Wireless Ad Hoc and Sensor Networks
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Lecture - 09
Routing in MANETs-Part-II

So, we now start the second part of the topic routing in MANETs. We have already seen in the different classification of routing protocols, different routing protocols, proactive, reactive, and hybrid. We have also seen one routing protocol belonging to the proactive category the DSTV routing protocol. Let us now continue and look at the other reactive routing protocols first, and thereafter will look into the other class of routing protocols, the reactive routing protocols, and the hybrid routing protocols.

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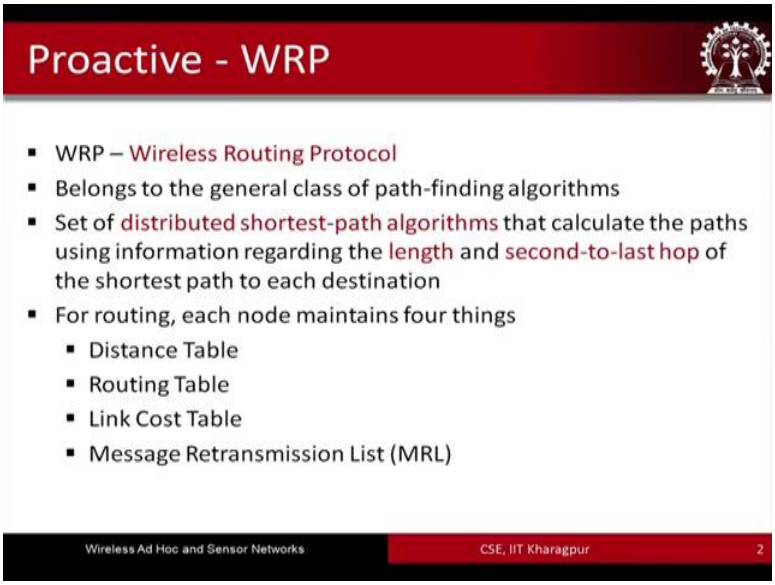

So, the next routing protocol is the proactive routing protocol- WRP which is Wireless Routing Protocol. It belongs to the general class of path finding algorithms. And here it basically finds a set of distributed shortest path algorithms that calculates the paths using information regarding the length and the second to last hop of the shortest path to each destination. So, here basically each node maintains four different things, four tables, four different types of tables, four different types of information.

So, WRP is conceptually similar because it is again another proactive routing protocol, so it is conceptually quite similar to DSTV. But the different types of information that

are maintained are different as you will be able to appreciate soon. And the whole premise under which it works is also bit different. So, what are these different types of information that I maintain? The first thing is the distance table, the second is the routing table, the third is the link-cost-table, and the fourth is the Message Retransmission List MRL.

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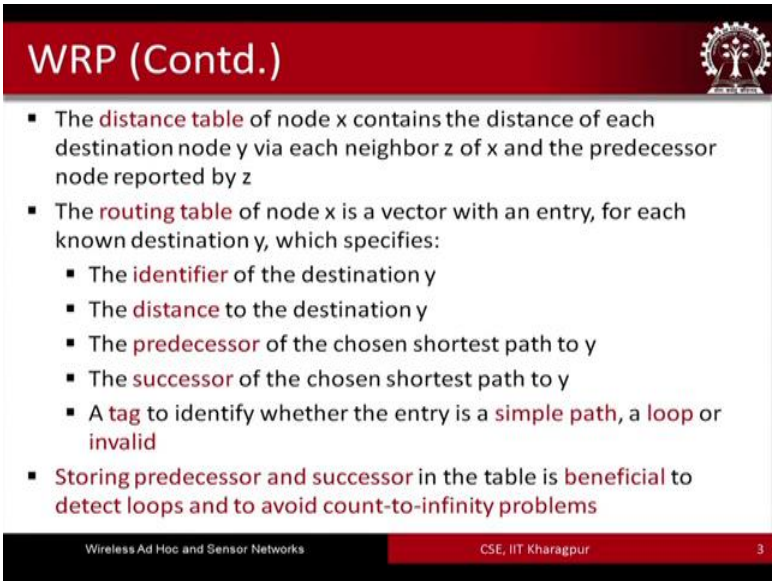

The distance table of any node basically contains the distance of each destination node via each neighbor of that previous node and the predecessor that is reported by the neighbor node. So, let me just repeat this once again.

The destination table of a node x contains the distance of each destination node y via each neighbor z of x and the predecessor node reported by z. The routing table of each node x is a vector with, so this was the distance table now we are getting into the routing table. So, routing table of a node x is the vector with an entry for each known destination y which specifies: the identifier of the destination y, the distance to the destination y, the predecessor of the chosen shortest path to y, the successor of the chosen shortest path to y, and a tag to identify whether the entry is a simple path a loop or is invalid.

So, you must have noticed that there are two entries: the predecessor and the successor. These predecessor and the successor information in a table or store because it is very beneficial, is information will be beneficial in detecting the loops and avoiding the popular count to infinity problem; account infinity problem is something I am not

repeating here assuming that you have the basics basic knowledge of routing in the internet where discount to a particularly with distance vector routing you know specifically with distance vector routing the count to infinity problem arises.

So, I am not going to elaborate this further.

