Wireless Ad Hoc and Sensor networks
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Lecture - 34
Underwater Sensor Networks-Part-II

Underwater sensor networks the second part. So, we have already understood the basics of underwater sensor networks, the utilize the usefulness the underwater sensor networks, and the basic architecture of underwater sensor networks. We have already understood those the applications of them the challenges behind the deployment of underwater sensor networks and so on. So, let us now focus on the different deployment models or underwater sensor networks.

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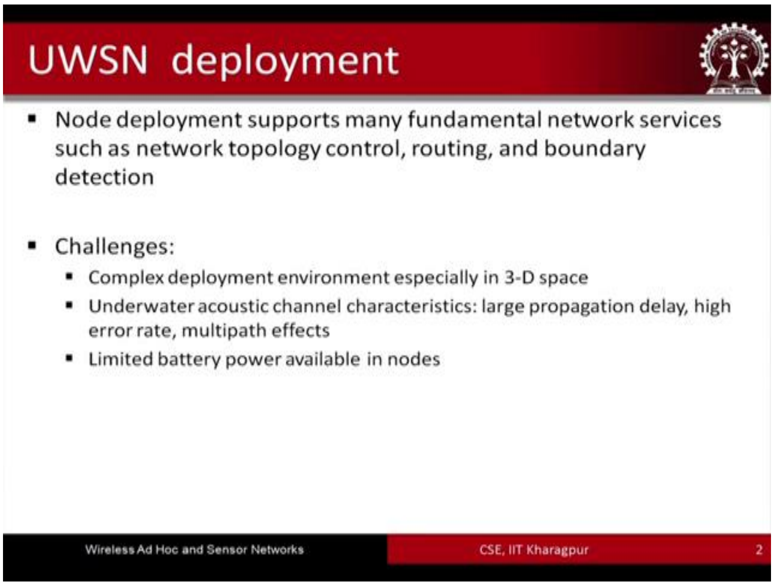

So, when we talk about underwater sensor network deployment there are different things that have to be kept in mind. So, first of all network topology control routing boundary detection these have to be kept in mind while you know taking care of the deployment issues there are different challenges in underwater sensor network deployment. So, these challenges are with respect to that we have a 3D space unlike in the case of terrestrial environments and the you know. So, deployment itself not only that the nodes have to be basically deployed in the 3D space, but also these nodes are subjected to different types of dynamic behavior in the water due to currents and tides and waves and so on.

So, this is one thing. The second challenge is that the acoustic channel itself is a you know is subjected to different things. So, there is number one large propagation delay there is high error rate and there a multipath effect. So, these are the ones that we have already seen in the first part of this topic UWSN. So, in the part one we have already gone through these different characteristics of underwater challenges and additionally we have limited battery power available in the nodes.

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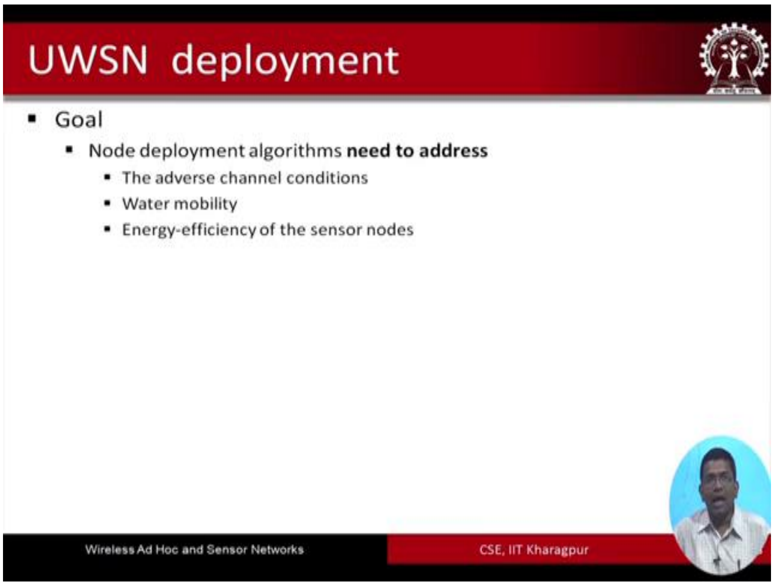

So, the goal of deployment is that we need to come up with some algorithms, that will address the adverse channel conditions, the mobility of water and energy efficiency of the sensor nodes.

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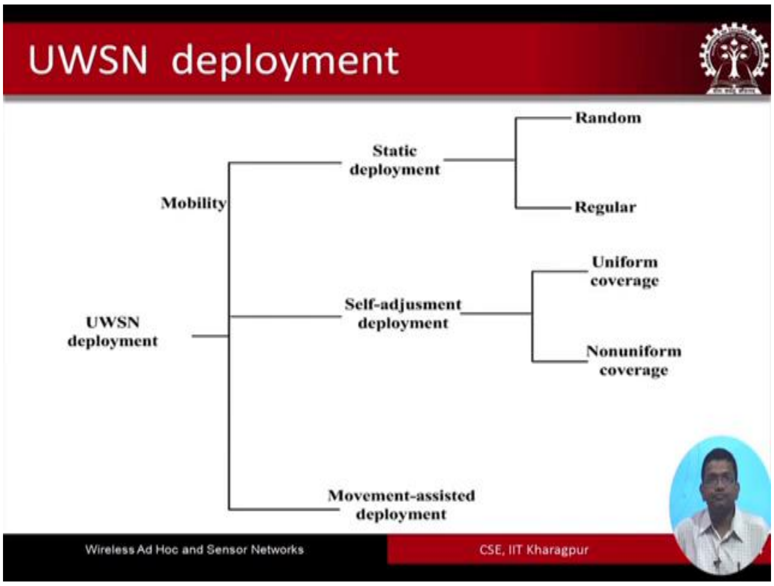

