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

Lecture – 36
Underwater Sensor Networks-Part-IV

We now come to the last part of Underwater Sensor Networks. So, we will talk about localization in little bit more detail we have already spoken about localization and purpose in the first part of underwater sensor networks.

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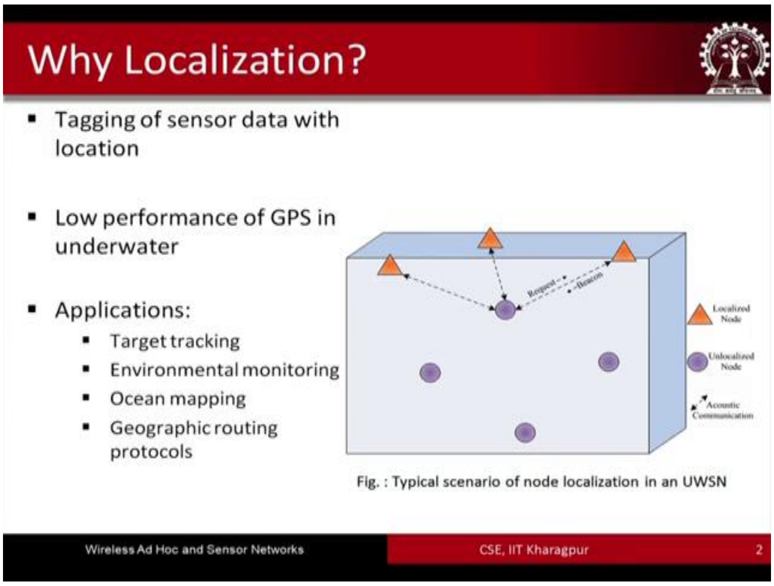

So, what is localization? Once again localization is about finding the locations of the different nodes in the network with respect to the known locations of the other nodes in the network. So, there will be some reference nodes whose location should be known and trying to locate the other nodes whose locations are not known as a function of the known locations of these nodes. So, this is how it looks like. So, what we have are; these nodes which are acting as a localized node. So, these localized nodes means; that these nodes their location are unknown and these are the all localized node. And there is acoustic node of communication over here or here or here as well.

So, initially what happens is this localized node they will be periodically sending out beacon packet right. So, beacon packets will be sent you know we advertise they are present. And any nodes which can here these beacon packets they can respond in the form of a request; they can respond in the form of a request they can send. That request will say that you know it wants to request the location of; you know it wants to request the location of that particular node. So, this is a unlocalized node which basically since that particular request and then you know corresponding to that the response is received and so on.

So, why do we need to localize in order to tag we have already seen this. So, localization is important for a number of reasons, one of the very important once is that the sensor nodes for example, these nodes when they are going to send the data to the surface sink along with at the location data also be sent. Otherwise that data will not be of much value, because the surface sink which has received the data it will not be able to know that which node we from which location has sent that particular data. So, you know one issue is that localization is a very important problem in any network. Now for terrestrial networks it is not a big problem, because nowadays we have a GPS facility which can help any of the nodes to know the location the exact geographic location; excitement with certain error of course you know geographical locations of these different nodes.

Now the problem is that GPS does not work underwater, so it has very low performance or almost low performance under water. So, in the absence of GPS how to localize these different nodes, right? So, this is the whole problem of localization.

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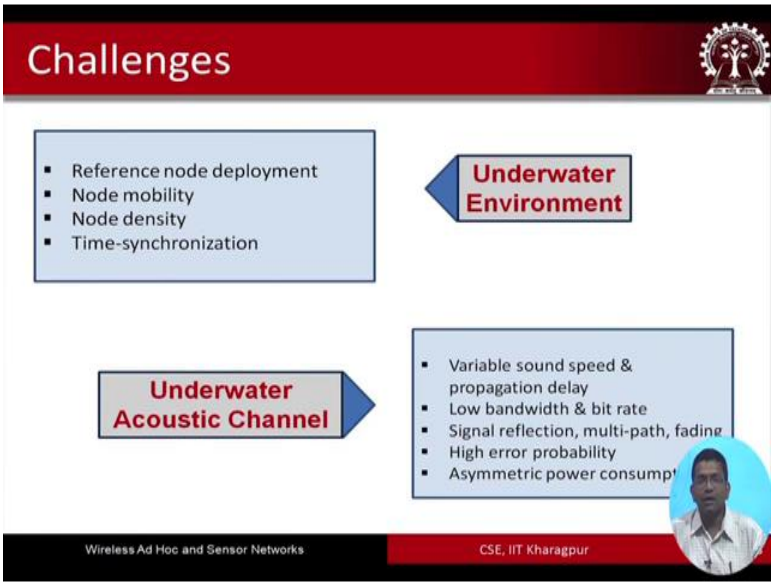

