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

Lecture – 10
Routing in MANETs-Part-III

We now come to the third and the last part of routing in MANETs. And here first as I promised to you during the previous part, previous lecture that here we are going to go through another reactive routing protocol which is called the AODV. And thereafter we will go through few examples of hybrid routing protocols which basically borrow properties from both proactive as well as reactive routing. So, let us now go through the AODV routing protocol.

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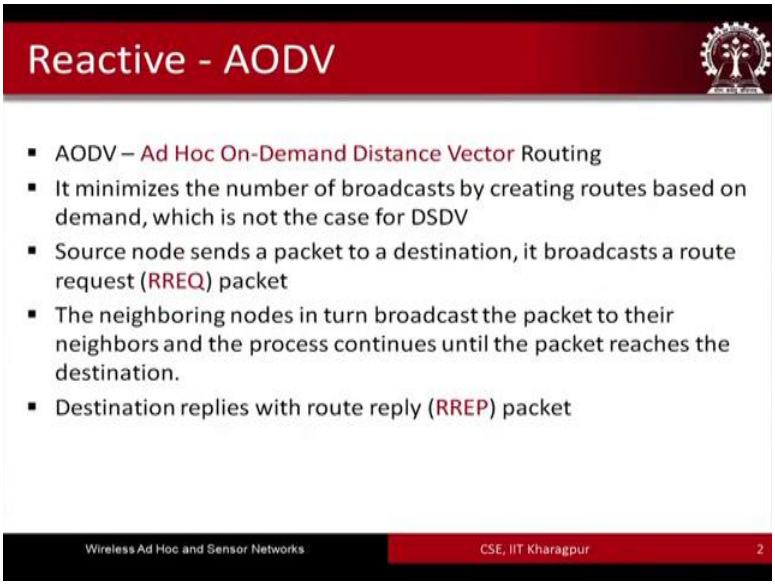

So, AODV like DSR is also another very popular, very well known reactive routing protocol. AODV basically stands for Ad Hoc on demand distance vector routing. It minimizes the number of broadcasts by creating routes based on the demand. So, this name stands for it, so it is on demand. So, basically you know whenever there is a demand the route is going to be discovered. So, it minimizes the number of broadcasts by creating routes based on demand which is not the case for DSDV.

So, DSDV was a proactive routing protocols so that is why you know it was maintaining the routing tables containing all the routing updates etcetera. And these tables were

shared with the neighbors and this is how the neighbors came to know that what is going on around, who is going to be the neighbor at different points of time for every other neighboring node; every other node.

So, that is not the case with AODV. AODV, if it is required on demand it is going to find the route. So, source node in AODV basically sends a packet to the destination, it broadcasts a route request packet. So, in AODV you will be able to see that you know AODV and DSR have lot of similarities. In the same way as all the proactive routing protocols earlier DSDV, WRP etcetera FSR they had lot of similarities. Here also AODV DSR you know in principle they have lot of similarities.

So, here basically it is a game between RREQ and RREP. So, RREQ packets are sent from the source to towards the destination which is basically again broadcast and rebroadcast at the intermediate nodes. So, basically the intermediate nodes the neighbor nodes will rebroadcast the packet to their neighbors in turn and the process will continue until the packets reach the intended destination node.

And the intended destination node basically receives the RREQ and one receiving it; it will initiate sending the RREP packet E stands for reply. So, RREQ was the route request packet, RREP is the route reply packet.

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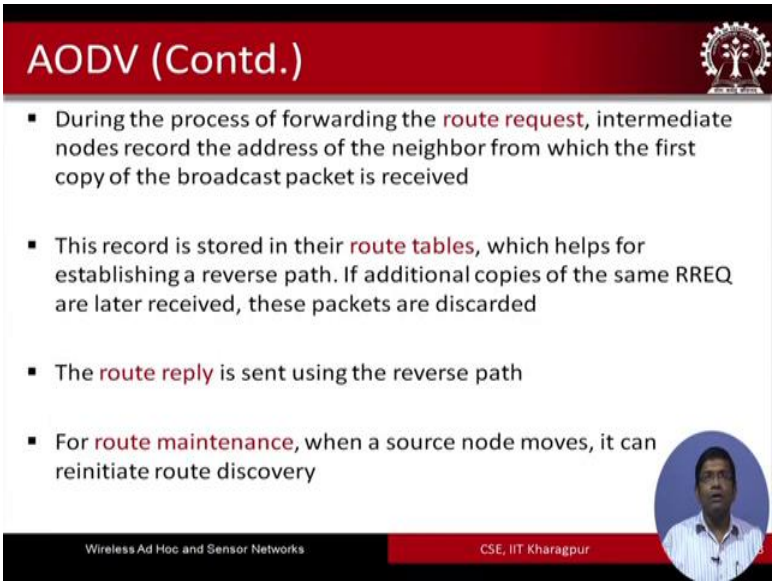

So, during the process of forwarding the route request intermediate nodes record the address of the neighbor from which the first copy of the broadcast packet is received. This record is stored in the routing tables, which helps for establishing a reverse path. If additional copies of the same RREQ are later received these packets are discarded. So, this is very interesting actually I will highlight this once more later on. So, basically you know here the help of routing tables is taken.

