Wireless Ad Hoc and Sensor Networks
Prof. Sudip Misra
Department of Computer Science and Engineering
Indian Institute of Technology, Kharagpur

Lecture - 11
Multicasting in MANETs

In the previous lectures, last few lectures what we have gone through is the basics of routing in MANETs focusing on unicast aspect. So, we now look at multicasting which is a very interesting and a very important problem in MANETs. There are different challenges that are faced in adopting the existing multicasting solutions that are available for the internet for use in MANETs and we will go through some of these challenges first we look at why we cannot adopt the existing multicast routing challenges in MANETs and then we will look at some of the examples of different routing, multicast routing protocols that have been proposed for using MANETs and also the classification of these different multicast routing protocols for use in this environments.

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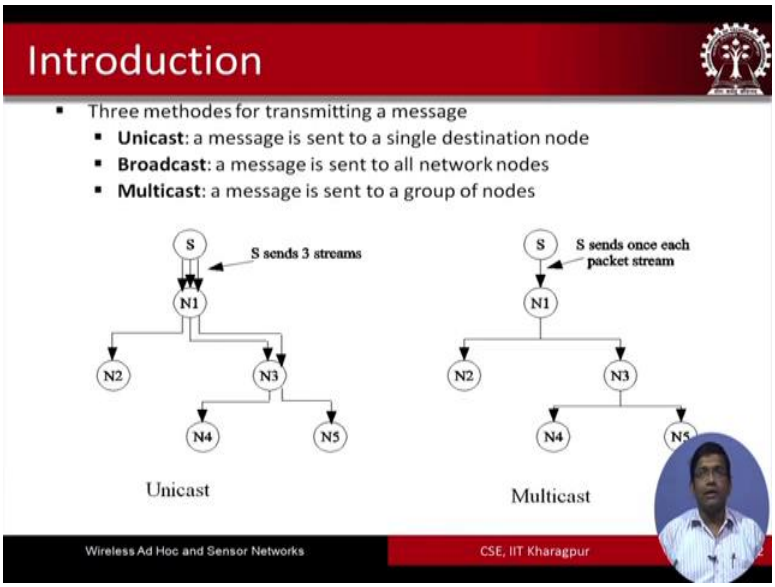

So, let us look at these figures. So, there are 3 methods for transmitting a packet - one is unicast that means, a message is sent to a single destination node as we can see in this particular figure. So, here as we can see that this is from S 1 to N 1 there is one stream from S 1 to N 2 there is another stream S 1 through N 3 another one and so on. So, this is an example of unicasting.

So, in this particular case what happens the in a case of unicasting a message is sent to a specific to a specific, a single destination node only. On the other extremity we have broadcasting where in message has to be sent to all the nodes in the network all the nodes in the network and in between we have the case of multicasting which we can see on the right hand side figure in front of us where different multicast groups exist and the source node basically has to send a packet only once and all the members of the group are going to receive a copy of the packet.

So, now we see that in this particular example we have the 2 side by side examples unicast versus multicast. In the case of multicast we have 3 sorry; in the case of unicast we have 3 nodes which are the N receiver nodes N 2, N 4 and N 5. So, for them to receive a packet there are 3 streams of packets that have to be sent from the source S for them to be able to receive the packets individually. On the contrary if multicasting is adopted then this node S will sent only once a packet stream. So, the packet stream is going to be sent only once and all these nodes are going to receive the copy of the packet they because they belong to the same group. So, this is what multicasting achieves it achieves sending a message to a group of different nodes in a more efficient manner than trying to do it in an Ad Hoc way using unicasting.

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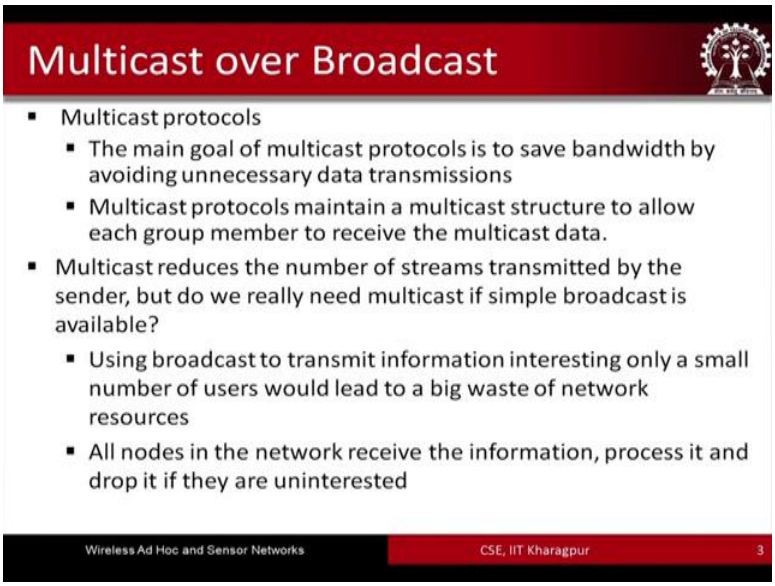

The main goal of multicast protocols is to save bandwidth by avoiding unnecessary data transmissions multicast protocols maintain a multicast structure to allow each group

member to receive the multicast data. So, multicast group the multicast structure has to be created first. So, that is an overhead that is an overhead and that basically you know once that overhead is taken; that means, the multicast group is formed then all that has to be done is that the source node has to be send to the packet and in a very efficient way in a very bandwidth saved manner the packet is going to be sent to all the members of the group.

So, multicast basically reduces the number of streams that are to be transmitted by the sender, but the question is that do we really need multicast if simple broadcast is available. So, now we are basically getting into the point that whether we should go for multicast or we should go for a broadcast because using broadcast to transmit information only if small number of users are there would lead to a big wastage of network resources. So, let me repeat. So, if there are only a small number of users. So, basically you know broadcasting would not be a very efficient solution because that would lead to bigger wastage of network resources on the contrary if multicasting is used that might be more efficient. All nodes in the network receive the information process it and drop it if they are uninterested.

