Wireless Ad Hoc and Sensor Networks
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Lecture – 22
Introduction: Wireless Sensor Networks- Part-II

Wireless sensor networks part II. So, in the part 1, we have looked at some of the basics of wireless sensor networks, in the next couple of lectures, we are going to go through different other advanced topics on sensor networks, but before we do that in this lecture we are going to look at some of the different applications of sensor networks and few other advanced topics, some of the advanced problems some of the problems more concerning how sensor networks can be used in practice for practical purposes under different circumstances different scenarios to help address different problems. So, we look at some of the specific problems and some of them actually are these works where done by us by our researchers in our group. So, we are going to have a look at them as well.

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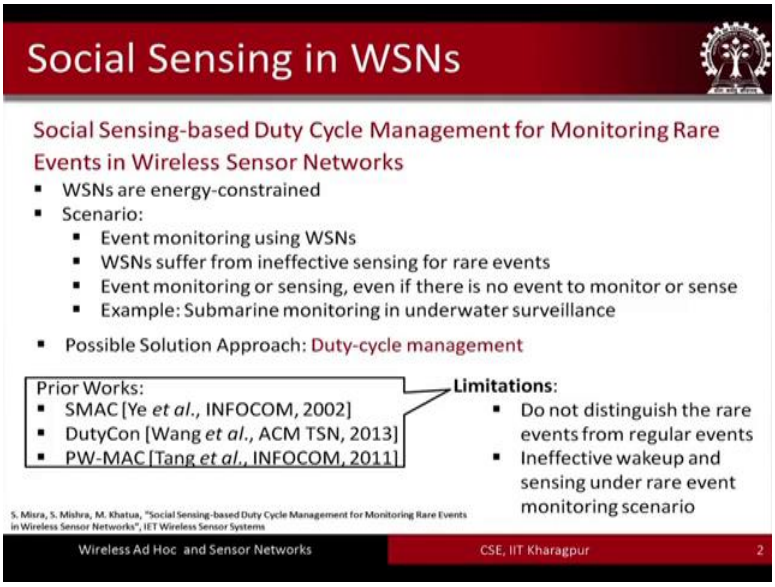

So, we look at the first thing that we are going to see is now it is; nowadays social sensing has also become very popular, social networks have become popular and human beings, they look around they have certain kind of feeling and then you know, so whatever they see whatever they observe then accordingly they start you know entering

their ideas and whatever they have we have witnessed they start entering the information into the social media like Facebook, Twitter, etcetera.

So, in one of these papers which again is authored by us, so what was done is we explored how social networks and how social sensing can be integrated with wireless sensor networks in order to monitor real events real events could be like you know events like for example, earthquakes, volcanoes, etcetera. So, these are events which do not occur which do not occur frequently regularly and so on. So, how social networks can be integrated with wireless sensor networks in order to adjust the duty cycle of wireless sensor networks.

So, what is meant by a duty cycle will cover later, but it is something like it is something like that how much is the active time a time for which a particular node is going to be active with respect to the total time duration that the node is going to function or remain active and in the (Refer Time: 03:10) state. So, this is something that we will cover in a later lecture.

So, this is one example this is an example where social sensing integrated with wireless sensing, sensor networks, Facebook integrated together. So, what happens is it has say that rare events like the ones that I mentioned for example, if there is some kind of a calamity or something like that. So, in such cases, these calamities they do not occur quite frequently, they occur rarely.

So, instead of keeping the sensor networks active at all times and waste the limited very limited energy in these different nodes what was suggested by us is what was proposed by us is that based on the social media based on these thing how people are reacting. So, based on those to adjust the duty cycle of these sensor networks so; that means that so the duty cycle of the sensor networks basically can be dynamically adjusted based on the feedback that is received from the social media and that is quite obvious I do not think that I need to elaborate more on this one this particular concept. So, this is pictorially this is how it looks.