So, here basically the routing tables they are going to store the information about who is going to be the next path, what the neighbors so that that will help in establishing the reverse path. And note the difference between AODV and DSR, how DSR operated. So, the route reply is sent using the reverse path; for route maintenance basically when a source node moves it can reinitiate the route discovery process.

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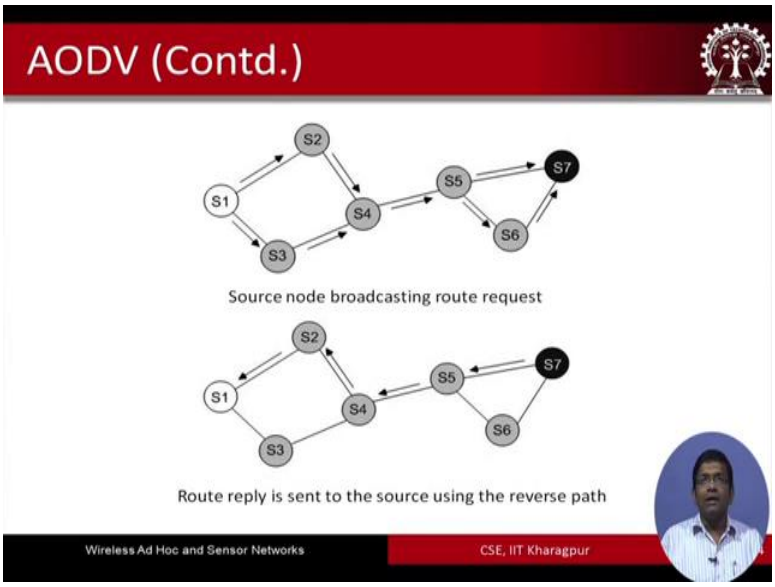

So, let us focus on this particular figure and try to understand it. It looks very similar to the figure that we had seen in the case of DSR, but there is a subtilty that creeps in to understand how AODV functions little bit differently from DSR. And that is what I will focus a little later. So, if we look at this figure. So, source node basically receives the pack. Source node has the packet, it broadcasts it the way it is shown, S 2 and S 3 are going to receive it, they are going to intern broadcast rebroadcast the packet, broadcasting, broadcasting, rebroadcasting and so on ultimately S 7 receives it. So, S 7

will finally, send it route reply back. So, in this particular case it is sending it using the reverse path the shorter part of the two.

So, this is again quite similar to what we had seen in the case of the case of DSR. Then where is the difference? It looks very similar to DSR; where is the difference? The difference is that if you recall in that figure a similar figure that you had seen in the case of DSR there were those headers that I spoke about which contained the entire path information middle of the packets that are going to flowing all around. So, these packets in their headers are going to contain the information of the entire path that the packet is going to go through.

So, that is because of the source routing feature of DSR. AODV is not a source routing protocol. AODV basically has tables and these tables will maintain the information about what are the neighbor nodes so that, that neighbor information can be used to send the reply back. So, S 4 for instance knows that it received the packet from S 2 and it will store in its routing table that it had received the packet from S 2. So, that once it gets a reply back from S 5 it knows where to send it back. So, it will send it back to S 2, because it was already stored in its routing table.

So, I hope that this certainty this subtilty difference between the functionalities of DSR and AODV are clear by now.

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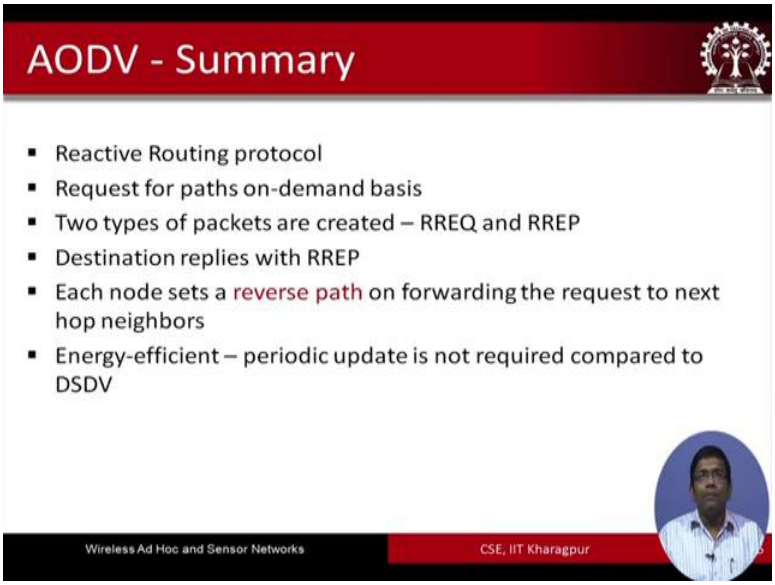

