Wireless Ad Hoc and Sensor Networks

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Lecture - 20
UAV Networks- Part- III

So we come to finally, the third part of this topic of UAV networks. So, we are going to now look at some of the more advanced concepts in the deployment and functioning of these networks.

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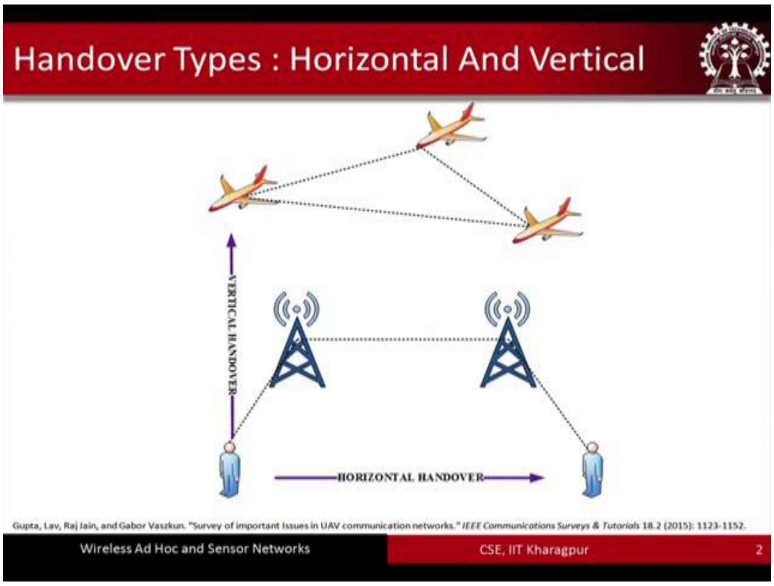

So, we will now try to understand the concept of handover. So, handover in UAV networks is very important. So, handover has to happen like in the case of cellular networks, handover or handoff has to happen because the nodes over here, they move whether we are talking about handoff when the nodes on the surface of the earth on the or the human beings or the vehicles when they are moving with respect to each other, or with respect to the base station on the earth, or whether it is due to the fact that the nodes which are flying they move with respect to the base stations on the earth and so on. Different types of handover has to happen to maintain the connectivity between the different nodes in the network; obviously, handover is handover basically improves the connectivity of the overall connectivity in the network, but it is at the cost of a minor increase in latency of communication.

So, there are 2 types of communications or rather 2 types of handovers or handoffs that are typically characterized in these networks. So, here what we see is horizontal handover is something that happens in the case of a pure mobile network where the nodes connect through base stations and so on. So, what happens is when this particular node this particular human being the human being moves gradually what is going to happen is that it is going to stay connected with this particular base station, until the signal strength between the mobile unit that this particular human has and the base station weakens to certain to an extent that the link basically disrupts. So, this is what is going to happen. So, it is going to move further and it then what is going to happen is it is going to come connected become connected to another base station. It is going to come within the region of operation of another base station.

So, when it comes in the region of operation of the second base stations. So, you know earlier it was connected to this base station it comes in proximity of another base station. So, this operation of breaking the connectivity with this base station and getting connectivity back with the next base station this particular operation is known as handover. And when we are doing it on the ground we term it in the case of in the context of UAV networks it is termed as a horizontal handover.

Vertical handover as this particular figure suggests occurs, when these nodes the nodes the human and the mobile phone that it that the human is using and the UAV, you know when they move out of the range of each other to a in a and the similar kind of concept that we have just understood in the case of horizontal hand over this particular thing is applied in this particular context to what we have is a vertical handover.

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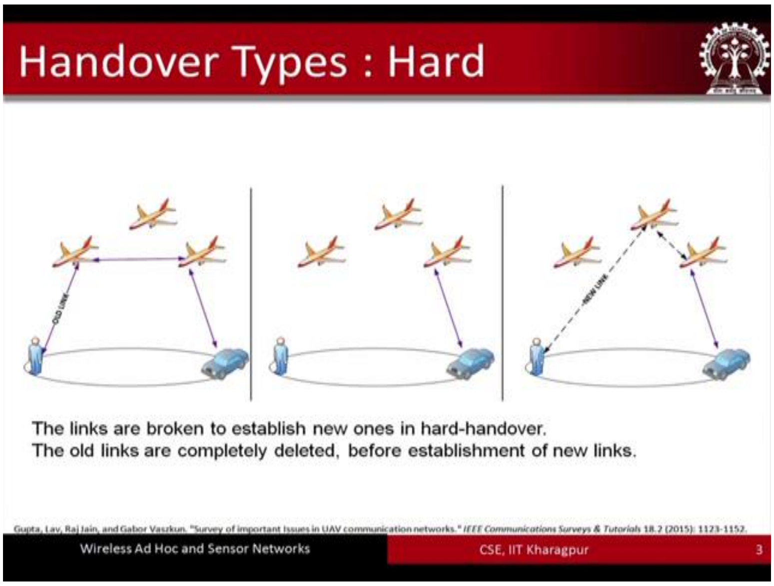

These handovers can be classified into 2 types. One is called the hard handover and the other one is called the soft handover. So, here pictorially we can try to understand how the hard handover occurs first. So, as you can see over here like in this particular scenario. The links are broken to establish, new ones in the case of hard handover. So, you see there was the old link due to the mobility of these different nodes or the nodes on the ground, this is what is going to happen this earlier connectivity is going to be lost and a new link is going to this is the new link, this new link is going to be established. So, the first the links are broken and the new ones are made right. So, this old link is broken. So, connectivity is lost first. So, there is a period when there is no connectivity with any other node from this point on, and then a new connectivity is set up with another UAV. The old links are completely deleted before establishment of the new links is the requirement of hard handover.