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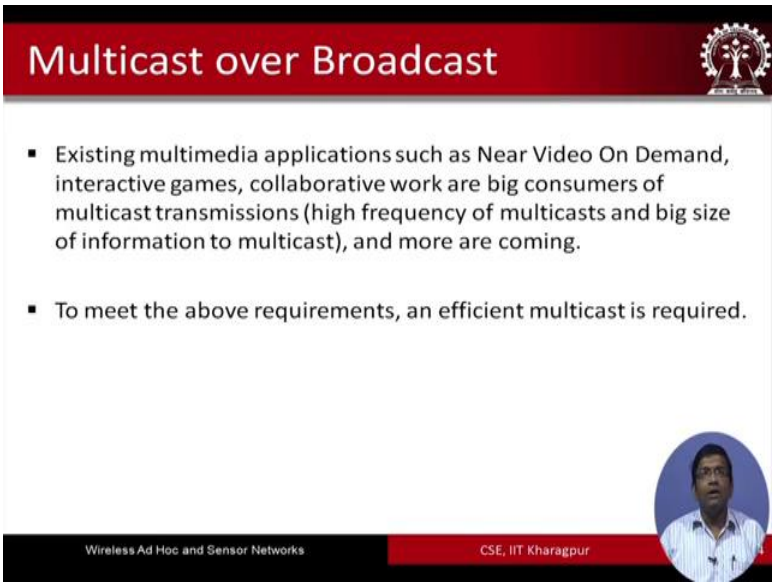

Existing multimedia applications such as near video on demand interactive games collaborative work are big consumers of multicast transmissions and there are many more different examples of multicast that are coming in the future. So, that is why

multicasting is required and we are talking about multicasting over MANETs because MANETs are goingly become popular and different attractive applications are envisaged are being planned for being used being run on top of this MANETs. So, that is why like the gaming applications, video on demand applications these are all examples of multicast applications and people are talking about running these applications on running these applications on a real MANET right. So, we need to understand how to perform multicasting in these environments.

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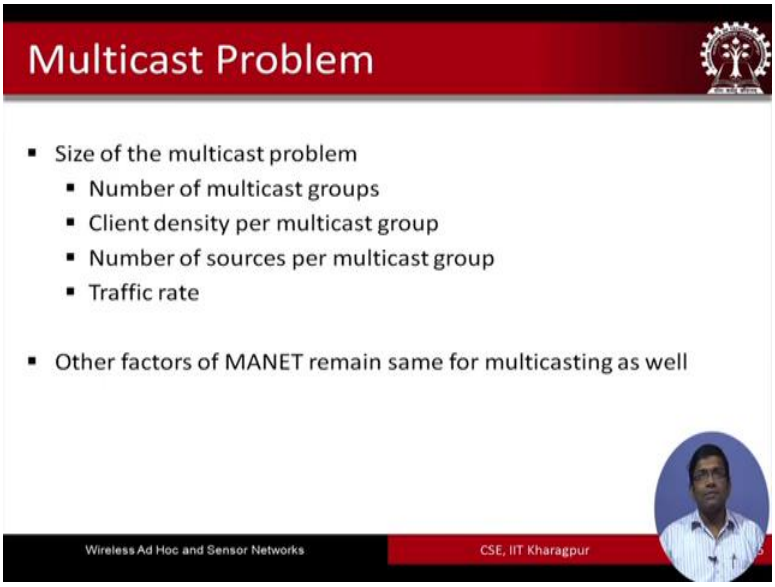

So, couple of issues when we talk about the multicast problem. The first problem has to do with the size - size with respect to again more specifically the number of multicast groups that have to be formed. I told you already that when we are talking about multicasting, basically one source node receives and all the members of the group basically consume that data right. So, then the question is that it is not one group in the whole network. So, we are talking about multiple groups. So, how many multicast groups are required, whether the groups are going to be overlapping. So, some of the nodes are going to be in both the groups and so on this is one aspect.

Client density per multicast groups; that means, that within a group how many clients you are going to keep, more, less or somewhere in between. Number of sources per multicast group, within a group one source or multiple sources, different sources pumping in different types of data or one source pumping in all different types of data

right. Traffic rate is another issue. So, there are other factors that also basically challenge multicasting in these environments.

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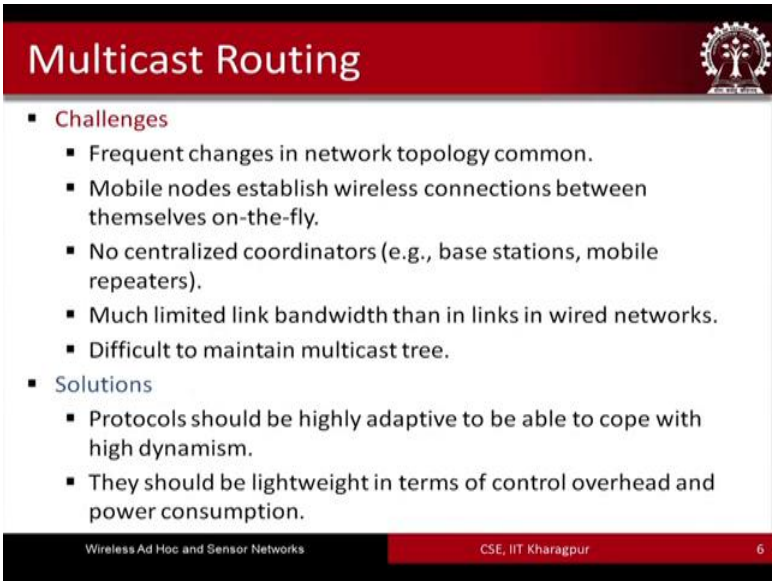

So, let us now get into the challenges more specifically. So, one thing we have seen is that in MANETs, these MANETs these networks basically have inherently a very frequently changing scenario, a frequently changing network topology where the nodes basically move quite fast and then because of the changing mobility of the nodes the wireless connections between these nodes are basically made and broken on the fly and there is no centralized coordinator who keeps track of the different topologies the changing topologies of the different of the network at different instants of time; no centralized coordinator. And on top we have a much limited link bandwidth than in the links that are experienced in wired networks or even in the other forms of wireless networks with centralized coordinators like Wi-Fi for instance. And the problem here is that we need to not only build a multicast tree or a group of trees a couple of trees, but we also intend we also need to maintain these multicast trees in this kind of challenging dynamic environment.

The solutions basically it should be in the form of protocols which have to highly adapt to the high degrees of dynamism that are experienced by these different nodes in the networks this would be light weight because too much of control overhead base protocols are not good. We have a very resource constrained environment in an

environment where power consumption is a big issue, environment where computation is also an important issue and environment where buffer is also an important issue, an environment where communication is also an important issue. So, in these environments we cannot think of having a protocol which is going to send lot of control packets all around and frequently often and try to maintain the connections of the different nodes, the multicast groups and so on.