In some it is a reactive routing protocol, which requests for paths on demand. Two types of packets are used: RREP and r r e sorry; RREQ and RREP. The destination replies with RREP corresponding to the RREQ that it has received from the source file all the intermediate nodes. And each node sets a reverse path on forwarding the request to the next hop neighbors. This is more energy efficient where periodic update is not required compared to DSDV.

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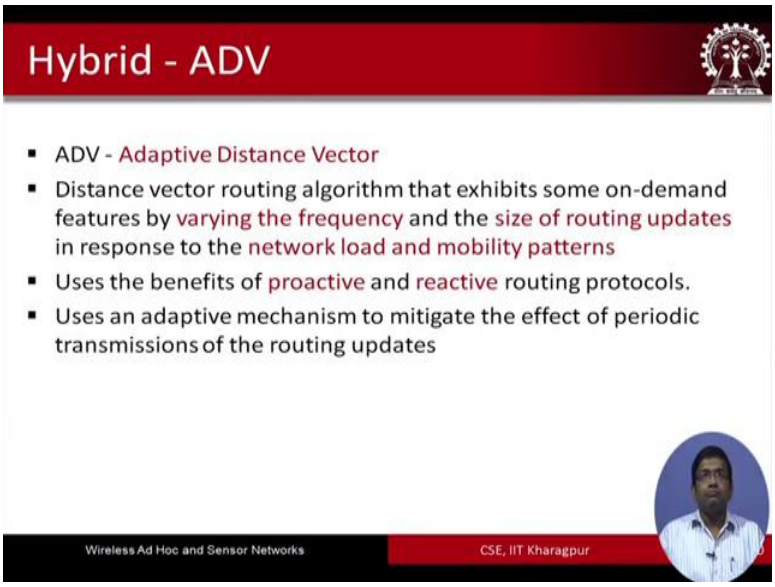

Let us now look at few hybrid routing protocols. ADV is a hybrid routing protocol- Adaptive Distance Vector routing protocol. It exhibits some properties which are on demand; on demand properties by varying the frequency and the size of routing updates in response to the network load and mobility patterns. And it also exhibits some proactive routing properties. So, it uses the benefits of proactive and reactive routing protocols uses an adaptive mechanism to mitigate the effect of periodic transmissions of the routing updates.

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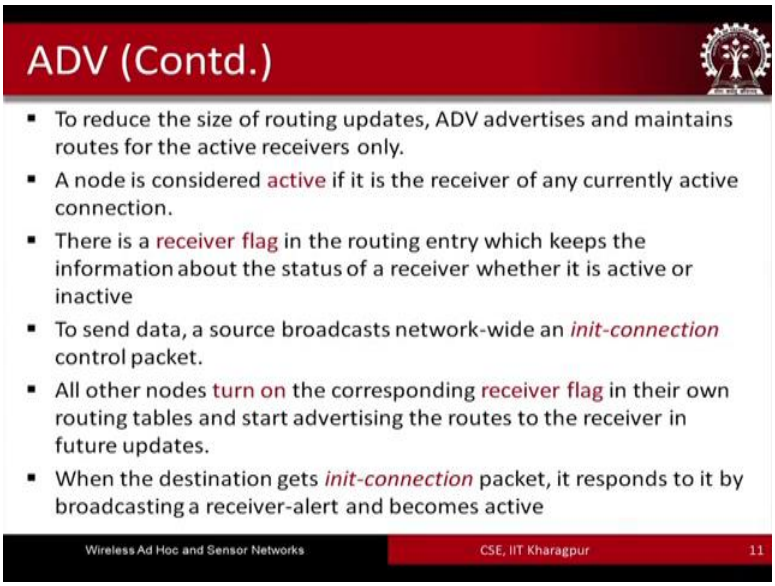

So, I will just go through the different points that we have in this slide highlighting the different features of ADV. So to reduce the size of routing updates ADV advertises and maintains routes for the active receivers only. So, ADV basically comes up with a terminology of an active receiver. So, what is an active receiver? So, a node is considered active if it is the receiver of any currently active connection; that means, that currently active connection means like there are different packets that are already flowing through it that the route has not been the connection has not been stale for a while ;I mean it is it is under used and so on.

