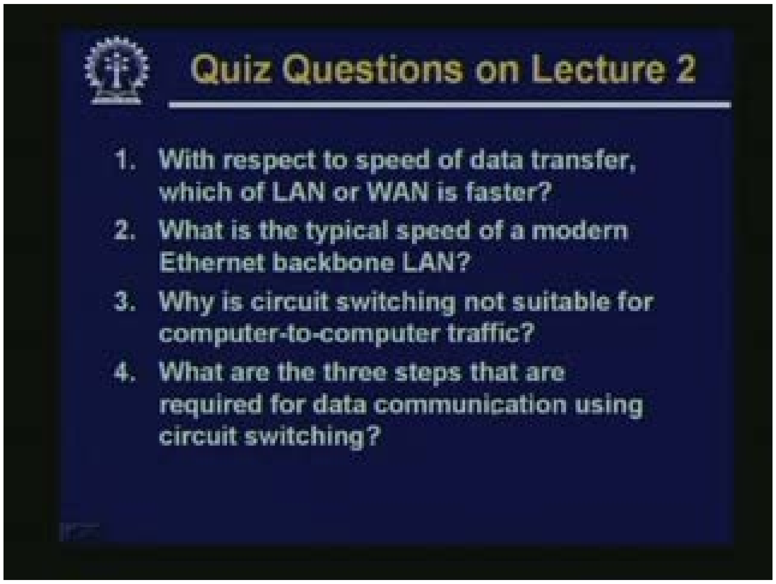


The first question says that with respect to speed of data transfer which of LAN or WAN is faster, this is a question. Second one, what is the typical speed of a modern Ethernet backbone LAN. While when I say a modern Ethernet backbone LAN of course there are alternate. I am expecting that means you will be telling the state of the art technology. What the state of the art Ethernet technology supports today. The third question why is circuit switching not suitable for computer to computer traffic I had mentioned that computer to computer traffic is bursty in nature. I think answer lies there. You can try to figure out the answer. Question four, what are the three steps that are required for data communication using circuit switching.

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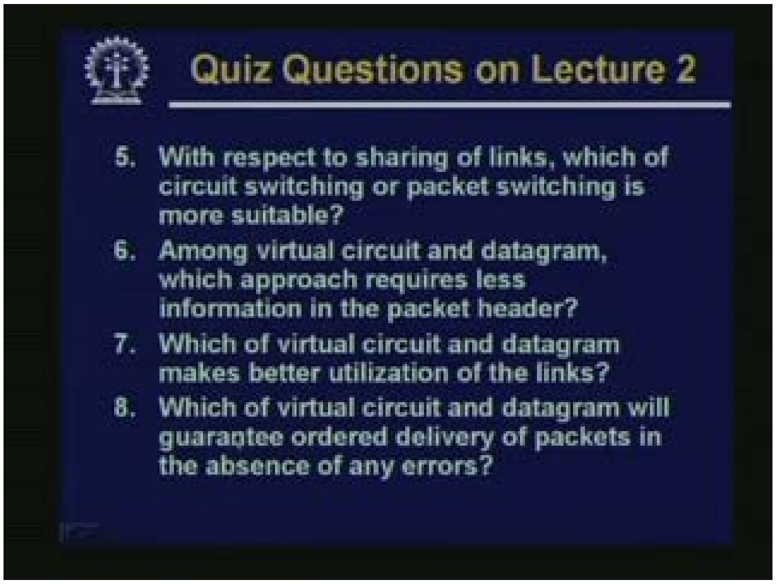

Question five, with respect to the sharing of links, which if circuit-switching or packet switching is more suitable? Well here let me repeat once that all though I had talked about these technologies in my regular lecture. I had talked about there are some links which will be dedicated some links which are shared. But in today's technology none of the links or the physical links are dedicated. What we see as dedicated at the resources along the link. For instance I may have a link which supports say 1 mega bit per second capacity, suppose I am multiplexing several voice links over it. Each voice links requires 64 kilo bit per second. This means that I can carry 16 such voice links over this 1 mbps link. So I am not dedicating the entire link to anyone voice link.