So, there are different challenges of underwater environment and the channel underwater acoustic channels. I am just going to read them once again, because you know we have already gone through them in different ways in the past. So, first of all reference node deployment is a very important issue, without that you cannot basically localize any of the other nodes whose poisons are not known node. Mobility is a very important challenge and an important issue to take care of; low density, time synchronization etcetera.

Now in terms of the acoustic: channels acoustic channel a has different characteristics; it has variable sound speed and propagation delay; low bandwidth and bit rate; signal reflection, multipath fading etcetera; high error probability; asymmetric power consumption these are the different properties of underwater acoustic channel.

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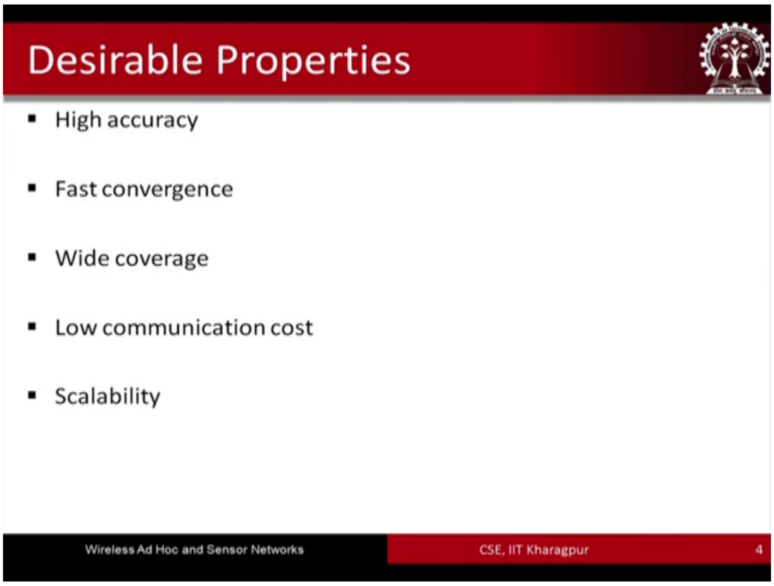

So, under those basically challenges one has to come up with localization schemes. Now the properties of underwater since you know localization schemes there are some desirable properties. So, the localization schemes have to be highly accurate that is quite obvious, because you know if there is too much of error in the localization of the different nodes then such a scheme basically which helps to get the (Refer Time: 04:48) the locations of the different nodes such a scheme will not be very useful.

So, high accuracy fast convergence; that means, that very quickly one has to come up with the location of the unknown nodes. So, first convergence, wide coverage; so wide coverage I do not need to elaborate for the low communication costs also the same thing and scalability. That means that the nodes we know the localization scheme that you propose if the number of nodes is increased you know such a mechanism can be basically extended to the new set of nodes that are deployed.

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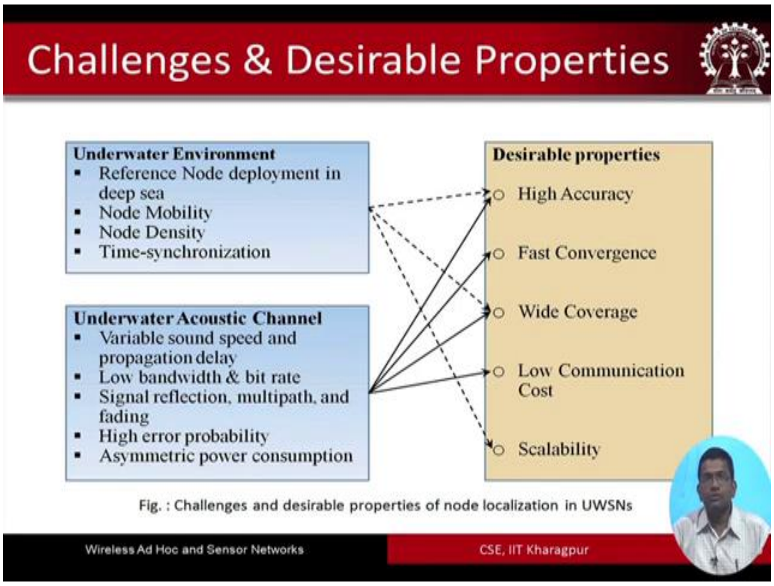

So, these are the mapping between the underwater in environment and underwater acoustic channel characteristics and the desirable properties in under water sensor networks.