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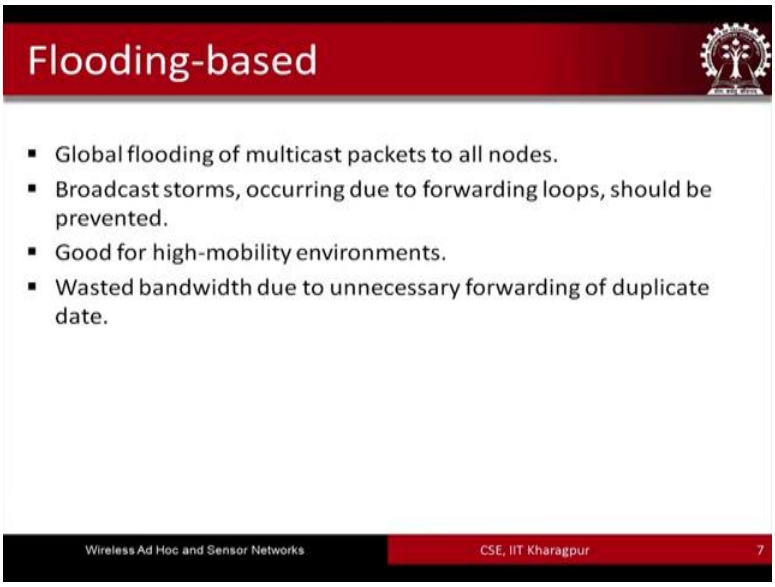

So, one way is if (Refer Time: 11:37) naive way, the naive way would be to flood flooding is an extreme form of multicasting extreme form means like you know, basically you know what you are doing is you are multicasting to all the nodes in the network that is the global fund flooding right. But as we know from our basic knowledge of networks that basic flooding is not good, it leads to the formation of something called broadcast storms, there could be different forwarding loops that could generate these storms and these are the things that should be prevented.

But keeping in mind that flooding is not so good we also have to consider that in some cases flooding is inevitable, it is inevitable because in some environments for instance high mobility environments the networks are so much mobile that the topologies are always changing. So, how can you basically create and recreate and maintain the multicast trees, the multicast structures at different points of time that basically will be rather more inefficient right. So, that is why sometimes basically flooding kind of

multicasting is inevitable, it is desirable rather to use flooding in these kind of environments and that is the one of the examples is the highly highly mobile environments highly dynamic environments.

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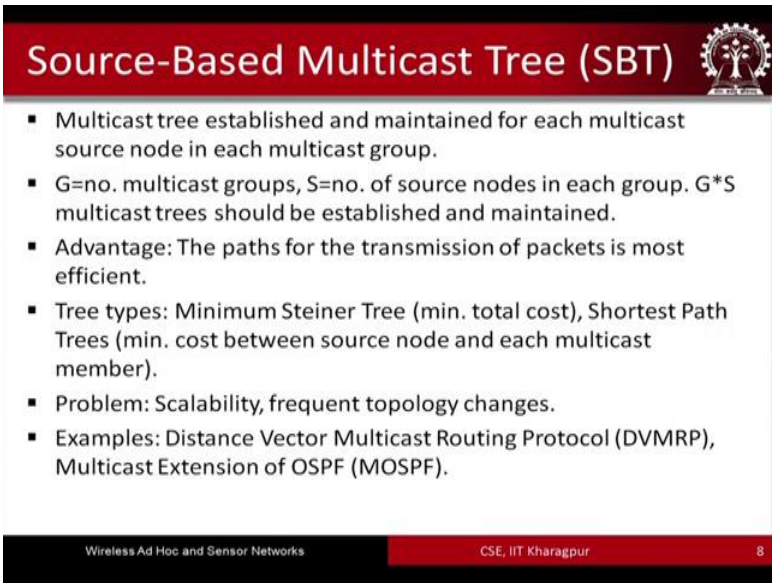

Then we have the source based multicast tree. In source base multicast tree this is the second classification of routing (Refer Time: 13:29). So, one classification of multicast routing protocols is flooding, the second is source base multicast tree where as the name suggests multicast trees are established and maintained for each multicast source node in each multicast group. So, basically we are maintaining a multicast tree structure, we are creating, we are establishing, maintaining, recreating if required and so on.

So, these basically has some advantages, but let us look at the problem the problem is that if you have g number of multicast groups for instance, S number of source nodes per group then; obviously, G times S number of multicast trees should be established and maintained. The advantage is that the paths for the transmission of packets is most efficient by adopting SBT based approaches, but the problems are with respect to scalability because if G times S number of multicast trees would have to be established and maintained and if the network is mobile the topology changes quite frequently and the network has large number of nodes. So, scalability becomes an issue. So, SBT based approaches are not good. Different types of trees can be established you can go for a minimum cost based like minimum Steiner tree kind of approach or a shortest path tree

and so on. So, that structure is unimportant, but whatever be the structure these problems are going to be encountered.

Some of the examples of SBT based classification, SBT based multicasting are DVMRP and MOSPF.

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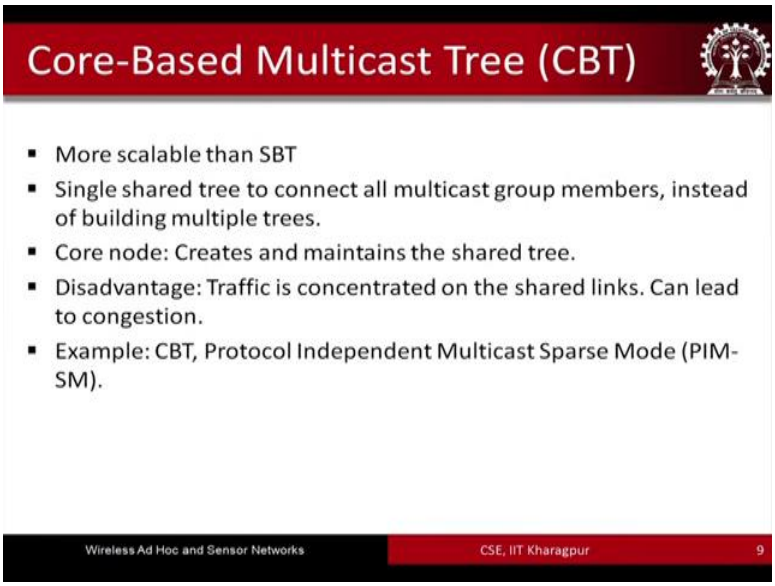

Core base multicast tree are more scalable than SBTs, here a single sheared tree is used to connect all multicast group members instead of building multiple trees. So, basically the idea is that if you want if you have a scenario where you need multiple multicast trees, it might be better rather we have a single shared tree which will form the core right. So, it will be sort of like a backbone which will form the core and the core will give connectivity to all the multicast source nodes and that is how multicasting is going to achieve, it is going to be achieved over the bigger network.

