Data Communications
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Lecture 20
Routing - I

Hello viewers welcome to today's lecture on routing. In fact this is the first lecture on routing in switched communication network.

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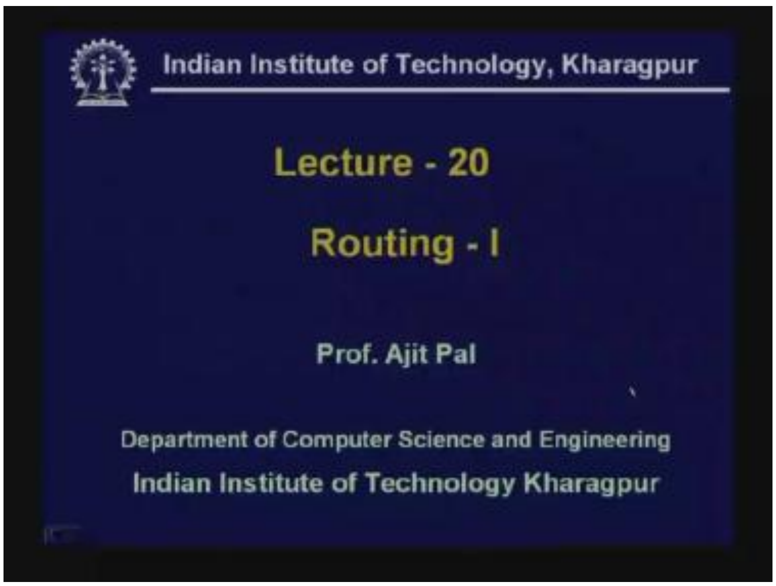

Here is the outline of today's talk. First we shall discuss about what is routing in other words we shall define routing then we shall consider various desirable properties of routing and as we shall see we have to develop routing algorithms. So whenever you develop routing algorithms we shall consider in detail about what are the design parameters then we shall discuss about two routing algorithms. One is known as fixed routing. In this context you have to discuss some algorithms on the shortest path or finding out the shortest path, Dijkstra's shortest path algorithm then we shall discuss another routing algorithm known as flooding.

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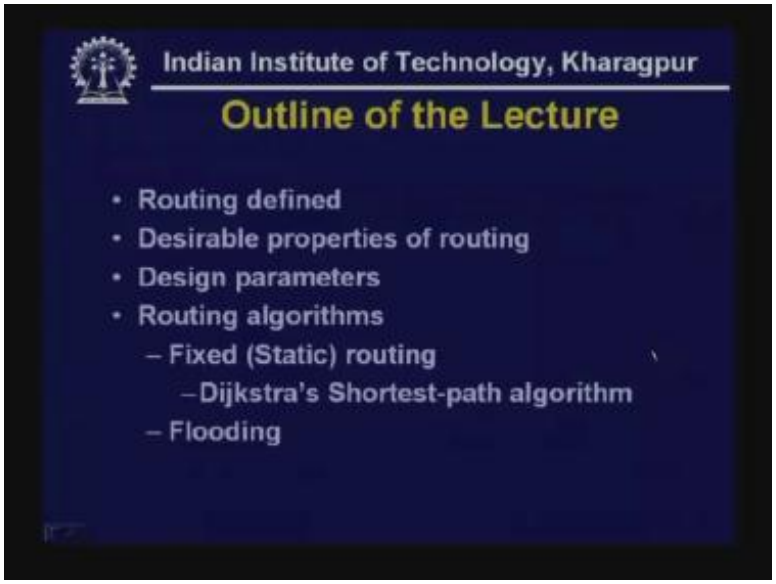

So we shall primarily discuss two important routing techniques in this lecture fixed routing and flooding and in the next lecture we shall discuss some more routing algorithms.

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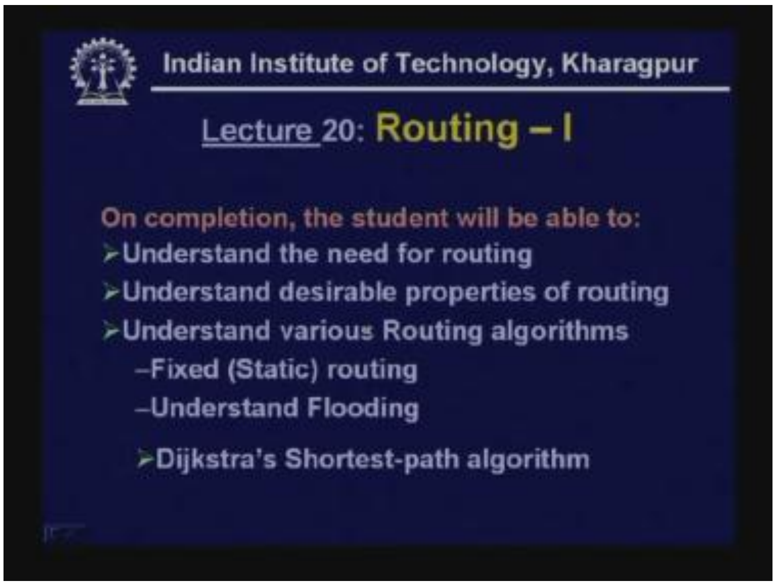

And on completion of this lecture the students will be able to understand the need of routing. They will understand what is routing and they will understand the desirable properties of routing. Then understand various routing algorithms such fixed routing, flooding and also as I mentioned the students will be able to understand the shortest path algorithm and they will be able to find out a shortest path from a particular source to a destination in a switched communication network based on this algorithm.

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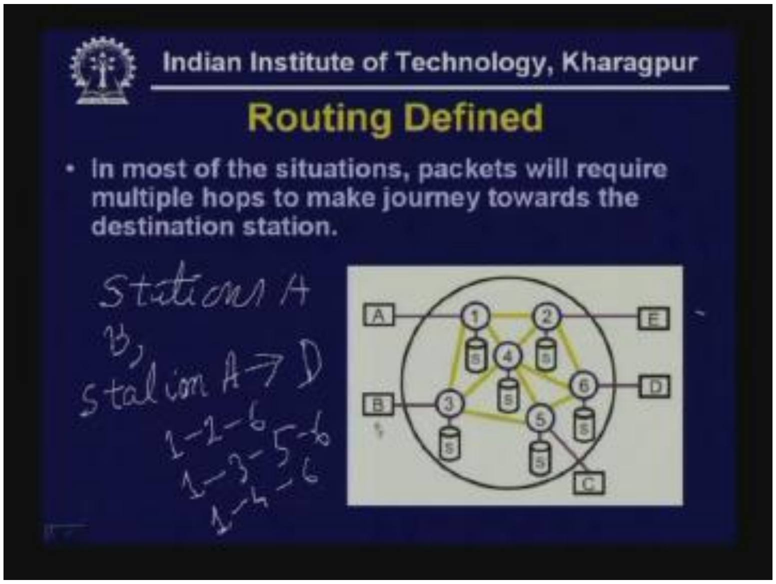

First let us focus on what is routing and why it is needed. Here a typical schematic diagram of a switched communication network is given. Here we have a number of stations A, B, etc and a number of nodes. Nodes are essentially switches and as we know the stations are connected to nodes and nodes in turn may be connected to some other node or connected to other stations.

And as we can see, suppose station A wants to send packets to station D in such a case this particular network or switched communication network has no direct path. or in other words A is not directly connected to the station D or in other words both of them are not connected to the same node. So as you can see from A it can go via several nodes it can go via node 1 then to node 2 then to node 6 so in this way the packets from station A can go to station D. As we find from this, this is not the only route or path there exists several alternatives. For example, it can go via 1 to 3 then to 5 then to 6 or it can go via 1 then to 4 then to 6 so you find there are several alternative routes.

Question arises which route is the optimum and at a particular instant a particular route may be efficient or in other words it will be better to send through a particular route and may be at the next moment because of node failure because of congestion that particular route may not be possible so we may have to send through alternative route. Hence the key point that I would like to make is from a particular station to another station source to destination there exist multiple paths and routing is the mechanism for finding out the most cost effective path from a source to a destination. So, for a source destination power the intermediate nodes through which the packets are to be routed is given by the routing algorithm. As a consequence routing is one of the most complex and crucial aspect of packet-switched network design.