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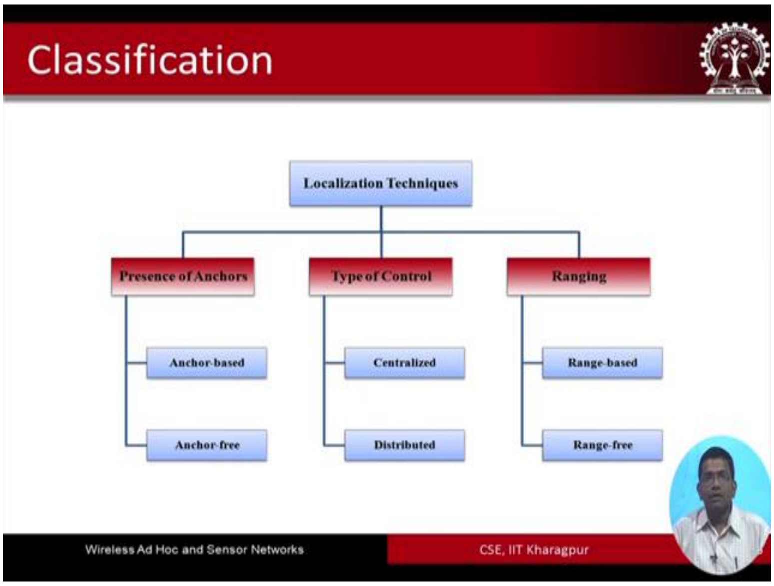

So, the localization schemes that have been proposed for underwater environments they can be broadly classified into three types: some schemes they assume the presence of anchors, so these schemes are called the anchor based scheme; some schemes basically do not assume the presence of anchors and these are called the anchors free schemes. The second category is the type of control that is used whether to centralized control or distributed control. And the third is ranging: range based schemes and range free scheme.

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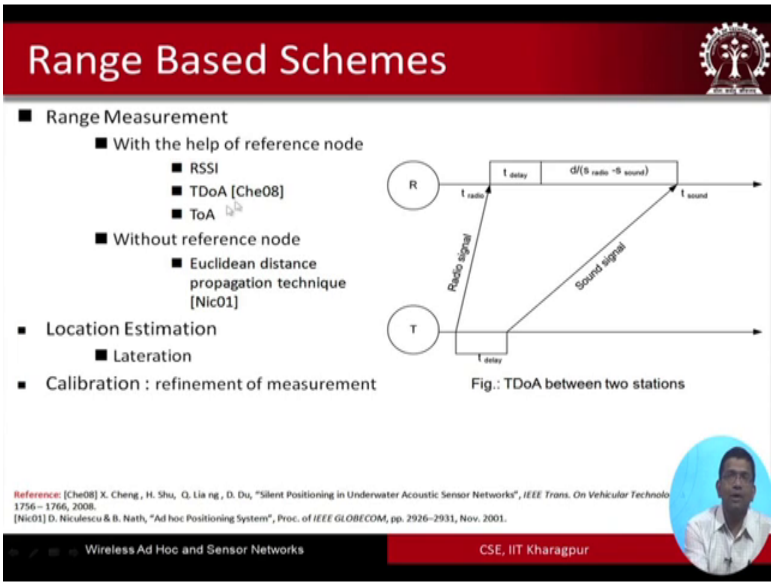

So, range based schemes there are many and range based schemes are quite popular. So, in range base schemes you know whether you are considering the existence of a reference node or not there are different schemes that are proposed. So, the first one is RSSI base scheme, TDoA is the second and a ToA. The RSSI is received signal strength indicator, TDoA is time difference of arrival, and ToA is time of arrival. So, time difference of arrival and time of arrival. So, all of these can help in understanding or localizing different nodes, but in these cases if you are using these mechanisms you have to ensure that there are some nodes which you can consider as the reference nodes whose locations are known.