So, based on different criteria, the underwater sensor network deployment algorithms can be classified into 3 types. Static deployment self adjustment self adjusted deployment and movement assisted deployment. In static deployment again you can have random deployment or regular deployment, in self adjusted deployment you have uniform coverage deployment or non uniform coverage deployment, and then you have the movement assisted deployment. So, broadly 3 classes of UWSN deployments static self adjusted and movement assisted.

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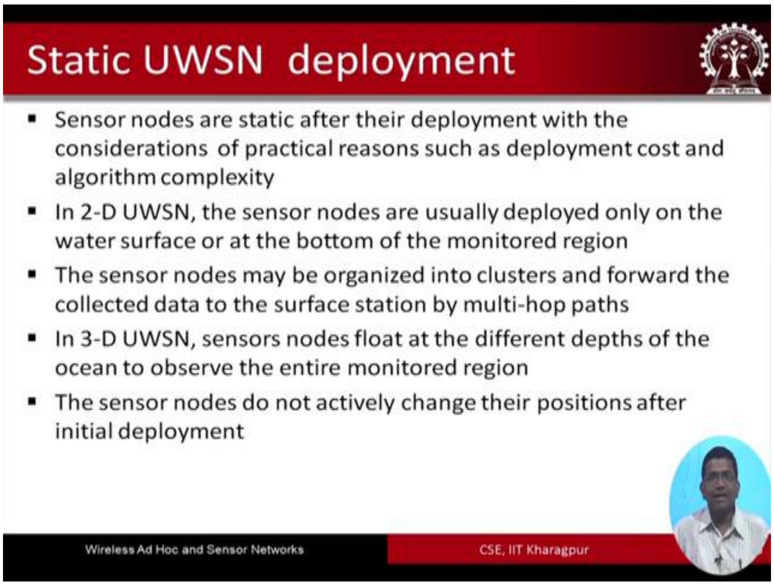

So, in static deployment the sensor nodes are static after their deployment with the considerations of the practical reasons such as the deployment cost and algorithm complexity. So, as the name suggests over here again. So, these sensor nodes somehow you make them static either you make them static on the ocean surface you know just you know just below the ocean surface you tag them through some buoys or something like that or you tag them in such a way that they are not going to move right.

So, you make them static. So, this is one possibility or you put them on the ocean floor and that way they can be made static. So, typically these are like 2D deployment mechanisms. So, either in ocean floor or ocean surface. So, in 2D underwater sensor networks the sensor nodes are usually deployed only on the water surface or at the bottom of the monitored region, but 3D deployment is also possible for static. Where the sensor nodes float at the different depths of the ocean to observe the entire monitored region and the sensor nodes do not actively change their positions after initial deployment.

So, basically the relative the relative displacement of these nodes they remain the same right. So, so these nodes they are basically fitted with certain you know mechanism by which even if there is the ocean current that will hit, it will again come back to it is original preconfigured position like. So, and these nodes are going to float at different you know different points in the ocean column. So, 2D is more typical for static UWSNs, 3D is also possible and both of these are using both of these models one can have static UWSN deployment

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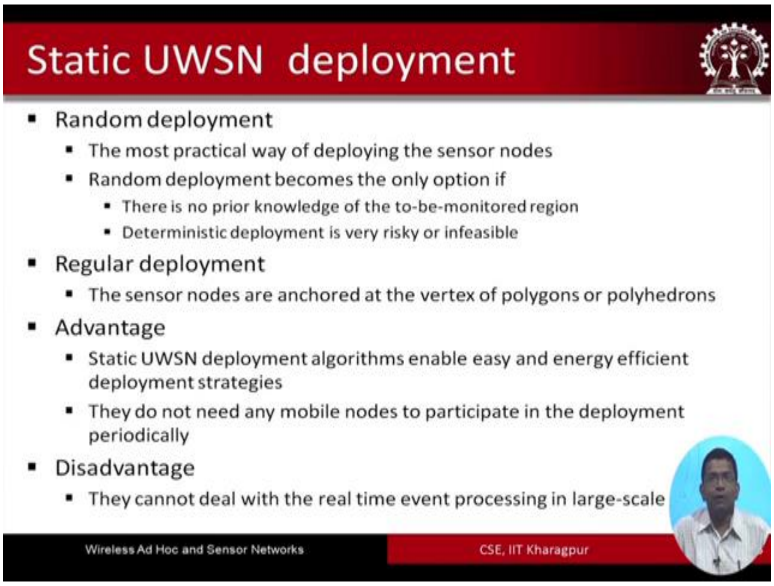

So, random deployment is one where basically, what happens is it, is it is more of a like practical way of deployment as it is in suggests that randomly a different positions different positions you are going to deploy the sensor nodes and in regular deployment basically it is p determined. So, maybe some kind of a polygonal shape is considered or a polyhedron shape, polyhedron shape is considered and these sensor nodes are anchored at the different vertices of these polygons and polyhedrons right. So, the advantages of static UWSN and deployment algorithms are that they are easy to deploy, they are any energy efficient, and they do not need any mobile nodes to participate in the deployment periodically the disadvantage is that they cannot deal with the real time even processing in large scale underwater sensor networks.