But I am assigning a dedicating fixed 64 kbps or 64 kbps of dedicated bandwidth to each voice link. This is what I mean by dedicating a logical link means across a path. Now question number 6. Among virtual circuit and datagram which approach requires less information in the packet header? While for answering this question you need to understand that how the packets are forwarded in virtual circuit and datagram what are the rolls of the intermediate nodes and what kind of information the intermediate nodes are using to take the routing decision. So I think the answer will come from there. 7 which of virtual circuit and datagram makes better utilization of the links simple. 8 which of virtual circuit and datagram will guarantee ordered delivery of packets in the absence of any errors.

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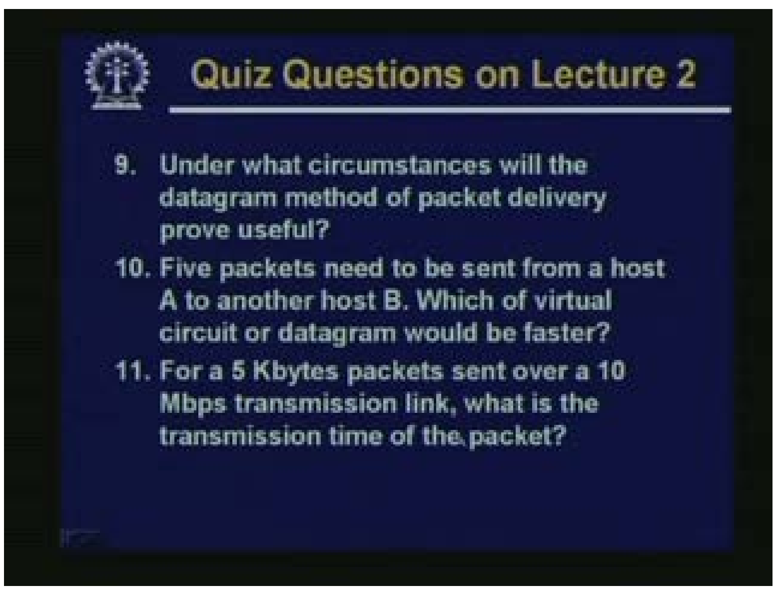


9, under what circumstances will the datagram method of packet delivery prove useful. See here I had mentioned in the lecture that datagram method will be faster in general. But you can try to figure out what kind of applications may gain by using datagrams. Because one thing is true I had mentioned datagrams do not guarantee delivery at the destination. There can be some packets which are not received. Some out of order delivery, so some applications which would not mind if this kind of things happened.

They will be or some environments where the chances of area or occurring or less most of the packets will be following in same pass. So here you can try to find out some environment or some situation where this kind of thing exists and datagram packet switching would be advantageous. Number 10, 5 packets need to be sent from a host A to another host B, 5 means a small number which of virtual circuit or datagram would be faster. Number 11, a small numerical problem for a 5 kilo bytes size packet sent over a 10 mbps transmission link. What is the transmission time of the packet? This you can very easily calculate. What is the time taken for one full packet to get transmitted over this link?