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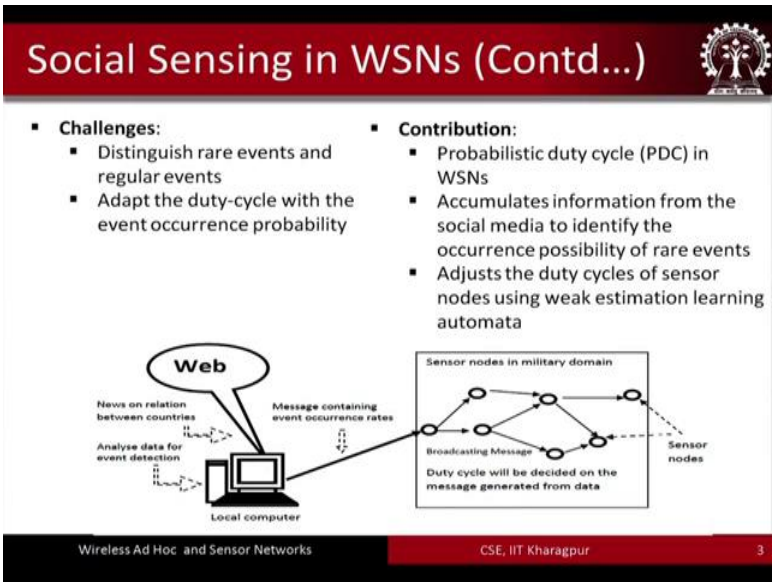

So, basically what we have done is we come up with a probabilistic duty cycle model for wireless sensor networks and this basically accumulates the information from the social media to identify the occurrence probability of a rare event and adjusts the duty cycle of the sensor nodes using a particular method, which is called the week estimation learning automated methods.

So, I am not going to go through this now and it is not required for one unless somebody is rarely interested in the research aspect of it. So, this is just to give a flavor of how social networks can be integrated with wireless sensor networks.

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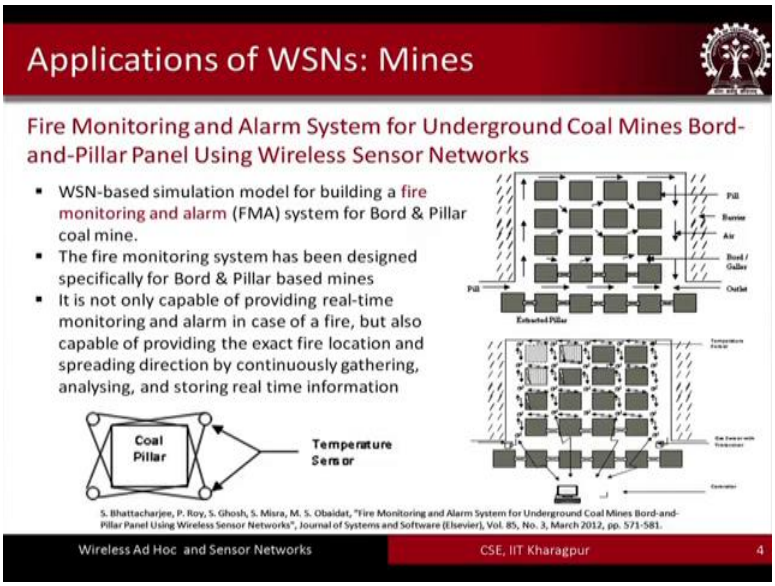

Another I have already told you that sensor networks have large number of different applications another application is use of sensor networks in the mines. So there are different aspects of sensing that can be performed inside the mines. So, if we are talking about coal mines for example, in the coal mines sensors and sensor networks can be deployed to monitor the occurrence of mine fire and generating alarms if there is indeed a man mine fire or even going further that not only generate alarms, but also actuate the bulbs the water pipes that would that would that would close the that would stop the fire from spreading further.

So, let us look at this particular figure that we see in front of us. So, in this particular figure, we show a particular type of coal mining which is known as the B O R D bord and pillar coal mining. So, in the bord and filler coal mining what happens is there are different columns, these pillars that that are caped and the coal is extracted from the from the areas around these pillars. So, basically coal is never extracted continuously and in a particular coal mine for the reasons because you know if it is done in that way then it the particular area where mining is done in that way that in such an area the there might be roof fall.