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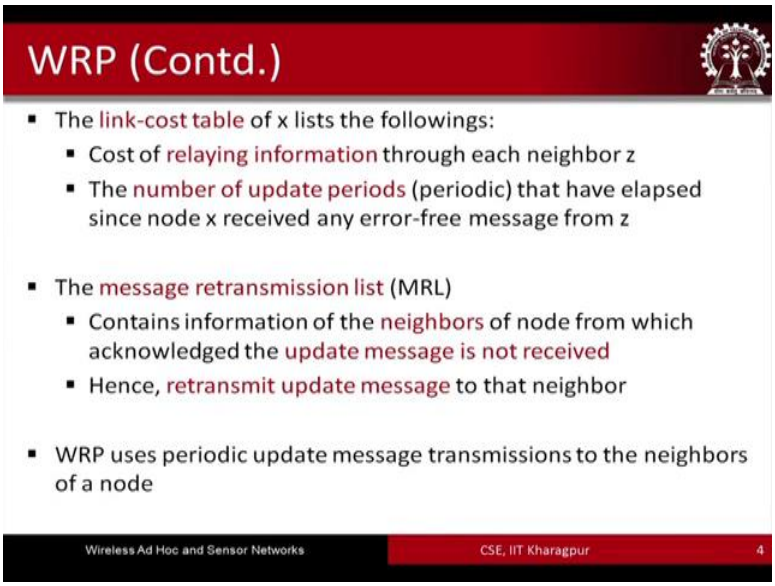

So, the third table is a link-cost-table. And the link a stable of x lists the following: the cost of relaying information through each neighbor z, the number of update periods that have elapsed since node x received any error free message from z. So, these are the two main things that the link costs table contents.

And the last one is the last information that is stored is the message retransmission list which basically contains the information of the neighbors of node from which acknowledged the update message is not received. Hence, returnsmit the update message to that neighbor. So, WRP this particular protocol uses a periodic update message transmission to the neighbors of the node in order to apprise them about the changes in the information contained in each of these tables.

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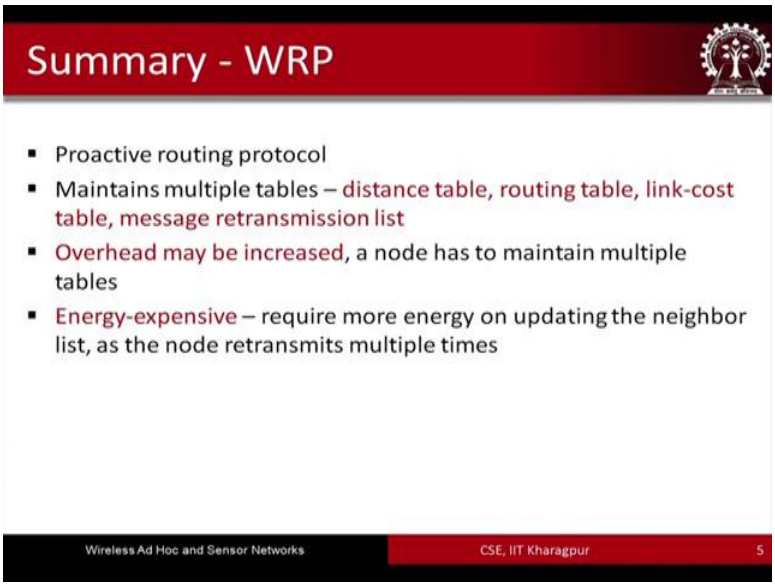

So, it is a proactive routing protocol in summary. It maintains different, information different tables, and lists distance table, routing table, link-cost-table and message retransmission list. Overhead may be increased as a node has to maintain multiple tables which was if you recall not the case with DSTV; DSTV was much more simpler, because there you are maintaining only a single table. And now you have increased, WRP has increased the number of tables.

And it is more energy expensive; it requires more energy, because more updates, more lists, more updates, more energy consumption and this is a drawback of using WRP over DSTV.

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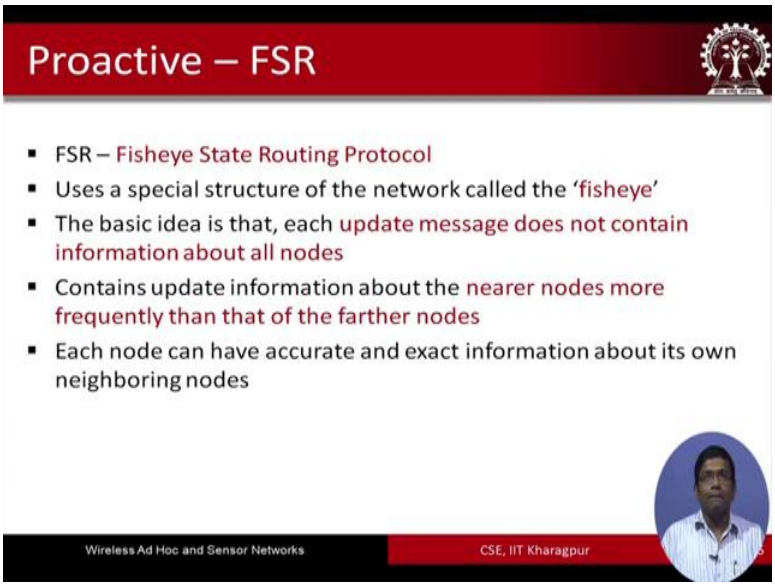

Another proactive routing protocol is known as the FSR- the Fisheye State Routing Protocol. The name fisheye state routing protocol is due to the fact that this routing protocol uses special structure of the network which basically looks similar to a fisheye. And I will show you how it looks, and then you can probably appreciate that why it is known as a fisheye state routing protocol.

Here basically the basic idea of this fisheye structure and overall premise under which this particular protocol works is that each update message does not contain information about all nodes. So, that is why which nodes are going to be updated at which times. So, basically what if FSR serve states is that the updates should be done more frequently to the nearer nodes then the further nodes. So, this is an assumption, this is an observation, this is the underlying assumption under which this protocol the FSR protocol works.