Let us assume that we have is scenario like this where there is a transmitter and there is a receiver. So, if there are two signals: a radio signal and a sound signal that are sent, then what happens is the radio signal will be reaching after certain duration of time and the similarly for the sound signal, but the sound signal probably will reach after longer duration of time in this particular example. But you just see here, we have considered only radio signal sound signal where you could have consider maybe two different sound signals and so on. And that is how you no one can go for using the time difference in arrival to between two stations and using that to compute the location. So, basically this is the T delay which is the actual delay and this is the T delay plus the time difference of arrival, and that time difference of arrival once calculated can help in localizing the different nodes by solving simple equation.

And without reference nodes also there are a few other mechanisms that are proposed; location estimation using lateration or trilateration with scheme. Basically, if you know the locations of three nodes using that, basically you can calculate the location of the fourth node and so on. And this can be extended further to get more accurate picture and accurately localizing other nodes in the network.

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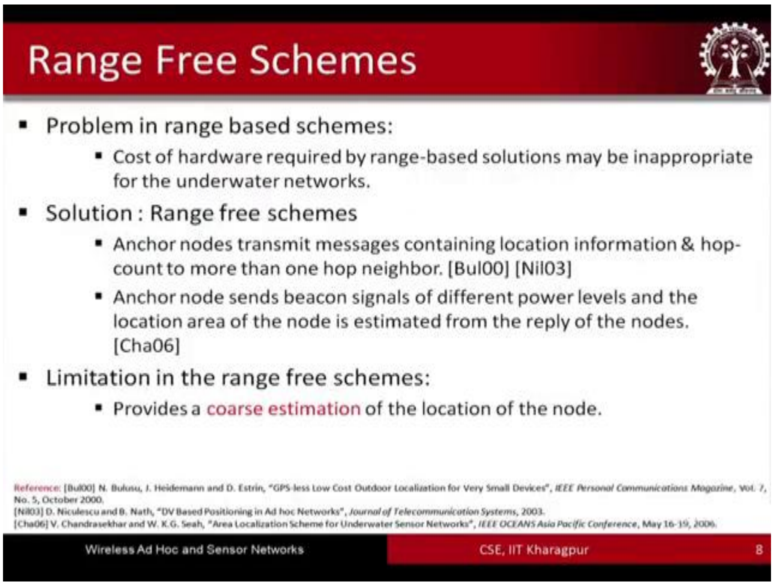

Range free scheme: the problem in range base scheme is that the cost of hardware required for range based schemes is not very useful, so the cost is quite high and it is inappropriate for underwater networks. So, the solution is range free scheme where anchor nodes transmit, anchor nodes means like the once where the locations are known. The anchor nodes transmit messages containing the location information and hop count to more than one hop neighbor. The anchor node sends beacon signals of different power levels and the location area of the nodes are estimated from the reply of the nodes.

So, the limitations of these range free schemes are that, it provides a coarse estimation of the location of the nodes.

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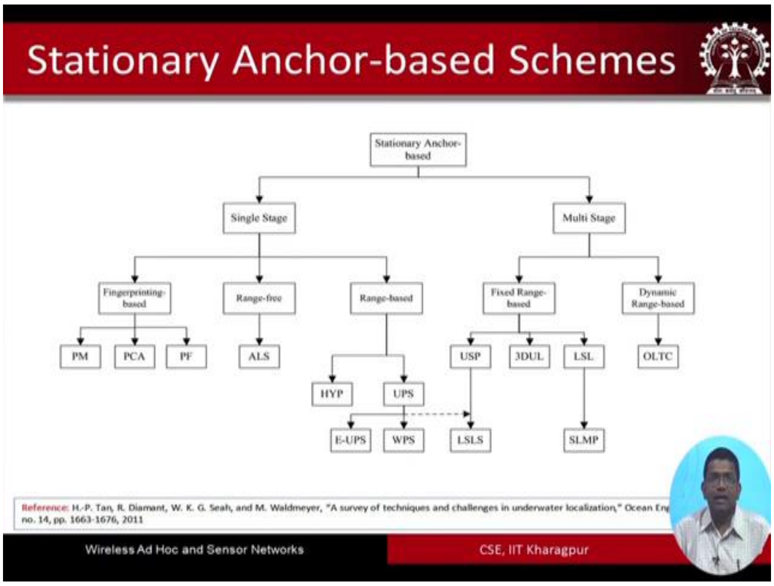

So, anchor based schemes basically can be classified into different categories: single stage scheme, multi stage schemes. And single stage can even be further classified into fingerprinting based range free, range based, multistage, fixed range based, dynamic range based. So, based on this even as you can see over here there are large number of different types of anchor based schemes which are proposed.