So, the roof fall means that the upper strata might collapse because coal is taken from the lower strata and because of the because of the vacuum that is created because of this particular type of extraction coal extraction, the roof might collapse and that is the reason

why these pillars are left and coal is extracted from around from surrounding these pillar areas. So, here what we see is that in such a bord and coal pillar coal mine; coal mining approach sensor networks can be used sensors can be deployed since these are the different sensors that are deployed there are temperature sensor there are gas sensors there are transceivers.

So, these sensors they can since the temperature the gas and gas could be methane sulfur dioxide and different other coal sorry coal mine specific gases these gases through a multi hop path could be sent to the to the transceivers station and from the transceiver station further they can be sent to centralized controller and typically these centralized controllers are on the surface of the on top of the mine. So, not underground, so this is how this is how the sensors are placed. So, we have one particular pillar and in the 4 corners of the pillar you have 4 different temperature sensors and these temperature sensors are going to measure the temperatures in around them. So, how many sensors are going to be put although here we have used 4 different sensors but another design might think of either increasing the number of sensors or decreasing depending on the specific coverage that has to be obtained for fire monitoring around in the coal mine in a space around the coal mine.

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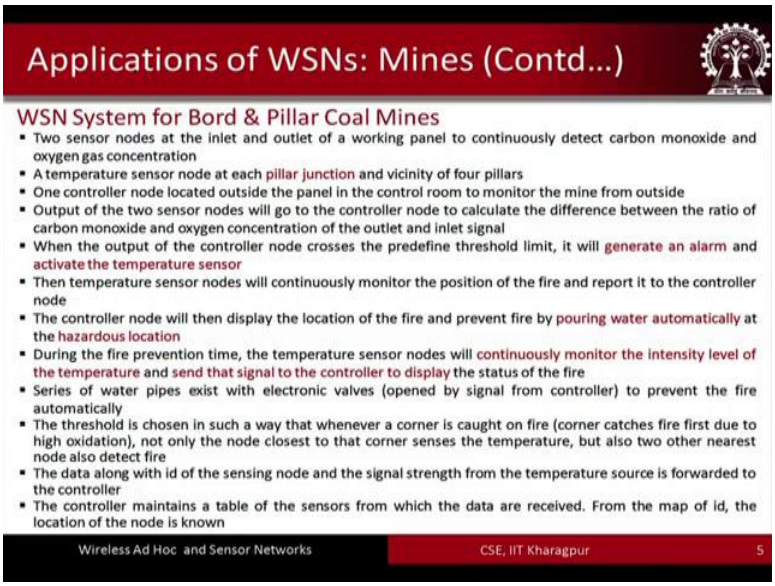

So, this is what I had just explained to you. So, there are different pillar junctions that are used and these are the pillar junctions which basically would prevent these pillars are the

ones which are going to prevent the roof fall. And in the 4 corners in the pillar junctions basically the temperature sensors are both and there are 2 sensor nodes that are put at the inlet and the outlet of the working panel to continuously detect other gases like carbon monoxide and oxygen gas concentration and alarms are generated if certain threshold of these gases and temperature are crossed.

Then together you know used some kind of intelligence some algorithm and then if indeed there is something and alarm is generated concurrently water starts water is poured using in the hazardous location using the water pipes by actuating the water pipe and then the entire thing is continuously monitored and intensity level of the temperature the gases and so on are monitored from the base station from the control from the control station.

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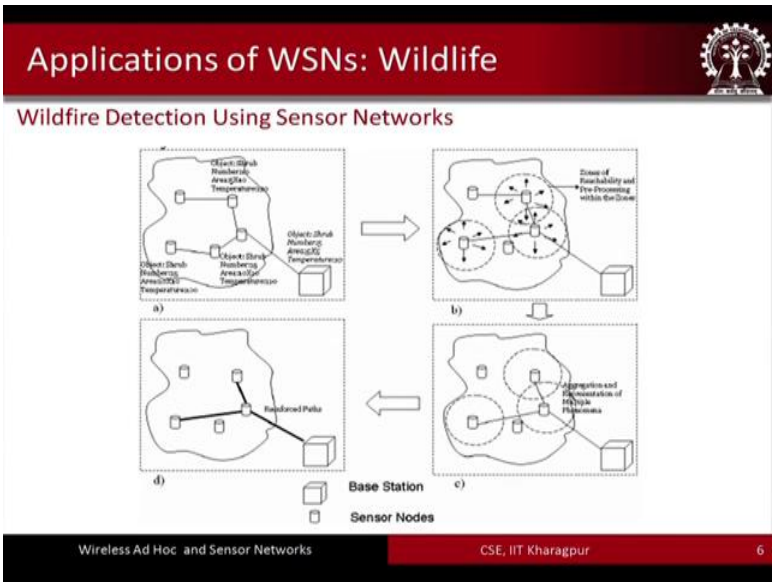