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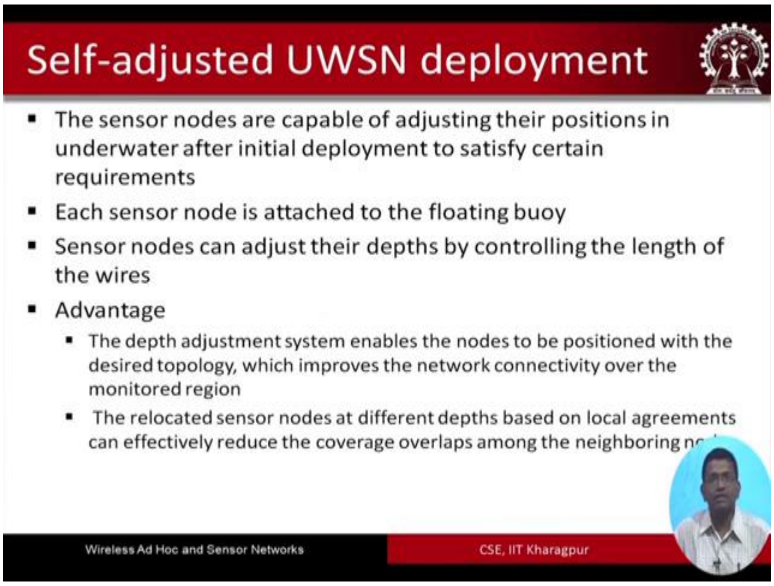

Self adjusted underwater sensor network deployment is the second type of deployment where the sensor nodes at will be of adjusting that position in underwater after initial deployment to satisfy certain requirements. Here each sensor node is attached with a floating buoy and the sensor nodes can adjust their depths by controlling the length of the wires. So, so basically you know. So, you place them somewhere the sensor nodes they can self adjust depending on how the bouys are programmed on which the sensor nodes are a fixed and you know. So, these nodes they can adjust their positions by themselves and they are going to maintain the positions in the ocean column. The advantages are like this that the depth adjustment system enables the nodes to be positioned with the desired topology, which improves the network connectivity over the monitored region. So, this is one advantage.

The second advantage is that they relocated sensor nodes at different depths based on local agreements, and that can effectively reduce the coverage overlaps among the neighboring nodes. So, this is relocation basically this relocation mechanism of these nodes at different depths that can basically improve the overall performance in terms of coverage etcetera, and that way the overall you know performance of the network also gets improved.

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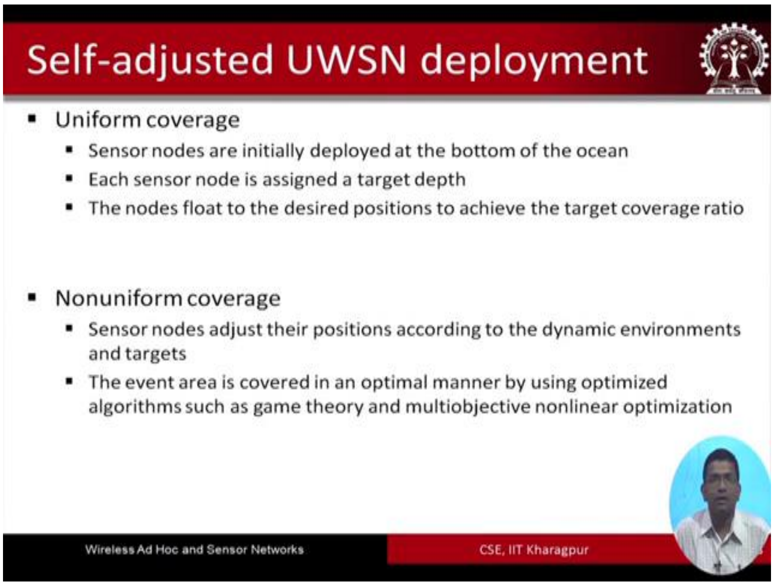

Uniform coverage and non uniform coverage sensor network deployment in uniform coverage the sensor nodes are initially deployed at the bottom of the ocean. Each sensor node is assigned a target depth and the nodes float to the desired position to achieve the target coverage ratio. In non uniform coverage the sensor nodes adjust their positions according to the dynamic environments and targets, and the event area is covered in an optimal manner by using optimized algorithms such as game theory or different types of optimization and so on.