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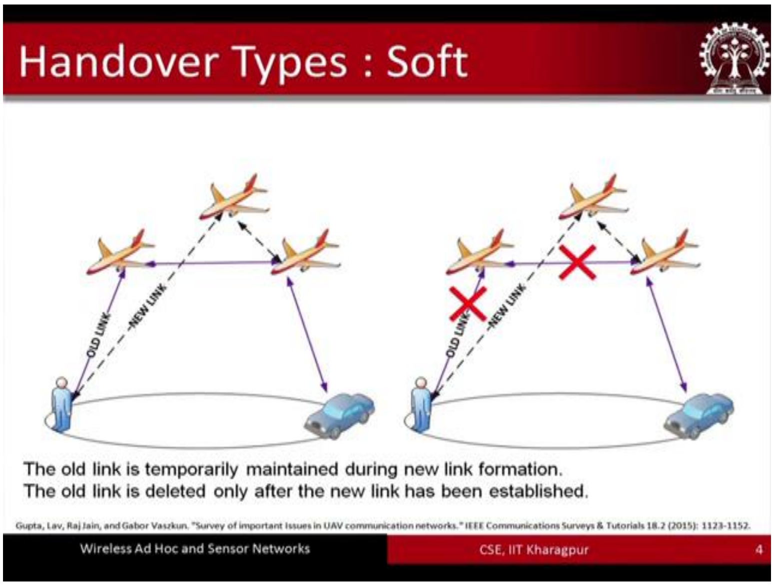

So, in the case of soft handover the old link is temporarily maintained during the new link formation. So, during the period when the new link is formed, the old link is maintained. And the old link is deleted only after the new link has been established. And this is the scenario that occurs. So, what we have is the old link and the new link to be established, and a old link is still maintained and first the new link is set up and thereafter the old link is deleted.

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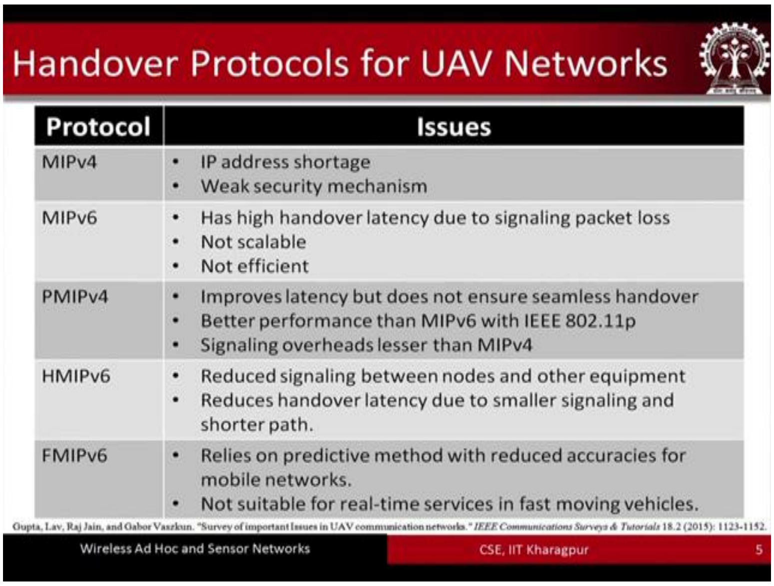
Handover Protocols for UAV Networks

Protocol	Issues
MIPv4	• IP address shortage • Weak security mechanism
MIPv6	• Has high handover latency due to signaling packet loss • Not scalable • Not efficient
PMIPv4	• Improves latency but does not ensure seamless handover • Better performance than MIPv6 with IEEE 802.11p • Signaling overheads lesser than MIPv4
HMIPv6	• Reduced signaling between nodes and other equipment • Reduces handover latency due to smaller signaling and shorter path.
FMIPv6	• Relies on predictive method with reduced accuracies for mobile networks. • Not suitable for real-time services in fast moving vehicles.

Gupta, Lav, Raj Jain, and Gabor Vaszkun. "Survey of important Issues in UAV communication networks." *IEEE Communications Surveys & Tutorials* 18.2 (2015): 1123-1152.

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So, there are different protocols for handover that have been proposed I am not going to go through them, but there are different issues and characteristics of each of these protocols MIPv4 is one such protocol with the issues that are listed in the table in front of you. Then we have the MIPv6, PMIPv4, HMIPv6, FMIPv6 these are the different protocols for handover in UAV networks.