Wildfire, the detection is another very important issue important applications of using sensor networks wildfire means forest fires. So, forest fire is something which is very common not only in India, but also abroad. So, as we already know that once there is some forest fire that occurs, it is very difficult to control the speed of the fire. So, that is the reason why you know why there is often big losses in of natural resources, once a forest fire or a wildfire strikes. So, in one of our works we basically worked on it how we can use sensor networks in order to monitor the occurrence of the wildfire and the speed of wildfire.

So, as we can see over here and these are the different sensor nodes that are deployed in a particular talent and these are the zones around these nodes which are monitored and then there are different agents which basically monitor these the phenomena that are occurring around these zones and then we get some reinforced path on the basis of which nodes are providing for continuously streaming the fire information and these paths are finally, used for sending for sending the data continuously to the base station or the sink node.

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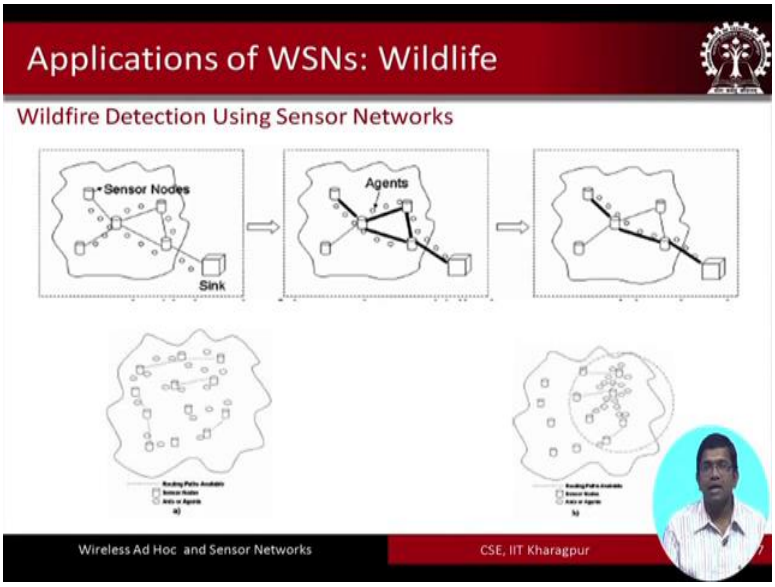

So, this is how these agents work around the sensor nodes and the sensor nodes are placed and these agents basically work around them. So, these are in this particular case they kind of agents that we had used are the end based agents. So, we have used a theory of and colony optimization. So, did not again need to understand how and colony optimization works it is basically the use of ands and the way the ands basically forage and the foraging behavior of the ands is adopted to come up with simple heuristics which can be used to find the different paths that can be used for sending the sensed data from the source nodes to the to the base station.

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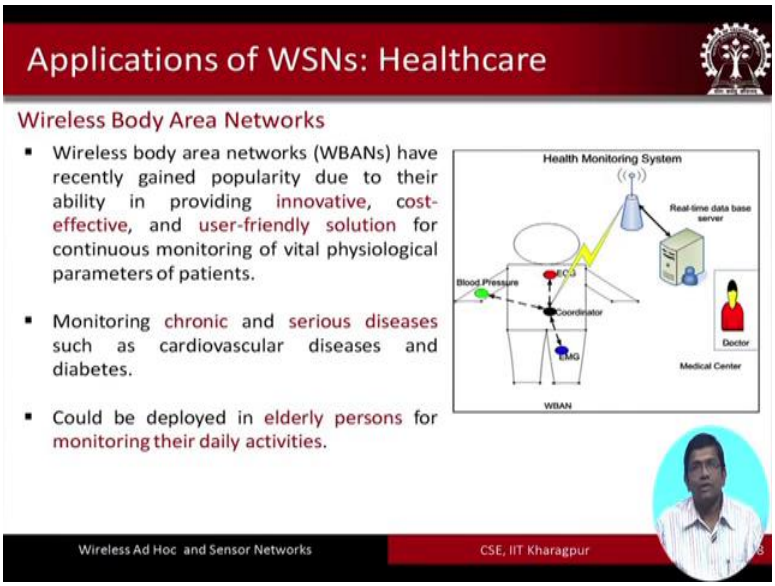