So, OLTC is something that to was proposed by us; me and my one of my students. 3DUL is also very important well known fixed range based scheme that is available in the literature. ALS is another and so on. So, a complete picture of the classification can be obtained by reading through this particular journal paper, which is survey of techniques and challenges in underwater localization, which was published in Ocean Engineering in 2011.

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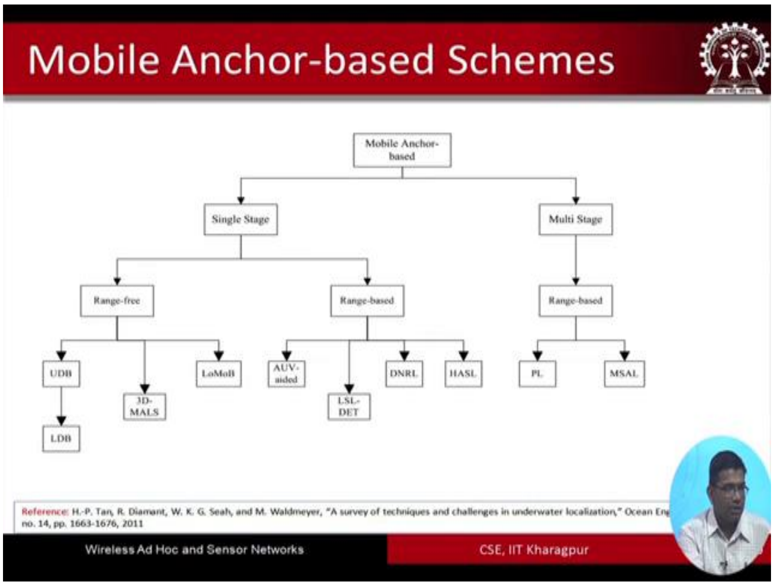

So, a mobile anchor base to those were the stationary anchor based scheme, here are the mobile anchored based schemes which can be again classified and sub classified as shown over here. So, again this particular reference gives a good idea about the different protocols and overview of each of these protocols belongs to these different categories.

So, that is localization and finally mobility. Mobility is very important and it is very interesting in underwater sensor networks. Mobility was also present in terrestrial networks, but that was intentional mobility. So, somehow if a particular sensor node may be a robot or a human being would make the mobile node move from one point to another. But, in underwater sensor network not only that such a you know intentional mobility can be achieved maybe using my time a sensor node with and UV or a mobile device and so on. By doing that, but also not only active mobility but also passive mobility; and passive mobility due to maybe the fact that there is some underwater current or there are different waves and so on which hit these nodes.

So, mobility is a very important consideration in the studies of underwater sensor networks, because these nodes are indeed going to be hit by different nodes due to the dynamism of the environment. And also both active mobility and passive mobility are possible in underwater sensor network.

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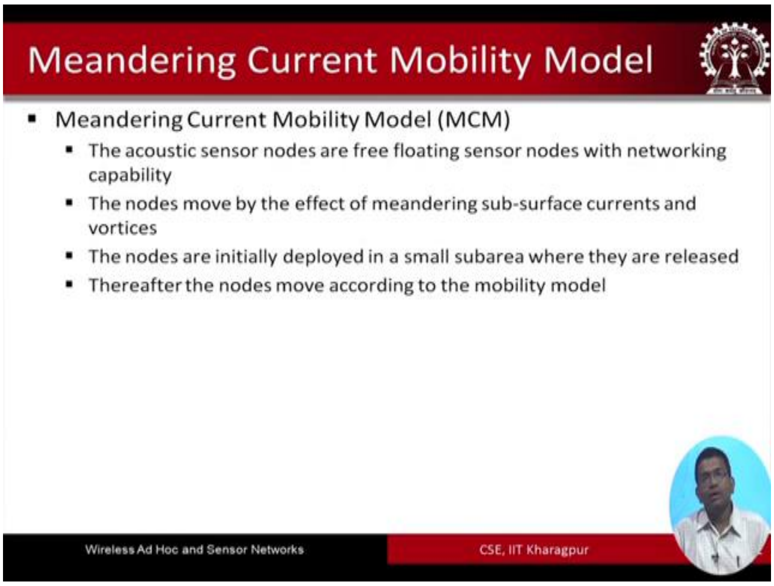