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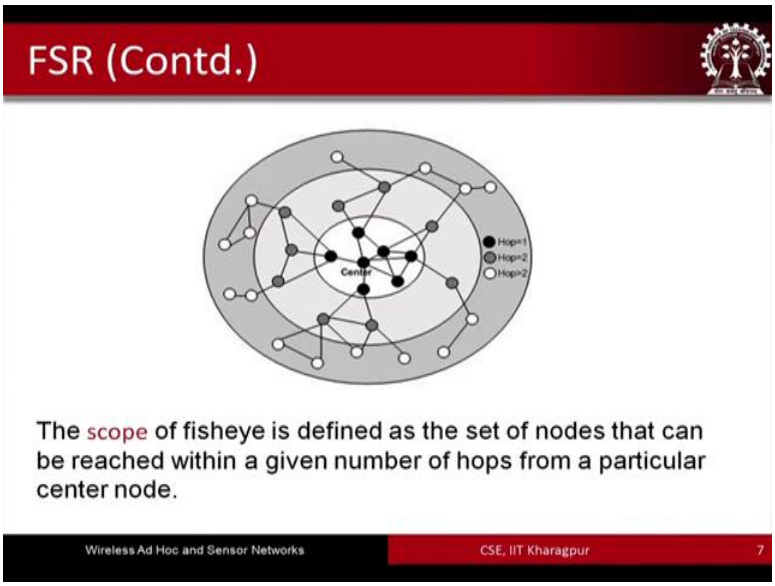

So, I already promised to you in the previous slide that I will show you the structure; fisheye structure that is basically assumed in the FSR protocol. And this is what you see; I hope that by looking at this figure you can understand that this structure basically looks like a fisheye. And this structure basically gives the name fisheye state routing to this particular protocol.

The scope of fisheye is defined as the set of nodes that can be reached within a given number of hops from a particular center node. So, now let us look at more closely at this figure. We have a center node, and we have a couple of its neighbors. So, we have one zone kind of, then surrounding it we have another zone, then a third zone and so on. So, the entire thing looks like a fisheye. So, basically when you are updating, you we are sending the updates these nodes within a particular zone are going to get more frequently updated than the nodes outside.

And how do you determine that how these zones are going to be demarcated? It is basically a preconfigured, a predefined, a given number of hops that determines the zones of these networks.

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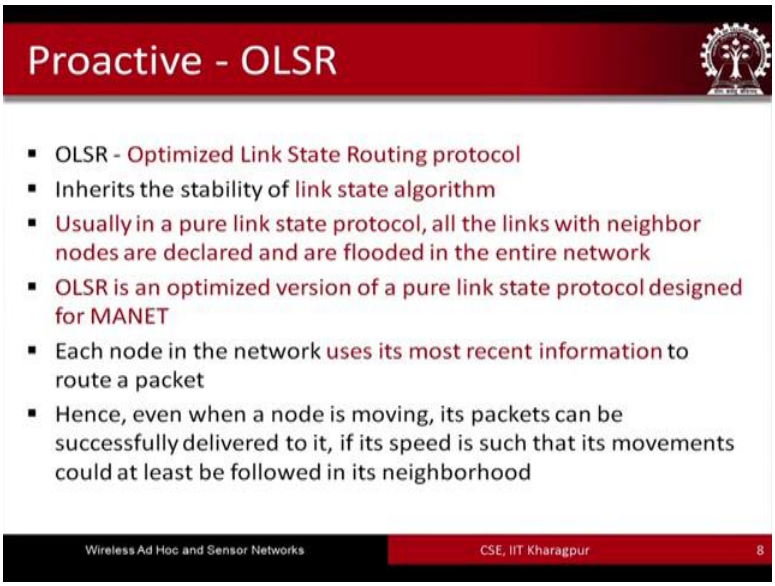

So, that was the FSR protocol? And we have looked at some of the features, I already told you before that we are going to focus at only the features of some of these protocols; the operational functionalities the highlights of these protocols. And not each of these protocols and detail because I believe that that is not required at this stage.

Now, let us look at another very popular protocol which is a proactive routing protocol again known as the OLSR protocol. The full form of which is Optimized Link State Routing protocol. This protocol inhales the stability of the link state algorithm. So, as you can recall from the internet routing there are two main classes of routing protocols: one is called the link state routing, the other is called the distance vector routing. So, OLSR basically belongs to the link state routing protocol, whereas DSTV belongs to distance vector routing. Because, you know they are actually you use sequence number, hops, number of hops, and so on and so forth.

So, here basically it is the link state, it belongs to the class of link state routing protocol. So, usually in a pure link state routing protocol all the links with neighbor nodes are declared and are flooded in the entire network. So, what OLSR does is it is also doing the similar kind of thing, but it basically does not flood the entire network, but it goes in an optimized manner. So, it is an optimized version of the pure link state routing protocol that is designed for MANETs. So, here each in node in the network uses its most recent information to route a packet.

Hence even when a node is moving its packets can be successfully delivered to it. If it is speed is such that the movements could be at least followed in the in its neighborhood.

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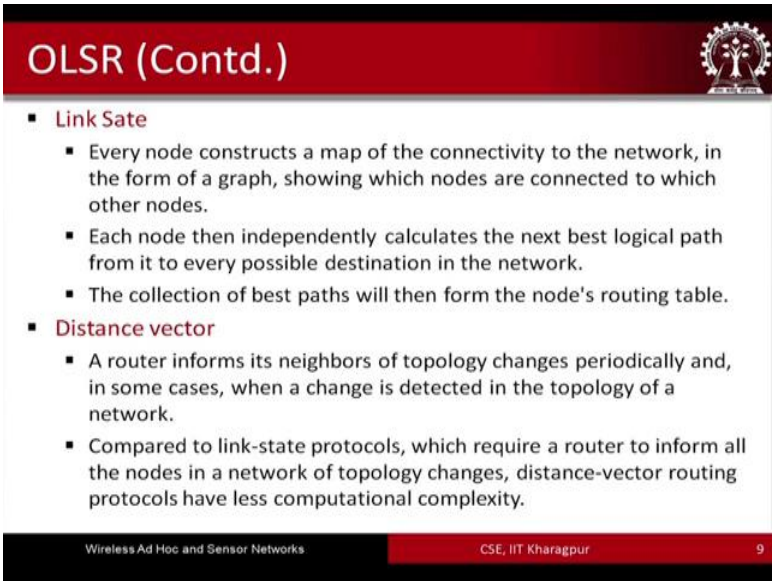

So, I think I will skip this part, and I will leave it for you to go through. Because this is just a recap of the difference between link state routing and distance vector routing. And both of these classes of routing protocols we have already covered. OLSR is a link state routing protocol, an optimized link state routing protocol: distance vector routing DSTV WRP these belong to the distance vector routing categories.