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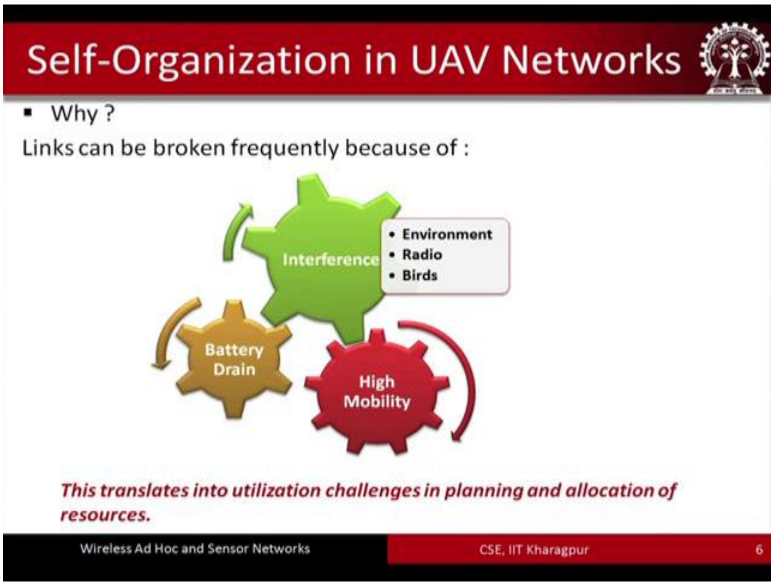

These UAV networks are self organizing. In fact, they are very much they are highly self organizing than other types of Ad-Hoc networks their topology changes quite fast the links have broken and made frequently quite frequently and so on. So, this is how you know this is what basically happens. So, because of this self organization of these UAV networks and the making and breaking of the links what we have is a scenario like this.

So, all these the interference issues mobility issues battery drainage issues you know all of these have to work together, in order to in order to consulate the utilization these things will have to work together to translate into the utilization of challenges in planning and allocation of resources. So, all these interference issues mobility issues drainage issues and battery drainage is quite faster in these nodes and this would have to be translated into utilization challenges in planning and allocation of resources in these networks.

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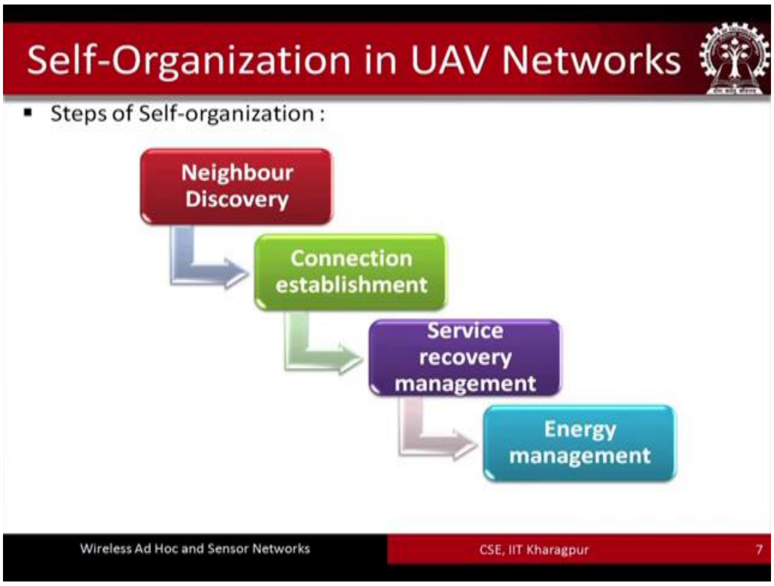

There are different steps of self organization the first thing is the neighbor discovery then comes the connection establishment. So, every node has to discover who their neighbors are then connection establishment, after the neighbors have discovered connection establishing connection with these neighbors service recovery management, energy management these are the different steps of self organization in UAV networks.

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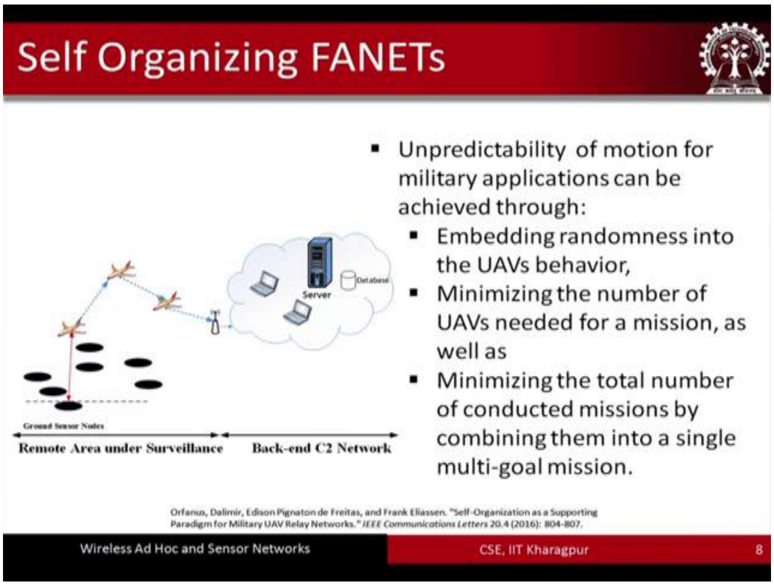

So, here is a picture of self organizing flying Ad-Hoc networks. So, what we have is in this type of systems, we have you know in the front end, we have a remote area which has to be surveilled. So, we have a remote area it has to be surveilled through UAVs then the data are send to an access point and through the access point to the back end server the data has to be sent. So, the unpredictability of motion for military applications can be achieved through embedding randomness into the UAV behavior. Minimizing the number of UAVs that are needed for a mission and minimizing the total number of conducted missions by combining them into a single multi goal mission. So, these are some of the different issues of use of the self organizing FANETs in military applications.