So, the main problem is that before you deploy underwater sensor networks you want to study the behavior by simulating these networks. For simulations as we have seen in a previous lecture that we need to have mobility models, which can mimic the behavior of movement of the different nodes in the ocean column. So, the meandering currents mobility model was proposed. So, the meandering current mobility models basically harnesses, the idea of how the meanders in reverse move right. So, this meanders how they move.

Accordingly, that kind of model is used accordingly to move the sensor nodes that are deployed in the coastal areas, or in the shallow water region. So, in the shallow water details basically these nodes which are deployed they are going to be hit by different kinds of meanders, and how these meanders are going to make these nodes move. So with that kind of adoption of that kind of models or idea a meandering current mobility model was proposed.

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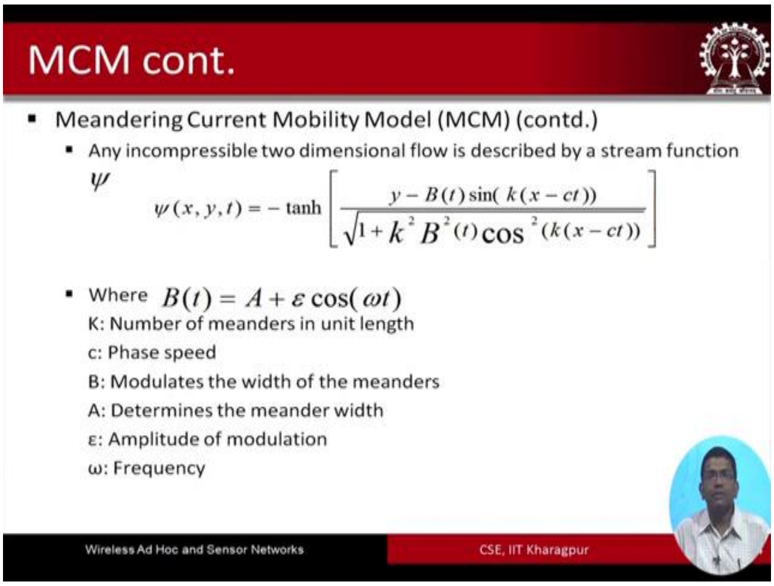

So, Meandering Current Mobility Model basically this is the formula which is basically which character is the two dimensional flow of the fluid using a stream function like this. So, this is the stream function. So, I am not going to go through this. So, these different parameters are explained over here.

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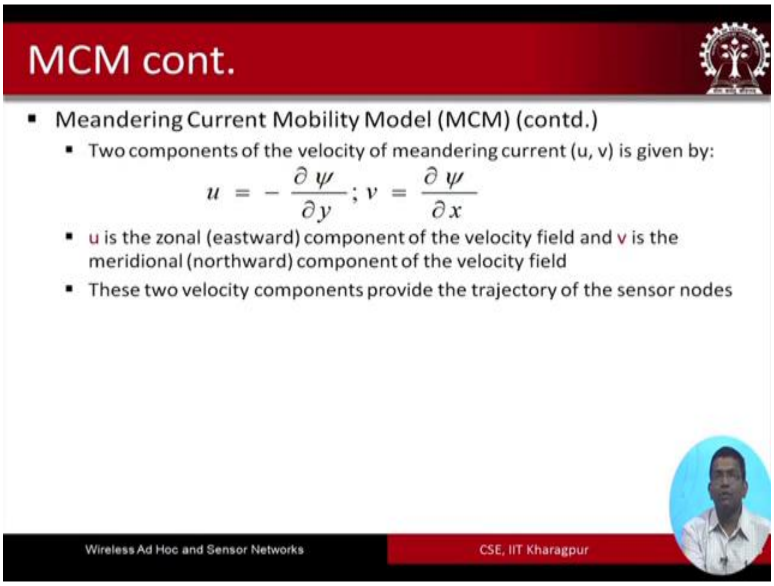

So, there are two components of the velocity of the meandering current: one is the u component and the other one is v component. And these u and v components can be obtained from that psi equation that we have seen in the previous slide.