There is another concept, another terminology the receiver flag. So, there is a receiver flag in the routing entry which gives the information about the status of the receiver whether it is active or it is inactive. So, the receiver basically will keep track of; it will flag like a 0, 1 kind of mechanism. So, the flag will be set to 0, let us say if it is inactive it; it will be set to 1 if it is active.

If the node is active to send data source broadcasts the network wide init-connection; init connection stands for initialization connection; init connection control packet. All other nodes turn on the corresponding receiver flag in their routing tables and start advertising the routes to the receiver in future updates. When the destination gets the init connection packet it responds to it by broadcasting a receiver alert and becomes active.

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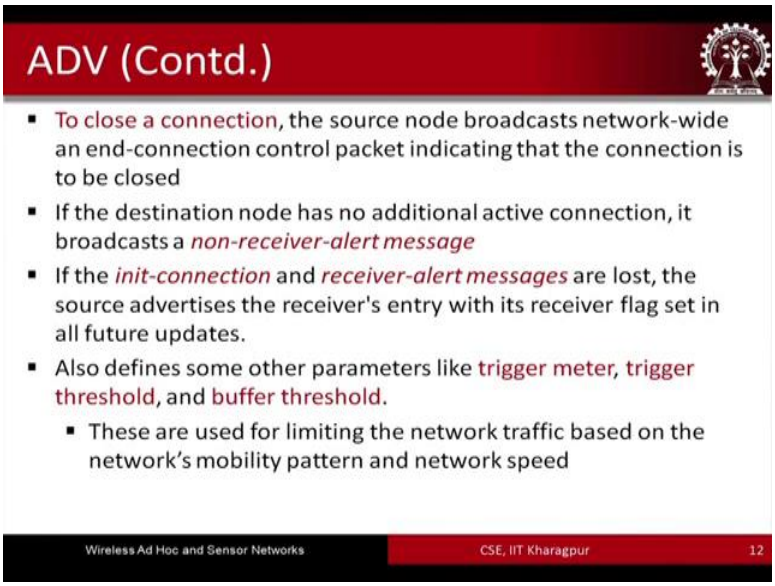

Now, to close the connection the source node broadcasts the network quite end connection control packet indicating that the connection is to be closed. So, end connection is the control packet that is used and broadcasted by the source node to the entire network when it is required to terminate a connection. If the destination node has no additional active connection it broadcasts a non-receiver-alert message; again a type of message that is proposed in this particular protocol the ADV protocol.

If the init connection and the receiver alert messages are lost the source advertises the receivers' entry with its receiver flag set in all future updates. Also it defines some other parameters like trigger meter, trigger threshold, and buffer threshold, which are used for limiting the network traffic based on the networks mobility pattern and network speed. So, these are the ones these are different parameters. I am not going to go through them. And these are already available in the reference of ADV and which is given at the end of these slides.

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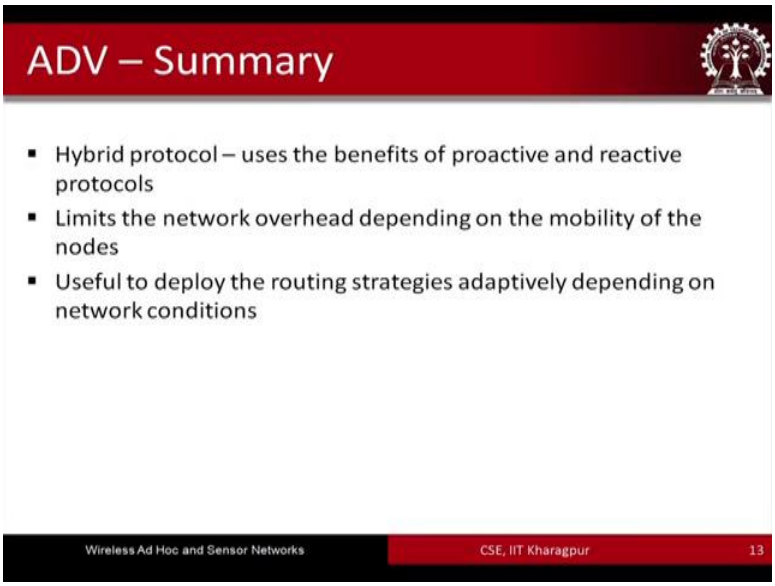

So, it is a hybrid protocol using the benefits of both proactive and reactive protocols. It limits the network overhead depending on the mobility of the nodes. It is useful to deploy the routing strategies adaptively depending on the network conditions. And adaptive: the why the adaptive, adaptation based on mobility, adaptation based on environmental conditions.