So, the core nodes basically create and maintains the shear tree, the disadvantage is the traffic is concentrated in by using this approach CBT based approach you have core nodes. So, core nodes means few nodes are going to get more congested because the traffic is going to be congested around those nodes only. So, that is a disadvantage of using CBT based approaches. So, CBT itself is a protocol. So, PIM-SM is another protocol which belong to this classification of multicast routing protocols.

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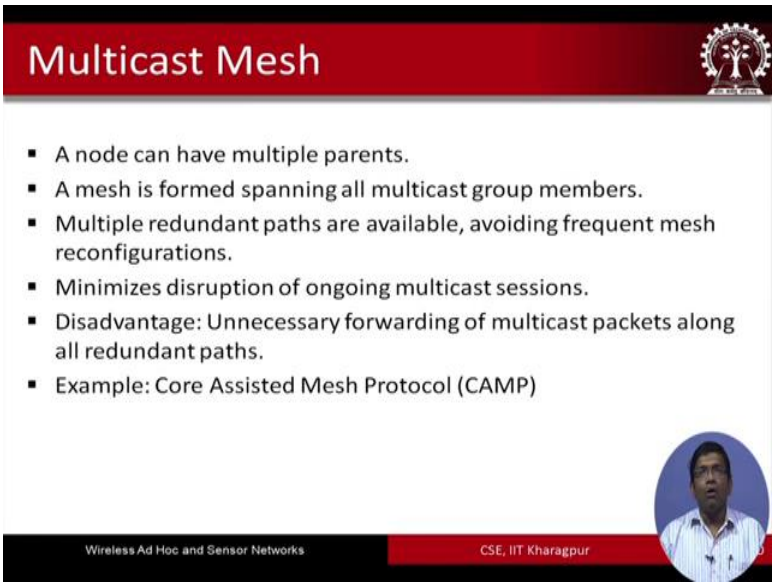

Another one is Multicast Mesh where a node can have multiple parents a mesh is formed spanning all multicast group members. So, as the name suggests, as the name suggests it is a mesh based structure that is maintained in using this kind of protocols a mesh based structure and as we know from our basic computing knowledge mesh basically, mesh structures are good because they increase the redundancy they increase redundancy, so that is good in terms of increasing the reliability of connections reliability in terms of reduced number of packet drops and so on. But as we can see that that basically is also a disadvantage because there is unnecessary forwarding of multicast packets along all redundant paths because that is the whole premise under which the mesh based any mesh based protocol works. So, basically redundancy is what is achieved using a space structures. So, camp is a protocol that belongs to the multicast mesh category.

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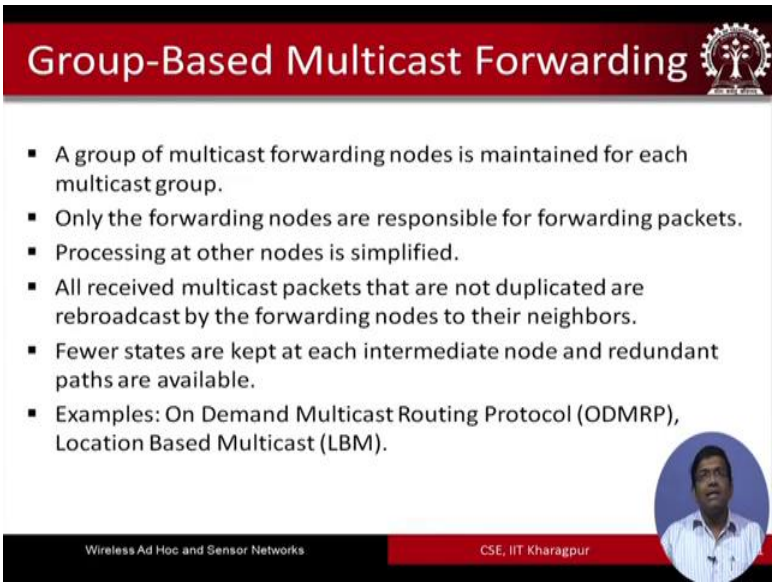

We have a group based multicast forwarding. So, where a group of multicast forwarding nodes is maintained for each multicast group only the forwarding nodes are responsible for forwarding the packets, processing at other nodes is simplified and all received multicast packets that are not duplicated or rebroadcasted by the forwarding nodes to their neighbor nodes. So, consequently fewer states are kept at each intermediate node and redundant paths are available. So, these are the different features of any group based multicast routing protocol examples belonging to this category are ODMRP and LBM.

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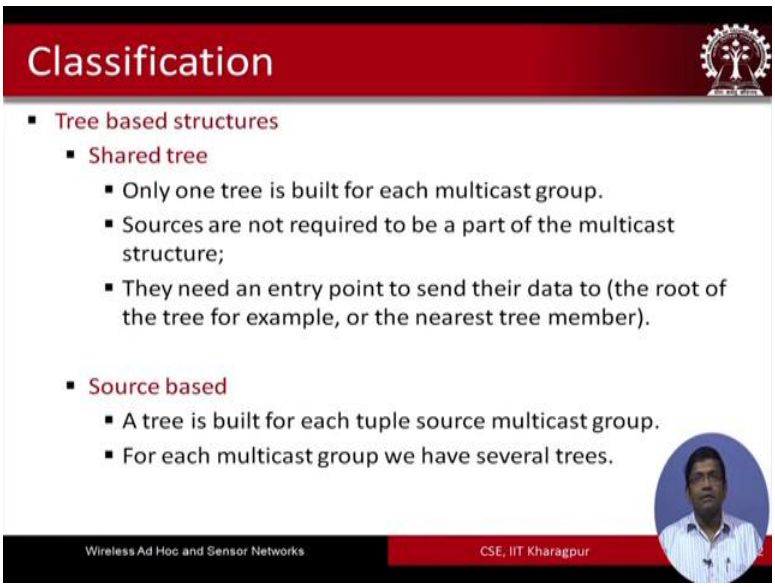

So, when we look at the tree based structure because we have seen that tree based multicasting is very popular in the internet right. So, if we look at, if we dissect little bit further the tree based structures we have a sheared tree approach and a source based tree approach. In a sheared tree only one tree is built for each multicast group and sources are not required to be part of the multicast structure they need to be, they are need to, they need an entry point to send their data to the root of the tree for example, or the nearest tree member.