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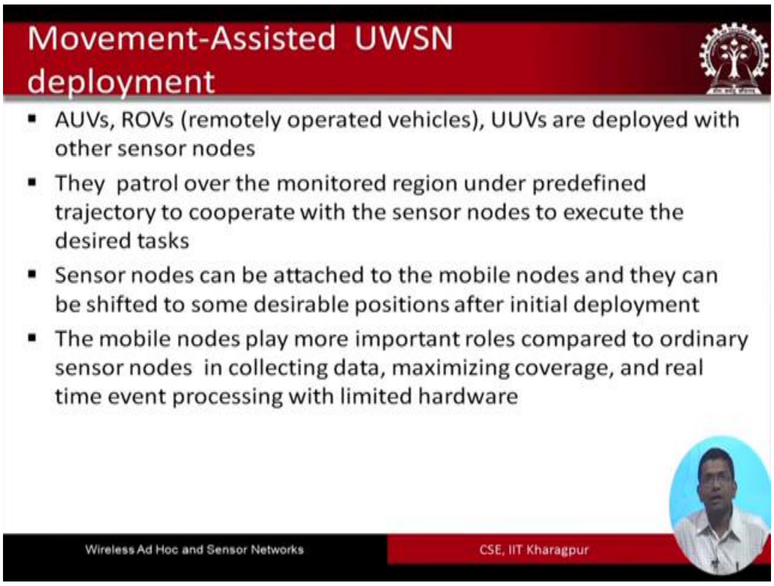

So, in movement assisted underwater sensor networks AUVs and ROVs etcetera are also deployed with other sensor nodes. So, these AUVs and ROVs etcetera UUVs they basically patrol over the monitored region, under predefined trajectory to cooperate with the sensor nodes to execute the desired tasks. So, the sensor nodes are deployed at different places and these AUVs ROVs etcetera they are going to move around these sensor nodes.

And they are going to help these nodes these sensor nodes which are deployed to help them to cooperate or communicate with each other the sensor nodes can be attached to the mobile nodes and they can be shifted to some desirable positions as well after initial deployment. So, you can basically have one of these sensor nodes a couple of this sensor nodes you know a fixed to these AUVs ROVs etcetera. So, when they move they can also take them away and take them to the new location and so on. So, this is this is movement assisted on our sensor network deployment.

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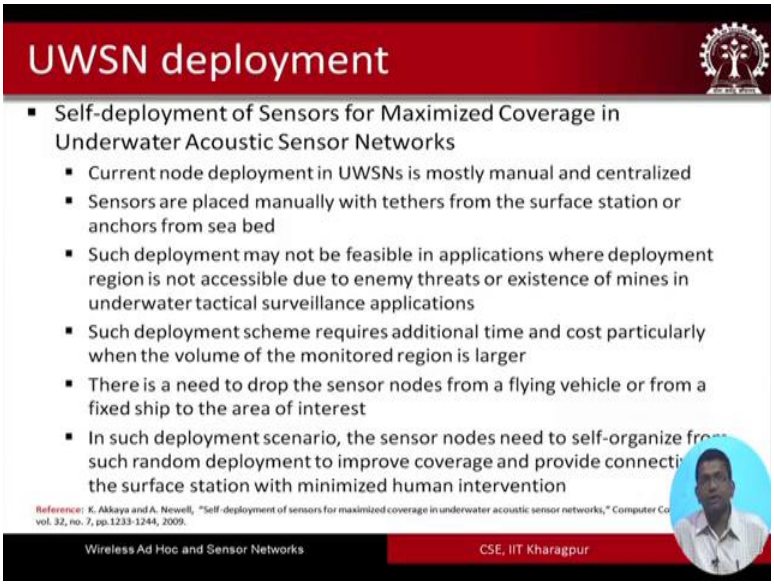

Now, let us look at a specific type of underwater sensor network deployment algorithm that is proposed, which is the self deployment of sensors for maximized coverage in underwater acoustic sensor networks. This particular paper was published by Akkaya and Newell in computer communications channel in 2009. So, these are the features of this particular deployment algorithm. The current node deployment in underwater sensor networks is mostly manual and centralized. Sensors are placed manually with tethers from the surface station or anchors from sea bed. These are the considerations at this particular algorithm by Akkaya and Newell. Basically take such deployment may not be feasible in applications where deployment region is not accessible due to enemy threats or existence of mines in underwater tactical surveillance applications. And such deployment scheme requires additional time and cost particularly when the volume of the monitored region is larger. And there is a need to drop the sensor nodes from a flying vehicle or from a fixed ship to the area of interest.

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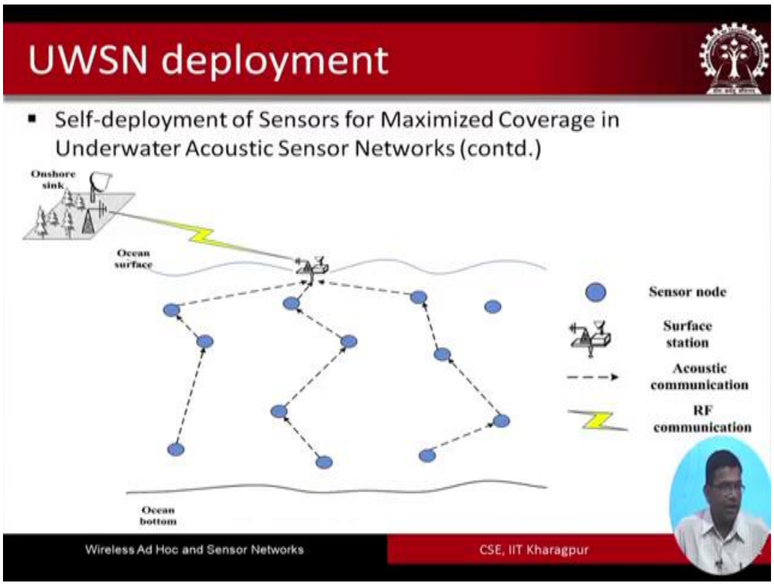