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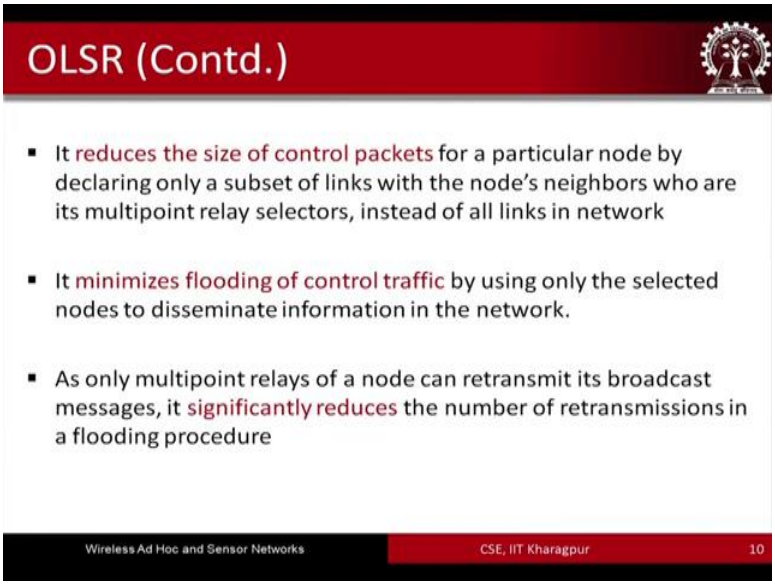

So, OLSR reduces the size of control packets for a particular node by declaring only a subset of the links with the nodes neighbors who are its multi point relay selectors instead of all links in the network. So, what it does is it attempts to optimize the flooding more specifically minimize the flooding of control traffic. So, what it will do, I will show you that it will designate some of the nodes in the network as something the term as the multi point relays. And what happens is only the multi point relays will be required to retransmit the broadcast messages, and the other nodes in the network who are also going to receive the packet if they receive they are not going to retransmit further.

As we can understand that it basically is trying to cut down upon the number of retransmissions that are going to be required in the flooding procedure. So, it is basically minimizing the flooding of control packets, minimizing, reducing the number of packets there are going to flowing all around. Why it is doing it? Again the resource constraints; we have a resource constrained environment, we cannot have so many packets flowing all around, cut down on it.

Select some nodes which have higher chances of delivering the packets to the rest of the network and deliver to them only; cut down on the number of repetitions, cut down on the number of nodes which are going to be repeating or forwarding the packets forward.

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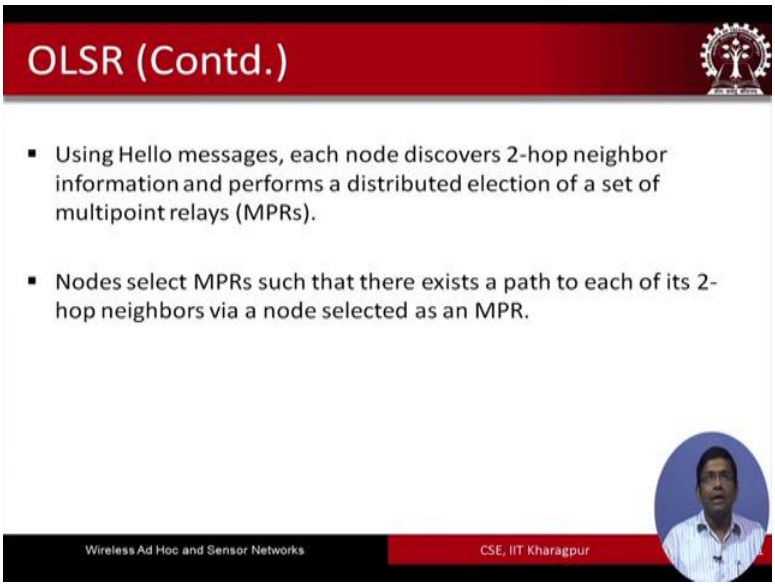

So, OLSR uses a Hello message, where each node discovers the 2-hop neighbor information and performs distributed election of a set of multi point listen. This is what I

was telling you that; that basically you know what it does is it will designate some of these nodes as the MPRs- the multi point relays. And these MPRs can be selected as 2-hop neighbors (Refer Time: 14:24) is that you know. So, I will show you how the MPRs are selected.