On the contrary in source based a tree is built for each tuple source multicast group and for each multicast group we have several trees. So, these are the 2 broad classifications of tree based multicast structures.

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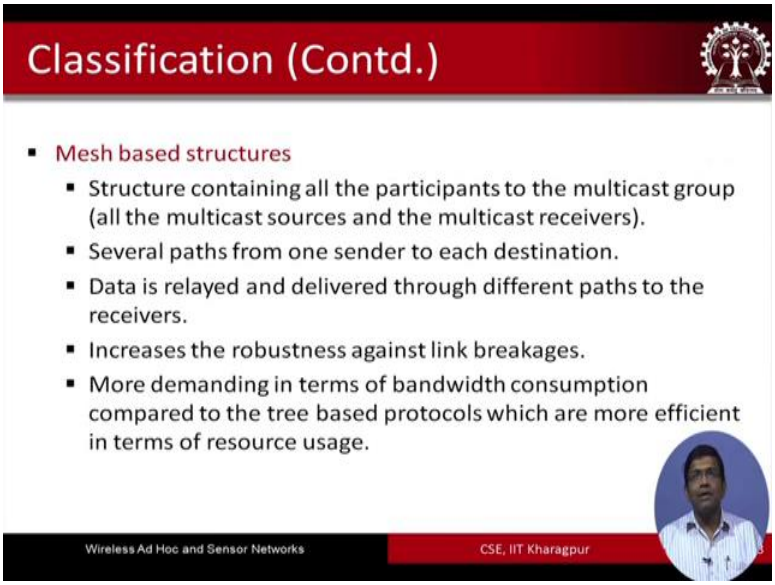

Mesh based structures I do not need to elaborate any further it is a mesh based structure that is adopted we are increasing the redundancy means we are increasing reliability, but we are also increasing at the same time the overhead because the same packet is going to flow around through a multiple links from multiple possible links from the source node from which the packet is going to MANET.

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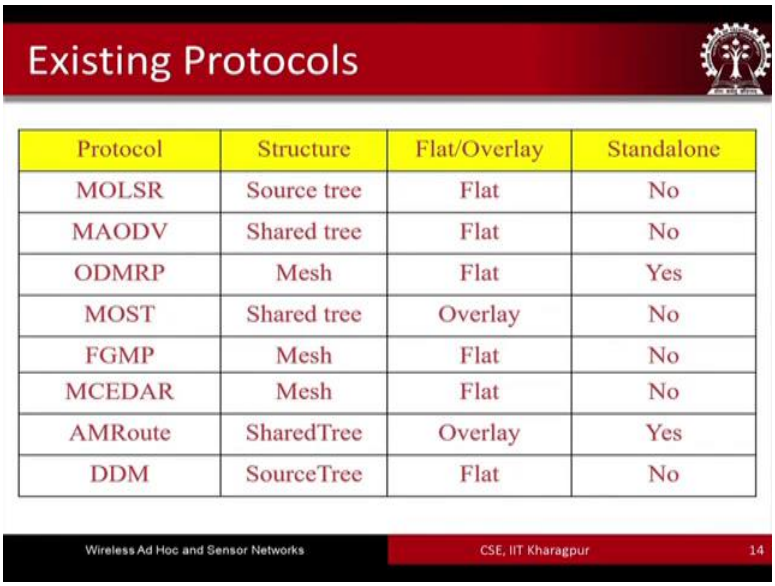

So, there are multiple routing protocols belonging to multiple, multicast routing protocols that have been proposed belonging to different categories source tree based shared tree based mesh based and so on. So, these are some of the examples that had been given MOLSR, MAODV, ODMRP, MOST, FGMP, MCEDAR, AMRoute, DDM these are just a few to name, there are likewise many many more routing protocols that have been proposed for multicasting in MANETs.

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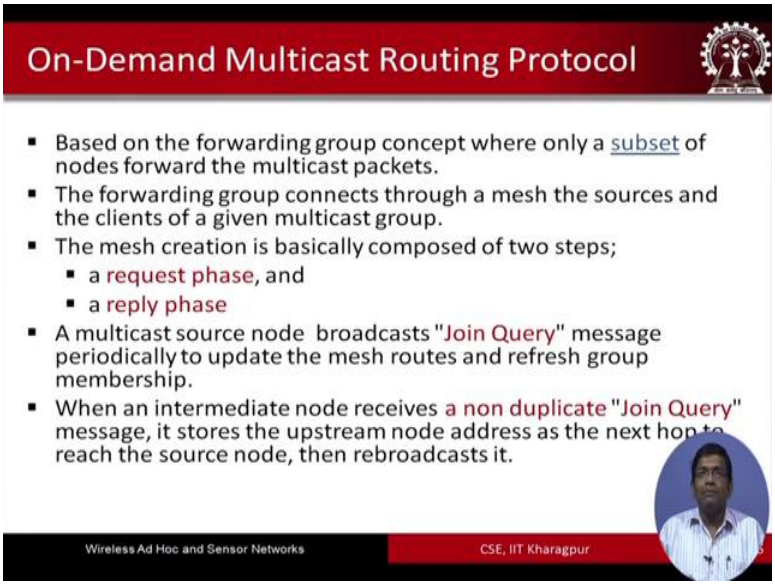

Let us now go through one routing protocol called the ODMRP. So, here basically it belongs to a group ODMRP belongs to a group based multicast strategy. So, where a multicast group is formed and it is created and this group concept is used where only subset of the nodes forward the multicast packets, not all the nodes only a subset of the nodes forward the packets. The forwarding group connects through a mesh the sources and the clients of a given multicast group the mesh creation is basically composed of 2 steps a request phase and a reply phase.

So, this is the core the heart of ODMRP, this is where ODMRP is how ODMRP functions request reply. So, request in the form of join query message and that is broadcasted periodically to update the mesh routes and refresh group membership and Join Query when an intermediate node receives a non duplicate, non join query message it stores the upstream node address as the next hop to reach the source node then rebroadcast it, because that is required because once you get the reply back you know you need to know how to send it back.

So, this is very conceptually it is very similar to the way even the reactive the general reactive unicast routing protocols work. So, here also it is very similar. So, we need to understand that it is a game it is a interplay between these 2 messages you know sending the join query getting a reply back, a join query and a reply back. So, these are the 2 messages that are used.