I already mentioned earlier that wireless sensor networks. One of the important applications of wireless sensor networks is healthier and this is again something that just for your information that many people worldwide including in our group in IIT, Kharagpur, we have done lot of work on the applications of wireless sensor networks for healthcare monitoring for remote healthcare monitoring and so on, the specific type of wireless sensor network that is formed by putting these different sensors the physiological monitoring sensors physiology monitoring sensors like ECG body temperature blood pressure and so on.

These sensors they can replaced on a human body in different places to measure the physiological condition of the patient and these together these sensors they can be connected with each other and these data the sense data they can be they are sent to an entity called the centralized entity called the coordinator. And from the coordinator the data the since data that aggregated sense data is sent to the health monitoring system and from the health monitoring system the data are accessed by doctors and nurses for efficiently monitoring large number of different patients at the same time.

So, these healthier sensor networks or the wireless body area networks they basically they can be used for different mode specific super specific applications of use of wireless sensor networks or body area networks for elderly patient monitoring; monitoring the quality of life of the patients how the patients behave how the elderly patients how they

behave in their homes their old homes and so on. So, this is something that is very important the other important thing is so remotely basically these patients or the elderly people who are not even the patients may be who are vulnerable to different things like fall falling down and so on.

So, they can be remotely monitored by the (Refer Time: 15:10) were centrally from one central point large number of difference you know elderly people they can be monitored. So, this is one thing second thing is in the hospitals these networks can be used third is for children, children often have different abnormalities, children come; children have often children are born with different abnormal health care health or abnormalities medical abnormalities children have different other problems and they are not able to express themselves the difference between children and elderly people or like normal; other normal means like other you know grown up adults is that the grown up adults they can express themselves.

Whereas the children they cannot. So, special types of sensor networks can be deployed on these children who are not able to express themselves and so that these children then they can be remotely monitored by the doctors or their parents and so on.

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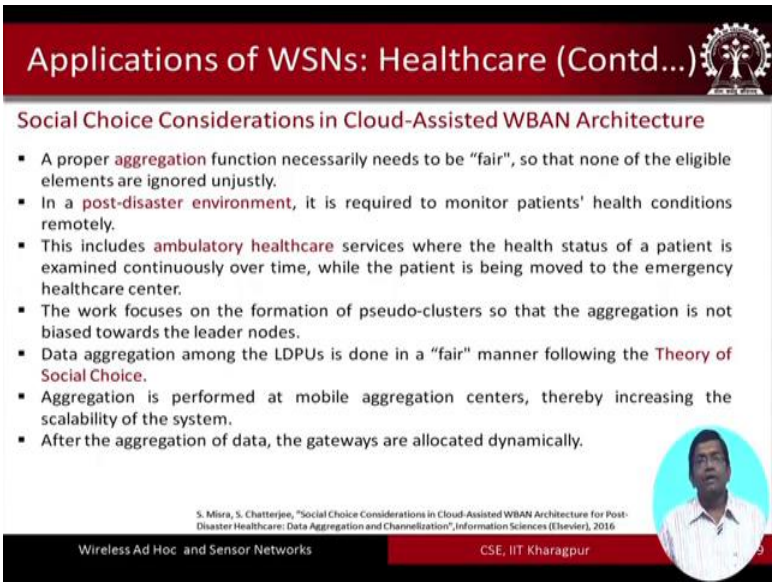

So, there are different aspects of use of wireless body area networks, wireless body area networks club with social choice theory social choice theory talks about giving fairness to the different nodes and how. So, let us say in a healthcare scenario what is very

important is that certain patients are often; they need more care than the other patients. So this thing is time varying at certain point of time certain patients who earlier may not have needed more care or more attention at a later instant of time they might need more focused here.