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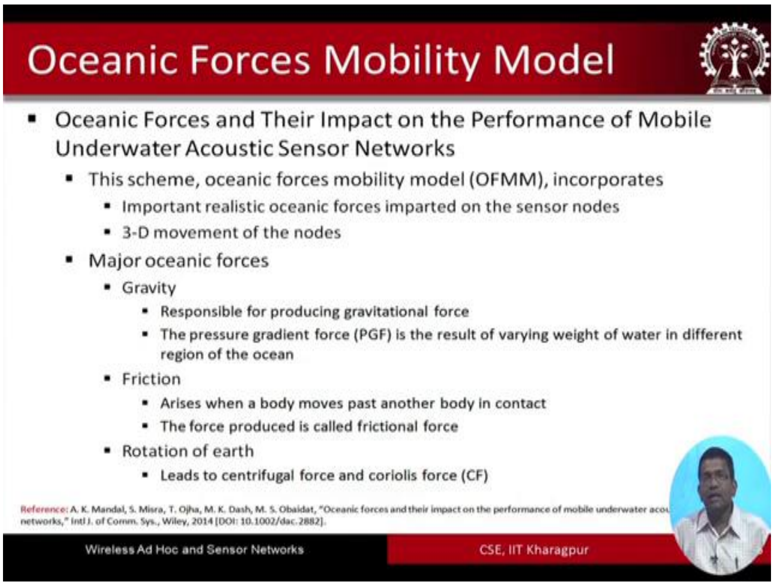

And finally, we come to the oceanic forces mobility model which was basically to proposed by us, by Amit Mundell Misra; that means, myself and two of my other students. So, here basically what we do is that getting inspired for rather taking help of different other forces which realistically occurred in a oceanic column, like gravitational force, other frictional force, force due to the rotation of the earth, coriolis force and so on.

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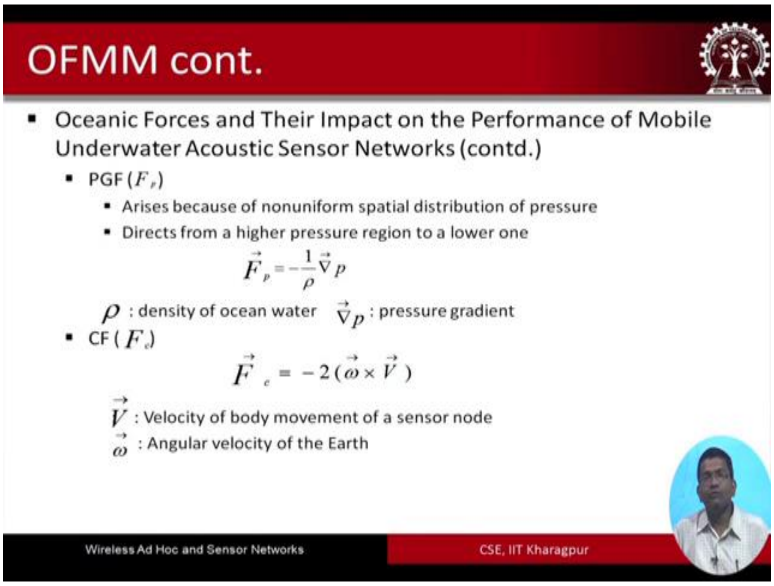

We basically come up with this particular model to mimic the mobility of the nodes which are going to float independently in the ocean column. This is the model, so I am not going to go through it in detail, but just to show you a picture of how it looks. So, these are the different forces that are acting on a particular node in the ocean column that is floating in the ocean column. And with the help of that with the calculation of that we basically one can use this particular model to simulate how the nodes are going to move with respect to time.