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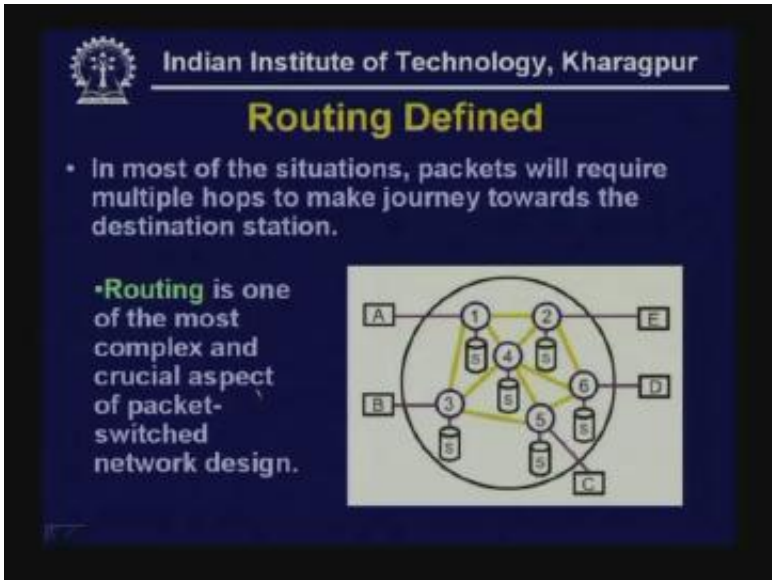

So whenever somebody is designing a packet-switched network the way routing has to be done placed a key or important role in the design that is the reason we shall devote two lectures on this routing.

Now let us see what are the desirable properties of routing.

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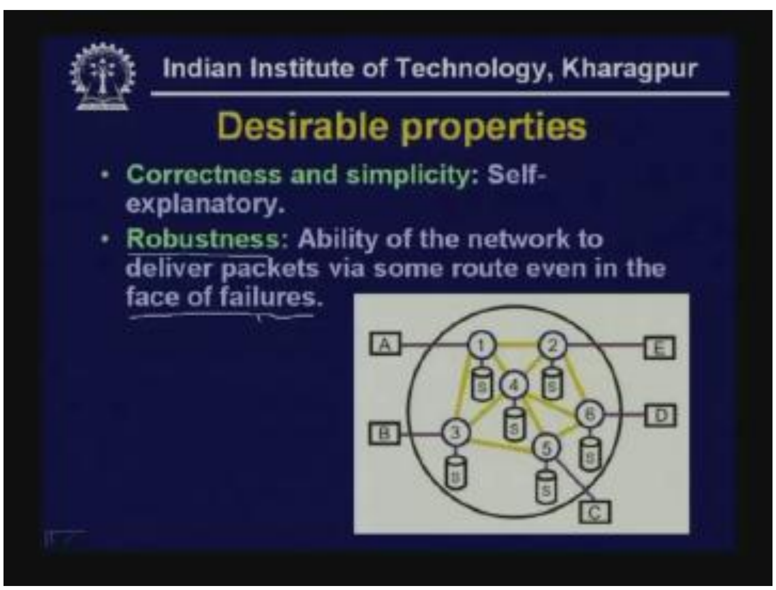

We want the routing algorithm to deliver a packet from a source to destination. Now, first two important properties are correctness and simplicity. These two terms are self explanatory. By that I mean whenever we say correctness that means the packet should be deliver to the correct destination. If source is A and destination is D it has to be delivered to the proper destination station. That is what is meant by correctness.

By simplicity mean the routing algorithm can be simple can be very complex depending on which one we are using. Now if it is complex then it will put large overhead on the nodes. So it is necessary to make the routing algorithm simple so these two terms correctness and simplicity are quite simple and easy to understand or self explanatory. Then we have the second important property that is robustness.

As you will see the network is a queue of packets the queue sizes is keep on changing with dynamically with time and also there is a possibility of some node failures. So under the situation of node failure, under the situation of congestion in some part of the network the routing algorithm should be robust so that it can deliver packets fire some route in the face of failures. Therefore even in the phase of failures or even in the face of congestion it is necessary that routing algorithm is able to deliver packets to the correct destination that is what is meant by robustness. So this property is very important. Whenever the load is changing dynamically failure is also taking place occasionally or frequently depending on the network.

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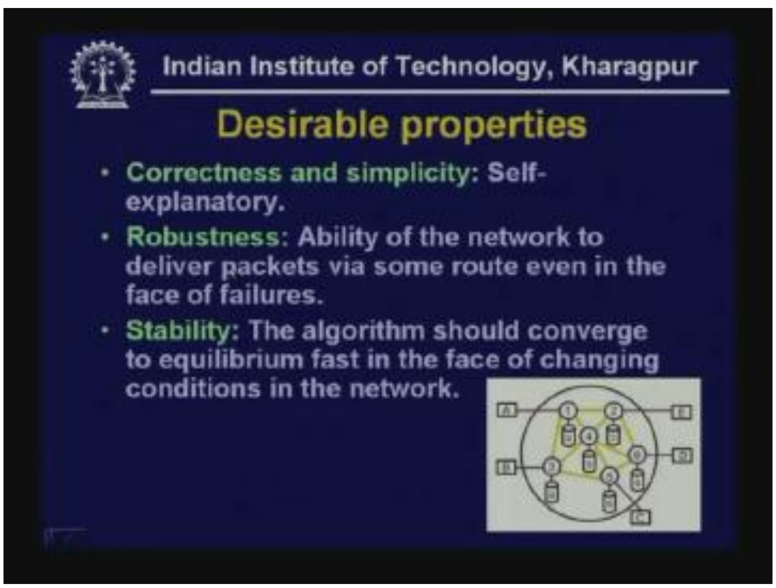

Third important property or fourth important property after correctness, simplicity robustness is stability. The algorithm should converge to equilibrium fast in the face of changing conditions in the network. As I mentioned the queue of packets may keep on changing quickly in the network. In such a situation suppose there is congestion in this part of the network then what can happen is a particular station can divert all the packets towards another nodes, not one station but all the stations can divert all the packets to another part of the network and because of that the congestion may develop in that part of the network. Again those packets are diverted to previous node previous part of the network where there was congestion. in this way because of quick routing of the packets or changing the routes from one congested area to another congested area what can happen is it cannot reach stability and as a result it may lead to unnecessary delay in delivering the packets. That is why it is important that the algorithm should converge to equilibrium fast in the face of changing conditions of the network. So, even when the loads are changing, even when there is some failure when the routing algorithm should be stable and should converge to equilibrium quickly. This is the important property of the routing algorithm.

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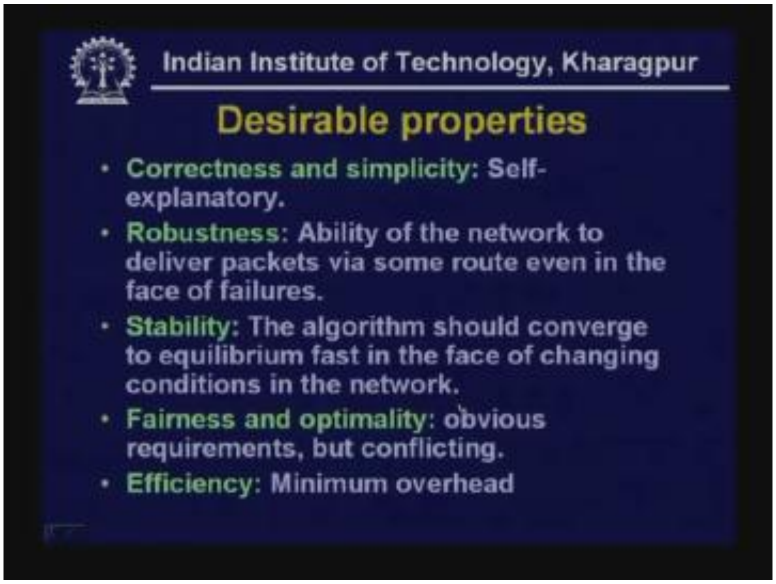

Finally comes the fairness and optimality. What is desired is each and every station should have equal right for getting a particular route for delivering their packets. But because of optimal routing it may be necessary that some packets on a particular station has been given some priority. So, if you give priority then fairness is violated. On the other hand if you give priority to some nodes or to a particular path for example if you give priority to packet which are to be delivered to adjacent nodes then the long distance nodes do not get the fairness. So these two terms are little conflicting. These two are important so there is you have to arrive at some trade-off between these two fairness and optimality. Obviously although they are conflicting you can arrive at some trade off and find out some mechanism of giving some kind of weightage or priority without violating the fairness or without compromising much of fairness.