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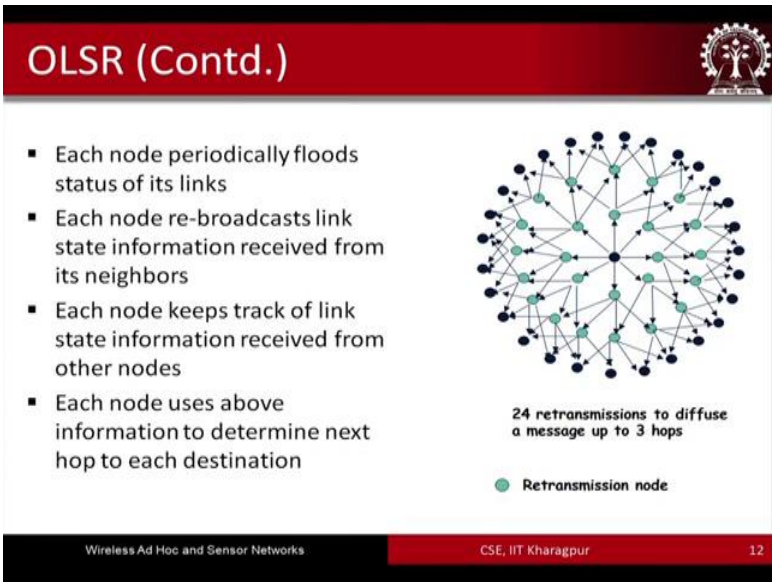

So, the nodes basically select the MPRs such that there exist a path to each of the 2-hop neighbors of a particular node via a node that is selected as an MPR. Here this is the scenario that we look at. So, let us look at this particular figure. So, here what we have is we have a central node and the central node basically if it broadcasts a packet. Then this is what is going to happen. We are going to be flooded with the number of packets that are going to be flowing all around.

So, each node basically floods periodically the status of its links. And then each node rebroadcasts the link state information received from its neighbors. And each node keeps the track of the link state information receive from the other nodes. And then uses the above information to determine the next hop to each destination.

So, as we can see in this figure from the central node outwards we have we encounter number of other colored nodes, these nodes which are the retransmitting nodes. These nodes basically they are forwarding the packets that are received to them they are going to retransmit the packets.

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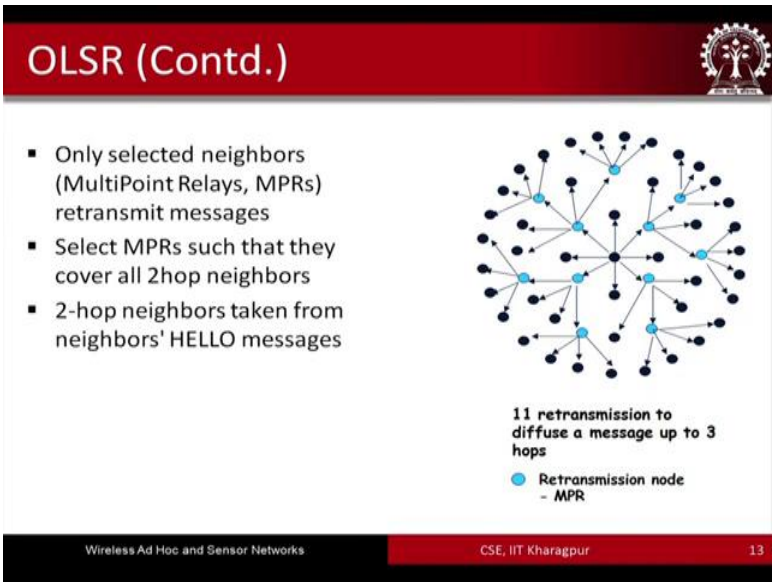

So, essentially what happens is that OLSR selects some of these nodes and terms them as the MPRs. These MPRs are the retransmitting nodes- multipoint relays the blue colored ones. So, in contrast to the previous scenario that we have seen this is the normal scenario. So, OLSR what it does is it reduces the number of retransmissions in this particular manner. And the way the MPRs selected is something that I have already told you. So, the MPRs selected such that these MPRs cover all to hop neighbors. And these 2-hop neighbors basically are taken from the neighbors HELLO messages.

So, this is the scenario, this is how the overall number of packets flowing all around is cut down upon.

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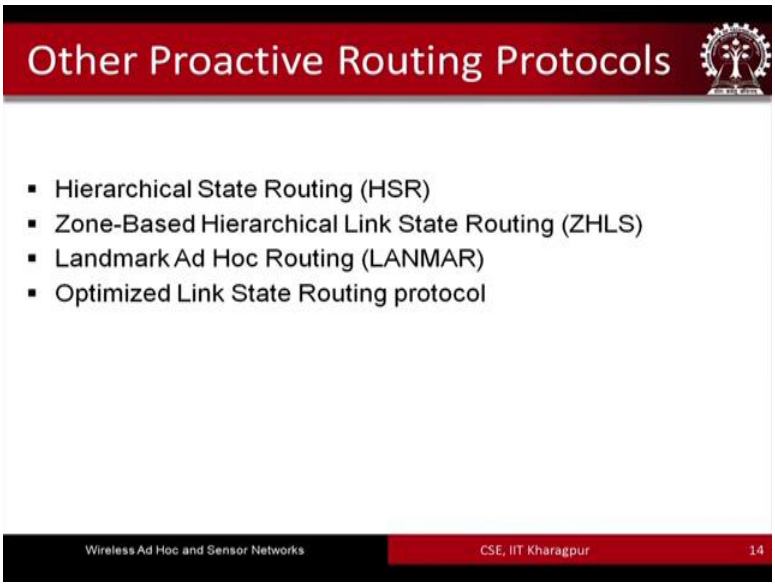

Their other proactive routing protocols that we are not going through, but there are many many many more which are available. Here are only a few others that I mentioned the names. I mentioned one is the Hierarchical State Routing protocol HSR, ZHLS- Zone-Based Hierarchical Link State routing protocol, LNMAR- Landmark Ad Hoc Routing protocol, Optimized Link State Routing protocol and so on. As I told you let me repeat once again that proactive routing protocols, reactive routing protocols for MANETs you know there are several such routing protocols that have been proposed in the literature. And the authors the respective authors they claim superiority of their protocols over others typically. And this is how there are so many different routing protocols that have been proposed.