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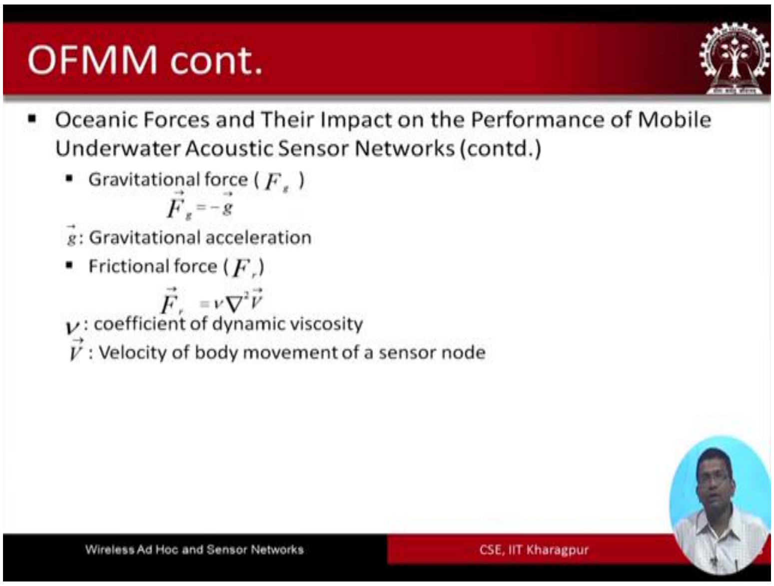

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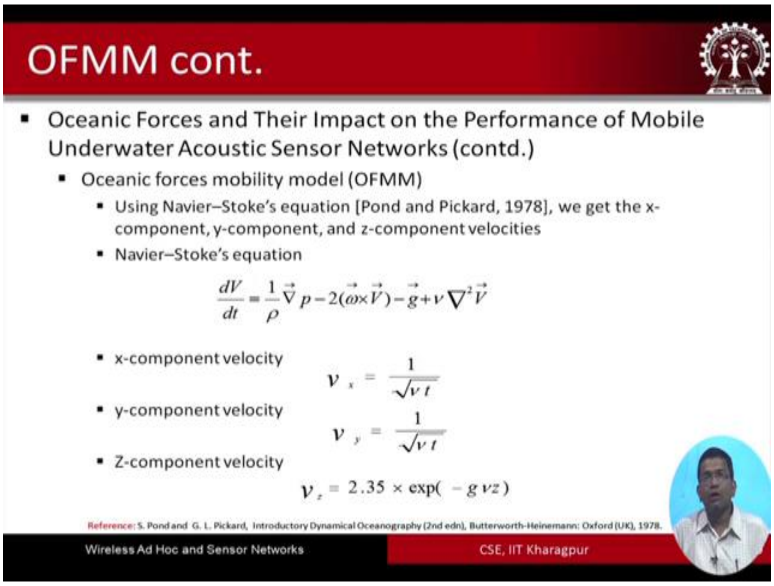

So, this is the Navier stokes equation which if you resolve this it can give you the x component, y component and z component of velocity. And these can be used for simulating the mobility of these different courses that we talked about.

So, with this we come to an end of the entire you know four lectures on underwater sensor networks. And we have seen that underwater sensor networks there are large number of different types of issues. So, issues ranging from different things, you know everything is very chaotic in underwater environments; the environment itself is chaotic. And even the velocity of the sound and the temperature the character the composition of the water etcetera etcetera in everything is very different and it changes spatial temporally it changes as we move in the underwater environment. There are lots of different types of noises. There are problems with respect to mobility; there are problems with respect to localization. Architecture itself, deployment itself are problems; plus additionally we have the traditional problems of designing MAC protocols and routing protocols for use in these networks.

So, it is a very interesting field. So, what I attempted to do is to through these four lectures just to expose you to the different issues of underwater sensor networks. Underwater sensor networks are a field of in depth study. So, it is not something that can be understood in just a few lectures, but the whole purpose of introducing or including these lectures in a wireless sensor network course is just to give an exposure of the different issues that are out there.

So, those who are interested, who I had also mentioned the different references you could go through these different references to know more about underwater sensor network; particularly research scholars might benefit from these references that I had mentioned. And there are lots of research works that are going on, on underwater sensor networks. There are lots of other opportunities of doing research on underwater sensor network still remains. But at the same time it is a challenging area of research as well.

So, with this I would like to conclude these lectures on Underwater Sensor Networks.

Thank you.