Wireless Ad Hoc and Sensor Networks
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Lecture - 35
Underwater Sensor Networks-Part-III

So, now we come to the third part of underwater sensor networks. So, here we are going to talk about the different architectures that have been proposed for underwater sensor networks. Now we are going to focus more on the architecture and thereafter little bit on few other different issues.

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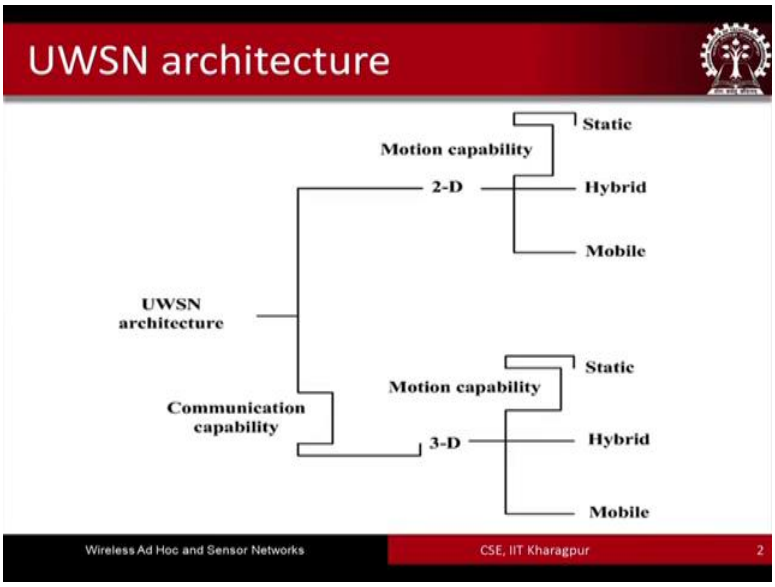

So, when we talk about architecture the underwater sensor network architectures that have been proposed they can be classified into 2D architecture and 3D architecture. So, under 2D depending on the motion capability or the motion of the different nodes in the network they can be even further classified into static 2D, hybrid 2D or mobile 2D, similarly for 3D as well static 3D, hybrid 3D and mobile 3D architectures.

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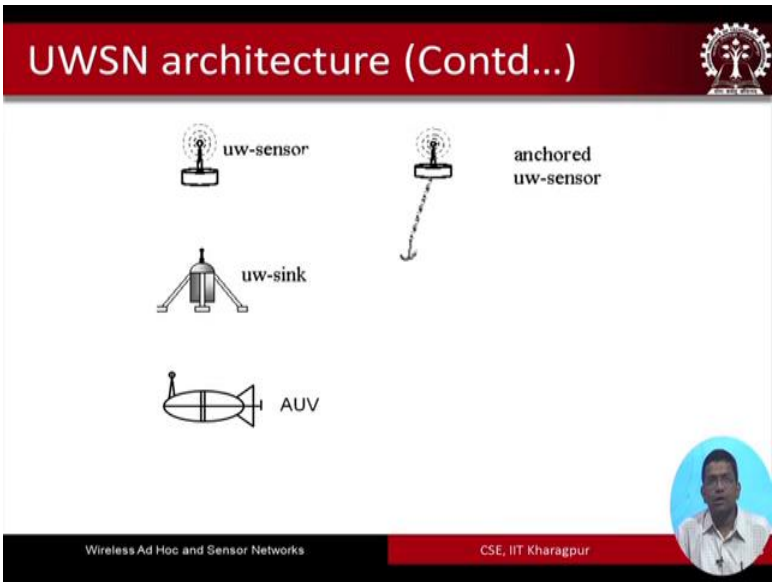

So, for underwater sensor networks there are different nodes that are used. So, first one is the underwater sensor itself AUV is the second one which is un autonomous underwater vehicle then underwater sink is a node which basically receives the which basically receives the data from the different sensor nodes and these there are anchored underwater sensor nodes which are denoted this way. So, these nodes are basically acting as anchors their positions are known and you know. So, their positions are known and these positions can be used by the other sensor nodes to localize themselves if their positions are not known. So, these labels are typically you know I am going to show you some of these architectures and in those architectures these labels are used.

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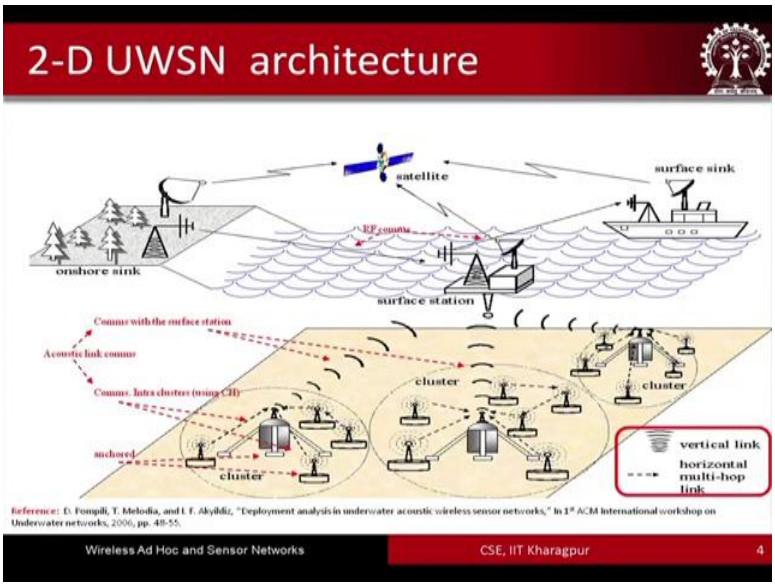

So, here first we look at the 2D underwater sensor network architecture. So, in the 2D architecture what we see is that we have the ocean surface like this and the sensor nodes are deployed on the ocean floor and these there are different clusters of nodes that are formed on the out of the sensor nodes that are deployed on the ocean floor and from this cluster heads there is a vertical link connectivity that is set up to the surface station and from this surface station basically the data are sent through satellites or whatever to the surface sink. This is the 2D architecture.