So, accordingly you know, they need both care. So, similarly if there is a patient who is suffering a you know; who is going to suffer from a heart attack who is going to have a heart attack. So, such a patient though you know when such a patient is monitored through a body area network the data that is sensed some such a patient that is more important compared to a patient who is suffering from fever, for example, so, health criticality of the data the data; that means, a packets and that are obtained from these critical patients and that is that is very important and it is very important that there should be more improved services you know network services that should be offered to these patients compared to the other patients who are not very critically sick. So, so that is why you know in one of our work we have explored the use of the theory of social choice in order to in order to enforce fairness of data delivery in a cloud enabled wireless body area network.

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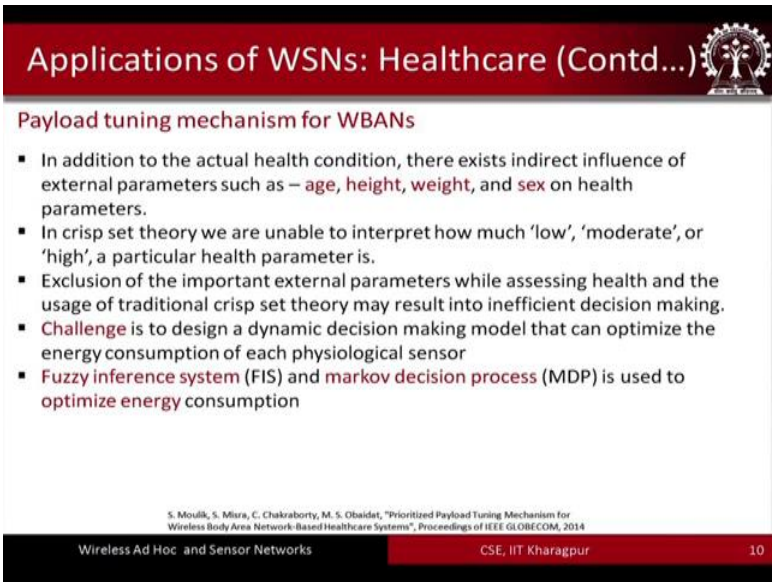

So, when we talk about wireless sensor networks in healthcare things which are very important are that as I was telling you that certain packets might have more importance might this should be given more importance compared to certain other packets. So, some

packets should have lower priority some packets moderate priority some other packets higher priority based on the health parameters of the patient who is being monitored. So, in this particular work this is an application of wireless sensor network for health care. So, in this particular work what we do is we tune the payload of the packets in a wireless body area network and accordingly we try to make the network efficient.

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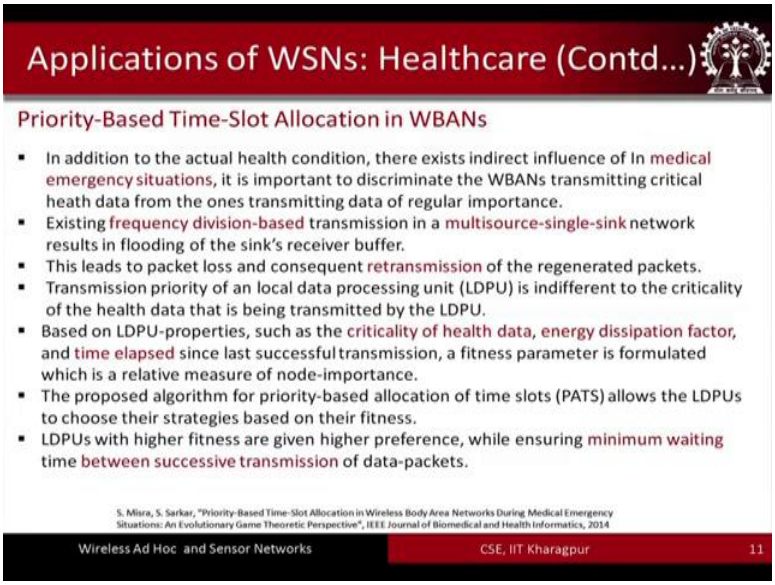

So, payload tuning in addition to payload tuning we also have come up with a solution for tuning the tuning the time slot. So, time slot tuning is another thing. So, typically you know frequency division multiplexing is used to send the data from the source nodes to the sink node. So, depending on the criticality of health data and other factors like energy dissipation time elapsed and so certain nodes and the packets that they send they should be given higher importance compared to the other nodes and this is something that I have already mentioned in a different way in a different context.