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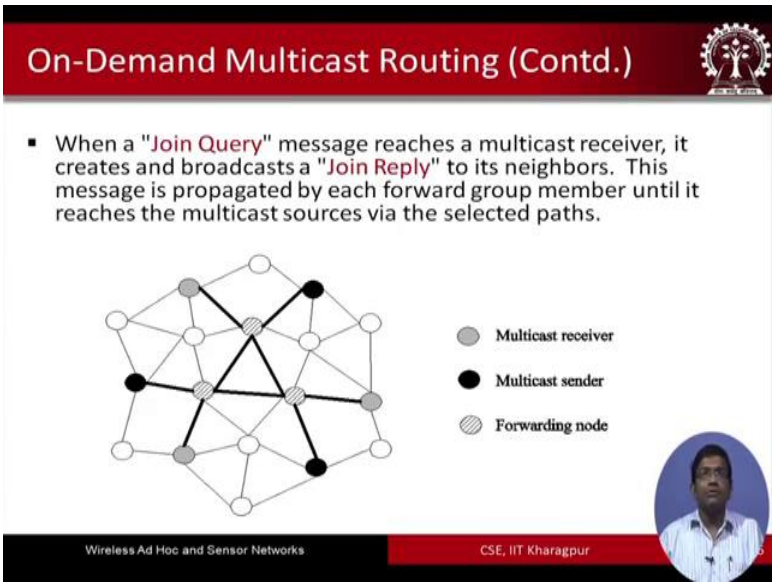

So, when a join query message. So, let us now look at this particular example. So, in this case we see that it is more like a mesh like structure with multiple redundant links from a particular node and this is the network that we have in our hand. So, here basically we have 3 classes of nodes these nodes the shaded ones, the gray colored gray shaded nodes are the multicast receivers, the dark shaded ones are the multicast senders and then we have the forwarding nodes which are the ones with which have hashed a labels in them.

So, let us now go through how these nodes they work hand in hand in order for them to together perform multicasting. So, when a joined query message we have already seen that it is a game between using join query and join reply. So, when a join query message reaches a multicast receiver. So, these are the multicast receivers to remind you. So, let us say that a joint query message is received at this multicast receiver it creates and broadcasts a join reply to its neighbors. So, these neighbors are going to get all the join reply. This message is propagated by each forwarding group member until it reaches the multicast sources via the selected paths and finally, as you can see that this multicast structure with this bold edges is formed.

So, in this multicast structure as we can see that we have these nodes the sender nodes and these are the forwarding nodes, this node is a forwarding node, this node is a forwarding node and this is a receiver node. So, sender can be sending to a receiver through the forwarding nodes this node will not forward. So, at the end of performing a ODMRP this node the hollow one, the white colored node it is not going to forward; however, this node and this node are going to forward so that the sender when it sends the packet the receiver nodes like these ones are going to receive them.

So, the source node we have multiple senders, we have multiple senders, we have of course, we have multiple receivers, but there are multiple forwarding nodes as well.

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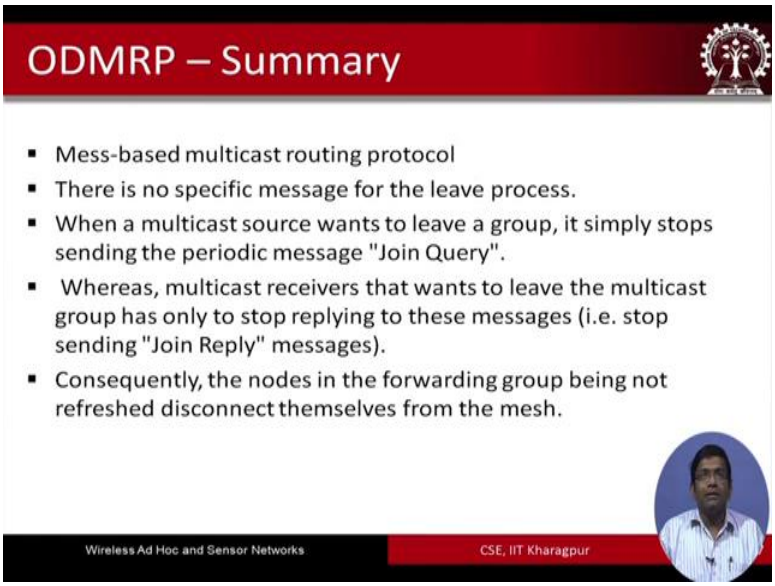

So, mesh based multicast routing is adopted. So, there is a small type way. So, it is m e s h not m e s s. There is no specific message for the (Refer Time: 25:53) process when a multicast source wants to leave a group it simply stops sending the query message whereas, multicast receivers that want to leave the multicast group has to stop sending the reply message. Consequently the nodes in the forwarding group being not refreshed will disconnect themselves from the mesh.

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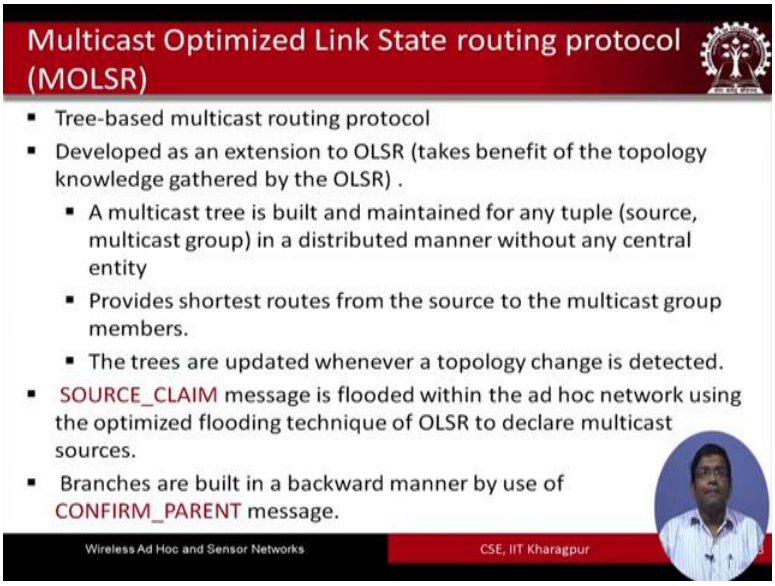

Now let us look at another one which also looks very similar. So, it is the MOLSR protocol. So, here basically the underlying unicast routing protocol. So, a multicasting is like an overlay right, it is an overlay over unicasting protocols. So, there is ultimately some unicasting routing protocols we will have to work beneath right. So, OLSR is the unicast routing protocol that is used in MOLSR. So, here basically there are 2 types of messages one is the source claim message and the other one is a confirm parent message. The source claim message is flooded within the ad hoc network using the optimized flooding technique of OLSR to declare multicast, so basically the way it is flooded is using OLSR, but it is similar kind of thing, it is a join query kind of thing right. So, here also the source claim and the branches are built in a backward manner by using the confirm parent message. So, there it was the join reply.