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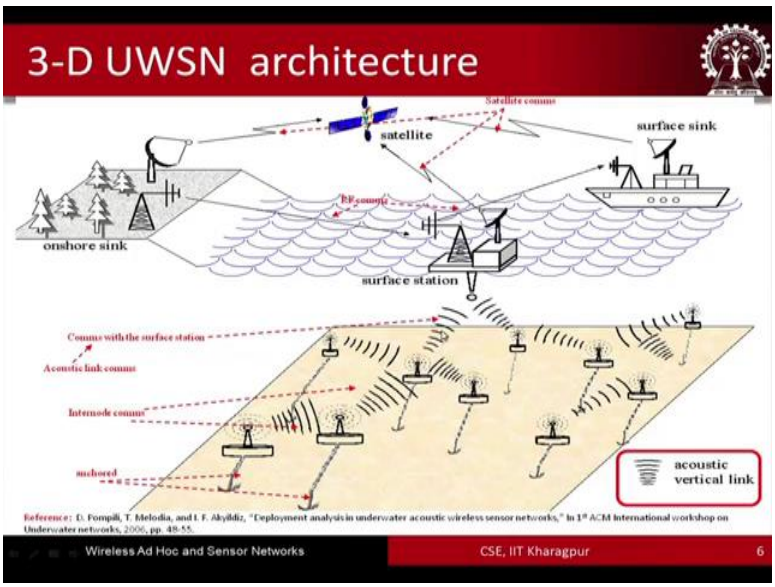

Then we have the 3D architecture where we have these anchored nodes as shown over here and these nodes basically are anchored to the ocean bottom. Then we have these nodes which are basically floating on the ocean surface on in the ocean column and there is acoustic mode of communication from them to the ocean they give a surface station. So, what we have? We have some nodes which are anchored to the ocean bottom and these nodes they are also able to communicate with each other plus they can send the data through acoustic means to the surface station and additionally we have these AUVs which can move all around and can help in communication between the different nodes plus they can also collect data and even they can extend the spatiotemporal coverage of communication in this diploid region.

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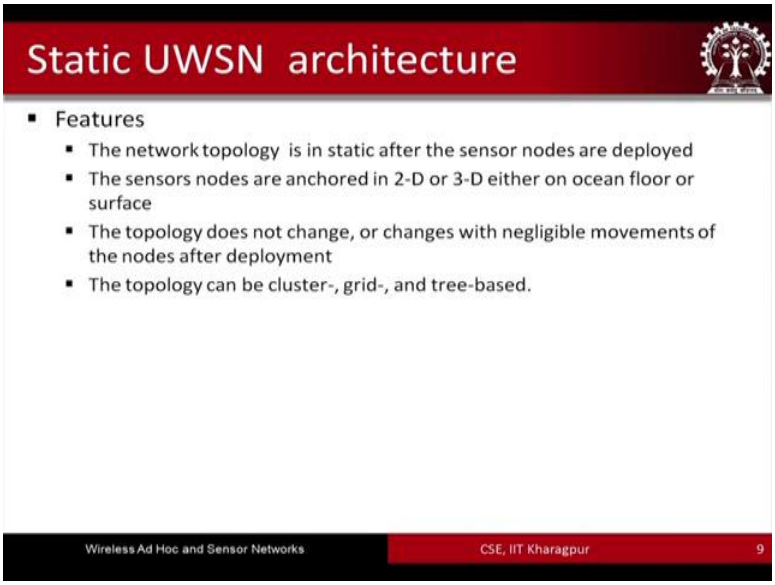

So, the features of static underwater sensor network architecture are like this the network topology is in static after the sensor nodes are deployed they do not move that topology does not change after the initial deployment the sensor nodes are anchored in 2D or 3D either on the ocean floor or on the ocean surface the topology does not change or it changes with negative movements of the nodes after deployment and the topology can be a cluster based topology, a grid based or a tree based topology that is adopted in this static UWSNs.

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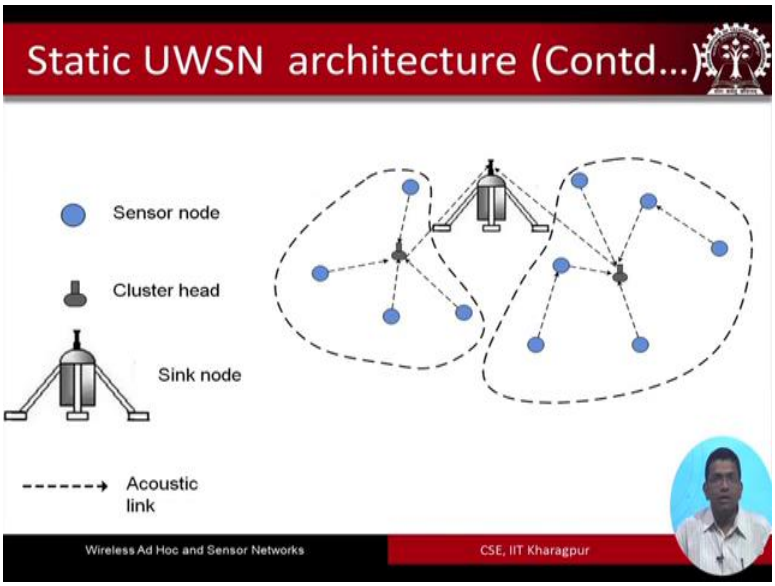

So, here is a picture of the static UWSN architecture here we have these blue coloured sensor nodes plus we have a cluster head to cluster heads are shown over here the 2 clusters and the corresponding cluster heads are shown and there is a sink node which basically connects with these cluster heads.

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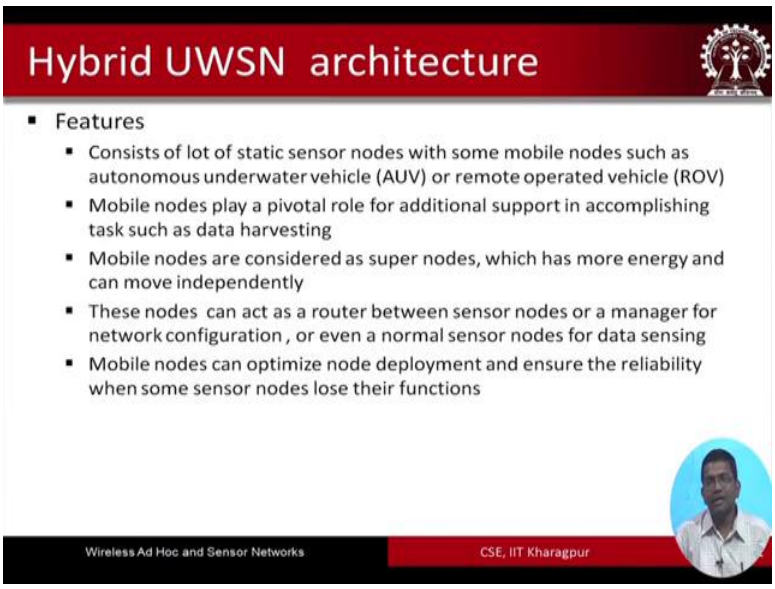

So, then we have the hybrid underwater sensor network architecture which consists of a lot of static sensor nodes with some mobile nodes and these mobile nodes are typically the AUVs and ROVs the mobile nodes basically play a pivotal role for additional support

in accomplishing tasks such as data harvesting the mobile nodes are considered as super nodes which have more energy and can move independently of each other. These nodes can act as a router between the sensor nodes or a manager for network configuration or even a normal sensor node for data sensing.