So, this is what it if it tries to adopt and it tries to improve the performance upon either of the reactive the solely reactive or the solely proactive routing protocols.

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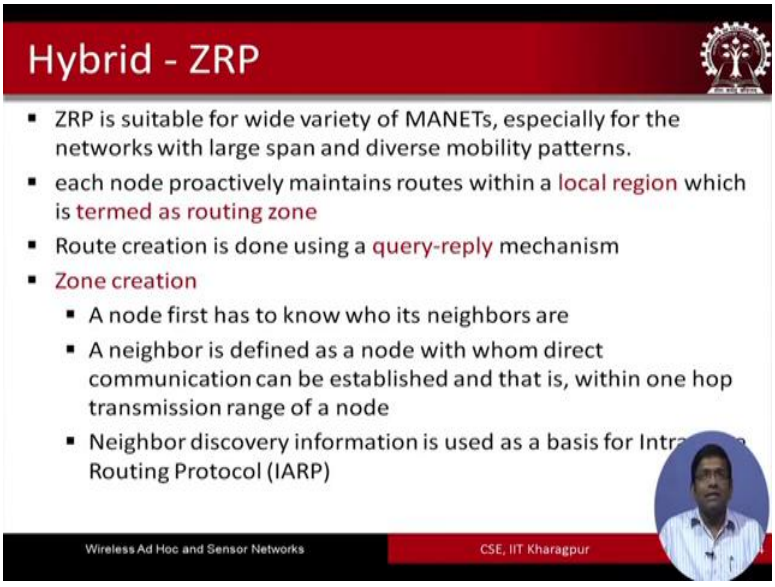

Another hybrid routing protocol is ZRP- Zone-based Routing Protocol. As the name suggests in this particular case what happens is the protocol basically creates different zones; different zones are created. So, each zone proactively maintains the routes within a local region which is termed as the routing zone. And route creation is done using a very reply kind of mechanism like we have seen in the case of AODV; so that is done. But, what happens is within a zone the proactive way of dealing with the routing is adopted and beyond the zone basically the node basically tries to adopt a reactive kind of mechanisms; that is how it becomes hybrid.

So, a node first has to know who its neighbors are. A neighbor is defined as a node with whom direct communication can be established and that is within one hop transmission range of a node. The neighbor discovery information is used as a basis for intra-zone routing protocol- IARP.

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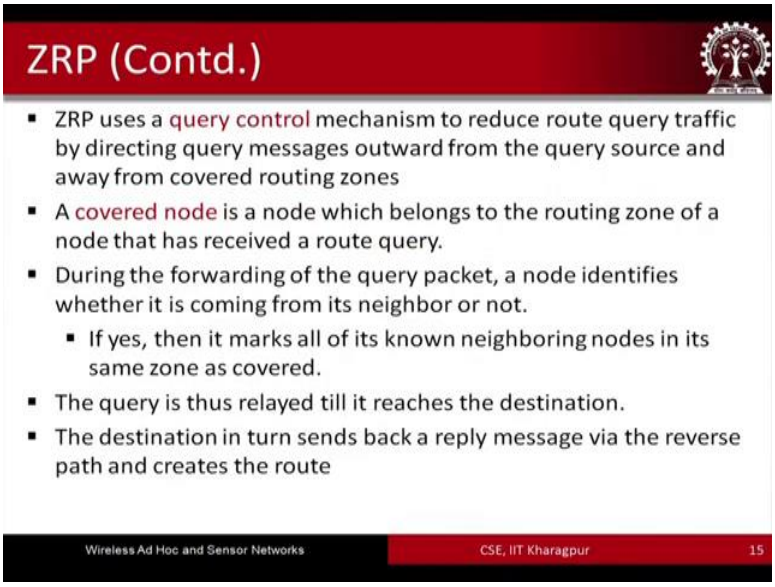

So, ZRP uses a control very control mechanism to reduce the route query traffic by directing query messages outward from the query source and away from the covered routing zones. Basically, there is a concept of a node being covered. A covered node is a node which belongs to the routing zone of a node that has received a route query.

So, as you can understand I think so far you are able to relate that why this zone is this concept of zone is used. You are trying to limit the way the broadcasts are propagated. So, basically you know so what happens is within a particular locality all of these nodes

they are going to behave the same. So, better to use the same and they are not going to be too much mobile and so on. That is what is expected. They are going to move in a similar way. So, that is why ZRP within a zone uses adopts a proactive routing protocol. Outside the zone it is a reactive routing protocol.