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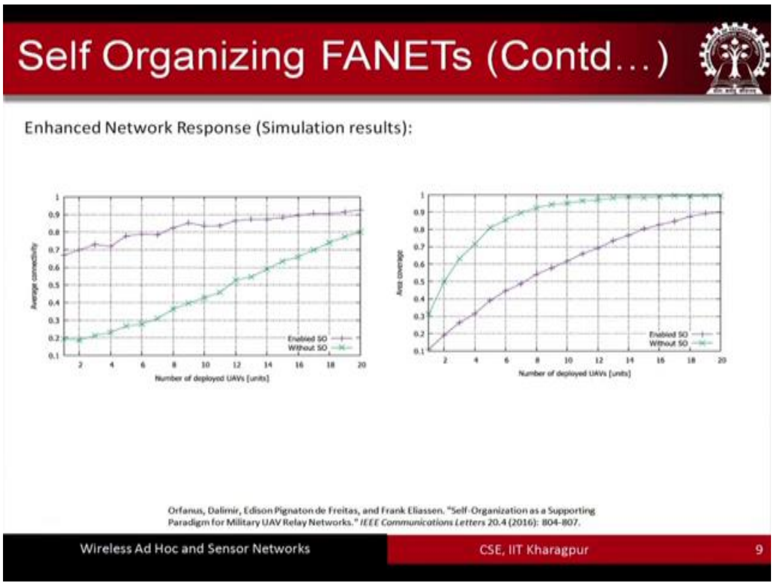

So, here is what we see is a comparison, you know it is a simulation based comparison of these networks. So, I am not going to cover these, but in terms of connectivity to comparison is made with respect to a connectivity area connectivity and coverage between the different nodes in the self organizing FANETs.

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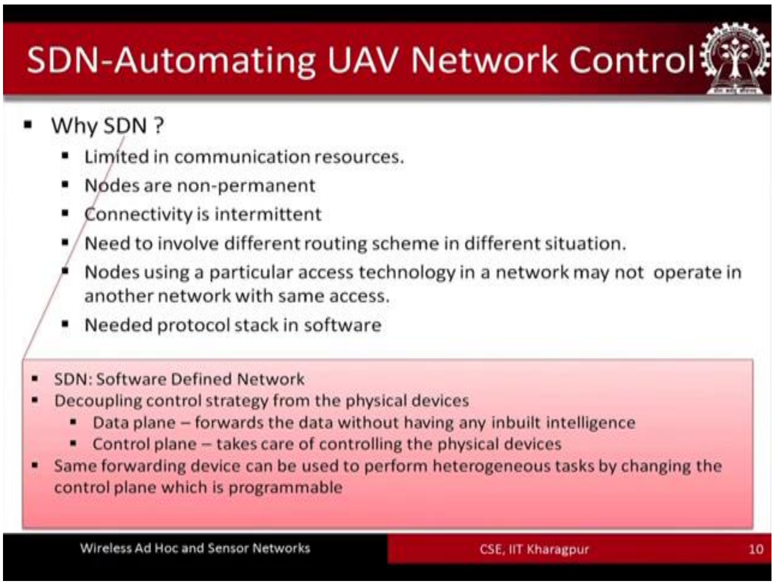

Now, what is very interesting is to have connectivity, you know is to harness the importance of or the usefulness of SDNs software defined networks and using them to power to make the UAV network control even more or full then a standalone UAV network, using SDN to do that. So, what is SDN? SDN basically is software defined networks. So, here the idea of software defined networks is to decouple the control plane. So, there are 2 planes, in the different nodes in this networks. One is the data plane and the other one is the control plane. The data plane is basically responsible for forwarding the data without having any inbuilt intelligence and the control plane basically takes care of controlling the different physical devices. The whole idea of SDN is to decouple the control plane from the data plane and that by doing that to make these networks more autonomous more efficient and easily adaptive to different changes. And that is what is required.

A desirable feature of UAV networks, the same forwarding device can use to perform heterogeneous tasks by changing the control plane and that change is programmable change and by if the control plane is isolated not isolated, but removed from the data plane is basically decoupled from the data plane and is sent to a particular controller the controller basically is tasked to take care of the control functions of the different nodes in the network and help to make these networks much more reconfigurable and much more you know self organizing in different ways. And that is where SDN can come to be can prove to be very useful.

So, why to use SDN once again there is a limit there is a limitation of the communication resources in these networks; that means, the UAV networks nodes are not permanent. Connectivity is intermittent and there is a need to involve different routing schemes under different situations. So, different router schemes on a different situation. So, it might, so, happen that you start with a particular routing scheme let us say a any kind of a proactive routing scheme. And then that routing scheme under the later circumstances may not be very efficient. So, how you know SDN can help the nodes in the network to adapt and change to the new class of routing scheme may be a reactive routing scheme automatically and much with much more ease.

So, nodes using a particular access technology in a network may not operate in another network with the same axis. And that is there is a needed protocol stack in terms of the software. So, the software, it is software defined radio. So, basically there are different software that is different algorithms that are running in order to make these things happen; that means, to make 2 separate out the control plane from the data plane and having the control plane control the different types of reconfigurability and self organizing behavior and so on.