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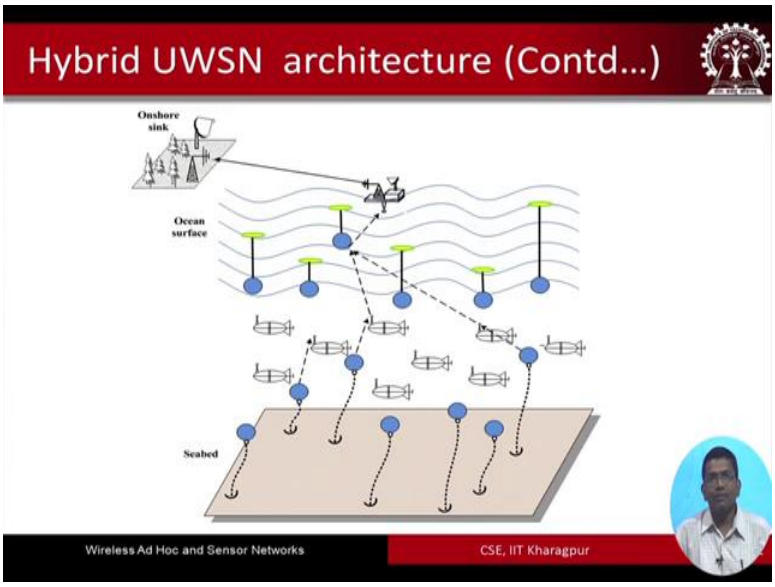

This is how the hybrid underwater sensor network architecture looks like. So, what we have are these surface anchored nodes, these nodes the blue coloured ones over here are not surface sorry, they are in the ocean bottom they are anchored to the bottom ocean bottom and there are some surface nodes which are floating with the help of boils. So, they are sort of like dipped under the ocean surface and these AUVs etcetera they are going to help in communication in between in the ocean column.

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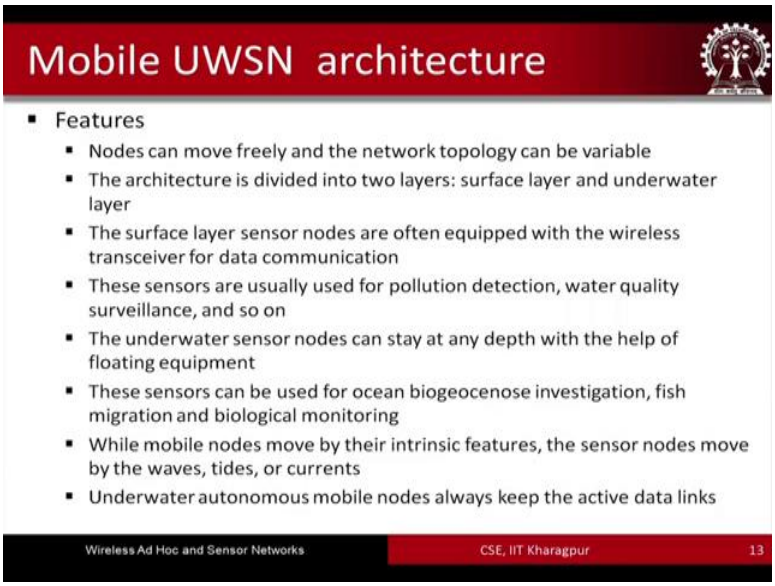

So, the features are that the nodes can move freely and the network. So, these are the features of the mobile underwater sensor network architecture and they can move freely the nodes can move freely and the network topology can be variable the architecture is divided into 2 layers - the surface layer and the underwater layer. The surface layer sensor nodes are often equipped with the wireless transceiver for data communication and these sensors are usually used for pollution detection water quality surveillance and so on. The underwater sensor nodes can stay at any depth with the help of floating equipments. So, these are some of the very prominent features of mobile underwater sensor networks.

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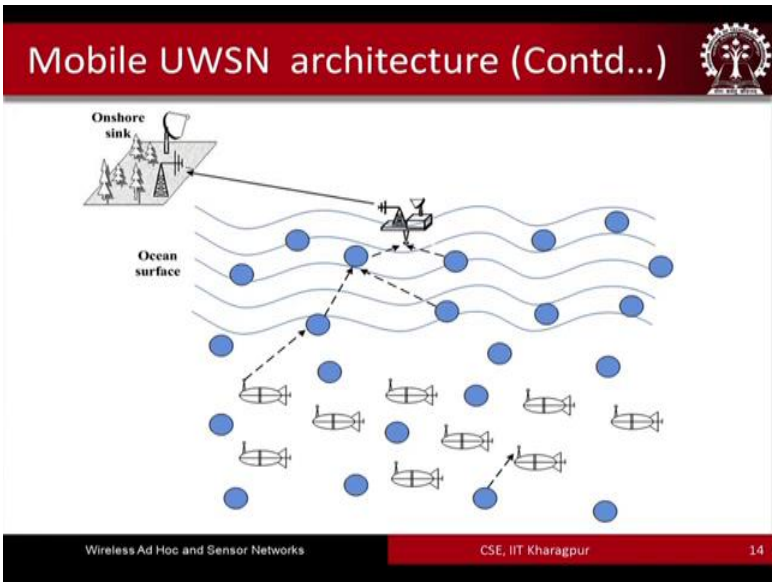

And here is a picture of the mobile sensor networks mobile underwater sensor networks. So, you can as you can see that you have these different sensor nodes which are not anchored like in the previous case, but these are like you know floating in the underwater column and also there are some UAVs which are also floating along with them.