Then finally we have what is called the efficiency. As I mentioned the overhead of routing should be as little as possible. But if the routing algorithm is very complex then it will put very high overhead on the nodes in the network. That is why the routing algorithm should be simple so that the overhead of efficiency of the routing is high and the packets are delivered in an efficient manner through the shortest path routes or at a low cost.

Now let us focus on the design parameters.

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Whenever you try to design a routing algorithm you have to take several parameters into account. First is the performance criteria. What performance criteria you will use in finding out the efficacy or effectiveness of a particular routing algorithm? One performance parameter is number of hops. As you have seen whenever packets are going in a network it is making several hops. So the count of how many hops it makes through the intermediate nodes can be a measure of the performance. Another parameter can be cost.

Suppose you have a node and you have several paths therefore you are having several alternatives so now bandwidth of these particular links may be different. Now if the bandwidth is high then the average cost for sending through that particular path may be smaller so you will try to send the packets through a high bandwidth route so that the cost is less. So the cost is inversely proportional to the bandwidth of a particular link.

Then comes to the third important performance criteria that is delay. Delay is usually dependant on the size of the queue. So, in a particular route if there is a long queue of packets then delay will be longer hence that delay can be measured as a performance criteria and the measure of delay can be obtained from the size of the queue or queue length.

Then fourth important criteria is the throughput. Throughput is essentially the number of packets delivered per unit time. So the number of packets delivered per unit time can be found out which can be used for measuring the effectiveness of a particular routing algorithms. These are various performance criteria that can be used in designing a routing algorithm.

Second question or second important parameter is the decision time.

Now decision time means when you will decide for routing a packet. The decision can be per packet basis. For each of the packet it is independently decided as what should be the route for that particular packet. On the other hand it can be per session basis. For example, in virtual circuit network as you know for a particular session a virtual circuit is established and all the packets for that session or during that session are sent through the same route or path. So decision time is important whether it is per packet basis or per session basis and accordingly you have to use a datagram type packet switching or you have to use virtual circuit packet switching.

Then the third important parameter is decision place. Here we have to look into various things like who will decide about routing and where it will be decided, whether it will be decided in each node and so on. That means each node receives a packet then it decides the route for that particular path to which particular output link it has to be forwarded so in that case we call it distributed.

Another possibility is that there can be a central control node so in that central control node we will have some kind of routing table which will decide about routing then we call it central routing. Or it can be decided by the originating node which is the node where it is originated. So with that it decides where it has to be, in which direction it will go or what will be the next node so the decision place can be each node, central node or the originating node in that case we call it source routing. So this is the third important design parameter.

The fourth important design parameter is network information source. Now as you see there exist algorithms for routing which does not make use of any information neither the topology, nor the offered load, nor the costs in different paths so it does not use anything so in that case we call it none. In the second case it may use some local information. For example, you have got a node and you have got say three links so the output queues the queue length in each of these path may be considered as the information used for routing so in that case we call it local it does not gather information from its neighbors or any other network.

The third possible alternative is that a particular node gathers information from the adjacent nodes from it neighbors and accordingly does the routing or it may be nodes along the route. A particular before routing gathers information from all the nodes along the route then decides whether it will forward in that route or in some other nodes or it can be very global. In such a case each node gathers information from all other nodes at regular interval and accordingly it makes some kind of routing table to decide about routing. Therefore that network information source can vary from none to all nodes and depending on that obviously the complexity also will vary.

Finally we have the network information update time. The network information update time can be continuous. In the first place as I told the routing algorithm should decide what kind of information it will use, whether it is local or from neighbors or none or global. So whenever it is local it can be continuous or if it is from the neighbors or if it is from all other nodes that it can be periodic or it can be that whenever some major load change is taking place only then it makes change in the routing algorithm. So whenever there is a major load change or topology change there is a change in network topology then only the network updates information and changes the routes accordingly. These are various design parameters which should be used in developing routing algorithms.

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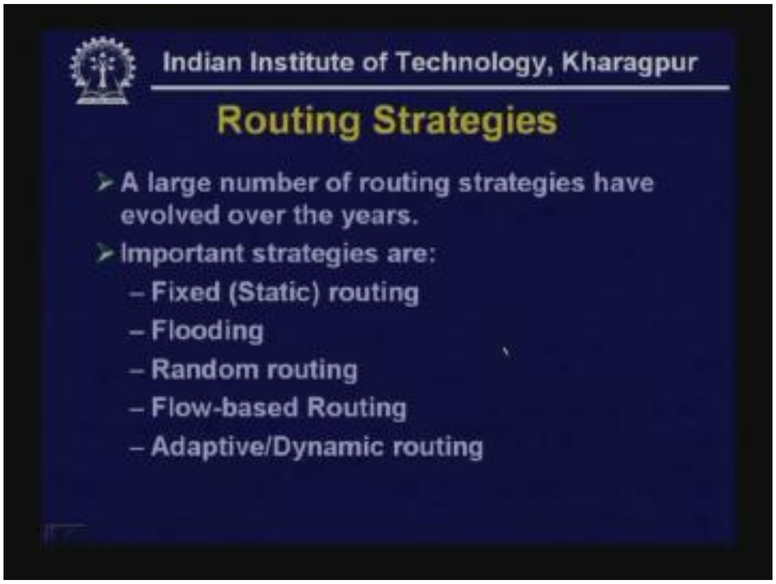

So a large number of routing strategies have been evolved over the years and some of the important strategies are fixed routing, flooding, random routing, flow based routing, adaptive or dynamic routing and so on. In this lecture I shall discuss about two important routing algorithms the fixed routing and flooding and the other algorithms we shall discuss in the next lecture.

Therefore first let us focus on fixed routing. In fixed routing a route is selected from each source destination pair of nodes in the network. The routes are fixed and they may only change if there is a change in the topology of the network. That means for a given topology of the network the routing is fixed so it changes only when there is a change in the topology of the network otherwise it remains the same. And question arises how fixed routing may be implemented?

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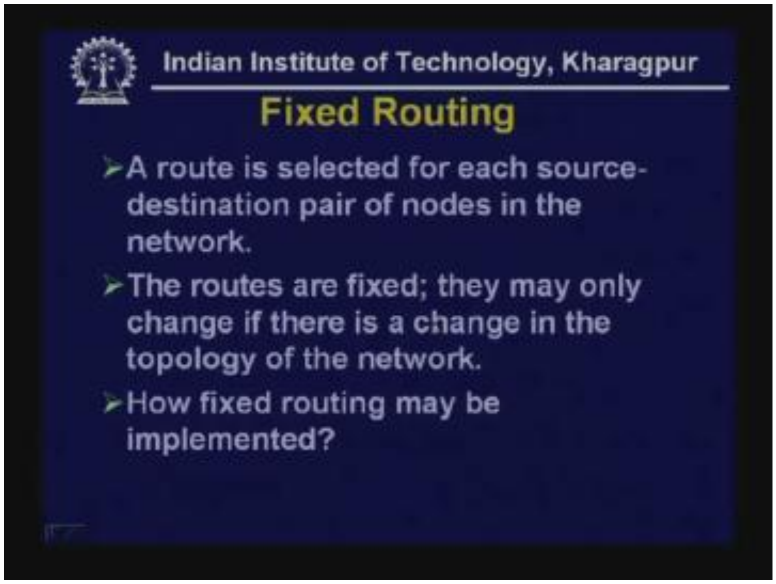

There are several alternatives, let us see how it can be done. Here as you can see there is a central routing matrix created based on least cost path which is stored at a network control center.