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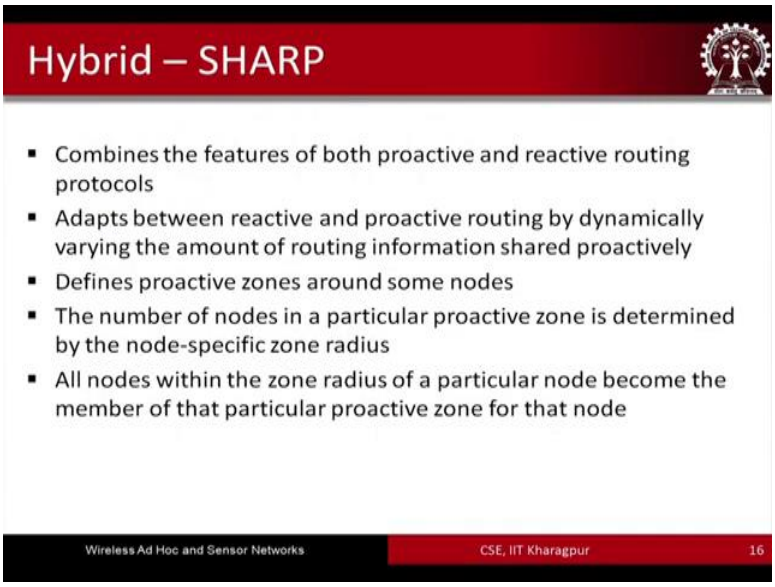

And the similar kind of mechanism is used in another hybrid routing protocol which is called the SHARP routing protocol, which again is a hybrid routing protocol where both proactive and reactive routing features are adopted.

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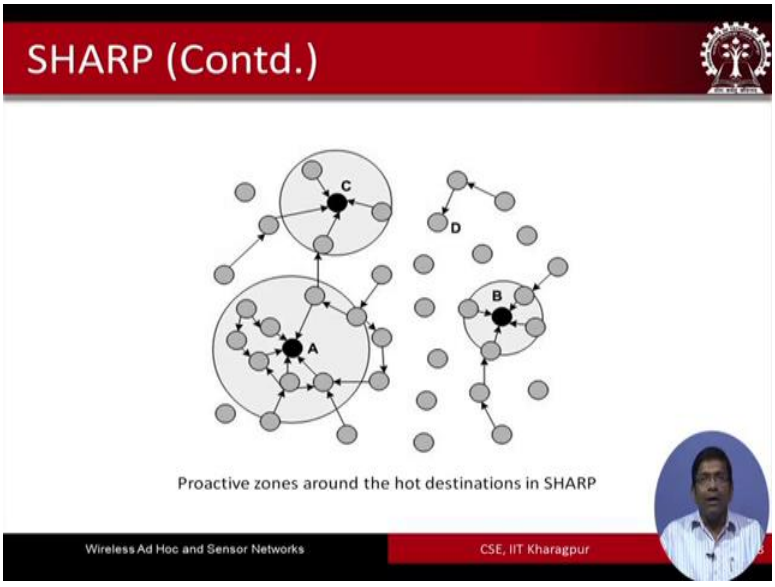

So, here also the concept of zone like in the case of ZRP comes into picture, but there is a difference. In the case of ZRP what happens is the zones all are centered at the individual nodes, but they all are of the same length. So, from one node for every node in ZRP they all have the similar radius of the zone, but if you look at in the case of SHARP they all have separate ADI. So, this is how basically SHARP functions. So, these proactive zones basically around the hot destinations are shown in this particular figure more specifically.

So, the dark shaded once A C and B are the nodes which are the hot spots, and the other shaded nodes around those nodes inside the circles are basically the hot destinations. And this is the main difference between ZRP and SHARP.

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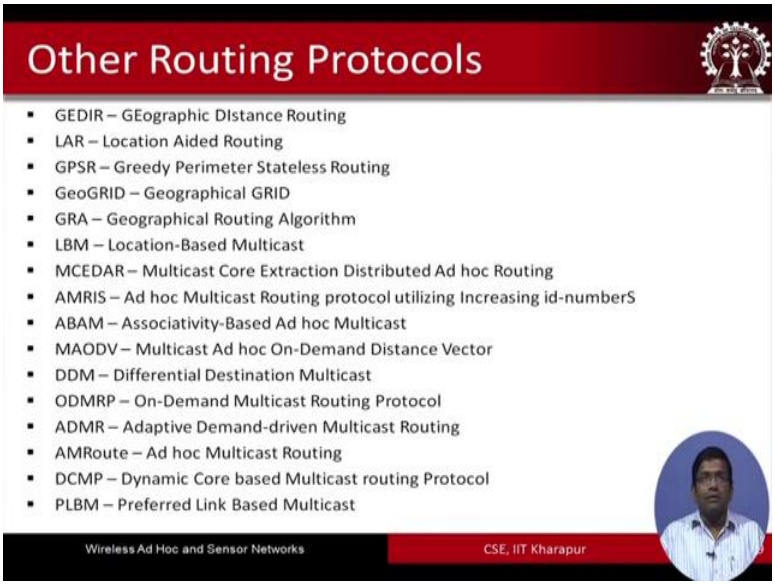