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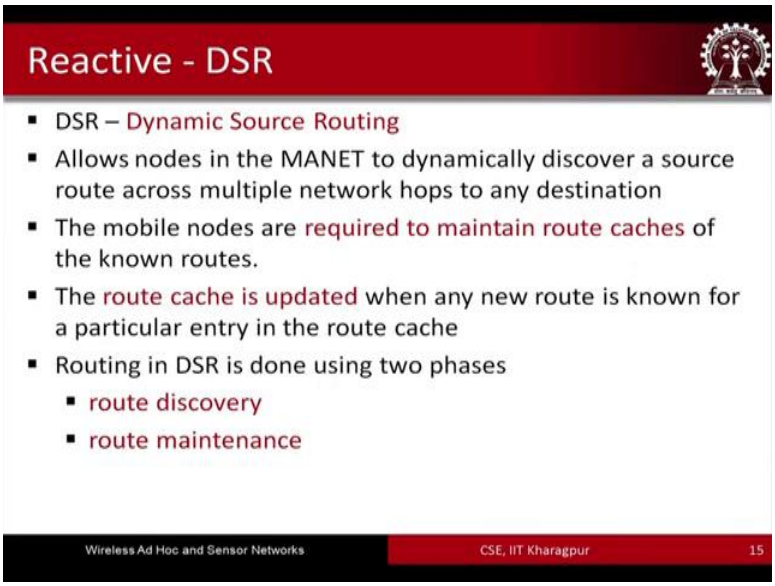

Now, let us look at the other class of routing protocols; the reactive routing protocols. The first reactive routing protocol that we are going to go through is known as the DSR routing protocol. The full form of which is the Dynamic Source Routing protocol. And remember one thing as this name suggests and we will revisit this once again that this dynamic source routing protocol as the name suggests is a source routing protocol. So, this is a source routing protocol. And this is what basically if it a distinct identity.

So, DSR and there are a few other reactive routing protocols that are already implemented in many practical implementations of these networks, and even in sensor networks. So, these are so popular, these are so much primitive and popular that they have already been adopted in many practical implementations. DSR basically allows the nodes in the network to dynamically discover a source route across multiple network hops to any destination. And I will show you I will explain to you how it works.

The mobile nodes are required to maintain the route caches of the known routes. The route cache is updated when any new route is known for a particular entry in the route cache. Routing in DSR is achieved in two phases: the first phase is called the route discovery phase, the other one is called the route maintenance phase. And this as you will see later on is a typical approach for most of the routing protocols if not all which belong to the reactive category.

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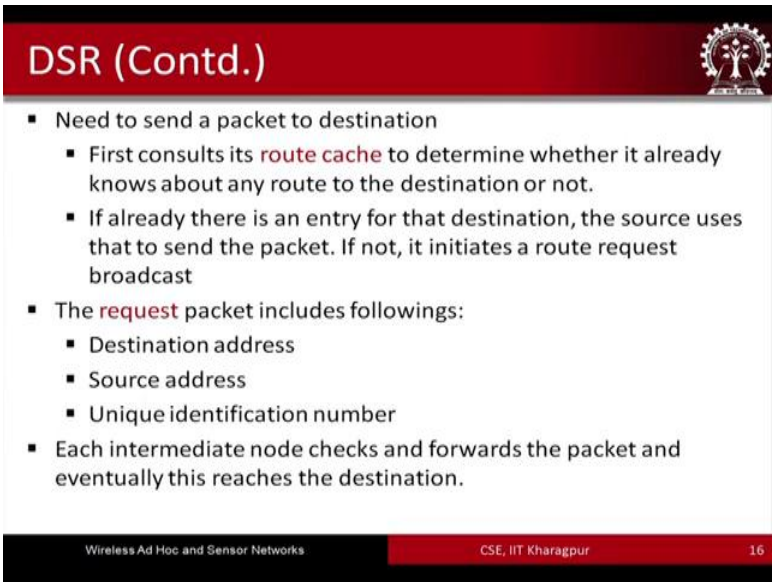

So, DSR basically you know what is required is to there is a need to send a packet to the destination. So, if there is a need to send a packet to the destination, DSR basically first consults the route cache to determine whether it already knows about any route to the destination or not. If already there is an entry for the destination the source uses that to send the packet, if it is not available it initiates a route request broadcast. The request packet includes the following: destination address, source address, unique identification number.

So, each intermediate node checks and forwards the packet and eventually this which is the destination. So, this is basically not required to go through all of these. So, source destination is something that is I understood, unique identification number you know it is a requirement for certain reasons we do not we can skip this for now.

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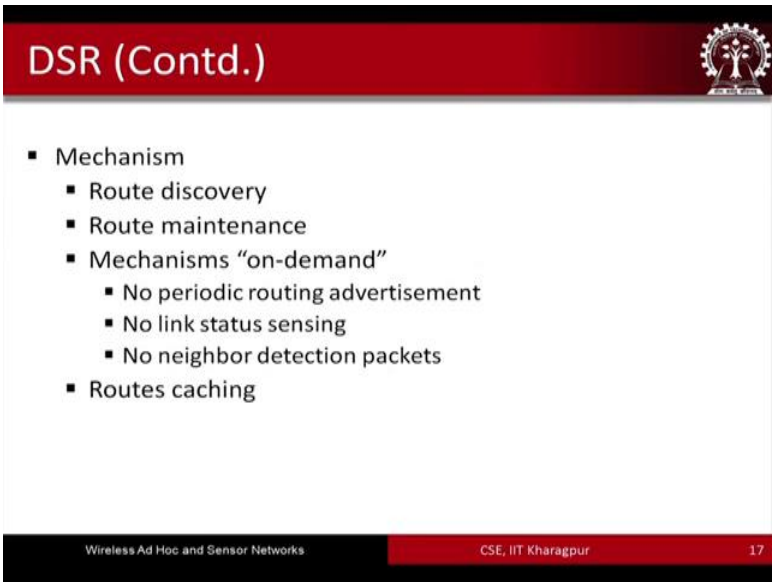

So, the way DSR works the mechanism is route discovery and route maintenance. So, first the routes have to be discovered if it is not already found in the route cache. And once it is discovered, it is maintained, it is used for routing all the different packets until the existing routes that were discovered are deemed to be invalid.