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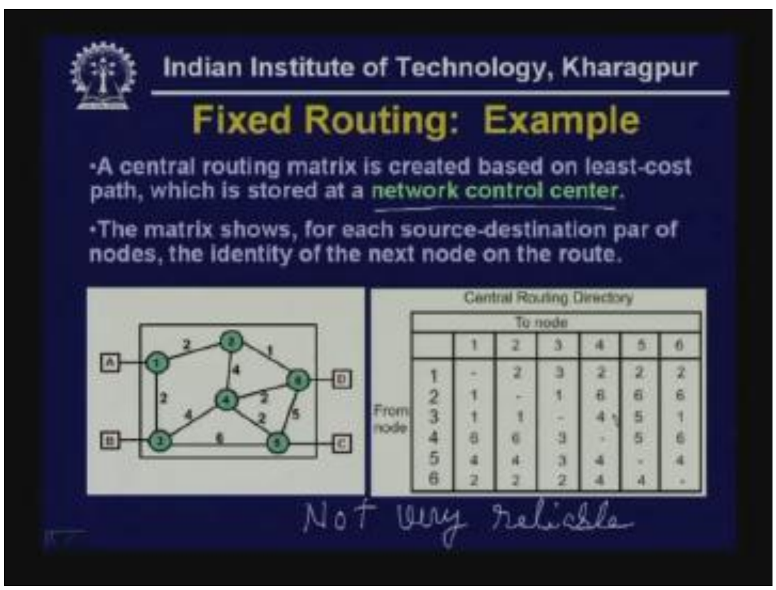

There is a network control center where this central routing directory is created and here suppose this is node 1 so from node 1 you have to send a packet to node 6 then what will be the next node or to which node it has to be forwarded. For example, if it is going to be 6 then next node to be forwarded is 2 and cost of each link is given here, and this cost may be based on queue length or it may be based on the bandwidth of the network whatever it may be some cost is assigned and the cost for each of these links are given here (Refer Slide Time: 23:33). Here the links are bidirectional and that's why we can say this is a weighted graph that means all the ages has some weight and these weights are essentially assigned as the cost of a particular link.

Now here you can see say from any node to any node what is the next node to which a particular packet has to be forwarded is given here. For example, if the destination is say 3 then from 1 it has to be forwarded directly to 3 because it is directly connected. On the other hand if it is 4 then it will be forwarded to 2 then it can be obtained. In this way such a big routing directory has to be stored in the network control center. This particular approach this centralized control has one draw back, the draw back if this network control center fails then everything will collapse that means the routing cannot be done as a consequence it is prone to failure that means it is not a very reliable approach.

Another alternative is to divide this routing directory and create separate directories for each of these nodes. That means in each node you can keep a small copy of this particular directory. Previously as we have seen there is a big directory and from this you can create directory corresponding to each of these nodes. Essentially for a given destination what will be the next node to which it has been forwarded that is being stored in this directory. That means if the destination is 2 next node to be forwarded is two and if the destination is 3 then the next node to be forwarded is 3 so this is the directory for node 1 and if the next node is 5 then it has to be forwarded to 2.

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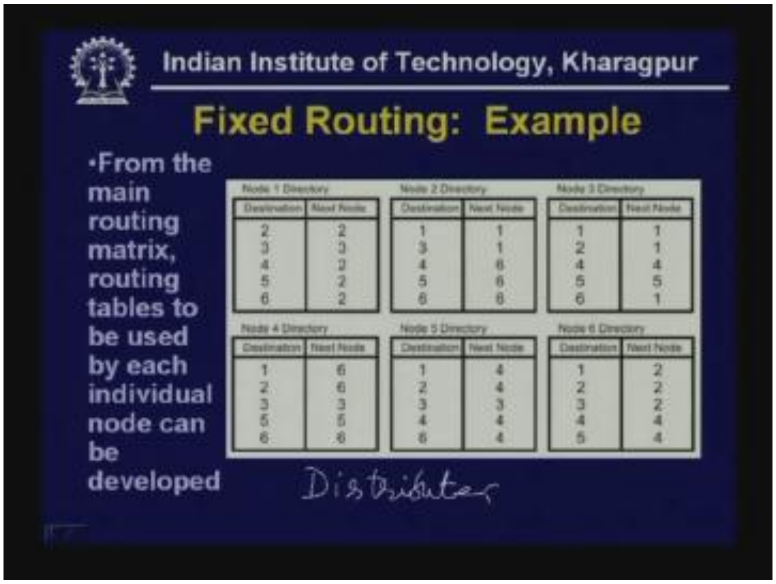

As you can see for 4, 5 and 6 if these are the destination nodes the packets are to be forwarded to node 2 for all the cases. This is quite evident from this topology. So 4, 5, 6 as you can see from one it will go to two for delivering three packets. So in this case the routing tables are used by each individual node where these routing tables can be developed and can be kept in each of these nodes. So this is a distributed routing algorithm. Here as you can see here each of these tables can be kept in each of these nodes and as a packet is received for a particular destination it is forwarded to the next node. In this way the routing can be done based on the information of next node available in the routing directory. So these are the routing directories to be kept.

Question arises how these routing directories will be created. That can be created based on some cost it can be least cost. As I mentioned a cost is associated with each link as we have seen. Now the simplest criterion is to choose the minimum hop path route through the network and this minimum hop route means we can find out how many hops the packet will take and based on that a routing table is created.

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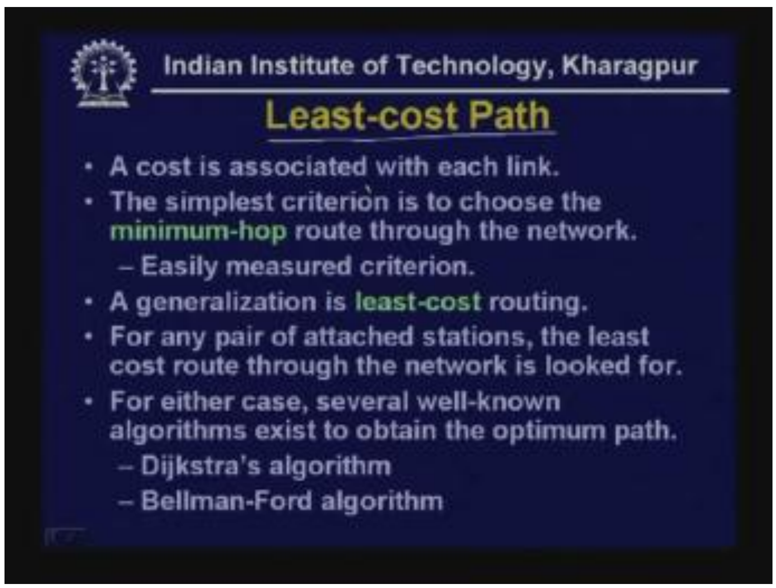

However, the generalization of this is least cost routing. as I mentioned this least cost can be based on several parameters like; it can be based on the load that means queue length at different paths of the network, it can be based on the bandwidth at different nodes or distance of different links so whatever it may be the least cost can be associated with each link and correspondingly least cost path can be created. So, any pair of attached stations the least cost route through the network is looked for.

Question arises how you find out this least cost route. For this several well known algorithm has been developed to obtain the optimal path. These two algorithms are very popular; Dijkstra's algorithm and Bellman Ford algorithm. These two algorithms are quite similar and performance is also similar. What they do is for a given topology and for a given cost associated to each of these links a least cost path is found out from a particular source to all the destinations which that is being done with the help of this least cost routing algorithm other than Dijkstra's algorithm for obtaining optimal path.

Let us see how it is done. It finds the shortest paths from a given source node to all other nodes in order of increasing path length.

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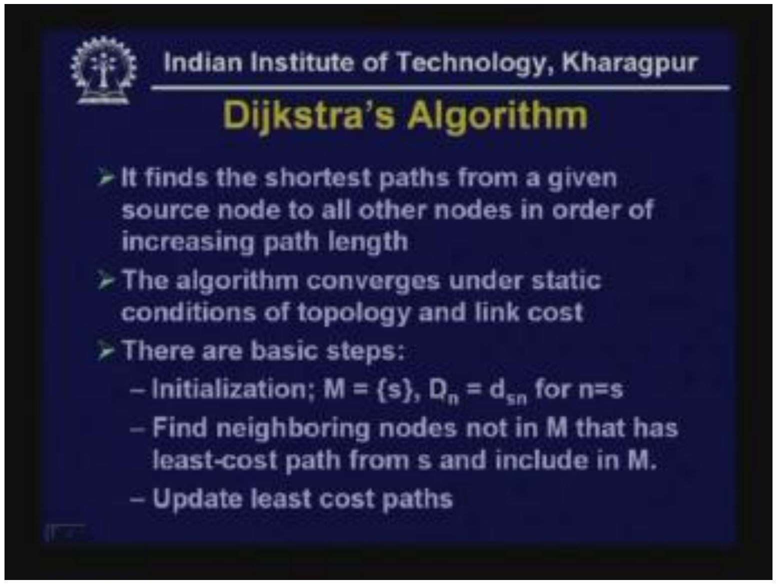

The algorithm converges under static conditions of topology and link cost. That means when the topology is fixed and link cost associated with each link is given then it will converge to a solution and it will give you the optimal path. It has got three steps. First is initialization. First it creates an initial set starting with the source node and also a cost D_n which is essentially the distance based on the link cost from source node to a particular node and when n is not equal to s for all nodes for which n is not the source node.