So, these are some of the characteristics of this deployment algorithm by Akkaya and Newell. So, this is the kind of consideration that was meant in their algorithm. So, they have the onshore sink and they have the ocean surface on the ocean surface they have this surface station. And this surface station basically you know there are different nodes on the sensor nodes, which are basically floating all around in the ocean column and this is the acoustic mode of communication and from this basically there is (Refer Time: 10:42) are brought to this particular surface station, and from the surface station to the onshore sink it is sent by RF communication this is the overall architecture that is considered by Akkaya and Newell.

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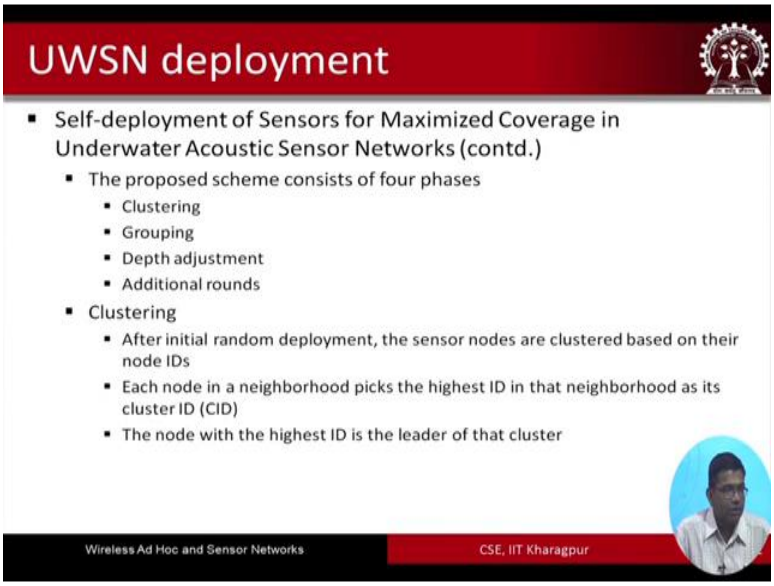

So, self deployment of sensors for maximize coverage in underwater acoustic sensor networks. So, so there are in this particular scheme Akkaya and Newell scheme there are 4 phases that have been considered to the clustering scheme, the clustering scheme clustering phase the grouping phase the depth adjustment phase and additional rounds phase. So, in the clustering phase basically after initial random deployment the sensor nodes are clustered based on their node IDs. And each node in a neighborhood basically picks the highest ID in that neighborhood as it is clustered ID. So, the clustered. So, the clustered IDs are selected is the nodes are initially deployed randomly and the clusters are formed the cluster IDs are selected and the node with the highest clustered IDs selected as the leader of the cluster.

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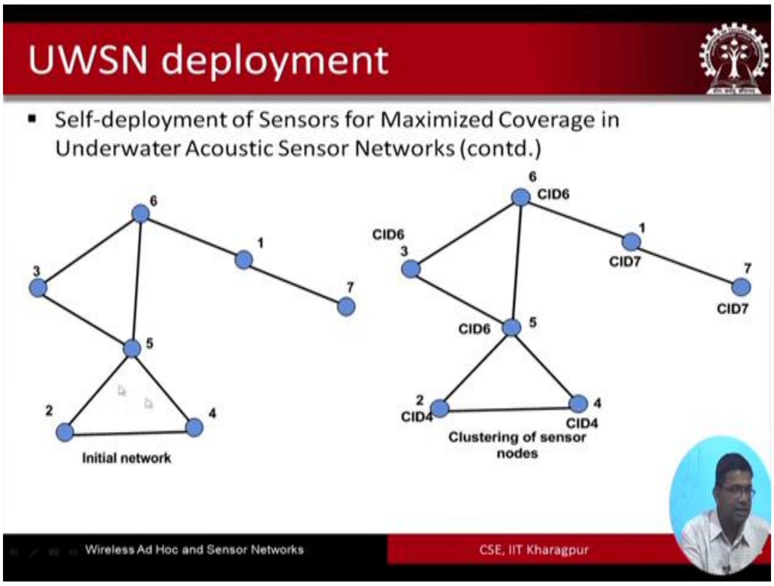

So, this is the initial network and from this you are going to form different cluster IDs like this right. So, these are the different cluster IDs and from these cluster IDs one can get the this is this is the cluster head right. So one can calculate the cluster head.