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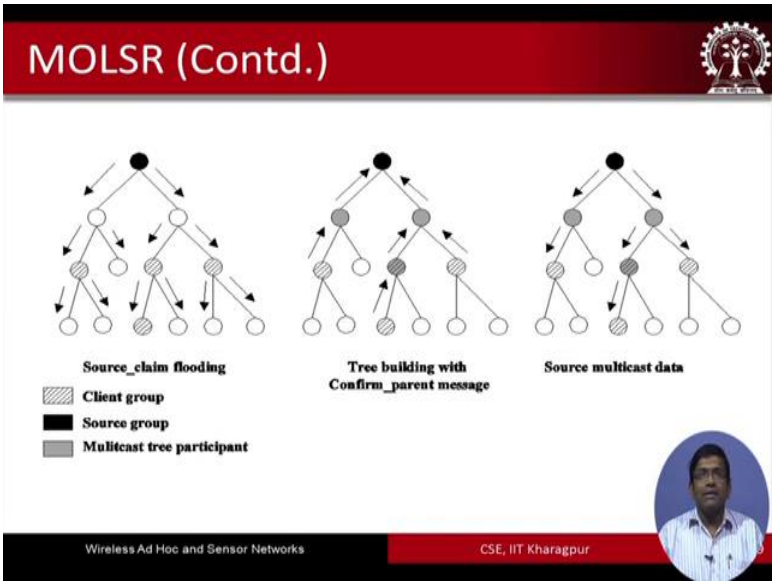

So, here as you can see we have 4 types of nodes again. So, initially we start with in this tree like structure we have the source claim message that is flooded all across in the along the nodes. So, these nodes are going to forward further likewise these ones also and so on and multicast, so this is initially how the source claim message is flooded across in the whole network. Now the nodes which forward it further; that means, which confirm, so the message was received by all, but there are only a few which sent a confirm parent message backwards.

So, as we can see over here this node did this node also did, so these basically will belong to that structure. So, these have confirmed to be participants in the multicasting whereas, these nodes the white colored ones did not send the confirmation back. So, there is not send a confirmation back means that they are not going to be part of the multicasting. So, ultimately this structure where the arrows are shown will be the one which will multicast the data that is sent from this source nodes and this becomes the multicast group, this becomes the multicast group. I hope that it is clear.

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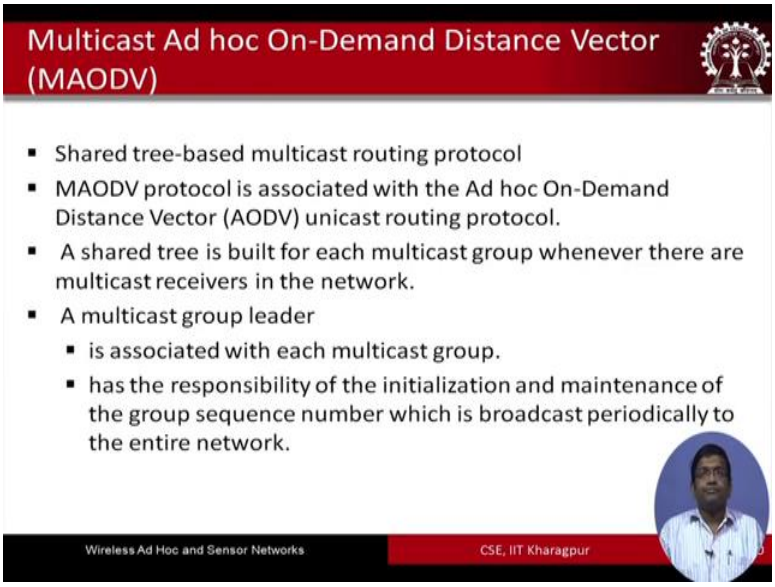

So, another protocol which is MAODV protocol which is unlike MOLSR which was based on the unicast routing protocol OLSR here is based on AODV routing protocol whereas, shear tree is AODV unicast routing protocol. So, here a shear tree is built for each multicast group whenever there are multicast receivers in the network their working principle is bit different in this case I will show you using a figure how this is different from the previous 2 instances. So, here a multicast group leader is associated with each multicast group and has the responsibility for after initialization and maintenance of the groups sequence number which is broadcast periodically to the entire network.

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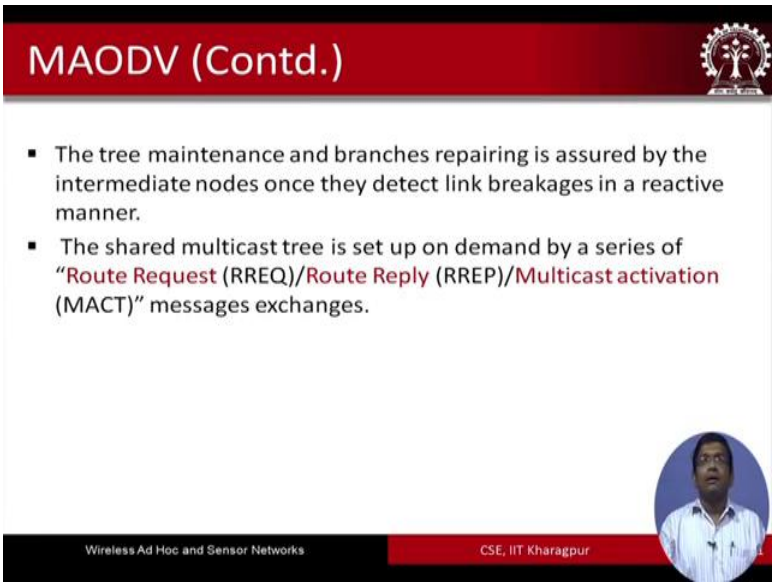

The tree maintenance and branches repairing is assured by the intermediate nodes once they detect link breakages in a reactive manner the shared multicast tree is set up on demand by a series of RREQ route requests, RREP route reply and MACT multicast activation message exchanges.