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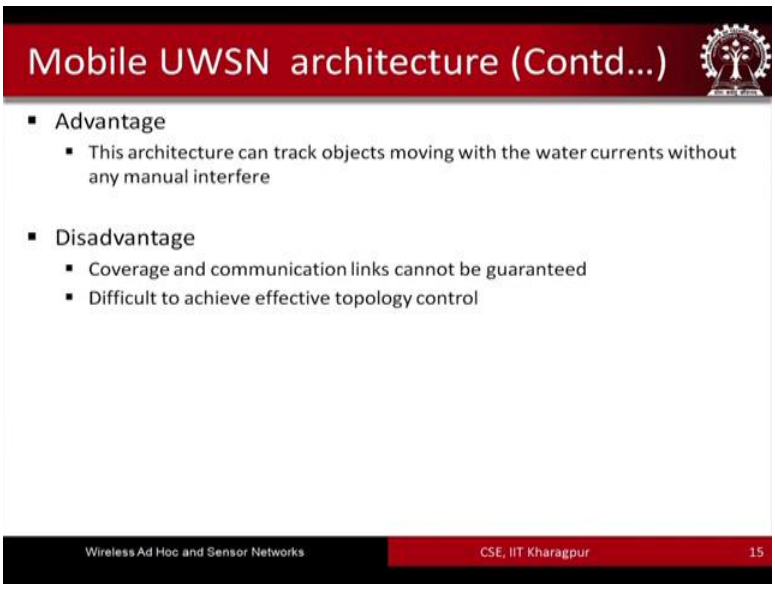

So, that the advantage of mobile underwater sensor network architecture is that architecture can track objects moving with the water currents without any manual interference and the disadvantages are like this the coverage and communication links

cannot be guaranteed in the mobile underwater sensor network architecture and this is quite obvious because due to active or passive mobility particularly passive mobility due to water currents, etcetera, etcetera. The initial coverage that is ensured may not be maintained at a later point of time and even the communication links that were existing at one point of time might have broken at a later instant of time due to quality of the different nodes.

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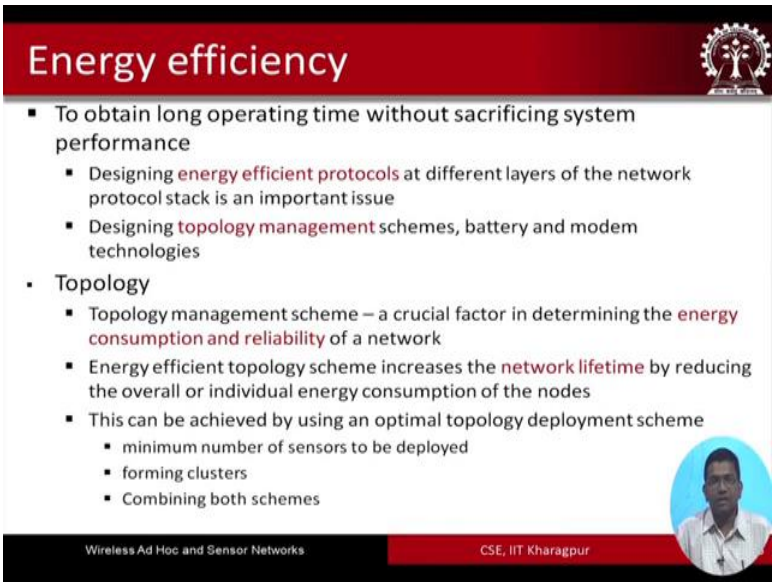

So, these are some of the advantages and disadvantage of this network this architecture. So, we have seen the static underwater sensor network architecture we have seen the mobile one and we have also seen the hybrid one in the static one. Typically what we have seen is the nodes are typically either placed in the ocean bottom or on the ocean surface and they do not move typically with respect you know even if there are ocean currents etcetera which are heating them not too much of mobility is there.

So, it is sort of like in the 2D there based 3D static mobility a static sensor networks are also possible to be deployed plus we have also seen that there could be and the hybrid sensor networks which basically where there are some static mobile static sensor networks which are deployed and which do not move for with time and even if there some ocean currents which heat them. And there are some mobile ones like the AUVs etcetera which basically move from one point to another in the ocean column and it is

hybrid because there is some mobility there is some nodes which are not mobile and so on.

So, it is a hybrid model and the mobiles under mobile underwater sensor networks basically the nodes which are deployed they all move. So, they all move, but the challenge over here is that at some points there can be network partitioning that can take place because of this particular mobility of the different nodes and it might be even difficult to get back the nodes to the original configuration as was initially planned.

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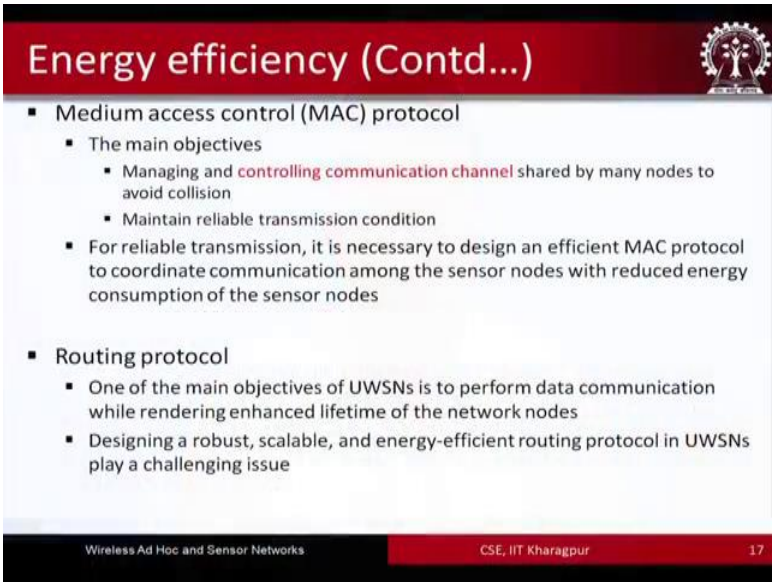

So, energy efficiency is the second issue. So, we have looked at architecture energy efficiency is very important issue energy efficiency with respect to the topology. So, topology you know. So, there are different aspects you know topology even topology management schemes that are deployed this should take into consideration the limited amount of energy of these different nodes underwater sensor nodes this you know additionally there should be battery considerations the minimum amount of battery consumption should happen the modem technologies that are used you know. So, whatever you know. So, all of these you know. So, the topology management basically should take into consideration energy consumption and reliability of the network.