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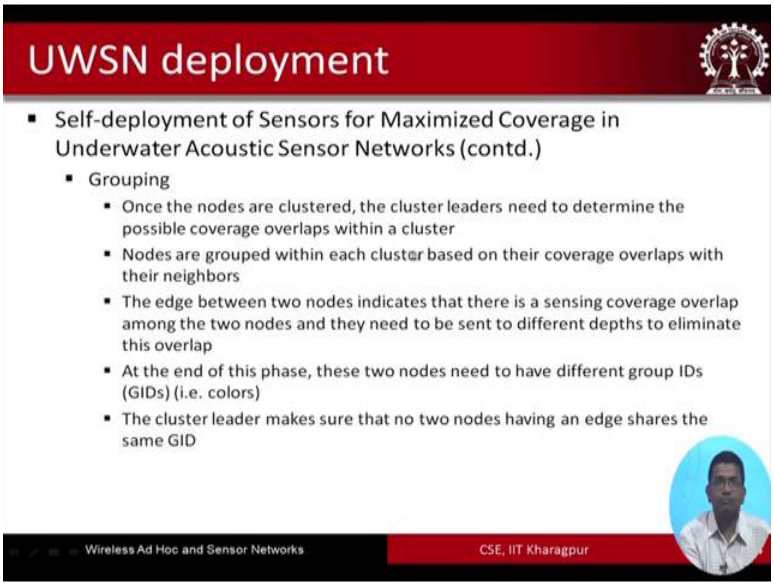

So, once these nodes are clustered the clustered leaders need to determine the possible coverage overlaps within a cluster. So, these nodes are grouped within each cluster, based on the coverage overlaps with their neighbors. The edge between the 2 nodes indicates that there is a sensing coverage overlap among the 2 nodes and they need to be sent to different depths to eliminate this overlap. So, this is how basically they want to maximize the sensing coverage overlap, and they want to send their first of all they are determining that there is some kind of an overlap and then we are going to send them apart as much as possible. So, at the end of this phase these 2 nodes need to know in to have different group IDs GIDs which are in noted 2 different colors.

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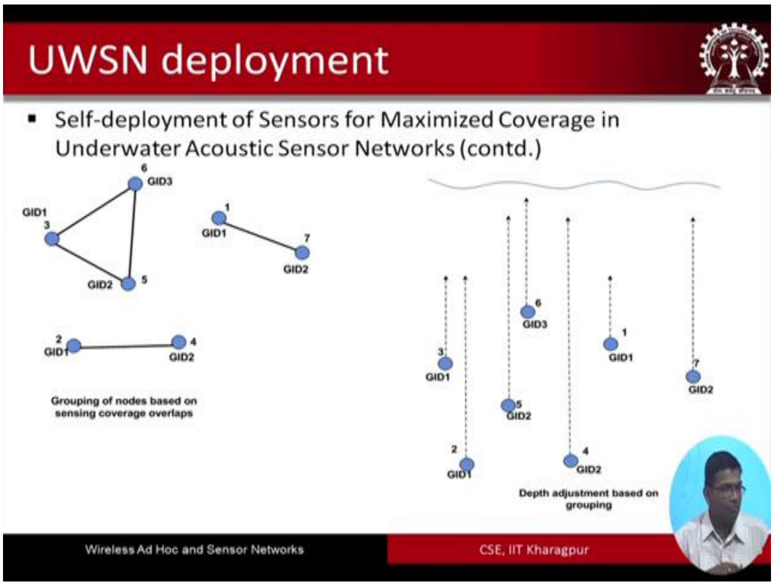

So, these different group IDs are formed GID 1 GID 2. So, these would look in the you know this is the depth view of these group IDs and the corresponding clusters etcetera, and this grouping of this nodes they are based on the sensing coverage overlaps.

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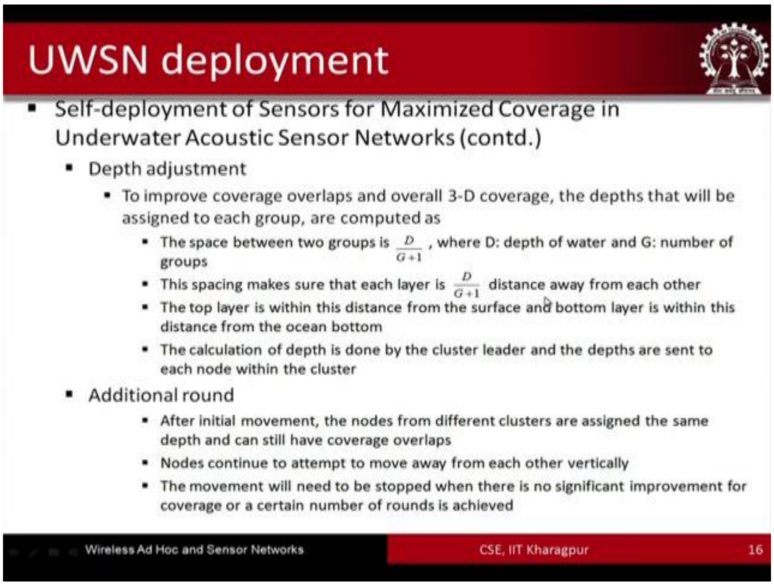

So, there are other phases after the clustering and grouping phase, there is a depth adjustment phase. So, to improve the coverage overlaps and the overall 3D coverage. The depths that will be assigned to each group are computed using this particular formula. So, the space between 2 groups is should be maintained as D by G plus one where D is the depth of water and G is the number of groups. So, this spacing makes sure that each layer is G by sorry D by G plus one distance away from each other.