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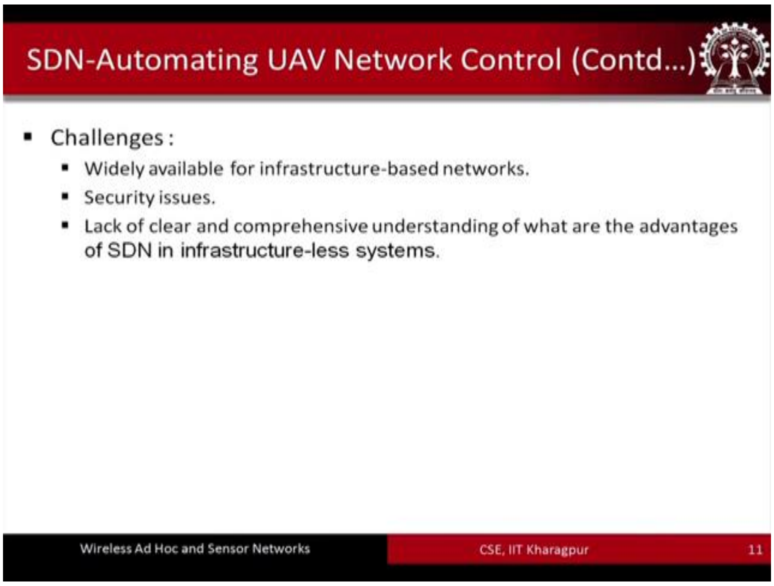

In these networks there are different challenges in implementing SDN in UAV network SDN based UAV network. And these challenges are with respect to security and with respect to you know the Ad-Hoc nature of communication between the different nodes in a plane in these FANETs. And SDNs typically have been has have been made available for implementation in infrastructure based networks where there is a centralized coordinator. And how do you implement SDN in the case of UAV Ad-Hoc networks where is going to be the controller, where is the controller is going to be on one of these other UAVs that is flying on the in flying in the air, or whether the controller is going to be on the ground. So, this is a very important issue.

One can easily conceive that the controller can be at the ground, but the main problem is that the that will be at the cost of much higher latency of communication overall communications reduced efficiency of the network and so on. Because you know controller should not be too far from the different nodes which have the data plane. Because by doing that the for each and every task where the controller has to get involved the you know the overall end to end communication end to end sending of back packets or data communication or sending or routing of packets from one point to another that is going to increase.

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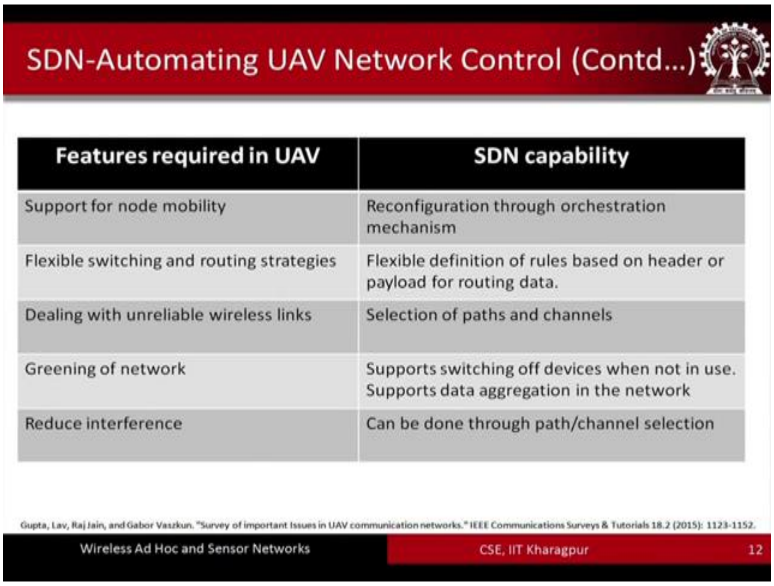

Features required in UAV	SDN capability
Support for node mobility	Reconfiguration through orchestration mechanism
Flexible switching and routing strategies	Flexible definition of rules based on header or payload for routing data.
Dealing with unreliable wireless links	Selection of paths and channels
Greening of network	Supports switching off devices when not in use. Supports data aggregation in the network
Reduce interference	Can be done through path/channel selection

So, these are some of the features that are required in a UAV. And their SDN capability are shown over here what is desired in terms of implementation of SDN in order to achieve these properties or that features in these UAVs. Support for node mobility is the first one and the SDN capability is reconfiguration through orchestration some kind of an orchestration mechanism.

The second one is flexible switching and routing strategies and the SDN capability is flexible definition of rules based on header or payload for routing data. The next feature is dealing with unreliable wireless links and the SDN capability is selection of paths and channels. Greening of network is the next feature of the UAV and the SDN capability that has to be supported the support supporting of switching of devices, when it is they are not in use and supporting of data aggregation in the network reduction. In interferences is the last feature and the SDN capability is can done through a path or channel selection in a using SDN.

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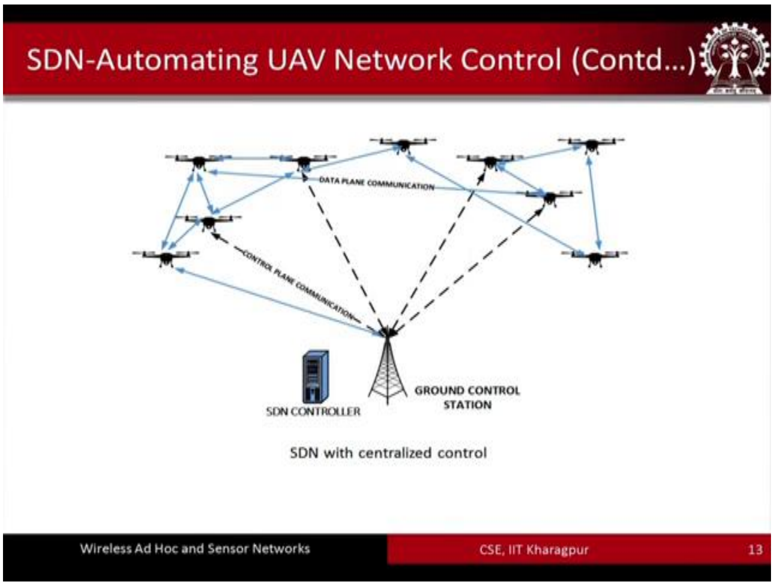

So, this is a picture a diagrammatic representation of the use of SDN with centralized control and this SDN controller. As we can see over here which basically takes care of all the control functions of the UAV networks; that means, the UAVs that are flying and the communication needs between them, as we can see over here there is data communication between these different UAVs that are flying in the plane and there is control communication between the UAVs that are flying and the ground station or the base station and, what is required is to have all these control functions perform through the centralized controller and this control.