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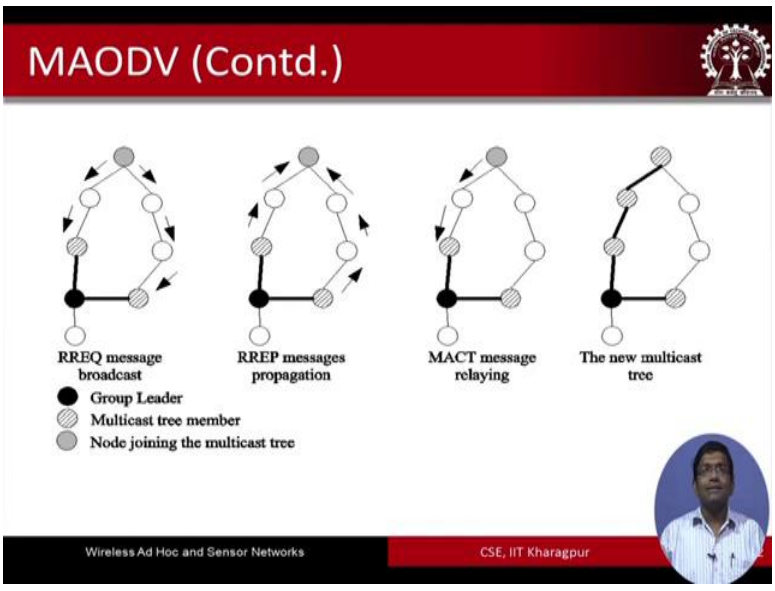

Let us now try to understand how this I told you already that the working principle is bit different from MOLSR or ODMRP right. So, let us now look at how this protocol functions. So, here as we can see in the on the left most figure, we have again four types

of nodes. So, we have this is the group leader then we have this is the dark shaded one is the group leader multicast group leader, then we have this shaded one which is basically the with the gray shaded one which is basically a node that wants to join the multicast tree and then we have the hashed ones which are the intermediate multicast tree members that are going to be used and the other nodes that are going to other nodes which are not belonging to any of these 3.

So, the route, any node which wants to join a multicast group initially in MOADV we would have to come in and they are going to broadcast with something called the route request message RREQ. Then the it is going to receive as we can see from this figure that it is going to this node is going to receive the RREP messages and the direction of RREP versus RREQ are shown which is opposite and thereafter some of these nodes are activated which basically relays the message and consequently at the end we have multicast tree that is formed and this is how the multicast tree looks like.

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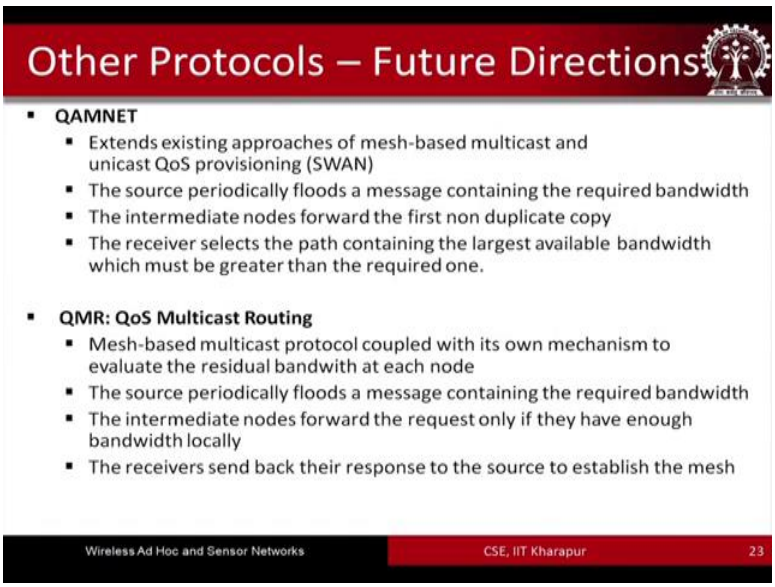

So, now we are not going to go through any of the other multicast routing protocols in further detail, but I would just like to mention that there are many others few of them are given over here. QAMNET is a multicast routing protocol; QMR is another multicast routing protocol which basically is based on quality of service guarantees. So, QoS multicast routing protocol is the full form of QMR.

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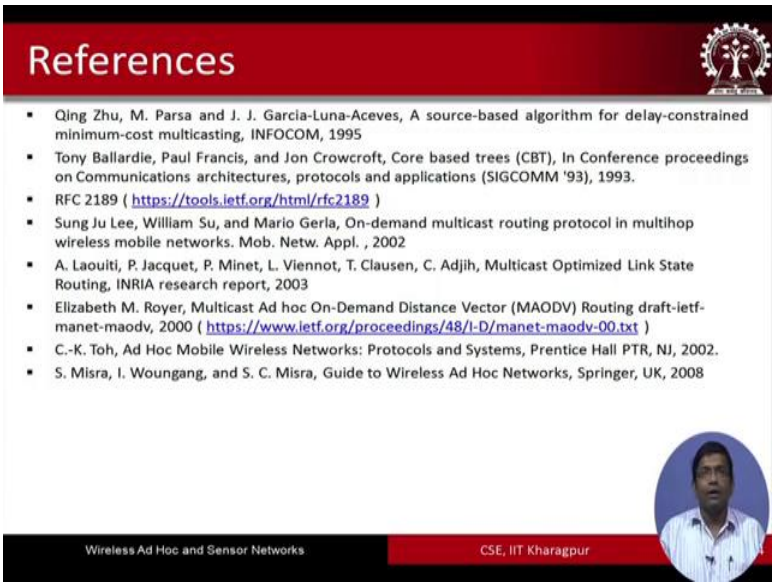

So, with this we come to an end some of these protocols that we have shown the features of which we have covered we have mind you that as I told in a previous routing protocol lecture that we do not intend to, we do not even (Refer Time: 33:41) require the students to know each and every protocol and its steps the different finer steps in detail that is not required, but what is required rather is to know the different features and the properties of these protocols, the environment in which each of these protocols are supposed to work whether it is a mesh based protocol or whether it is a group based protocol and then broadly how the protocol works. So, this is what I attempted to ensure through these lectures to propagate the knowledge about this particular aspects. So, the last slide basically showed all these different references and with this we come to an end of this lecture.

Thank you.