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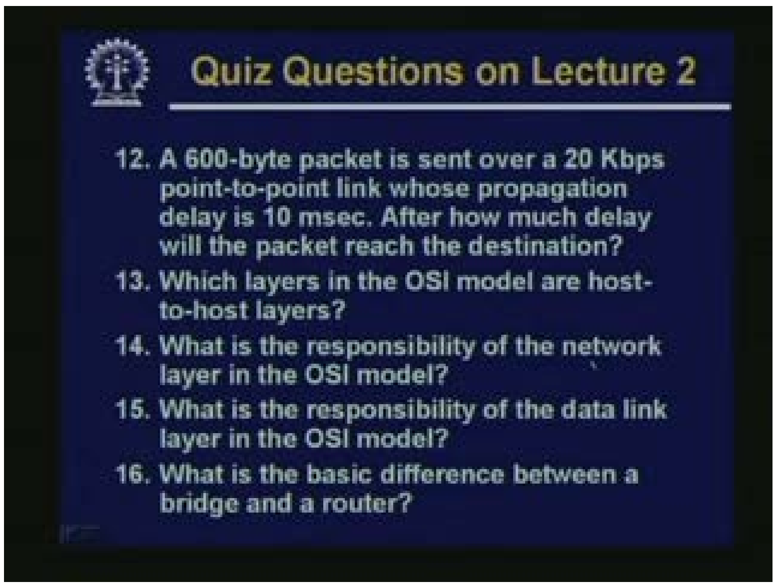


Number twelve. Again a small numerical question a 600 byte packet is sent over a 20 kbps point to point link whose propagation delay is also specified. The propagation delay you recall is the time taken for 1 bit to go from one end of the channel to the other. It has nothing to do with the speed of the channel. These two are different after how much delays will the packet reach the destination. Just here I am giving a hint. Here the total delay will be equal to the propagation delay plus the packet transmission delay. This you must calculate, in this way which layers in the OSI model are the host to host layers. What is the responsibility of the network layer in the OSI model? What is the responsibility of the data link in the OSI model? What is the basic difference between a bridge and a router? So I believe we have discussed all these things. You should not find any difficulty in answering this question. Now in our next module we would be starting our discussion on TCP IP which will be laying. You can say the foundation for our future discussions on networking routing architectures, internet protocols and other technologies. So with this we come to end of today’s lecture. Thank you.

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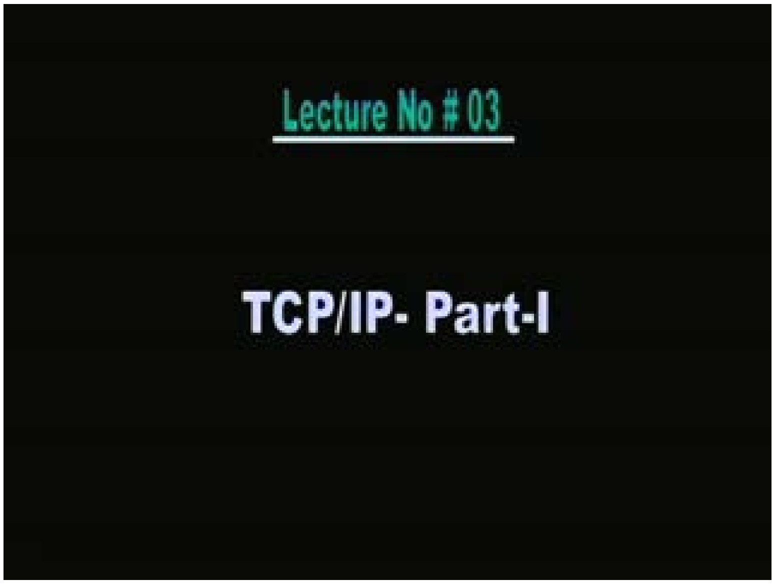


And this lecture is entitled TCP IP part one. So in this module two we would covering the topics in 3 lectures. Here we would be mainly talking about the TCP IP protocols. In fact TCP IP is not a single protocol; it is a suite or a family of protocols. We would be looking at some of the important members of this family. But first let us try to understand what TCP IP is and how it has evolved over a period of time. So talking about the internet.