So, and energy consumption basically directly determines the overall network lifetime because you know if some of these algorithms are implemented which consume more energy at the different nodes then that will lead to some of these nodes dying out of the

limited energy that they have and that will lead to reduced network lifetime and you know. So, that is that is not very desirable.

So, these are some of the issues that have to be taken care of with respect to energy efficiency and you know topology now energy efficiency and MAC protocol. So, any MAC protocol that is designed where you know MAC protocols basically have objectives such as managing and controlling communication channel that is shared by many nodes to avoid collision and maintaining reliable communication conditions right. So, this is what the main objectives of MAC any MAC protocol is and. So, for reliable transmission for reliable communication it is necessary to design an efficient MAC protocol to coordinate the communication among the sensor nodes with reduced energy consumption of the nodes.

So, reduced energy consumption is very important you can one can come up with different very you know to you know very efficient MAC protocols you know which can perform very well, but at the same time these protocols will be consuming too much of energy and it is not desirable to have any such kind of MAC protocol to be deployed in UWSN environments because these nodes are more energy constraint than the other types of sensor network nodes.

Routing is also something. So, any routing protocol that is designed you know should not only be robust scalable and robust and scalable, but this would also be energy efficient right. So, energy efficient, see in topology management in medium access control in routing and so on.

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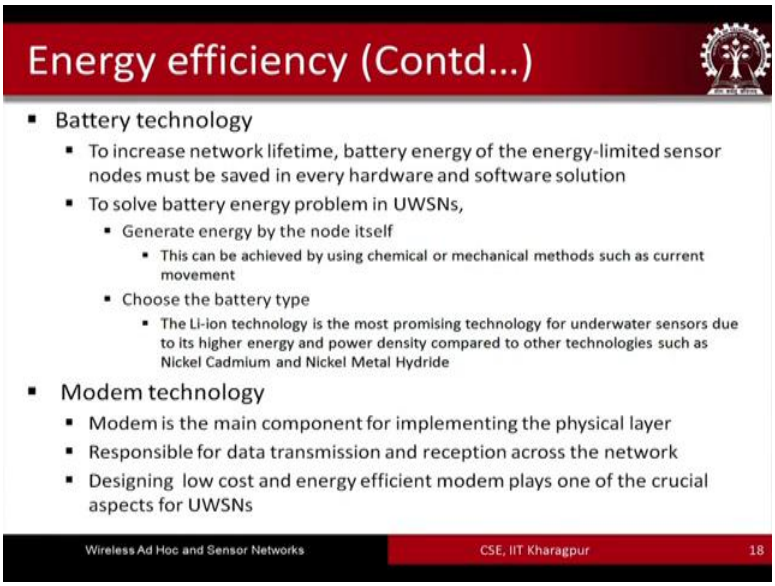

So, these are some of these important issues battery technology that is designed you know. So, batteries should be designed in such a way that they are going to last for long durations of time, so particularly as I said before that underwater sensor networks not only they consume more battery, but also the battery requirement is much more because these nodes once we are deployed in the ocean column where deployment itself is a very costly affair. So, once we are deployed you know it is you know one cannot think of the nodes dying out of their battery quite fast and you know getting rid of the node in the communication. So, it is very important to design batteries which can last for long durations of time thereby giving increased lifetime of the network.

Modem technology you know. So, basically the modems that are designed this would not only be loop of low cost acoustic modems, but they should also be energy efficient and. So, in low cost you know being of low cost and energy efficient are 2 very important things important characteristics of acoustic modems that are designed for UWSNs.

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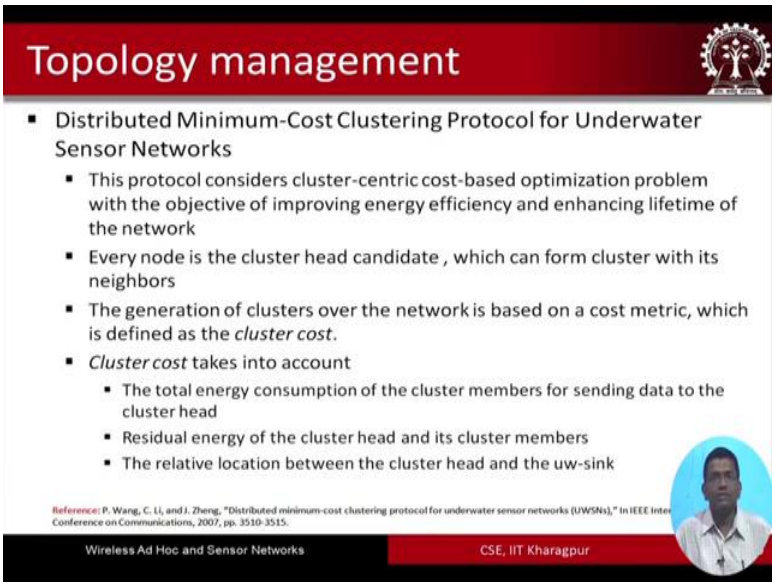

So, here is a topology management scheme that is proposed for UWSNs specifically it is called the distributed minimum cost clustering protocol for underwater sensor networks it was proposed by Wang et al in 2007, in IEEE EICC conference it was published. So, this protocol basically is a cluster based protocol and here every node is either designated as a cluster member or a cluster head. And initially the cluster node is a cluster head candidate which can form cluster with its own neighbours the generation of the clusters over the network is based on the cost metric which is defined as the cluster cost, and this cluster cost basically takes into account the total energy consumption of the cluster members for sending data to the cluster head the residual energy of the cluster head and the relative location between the cluster head and the sink.