So, what is important is to have this thing reduced because too much of control plane communication will lead to increased latency of communication between the different nodes in these networks and dissemination of the data, that are collected by these UAVs in these networks, through the base station to the other points or the control station where the mission is being monitored and controlled.

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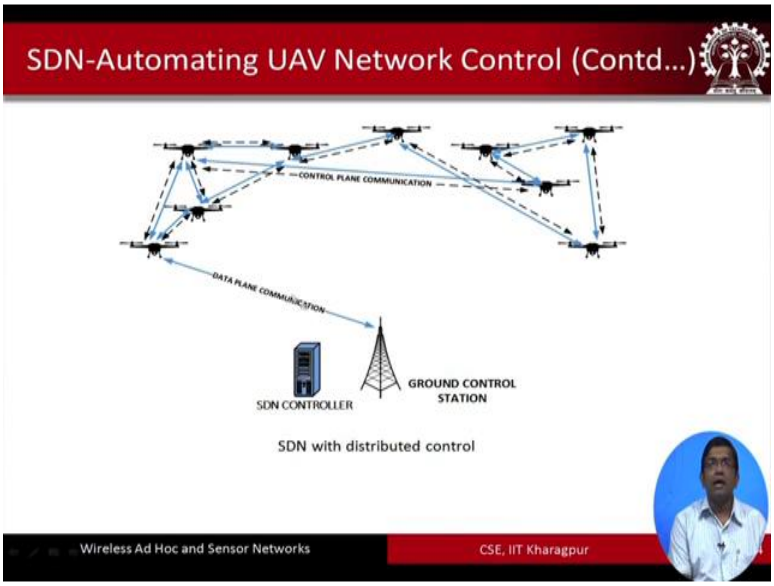

This is a SDN with distributed control that is shown the earlier one was with the centralized control and here basically is SDN with a distributed control where as you can see you know the controller. So, what we have over here is the control plane station a control plane communication again occurs between the different nodes UAV nodes like over here and the data plane communication can occur from one of these nodes in these networks to the ground station.

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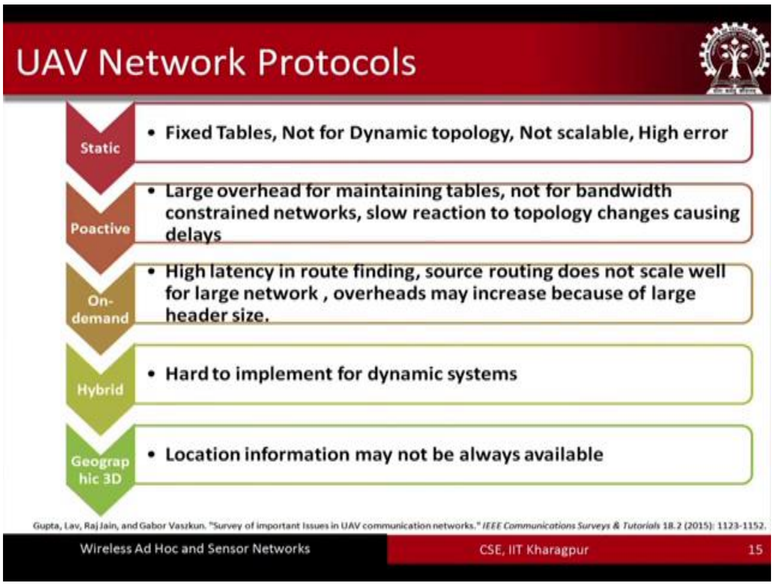

The UAV networks you know for UAV networks there are different protocols that have to be proposed. And we primarily focus on the routing protocols routing is the most important issue in these networks. And achieving desirable routing is the first thing that people try to achieve in these networks. So, these networks have fixed tables which are not for dynamic topology not scalable and highly error prone. So, in such a case we have a static network, proactive one with large overhead for maintaining tables not for bandwidth constant networks, slow reaction to topology changes causing delays on demand a high latency in route finding source routing does not scale well for large networks overheads may increase because of large header size hybrid hard to implement for dynamic systems and geographic 3D location information may not always be available.