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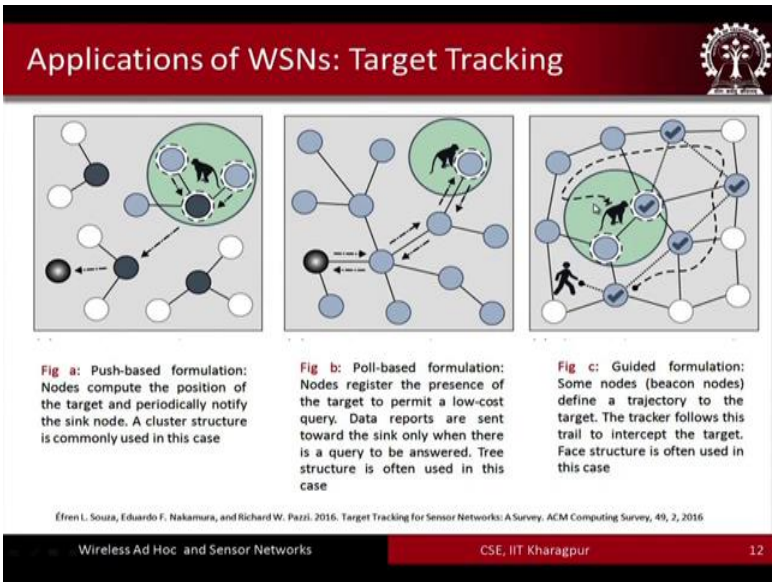

Another application of wireless sensor network is target tracking target tracking means it is object tracking some object has to be tracked. So, there are 2 different scenarios that I am going to show you, first in this particular scenario a particular animal is being tracked the activities of the animal the movement of the animal is being tracked using with the help of the sensor nodes that that are shown over here. So, here basically what happens is the sensor nodes you sensed that sensed they send the sensed data in a push best manner.

So, they would send the they would sends the data they would since the data of this activity of the animal and they are going to push it towards the sink node on the other hand this is an example of tracking where the a query is it is a poll based formulation where a query is sent first and this particular sensor node it sends the response back because it is the one which is sensing the activity of this particular animal and guided formulation is another third type of formulation where some nodes basically defined a trajectory to the target some nodes we find the trajectory to the target and the target and the tracker basically follows these trailed to intercept the target and so, basically you know to clarify further.

So, what happens is along with this particular sensor node, the sensor along with this particular animal the animal might be tagged with something which will force this animal to move in a particular way and that way these particular sensor nodes which are

goes to the track of the movement of this particular animal they can be activated and that is known a priori and the movement of the animal can be tracked accordingly.

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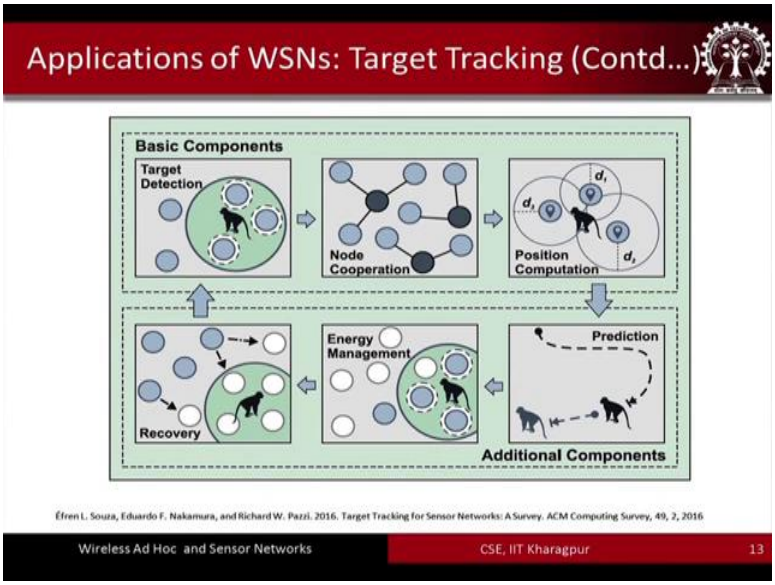