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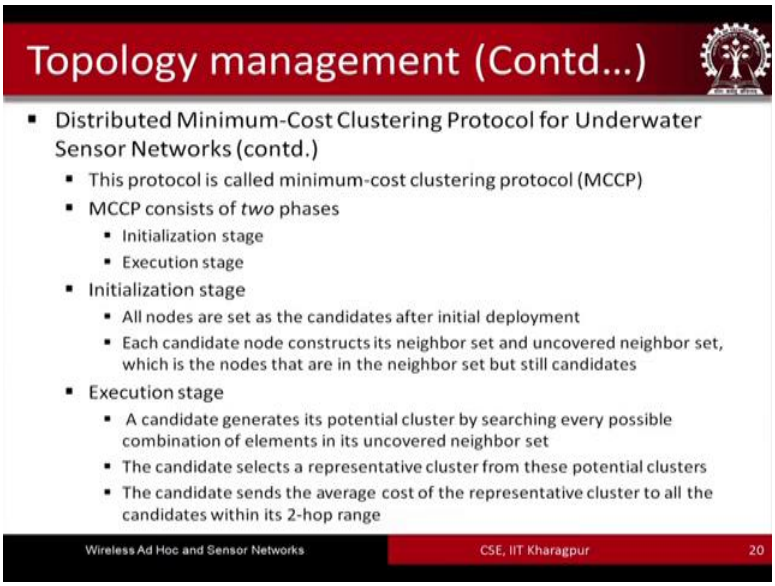

So, this protocol is called minimum cost clustering protocol MCCP which consists of 2 phases the first phase is the initialization phase. The next one is the execution phase in the initialization phase basically as this name suggesting in initial it talks about initial deployment of the different nodes and each candidate node basically after deployment it constructs the neighbour set and the uncovered neighbour set which is the nodes that are in the neighbour set, but still our candidates.

Execution stage a candidate basically generates its potential cluster by searching every sensor every possible combination of elements in its uncovered neighbours set the candidate selects a representative cluster from these potential clusters, the candidate sends the average cost of the cluster representative clustered to all the candidates within its 2 hop range.

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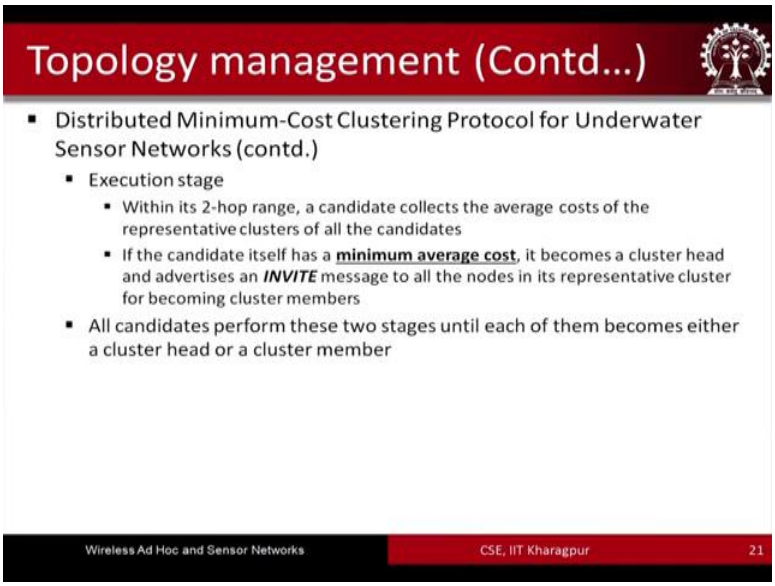

In the execution stage when it is 2 hop range within its 2 hop range; that means, within the 2 hop range of a node a candidate collects the average costs of the representative clusters of all the candidates if the candidate itself has a minimum average cost it becomes the cluster head and advertises an invite message to all the nodes in its representative cluster and as for becoming the cluster members.

So, it is a similar kind of typical cluster based topology management approach where basically a node is initially designated as a cluster head and that node basically you know it sends some invite messages or you know, it sends some it broadcasts some messages and that those messages basically you know are received by the neighbouring nodes and these neighbouring nodes if they want to join the cluster they are going to respond back and these nodes eventually you know they form together they form the these clusters.

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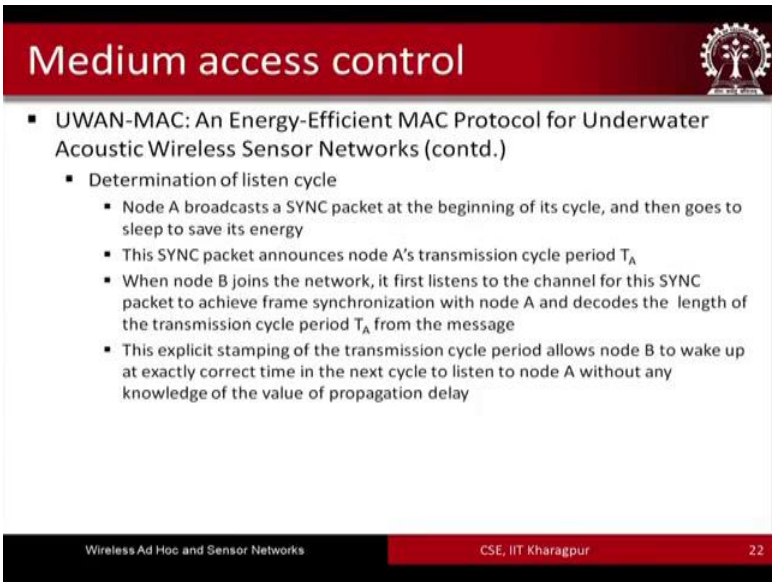

So, a MAC protocol was there are different MAC protocols that have been designed one MAC protocol is the UWAN MAC which is the full form is an energy efficient MAC protocol for underwater acoustic sensor networks. So, here basically it works in different phases the determination of listen cycle determination of transmit timers and so on.