Next one is find neighboring nodes not in M that has least-cost path from s and include in M. In this way in an iterative manner you will find that it will choose a particular node and include in M and update the least cost paths. So let me illustrate this with the help of an example. So here as you can see we have got a network and the topology is fixed and the interconnection is fixed and the cost associated to different links are given here in this network. Now as I told in first iteration M is the source node so here the source node is 1 (Refer Slide Time: 30:53) and as you can see this node is connected to node 2, node 3 so the cost for this path from 1 to 2 is 2 then cost from 1 to 3 is also 2 and since from 1 we don't know the cost for 4, 5 and 6 right now so these are given as infinity so there is no path to 4, 5 and 6 and the cost is given as infinity in the begin and this is after the first iteration.

Then after the second iteration this 2 is included as part of M because this is the least-cost path among the available paths. So, after including 2 now you can get a path to 4 as well as 6. So, for 4 the path is now through 1, 2 and 4 so cost is 6 so 2 plus 4 so these are the link costs these are added and you get a cost 6. Now this 5 is not yet linked there is no path from 1 to 5 through 1 or 2 so for 6 as we can see the path is 1, 2 and 6 so the cost is 2 plus 1 is equal to 3 as it is given here.

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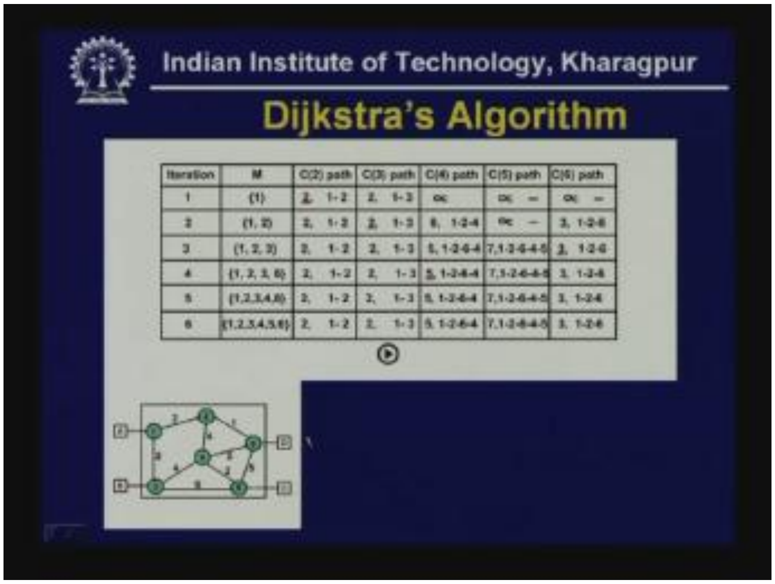

Now in the third iteration 3 is added in the least and after adding 3 obviously the 5 is also now reachable from 1. After including 3 now you find that the cost from 1 to 2 remains the same, cost from 1 to 3 remains the same but cost for 4 has now changed because now there is a path. after including 6 because 6 has been already included here so now there is a path 1, 2, 6 and 4 so now the cost is 5 and here to 5 the cost is now 7 (Refer Slide Time: 33:21) through the path 1, 2, 6, 4 and 5 so cost is now 7.

Now 6 is added to the list and after adding 6 we find the cost is 1, 2, 3 and 6 and the cost remains unchanged for this, for this and for this, actually in the previous case it should have remained 1, 2, 4 **here is a mistake… 33:46,** here cost should become 5 with 1, 2, 6 and 4 after including 6 so now cost is reduced from 6 to 4 through a longer path so the number of hops are increasing as you can see from this but cost is decreasing.

For 5 the cost remains same 1, 2, 6, 4, 5 so cost is 7. Now this cost also remains same as 1 to 6. Now you have to include 4 into this set and this list is now 1, 2, 3, 4, 6, and this cost, this cost, this cost (Refer Slide Time: 34:36) remains unchanged, here also it remains unchanged 1, 2, 6, 4, 5 it remains unchanged and here it becomes 1 to 6 and now we find the final solution and everything remains unchanged.

Therefore we find that from node 1 after sixth iteration we get paths to all the remaining nodes. For 2 it is 1 to 2 cost is 2, for 3 it is 1 to 3 because direct link is there and cost is 2, for 4 the cost is 5 through the path 1, 2, 6, 4. So when we cleared the table you have to forward it from 1 to 2 for a packet with destination address 5. Similarly, for node 5 the cost is 7 and again it has to be forwarded to 2 but it will make several hops like 1 to 2, 2 to 6, 6 to 4 then ultimately it will go to node 5. Similarly for delivering packet to 6 the path is 1 to 6 and cost is 3. So from this you can create the routing table which I mentioned earlier. Whether it is a central routing table or distributed routing table it can be created from this least-cost path algorithm given by Dijkstra. It is quite an efficient algorithm and it is widely used.

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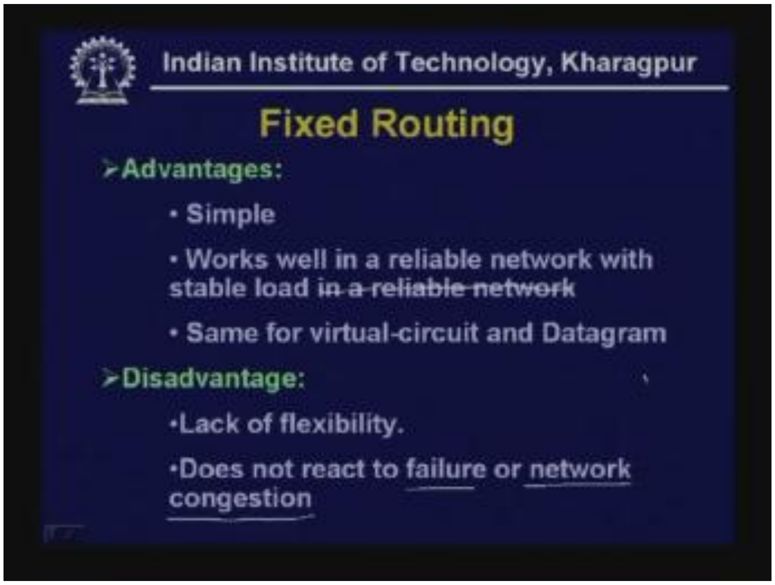

Now what are the advantages and disadvantages of fixed routing? As we have seen fixed routing is simple, simple in the sense for a given topology the cost is given and the least-cost paths are obtained using Dijkstra's algorithm or Bellman ford algorithm. You can use it and it is quite simple after the routing table is created. And it works well in a reliable network with stable load. Another important feature is whether it is virtual circuit or it is datagram type of packet switching this fixed routing algorithm is same and it does not change because route is decided based on routing table created based on those least-cost routing algorithm.

It has got several disadvantages. The first disadvantage is there is lack of flexibility. Lack of flexibility arises because the network dynamic in nature. It cannot take care of changing situations changing load conditions because the routes are fixed. As long as topology does not change the route does not change so it does not react to failure or network congestion. These are the limitations of this fixed routing algorithm and that is why fixed routing algorithm is not very suitable whenever we are working in real life. In real life we have to take care of the dynamic conditions and we have to use those adaptive algorithms.

However, this fixed routing is used in some situations where the network is reliable and load is developed. Next we have the flooding algorithm. This flooding algorithm has a very unique property, it does not require any network information neither the topology nor the load condition nor the cost of different paths or anything but what it does is, every incoming packet to a node is sent out on every outgoing line except the one it arrived on. So it simply forwards in the entire path except through which it has gone. Let us see how it happens. So let us assume a packet from A has to be delivered to some destination may be D or may be C.