So, what are the mechanisms for this on demand feature? So, basically there is no periodic routing advertisement like in the case of DSTV or other routing protocol proactive routing protocols. There is no link status sensing, there is no neighbor detection packets. So, all of which were something that you would typically find if you were using a proactive routing protocol. And there is routes which are cache at the different nodes.

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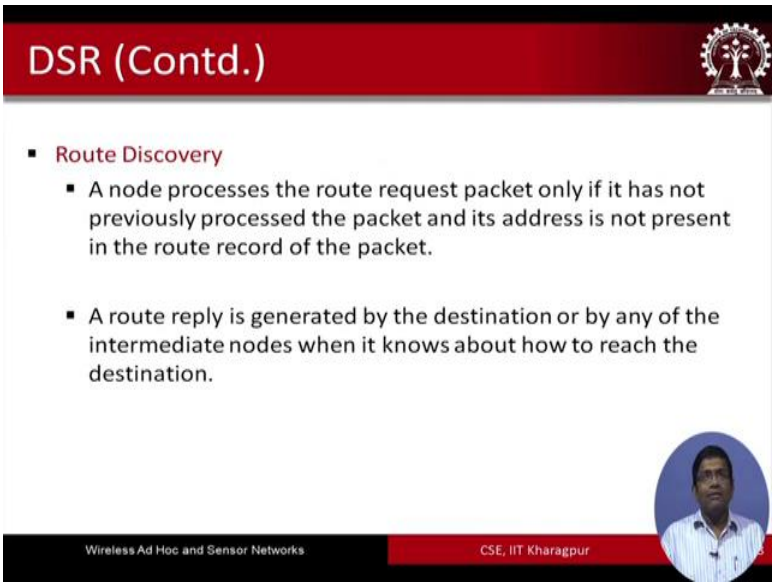

So, I told you that we start with the route discovery and then will get to the route maintenance. So, route discovery a note basically processes the route request packet only if it has not previously processed the packet and its address is not present in the route record of the packet. So, then it starts the discovery process. So, a route reply is generated by the destination or by any of the intermediate nodes when it knows about how to reach the destination. So, this part the law the later part is very important.

So, basically the route reply has to come from either the intended destination the final node to which the packet is going to be sent or if there is an intermediate node from whose route cache it finds out that it knows how to reach that intended destination, then it will not forward the packet, but it will send the reply back, saying that ok I know how to reach their destination corresponding to the packet that you have sent me.

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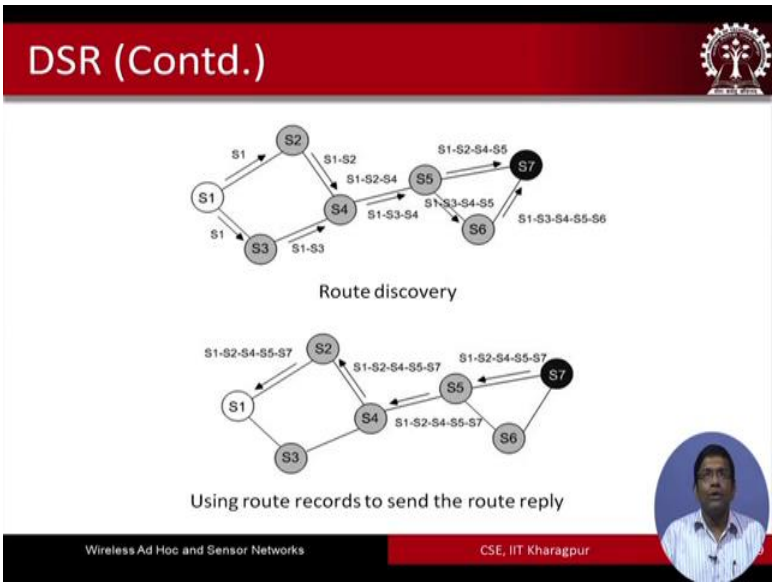

Let us now look at this figure and try to understand how the route discovery process works. So, we have a scenario nodes S 1 through S 7 as we can see in this figure. So, as we can see that this is the mechanism by which the packets are going to be propagated in the network. So, S 1 it will send out its packet with the header marked as S 1 to both the nodes S 2 and S 3. S 2 on receiving it will add to S 1, the S 2 tag and then forward it further. S 3 will also do the same, so if we it sends S 1 S 3 to S 4. Now S 4 receives it and it forwards further by tagging further the header; I mean in the header taking further the address of that. And then both of these S 1, S 2, S 4, and S 1, S 3, S 4 they go further.

And finally if we follow the entire process then what happens is two copies that were sent one from here and the other one through here, one through here rather one through here; so both of these copies are going to be received at the destination S 7. However the paths S 1, S 2, S 4, S 5 and S 1, S 3, S 4, S 5 and S 6. So, one is this path and the other one is this path and this is the discovery process.

So, the initially the discovery packets are sent and then the corresponding route records are updated and the reply is sent in this manner. So, note S 7 can either adopt; so it received two copies of the packets that were sent. So, it can adopt either of these two packets. So, let us say in this particular example it is shown that it adopts the one with lesson number of hops. So, it basically sends the confirmation back in this manner. This will be encoded into the header of the reply packet that is sent; out reply packet that is

going to be sent by S 7; S 5 receives it. S 5 now knows by looking at it that it should send it to S 4, because this is what is encoded in the header of the packet in this form; so S 4. Then S 4 again knows who to send it to; that means S 2. S 2 knows that it has to send it to S 1.

So, as we have seen that because DSR is a source routing protocol from the start, from the source S 1 to S 7 when a packet is going to be sent the entire path that the packet is going to traverse is basically encoded into the header of that particular packet.