And with this we come to an end of the hybrid routing protocols. So, we have already gone through few examples, features of some of these example routing protocols belonging to the proactive category, reactive category, and the hybrid category. There are many other routing protocols that are available. A few of them are listed over here.

It is not possible or it is rather not required for a student of this course to know each and every routing protocol or more routing protocols that is not required. What is sufficient to know is the working principles of proactive routing protocols, reacting routing protocols, and the different features in which the reactive routing protocols the function.

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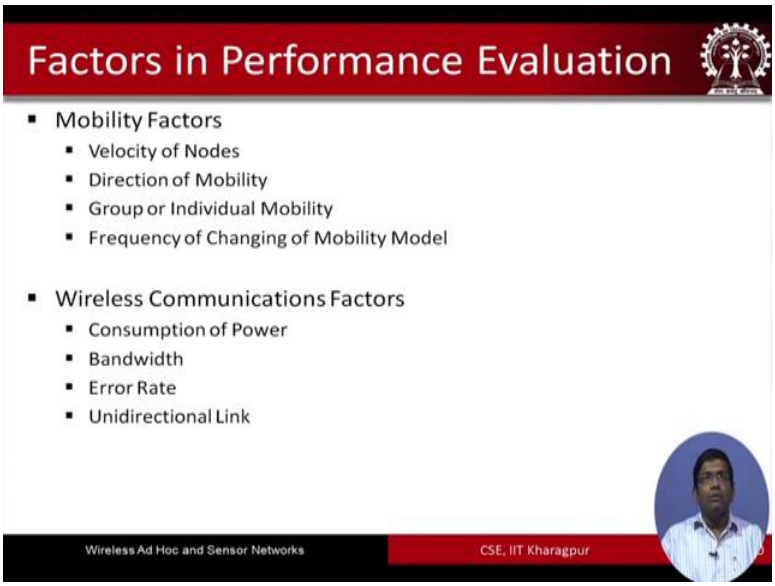

So, these are some of these routing protocols. And now we look at some of the factors that are required; factors of performance evaluation. So, there are factors which are mobility related. So, factors such as velocity of the nodes, the direction of mobility, the group whether it is a individual node which is moving or is it a group that is moving, or the frequency of changing of the mobility model. These are the ones that determine the performance of the different routing protocols that are adopted for MANETs.

Apart from the mobility factors, there are wireless communication factors, factors with respect to consumption of power, bandwidth, error rate, directionality of link, which again are crucial factors that play role in determining the performance of routing protocols.

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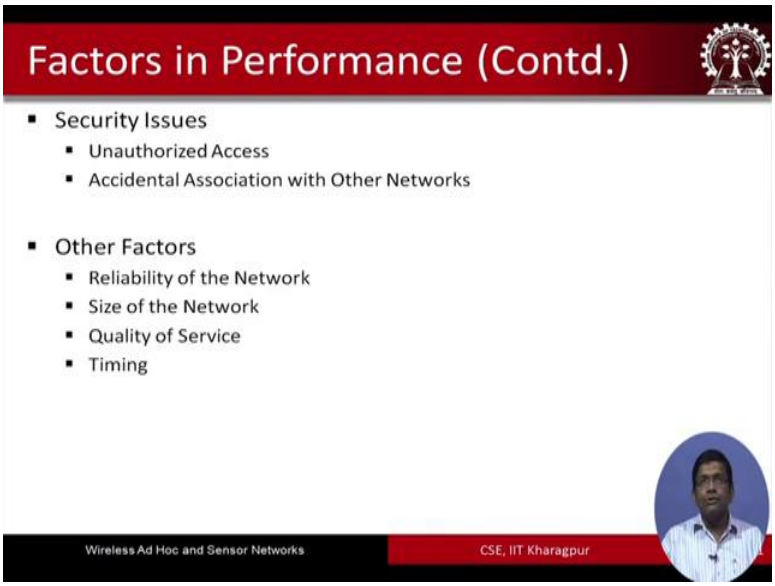

Security issues are also very important. And additionally there are other factors, such as the reliability of the network, size of the network, the quality of service, the timing, and many other factors which are even not listed here which basically determine, which basically affect the performance of routing protocols in MANETs.