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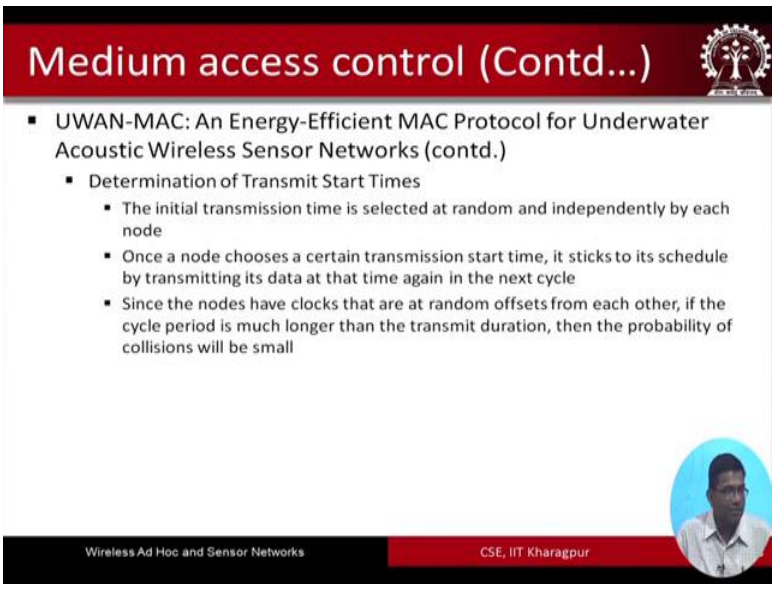

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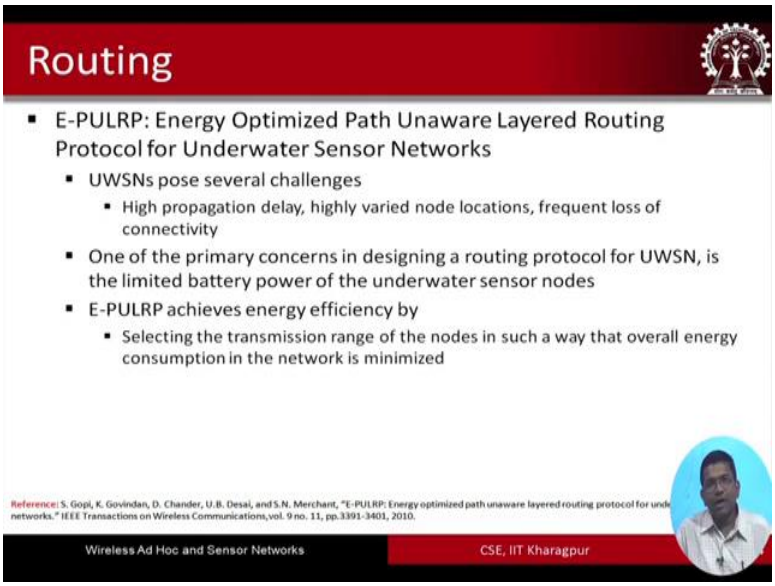

So, I am not go gone through it, but each of these 2 phases they talk about you know how to perform medium access control in these environments in an energy efficient manner routing is a very important problem in any network and similarly for underwater sensor networks as well. So, one of the primary concerns in designing a routing proto protocol for these networks is the limited battery power of the sensor nodes.

So, a protocol called EPULRP was proposed it achieves energy efficiency by selecting the transmission range of the nodes in such a way that the overall energy consumption in the network is minimized.

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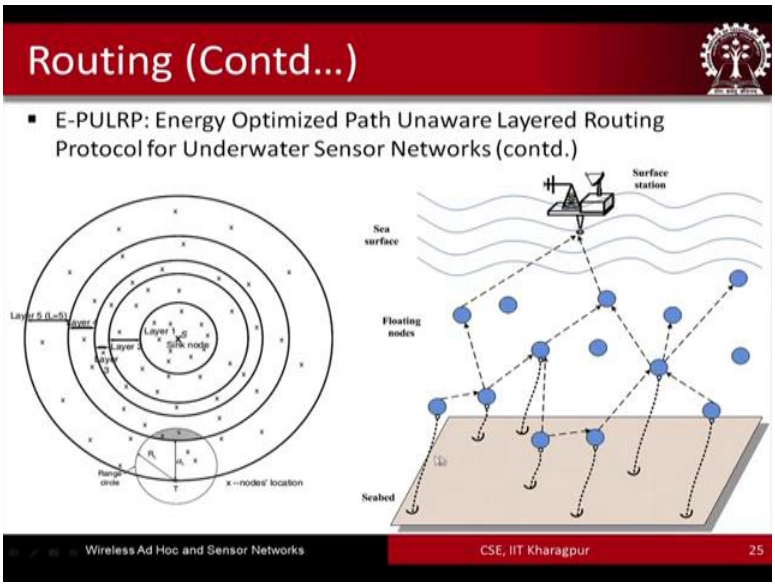

This is how diagrammatically the EPULRP protocol looks like. So, here what we have for in terms of the architecture this is how it looks we have you know these are the anchored nodes to the seabed and these are the floating nodes and. So, these floating nodes they can communicate with these anchored nodes and these nodes they can send the data to the surface sink, but what is interesting to see is on the left hand side as we can show over here these layers around these different nodes in the ocean column are formed. So, there are different layers concentric layers that are formed layer 1, layer 2, layer 3, layer 4 and layer 5.

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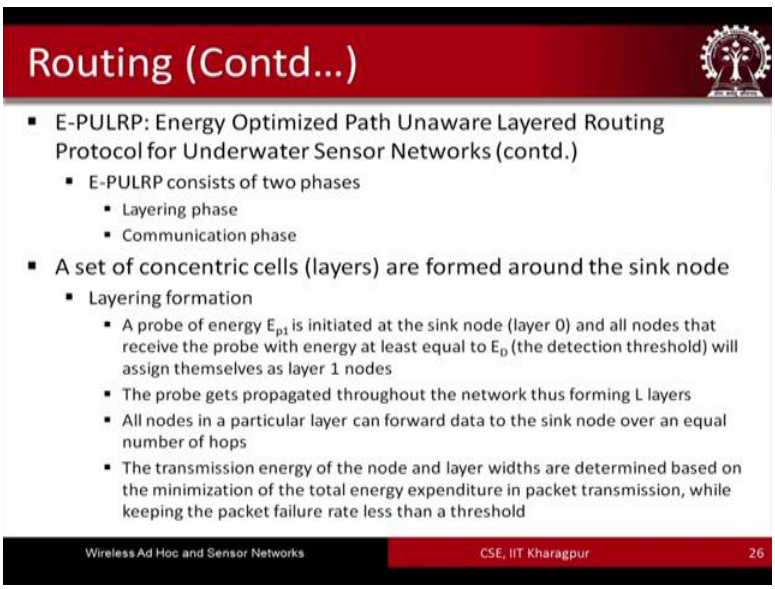

So, how are these layers formed? So, we are going to look at this shortly. So, these phases for forming the layers is called the layering phase and thereafter once the layers are formed then you get into the communication phase. So, in the layering phase a proof of energy a proof of energy EP 1 is initiated at the sink node in layer 0 and all nodes that receive the probe with energy at least equal to E D which is the detection threshold will assign themselves as layer one nodes. The probe gets propagated throughout the network thus forming l layers all nodes in a particular layer can forward the data to the sink node over an equal number of hops and the transmission energy of the node and the layer width are determined based on the minimization of the total energy expenditure in packet transmission while keeping the packet failure rate less than that particular threshold.