So, then the next phase is basically the additional rounds phase after initial deployment. The nodes from different clusters are assigned the same depth and they can still have coverage overlaps. Nodes continue to attempt to move away from each other vertically. The movement will need to be stopped when there is no significant improvement for coverage or a certain number of rounds is achieved.

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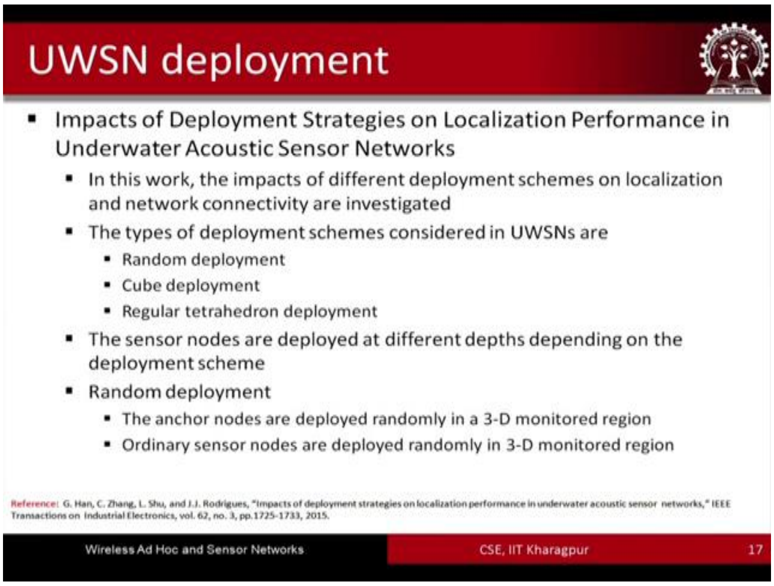

So, this was one very important deployment scheme that is known. And the other one is basically that this is proposed by Han Zhang Shu and Rodrigues in (Refer Time: 14:44) injections on industrial electronics in 2015. So, here basically this particular work it is more focused on the impact of the deployment strategies on localization performance in these networks.

So, in this was the impact of the different deployment schemes or localization and network connectivity are investigated. And the different deployment schemes that are considered are the random deployment. The cube deployment cube deployment means that you know cubes are considered and at the corners of the cubes the sensor nodes the anchor is placed. And regular tetrahedron deployment means that the tetrahedral shapes are considered and the nodes are placed at the different vertices of the tetrahedral then these are going to act as and the anchor nodes. So, the sensor nodes are deployed at different depths depending on the deployment scheme. And so the in the random deployment the anchor nodes deployed randomly in a 3D monitor region the ordinary sensor nodes are deployed randomly in the 3D monitor region as well.

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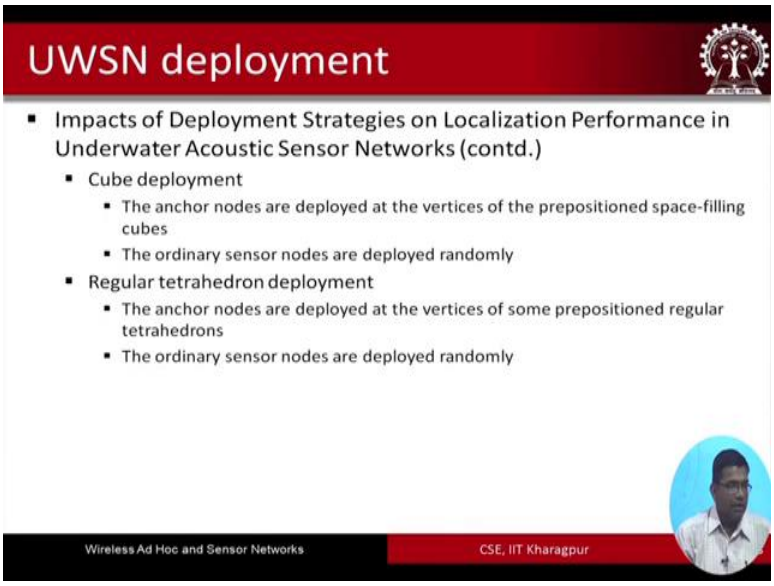

In a cube like deployment the sensor nodes are deployed at the vertices of the prepositioned space filling cubes the ordinary sensor nodes are deployed randomly around those and in the regular tetrahedron deployment the anchor nodes are deployed at the vertices of some prepositions regular tetrahedrons and the original ordinary sensor nodes are deployed randomly around them.