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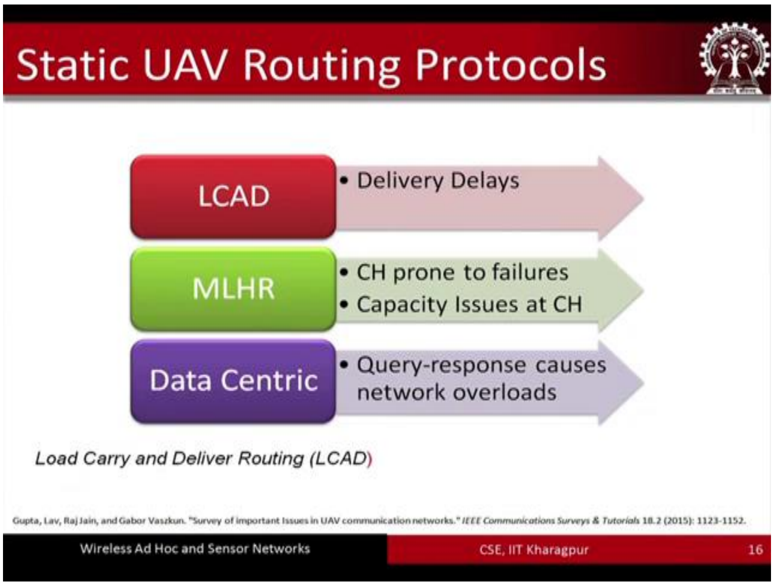

So, static UAV routing protocols these are the some of the different routing protocols that have been proposed LCAD is one MLHR is another. And a MLHR is another a third one is the data centric routing protocols. We solve query responses and those basically increase the overall network loads. So, these are the acronyms and I am not going through the full forms of LCAD and MLHR these are well known in UAV network community, and I will do not need to go through them and explain them here.

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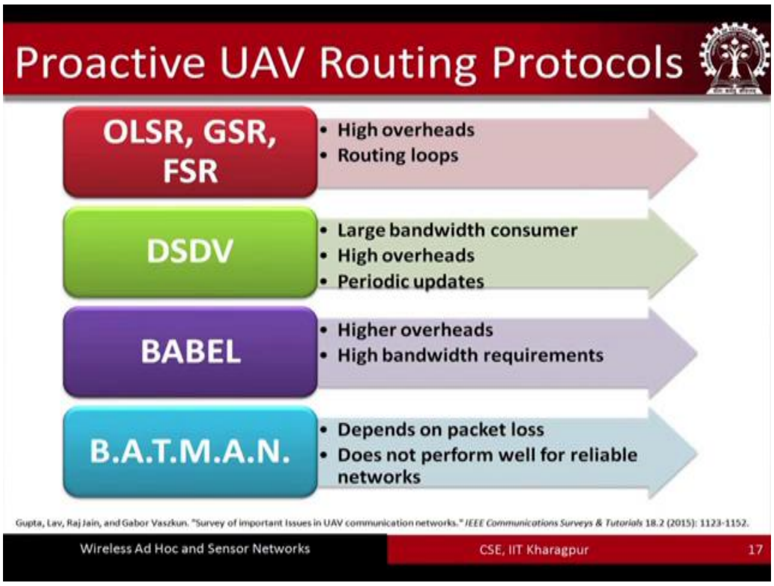

So, in terms of proactive routing protocols these are the different proactive routing protocols that are proposed for UAV networks. The traditional ways are GSR FSR that we are supposed for MANETs who could still be used here protocols like DSDV could also be used plus we have 2 other new proactive routing protocols for UAV networks BABEL is one and B.A.T.M.A.N is another, and their corresponding features are mentioned in your slide that you are reading.

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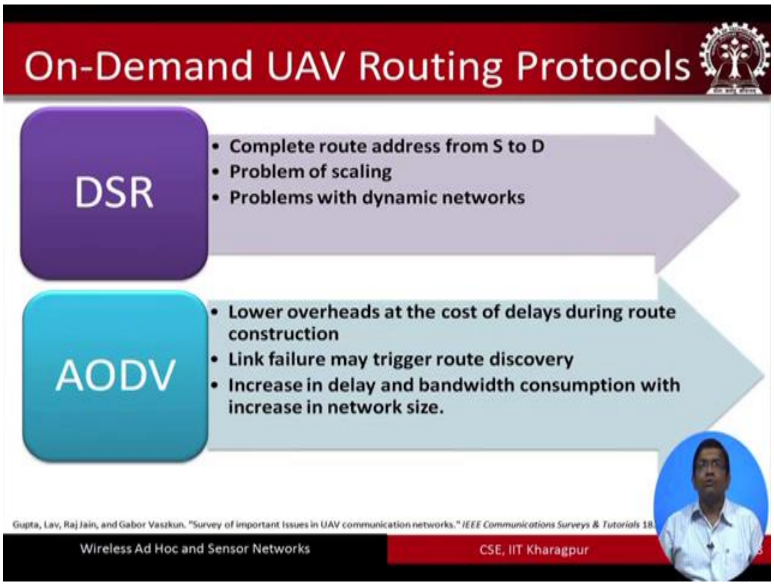

For on demand routing DSR and AODV which are the 2 very popular routing protocols that we used for MANETs are also adopted for use in these networks.

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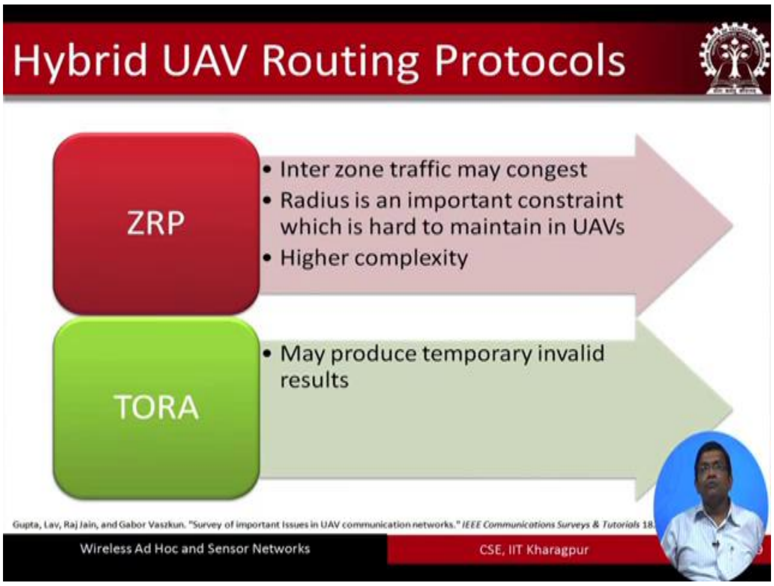