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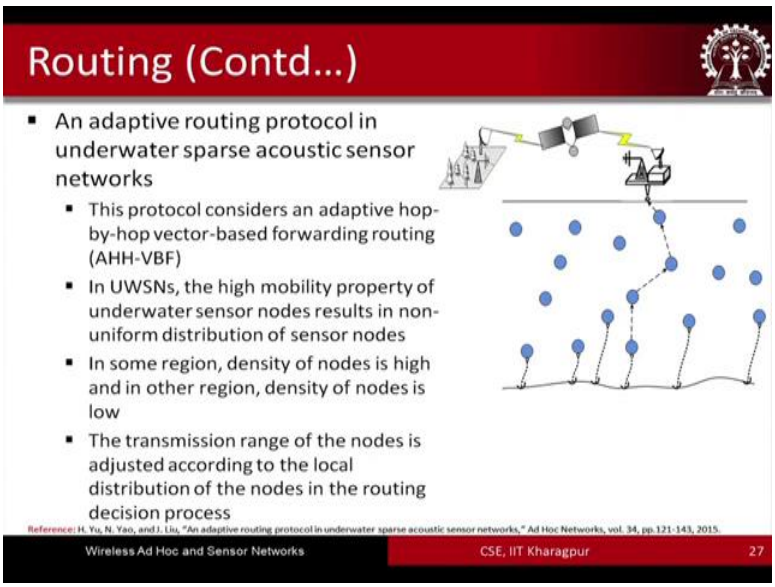

So, a protocol called AHH VBF; AHH VBF; full form is adaptive routing protocol for an underwater sparse sensor network was proposed it is a vector based routing protocol. So, here basically so, in these environments the high there is high mobility property of underwater sensor nodes that results in non uniform distribution of these nodes. So, in some region the density of the nodes is high and in some other region the density of the nodes is low consequently. The transmission range of the nodes is adjusted according to the local distribution of the nodes in the routing decision process.

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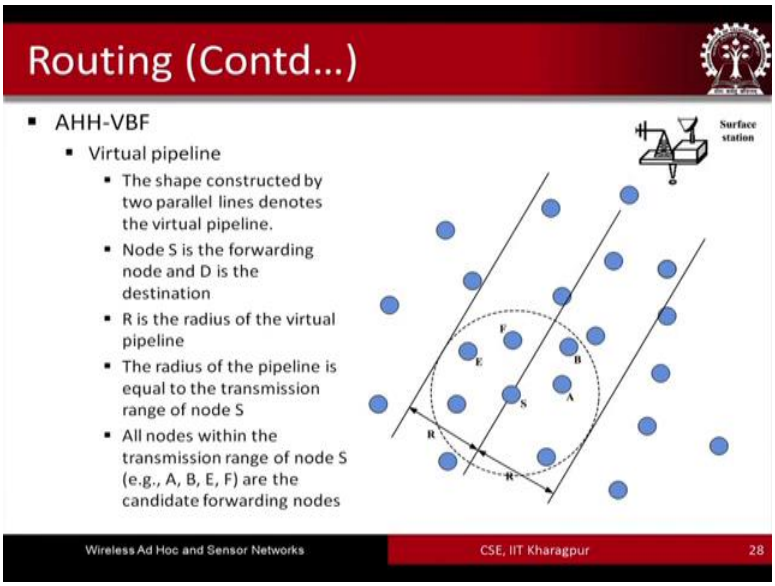

So, this particular approach, this particular scheme the way it works is by creating something called the virtual pipeline. So, the virtual pipeline is something like this that you know from these sensor nodes to the surface station from the target wants to the surface station a virtual pipeline kind of thing is constructed around the source node. So, so and this has the radius r you know. So, this r is basically the radius of the virtual pipeline and the radius of the pipeline is equal to the transmission range of this node s. So, it is made in such a way that the radius r is equal to the equal to the transmission range of the node S. So, all nodes within the transmission range of node S. So, in this particular case; that means, ADE and f all of them are the candidate forwarding nodes.

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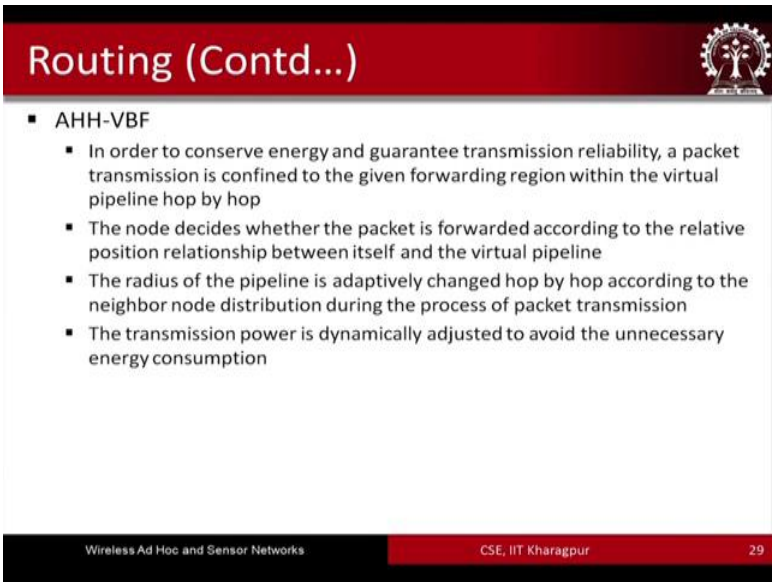

So, in order to conserve energy and guarantee transmission reliability a packet transmission is confined to the given forwarding region within the virtual pipeline hop by hop. The node besides whether the packet is forwarded according to the relative position the relationship between itself and the virtual pipeline. The radius of the pipeline is adaptively changed to hop by hop according to the neighbour node distribution during the process of packet transmission.

So, with this we come to an end of this module and this is the third one and the last one is remaining where we will talk about localization.

Thank you.