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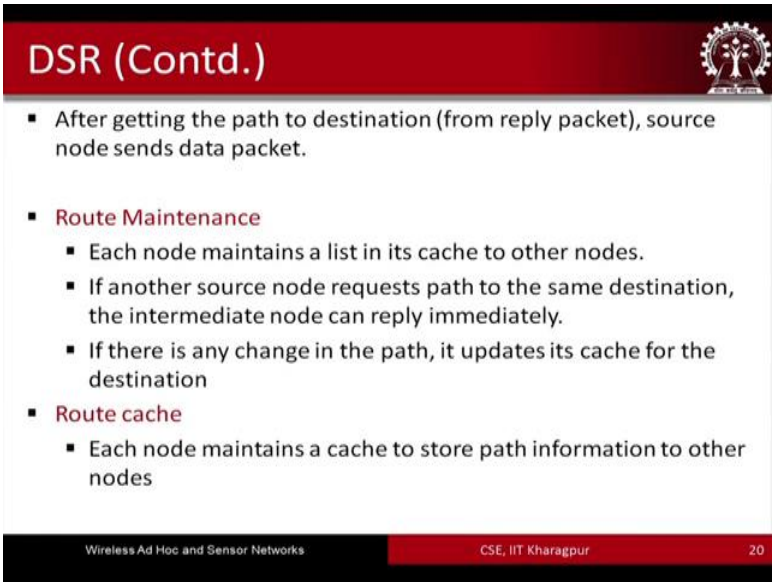

So, after hitting the path to the destination using that second mechanism of reply the source node sends the data packet. Then this is that was the discovery phase, then comes the route maintenance phase, where each node basically maintains a list in its cache to other nodes. If another source node requests the path to the same destination the intermediate node can reply immediately.

So, that is the reason why this is cached; the route information is cache at the intermediate nodes. If there is any change in the path it updates its cache for the destination. Route cache each node maintains a cache to store path information to other nodes.

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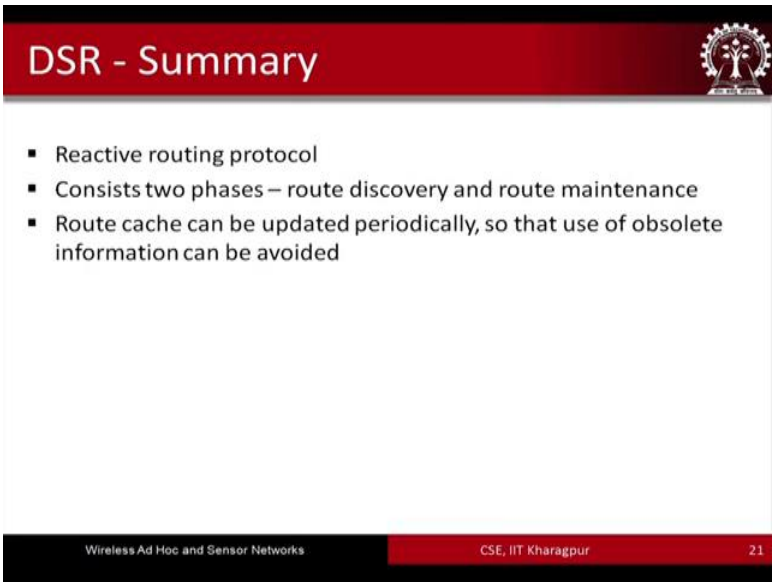

In summary: DSR is a reactive routing protocol which consists of primarily two phases; one is the discovery phase, the other one is the maintenance phase. And route cache is updated periodically so that the obsolete information can be avoided.

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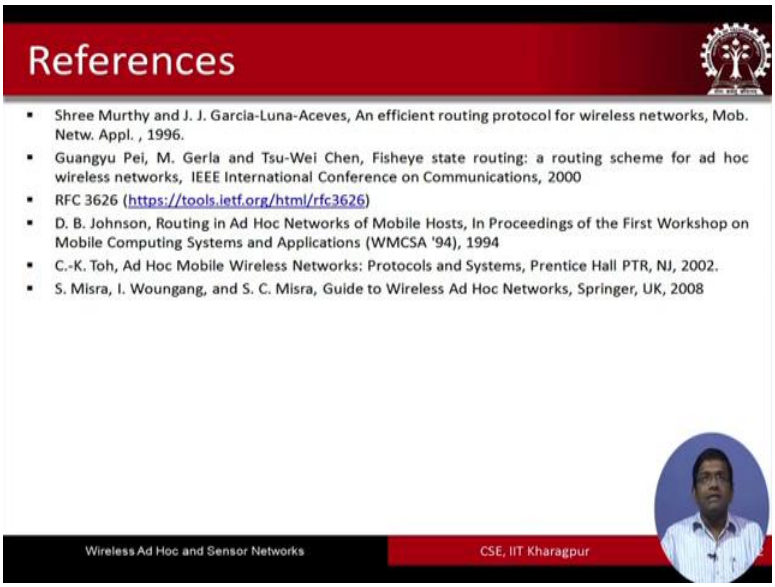

So, here are the references. And the references for; I mean the last two basically will are the books. And the other papers basically will give you the references corresponding to the other protocols that we have gone through today; t FSR protocol, OLSR protocol, and the DSR. So, DSR protocol was proposed by D. B. Johnson, and this is where it was

published in proceedings of the First Workshop on Mobile Computing Systems and Application. So, DSE is a very popular reactive routing protocol that is used in MANETs.

So, with this we come to an end of this second part of routing in MANETs. And there after there a few other routing protocols belonging to the reactive category which we are going to cover in the third part. And thereafter we are going to go through few hybrid routing protocols as well in that set of slides. So, with their after you know the unicast routing will be covered, will also go through the multicast routing after covering all of these topics.

Thank you.