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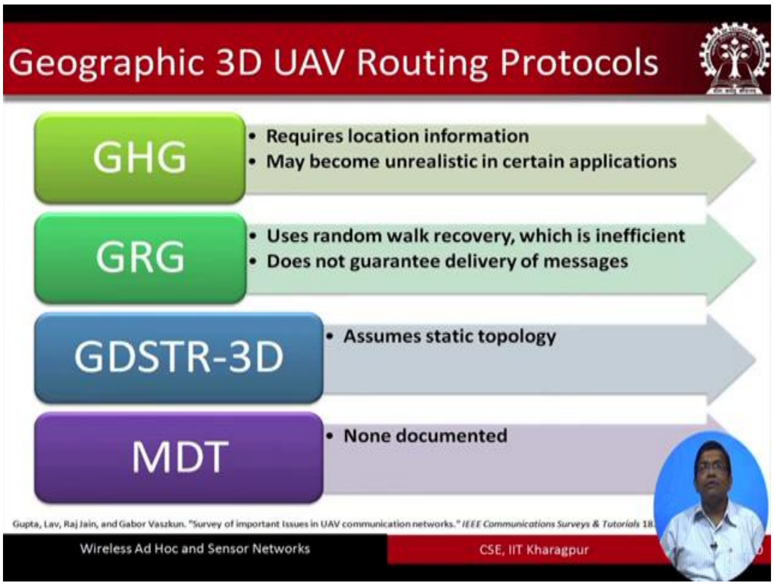

Hybrid UAV routing protocols the same ZRP zone based routing protocol and TORA which we had also seen which are also well known in the MANET community could also be used here. There are geographic 3D UAV routing protocols GHG GRG GDSTR-3D DMT. These are some of the geographic routing geographic routing protocol that have been proposed for use in UAV networks.

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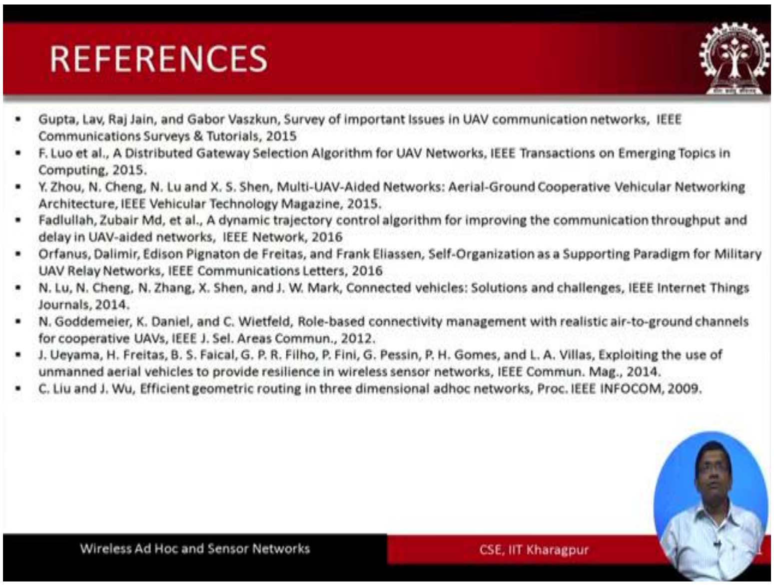

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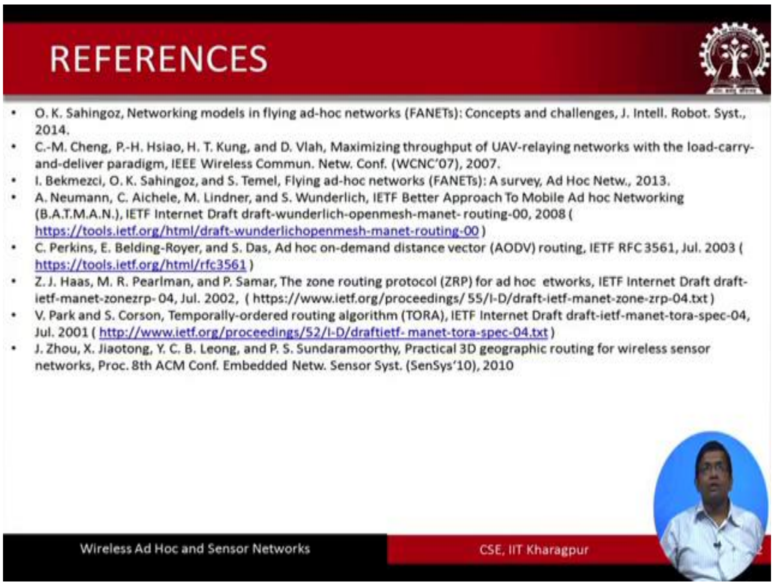

And finally, we come to the list of references corresponding to the material that was covered in this part of UAV networks.

Thank you.