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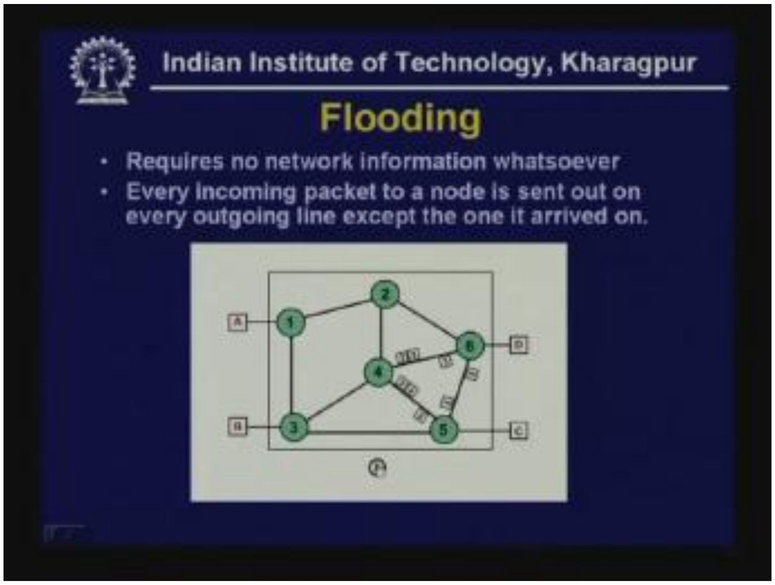

So from A it is sent through both the links. So the packet has received by 2 and 3 through these links. now what two will do it will forward through these two links and three will also forward through these two links as you can see here (Refer Slide Time: 39:41). Now 4 has received, 5 has received and 6 are received, these three nodes have received packets so they will again forward in all directions. Thus to deliver a single packet a large number of packets are generated this is a very alarming situation. So we find that this technique has some important characteristic.

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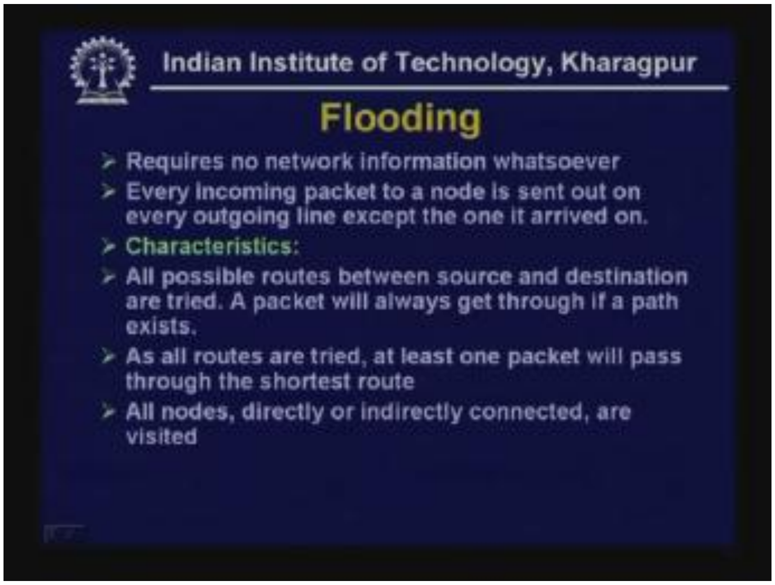

All possible routes between source and destination are tried. A packet will always get through if a path exists. The flooding algorithm has some important characteristics. The first important characteristic is that all possible routes from source to destination are tried because the packet is visiting all the destinations all the nodes and it explores all the nodes and as a result it will always get through if a path exists that means it is very robust. Under any condition failure or congestion a packet will be delivered it is guaranteed so that is why it is very robust and reliable.

As all routes are tried at least one packet will pass through the shortest route. Not only it will deliver a packet to the destination but possibly multiple packets will be delivered and one will be delivered through the shortest path. So the first packet that it will receive is through the shortest path with minimum delay. This is another important feature. When somebody is trying to find out the least-cost path it can be used also from source to destination, it is a dynamic condition.

Third important feature is all nodes directly or indirectly connected are visited. Because of these important characteristics this flooding algorithm is very useful however it has got several disadvantages. The limitations are flooding generates vast number of duplicate packets. As we have seen to deliver a single packet many multiple copies are being made and if it is not contained the number of such duplicates will increase alarmingly, the number increases in an unbounded manner so suitable damping mechanism must be used.

If we use flooding then the network will receive a large number of packets which may make it congested, we don’t want that. So, to overcome what has to be done is we have to make some measure such that the number of packets does not increase in an unbounded manner, it does not increase alarmingly.

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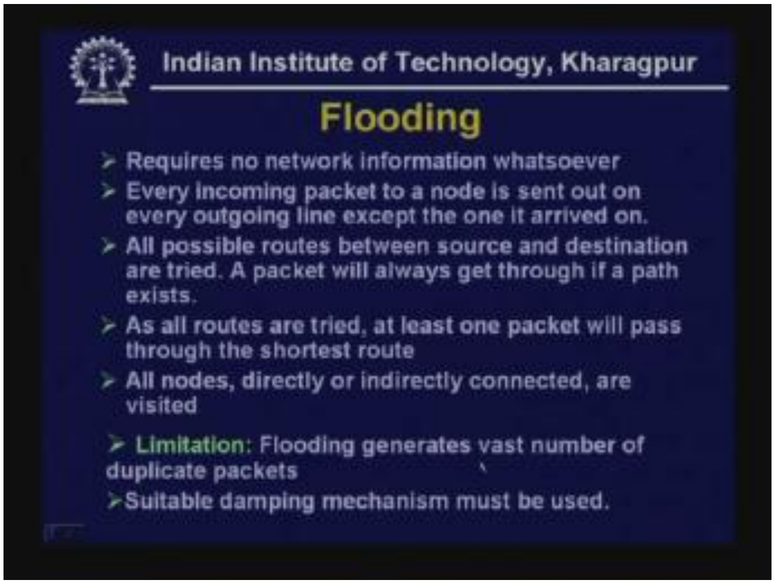

Let us see how it can be done. One important technique that is being used is known as hop count. Hop count is a technique that is used in some situation, a counter is used it is contained in the packet header which is decremented at each hop. That means the header is initialized with some value. You may be asking with what value it should set? You can set some number but if no number is known then usually the full diameter of the subnet can be used. Essentially it is the worst guessed value.

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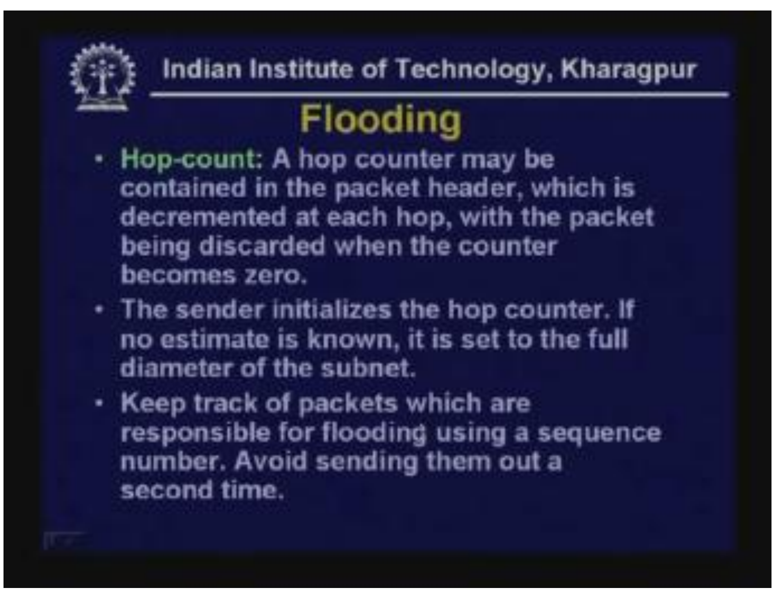

So, if no other value is known and if counter is set with some worst guessed value then after each hop that count value is decremented by 1 and whenever it becomes 0 that particular packet is discarded, it is no longer forwarded and as a result the number of packets will not increase alarmingly. This is a very important feature. This hop count helps us to minimize the number of packets under flooding condition. Another technique that can be used is it keeps track of packets which are responsible for flooding using a sequence number. That means the sequence number keeps track of which packet is flooding the network. So whenever it comes the second time it is not forwarded. So it avoids sending that packet the second time it comes to the node. For the first time it is forwarded and that sequence number information is monitored and whenever it comes again it is not forwarded. This is another important technique that can be used to reduce the number of packets whenever you are using flooding.

Now there is another approach and this is in someway a modification of flooding known as selective flooding. It's a variation of flooding technique. What it does is the routes do not send every incoming packet on every line, only on those lines that go in approximately in the direction of destination. In the example we have discussed we have seen that a packet is forwarded in all directions except through which it has received the packets.