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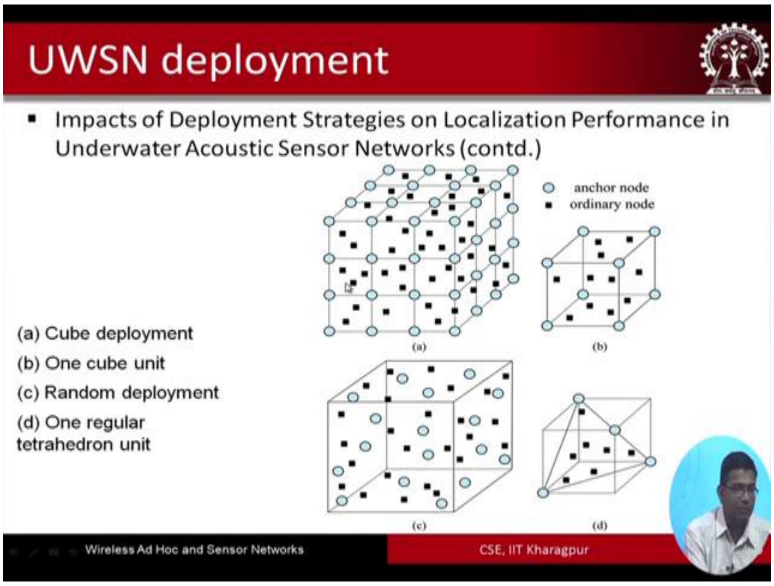

So, this is how it looks like you know this is the cube like deployment over here and where this is like the one cube unit. So, you have these anchor nodes which are placed in a cube vertex of these cubes the constant cubes. And these ordinary sensor nodes basically are placed randomly around them. And the similar kind of thing is shown in a different way over here we are considering a regular tetrahedron unit and where the anchor nodes are placed at these different vertices of their tetrahedral and the random nodes are placed around these nodes

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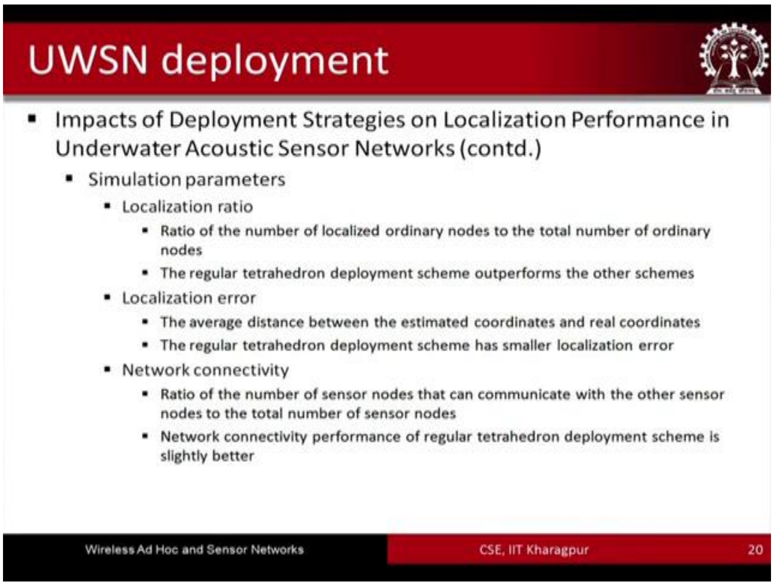

So different simulation parameters were considered in order to study the performance of these localization ratio is 1. So, localization ratio is about the ratio of the number of localized since ordinary nodes to the total number of ordinary nodes localization error is the other parameter that was studied the ever which is basically defined as the average distance between the estimated coordinates and the real coordinates. And the network connectivity which is the ratio of the number of sensor nodes that can communicate with the other sensor nodes total number of sensor nodes.

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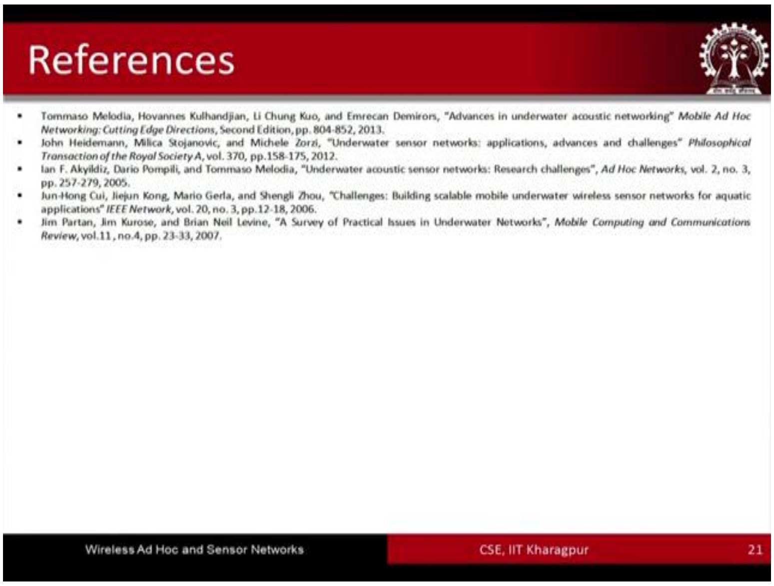

So, with this we come to the end of underwater sensor networks part 2. So, here we have seen that there are different deployments strategies that have been proposed in the literature. So, these different it is not like you know one type of deployment sachems is used for serving different applications. There are different schemes are used for different applications and so on. So, it is also not that 2D scheme is better or a hybrid scheme is better. So, it could be that in some cases like you know 3D or a 2D or even a hybrids scheme could be better than the other schemes that are maybe. So, these are some of the references for this part of the lecture.

Thank you.