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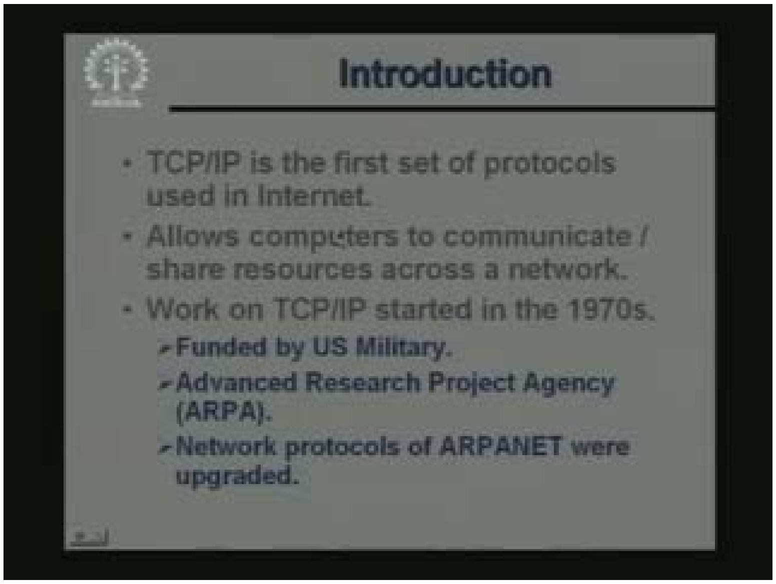


TCP IP is a protocol which well you can say it stated as early as in 1970s and it got very quickly accepted by a white community of users. In fact when the internet came into the being, TCP IP was the prime vehicle which was used to connect the computers in the internet and to allow them to communicate over the network. Using TCP IP the computers were able to communicate among each other. And also another very important thing, they were able to share some resources across the network. Some of the resources like dig space or some of the some of the expensive equipment's were expensive in those days and over the network it was possible to share those resources.

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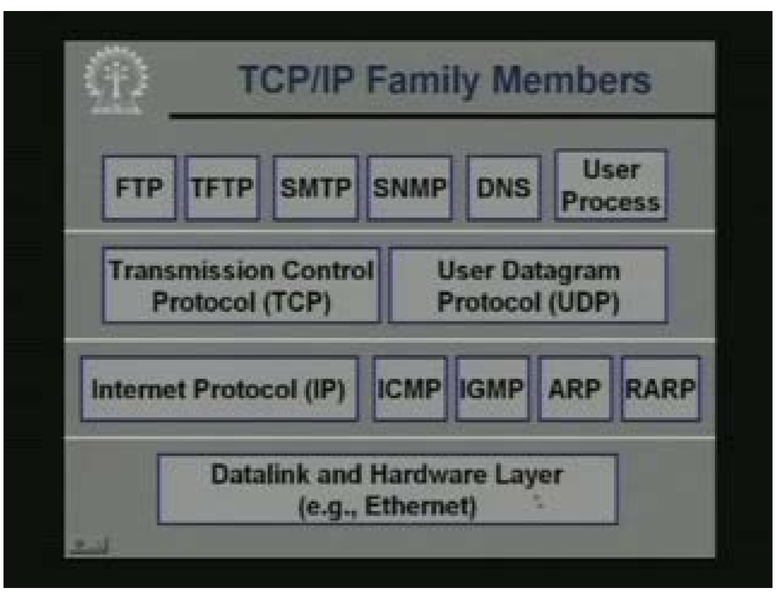

Now let us have a very quick look at the important members of the TCP IP family. This diagram summarizes the different important family members in TCP IP. Of course at the lower level we have the data link and the hardware layers this refers to the network interface card as I told you. Typically we use Ethernet at this level at the next higher level, this is the network layer level in TCP IP the protocols that works at the network layer level is called internet protocol or in short IP. So IP is the main protocol which is working at the network layer level. But in addition there are several auxiliary protocols like internet control message protocol, group message protocol, address resolution protocol and reverse address resolution protocol which also works at the network layer level.

But they have specific functions like ICMP is used to generate and send some error messages, like for example address resolution protocol is used to translate from an IP address into an Ethernet address. For example, so IGMP and RARP also have some specific purposes. But in a typical application you will be using internet protocols. These protocols are typically hidden from the applications. These are invoked and used in a transparent way. As a user you will not be able to see that they are been used or as a programmer also. You will not be using them directly.