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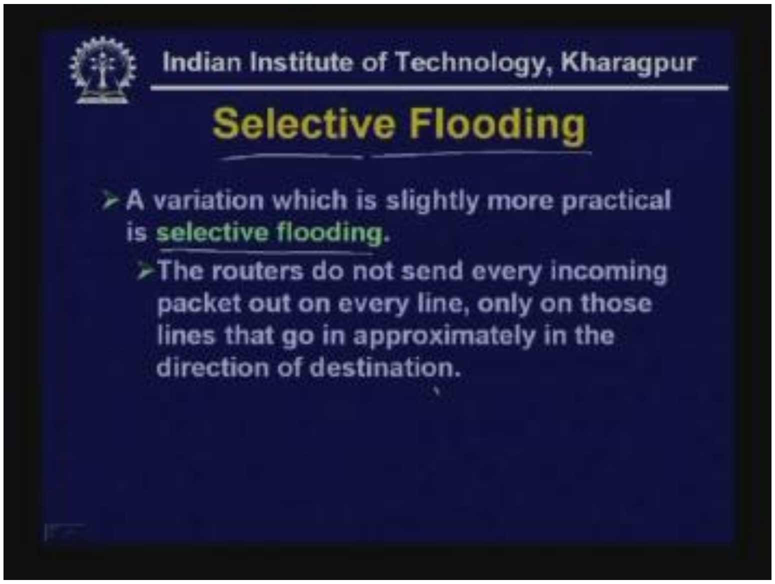

Now it may be forwarded direction in the opposite direction of the destination that is being restricted in the selective flooding technique. There what is known is in which direction the destination exist. Some weightage can be given for forwarding the packet in a particular direction so that weigthage can be used to decide whether it is going towards the destination or in the opposite direction of the destination. Thus the selective also restricts the number of packets in the network.

Hence we find that flooding has some important properties, some limitations but it has some important utilities because of the advantage. First of all flooding is highly robust and could be used to send emergency messages. for example whenever there is a war there is possibility that some of the nodes will be destroyed by the enemy, some link may be destroyed or the network topology keeps on rapidly changing or the load keeps on rapidly changing but some emergency message has to be sent to a particular destination under such case flooding technique can be used hence in military applications it is very useful. Then it can be used to initially set up the route in the virtual circuit.

As we know in the virtual circuit initially a route is set up. Question arises, how it will be set up? It can take help of the flooding algorithm to find out the best possible route. So, whenever the destination node receives the first packet with minimum delay it sends an acknowledgement with information about the routes through which the packet has gone and that can be used to set up the virtual circuit. Subsequently all other packets can be sent through the same route. And as I already mentioned flooding always chooses the shortest path since it explores every possible path in parallel. This is another important advantage and that is the reason it is too useful.

It can be useful for the dissemination of important information to all nodes. There are some situations where you have to broadcast a particular message. All the fixed routing algorithms are essentially from a source to a destination, it is not for multicasting, it is not for broadcast. But flooding can be used for broadcasting. Suppose you have to upgrade some configuration or pass on some information to all the nodes in the network in such a case flooding can be used. So we find that in spite of the disadvantages of flooding because it increases the load in the network it has many utilities because of its robustness and other advantages.

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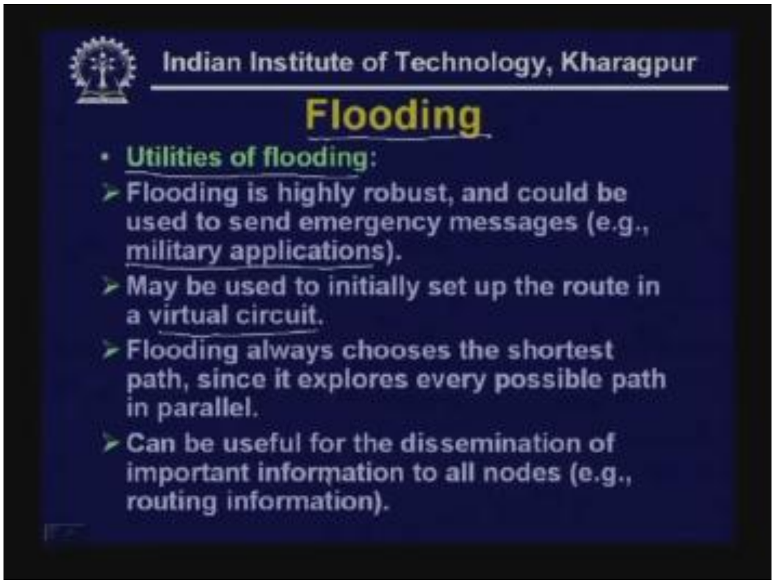

Thus in this lecture we have discussed why routing is important, what are the important features that is desired from routing, what is parameters that is used in routing and we have also discussed two important routing techniques that is fixed routing and flooding. Now let us consider some review questions.

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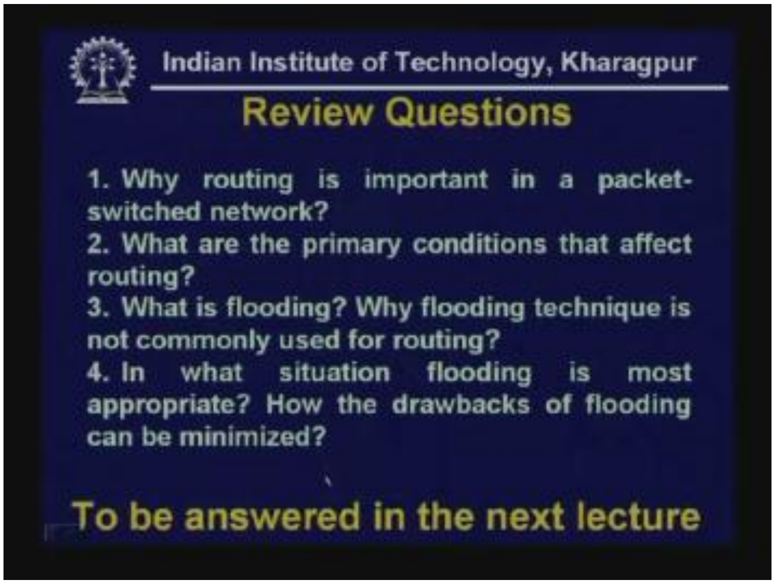

1) Why routing is important in a packet-switched network
2) What are the primary conditions that effect routing?
3) What is flooding? Why flooding technique is not commonly used for routing
4) In what situation flooding is most appropriate? How drawbacks of flooding can be minimized?

These questions will be answered in the next lecture.

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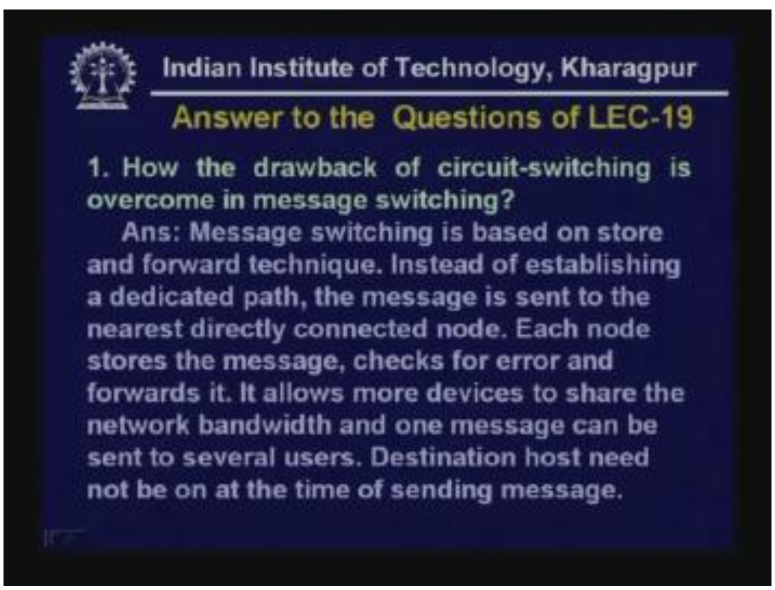

Now it is time to give the answers to the questions of lecture minus 9.

1) How the drawback of circuit switching is overcome in message switching?
Message switching is based on store and forward technique. Instead of establishing a dedicated path the message is sent to the nearest node which is directly connected. Each node stores the message, checks for error and forwards it. It allows more devices to share the network bandwidth and one message can be sent to several users. Destination host need not be on at the time of sending the message. so we find in case of circuit switching which we use in telephone network unless the destination telephone number is free and the person will be receiving the message is awake or available in the house you cannot set up a link and talk over the telephone.