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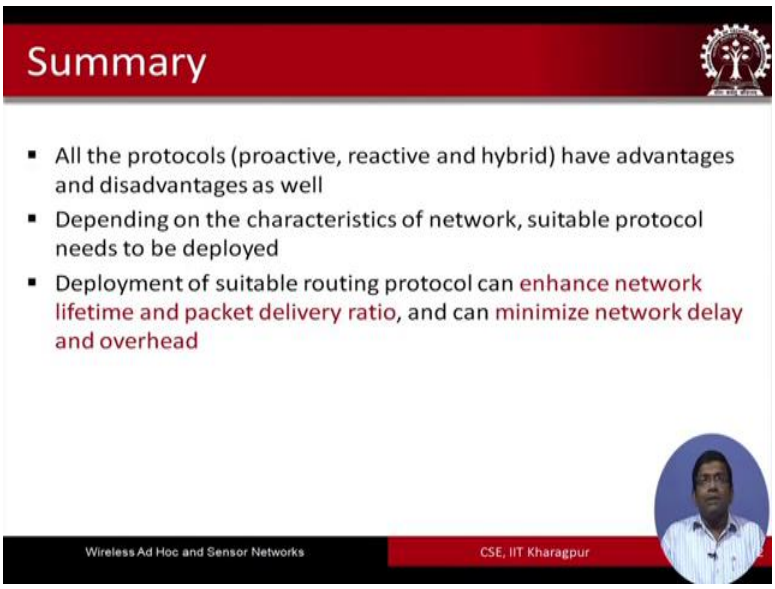

So, now we would like to sum up all the protocols proactive reactive or hybrid that we have gone through, have different advantages and disadvantages. One cannot claim that reactive is the best or hybrids are the best. It in fact, cannot always be said that one type

of routing protocol or within one specific routing protocol is the best or in a lighter way a better routing protocol compared to others; it cannot ever be said.

So, many times the performance of a routing protocol varies depending on the environment, depending on the circumstances, some of these circumstances I have already told you; circumstances of mobility, features factors of mobility, wireless communication environment where they are operating and so on, which basically dictate the performance of these protocols.

In essence what I would like to mention is not that we can always claim that a protocol or a set of protocols is the best among all available protocols. Depending on the characteristics of the network the suitable network protocol needs to be deployed. The deployment of suitable routing protocol can enhance the network lifetime and packet delivery ratios which are basically important performance indicators. And another very important performance indicator is the network delay, the overall propagation delay of a packet. So, when you are adopting a particular routing protocol how much delay the packets incur for them to go from the source to the destination. And how much is the overhead, what is the overall overhead, over it control overhead typically.

So, control overhead, communication overhead, computational overhead, which basically all of these basically can be combined to have an energy overhead; because if the protocol will make the nodes to perform to send more packets more control packets or perform more computations that basically increases the overall energy consumption of the nodes and decreases the overall network lifetime. So, these are some of the different performance indicators, performance metrics, performance measures which are used to assess the different types in protocols.

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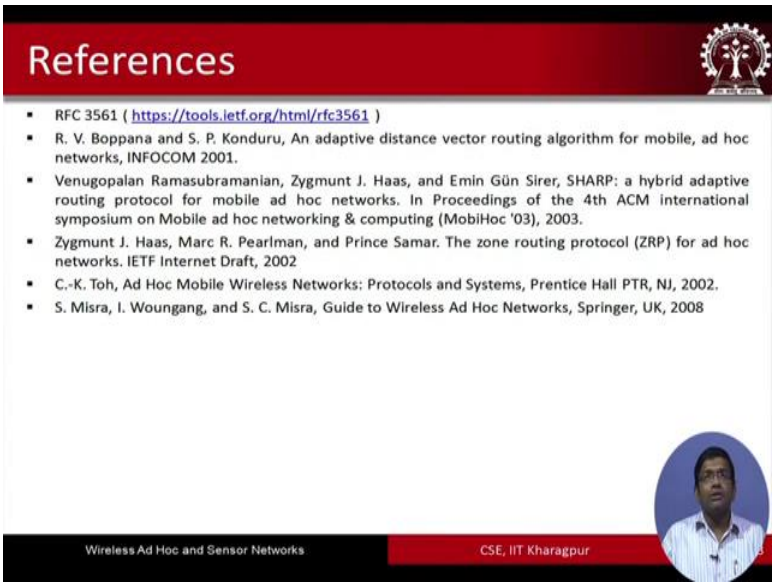

Here again a few references. So, I think it is quite obvious, and you know I would suggest that the student basically goes through each of these references because they will give detailed little understanding or the working of the corresponding protocols that we have discussed.

Thank you.