On the other hand if you want sent say email, if somebody sleeping at that moment then also you can send the email so that's the difference between circuit switching and message switching. So, message switching first of all does not make full utilization of the bandwidth and the dedicated path has to be set up before sending any message which is not necessary in message switching but which is best on store and forward even when the destination node is in not on or the person using that particular node is not awake the packets can be forwarded in message switching and it will be delivered. That's how the drawback of circuit switching will overcome in message switching.

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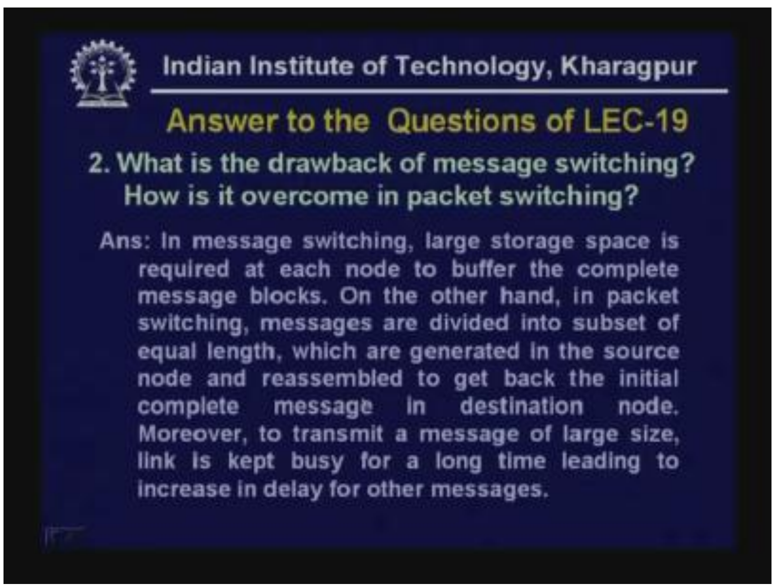

2) What is drawback of message switching? How is it overcome in packet switching?

In message switching large storage space is required at each node to buffer the complete message blocks. On the other hand in packet switching messages are divided into subset of equal length which are generated in the source node and reassembled to get back the initial complete message in destination node. Moreover, to transmit a message of large size link is kept busy for a long time leading to increase in delay for other messages.

As we have discussed in the last lecture message switching has got a number of drawbacks. First of all it monopolizes the storage. It blocks a large storage area because messages are of large size. Moreover whenever it is sent it takes very long time and as a result it monopolizes the link and also the possibility of error increases because the length of the message is long. On the other hand whenever you are doing packet switching messages are divided into smaller sizes and as a consequence possibly it does not require larger storage, it does not monopolize a link and also possibility of file transmission reduces because packets are of smaller sizes.

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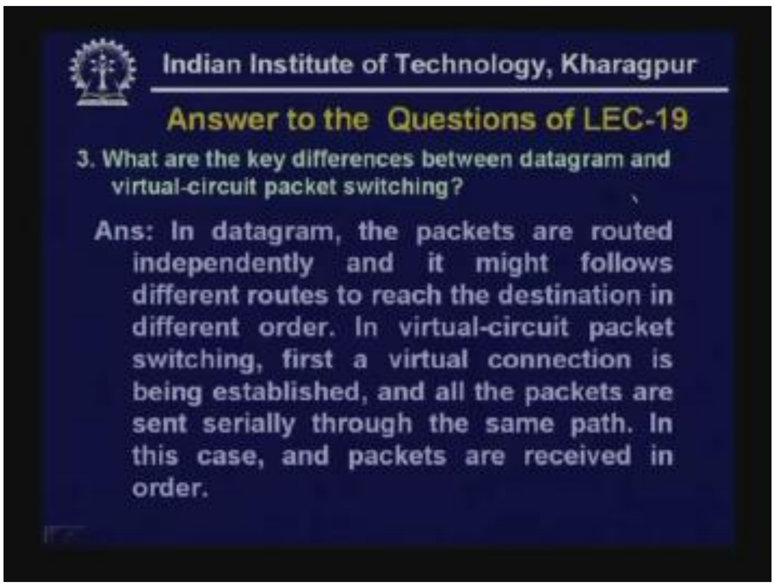

3) What are the key differences between datagram and virtual circuit packet switching?

One point that I would like to make is both datagram and virtual circuit packet switching are based on store and forward approach. However, there is a difference between the two. In datagram the packets are routed independently and it might follow different routes to reach the destination in different order. That means each packet is treated independently. So what can happen is like it happens in a postal system the different packets may go through different routes and may be delivered out of order.

On the other hand in virtual packet circuit switching first a virtual connection may established may be by flooding and all the packets are sent serially through the same path. In this case packets are received in order. So, in virtual circuit packet switching it is also store and forward approach but the only difference is that it is sent through same path and as a result the packets are delivered in order.

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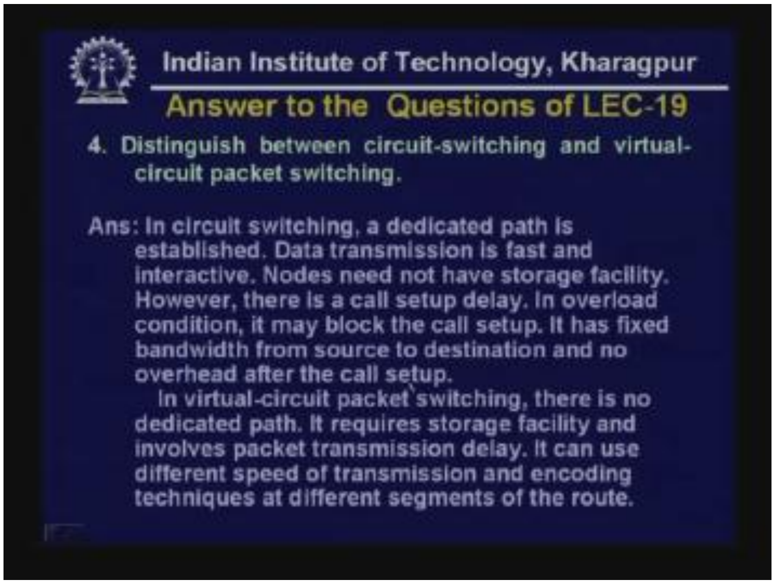

4) Distinguish between circuit switching and virtual circuit packet switching.

In circuit switching a dedicated path is established, data transmission is fast and interactive, nodes need not have storage facility however there is a call setup delay. In overload condition it may block the call setup, it has fixed bandwidth from source to destination and no overhead after the call setup so there is no extra overhead except the propagation time.

In virtual circuit packet switching there is no dedicated path, it requires storage facility and involves packet transmission delay because you are storing it and then forwarding it so there is a packet transmission delay. It can use different speed of transmission and encoding techniques at different segments of the route which cannot be done in circuit switching.

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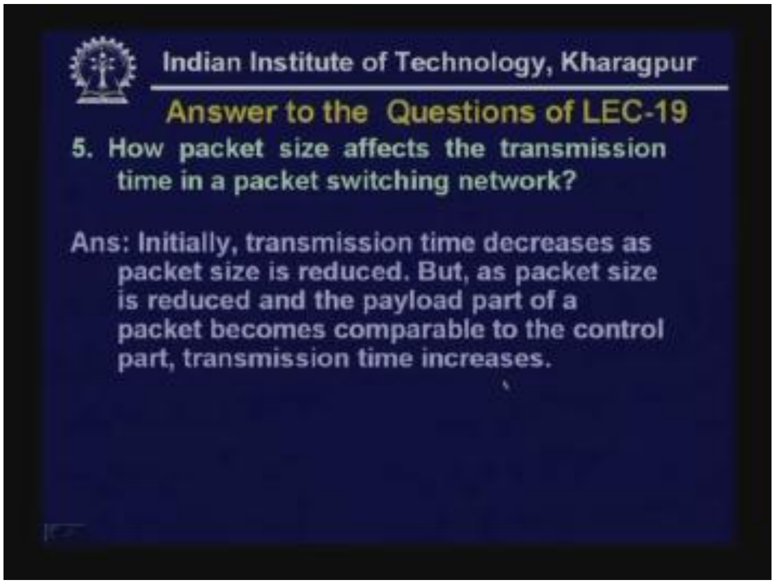

5) How packet size affects the transmission time in a packet switching network?

As I mentioned initially transmission time decreases as packet size is reduced but as packet size is reduced and the payload part of the packet becomes comparable to the control part the transmission time increases. That means if the header size becomes comparable to the payload size then the transmission time increases. This I have discussed in detail in the last lecture. So, friends with this we come to the end of today's lecture, thank you.