There are different basic components of target tracking using wireless sensor networks the first thing is to detect the target the first thing is detect the target. So, this is what is shown pictorially over here that there is a target. So, that has to be detected first the second thing is cooperatively the nodes would have to track the movement of the target the third is the position computation position computation means that with respect to each of these nodes you know how where with respect to the three positions of the sensor nodes where this particular animal is physically located at a particular instant of time.

And then what happens is as the animal moves further again trying to re do the same thing we compute the position the new position with respect to through three other nodes maybe and try to understand what is the new location new position of the animal energy management I do not need to elaborate further energy management is very issue.

Is a very fundamental issue and additionally recovery; so once the animal is detected, it is trying to be tracked. So, trying to recover the data of the movement of the animal and whatever is supposed to be sensed you know sending a recovering that data and that that becomes important. So, these are primarily the 6 different important components of target tracking using wireless sensor networks.

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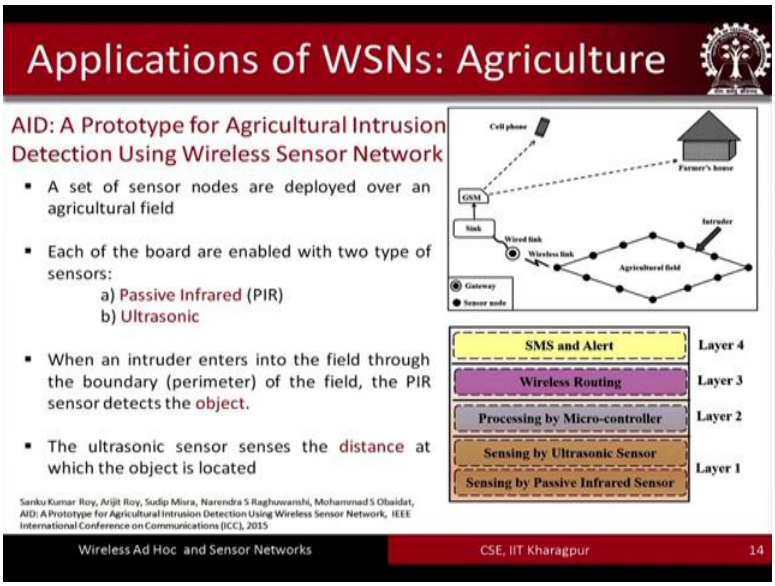

As I told you earlier that sensor networks are used in agriculture as well agriculture, there are a large number of different issues in an agricultural field one of the issues is basically that particularly in a country like us ours in India, what we have are agricultural fields where the crops and the agricultural produce in the fields they are basically the sub you know they are vulnerable to theft they are not only vulnerable to theft by human from humans. But also any other animals like goats and cows and different other Cattles, they might get if they get into the field they might damage lot of the agricultural produce like the crops and the other you know agriculture in the food commodities that are produced in the field.

So, we proposed a mechanism a prototype for agricultural intrusion detection using wireless sensor networks. So, if this is an agricultural field we place different sensors around the field sensors that we have used this is a work that we have actually implemented a prototype of this work has actually been implemented in our agricultural field and IIT Kharagpur and what we have done is we have used 2 types of sensors, but the other types of sensors might have also been used would have also been used. So, we have used in our work 2 sensors one is the passive infrared sensor, the PIR sensor, the other one is the ultrasonic sensor.

So, basically when an intruder enters into the agricultural field through the boundary or the parameter perimeter of the field the PIR sensor detects the object and the then the

ultrasonic sensors senses the distance at which the object is located. So, sensing the pigeons in the field and then how far it is located from the boundary etcetera. So, this is very; this, what is sensed using these 2 sensors.

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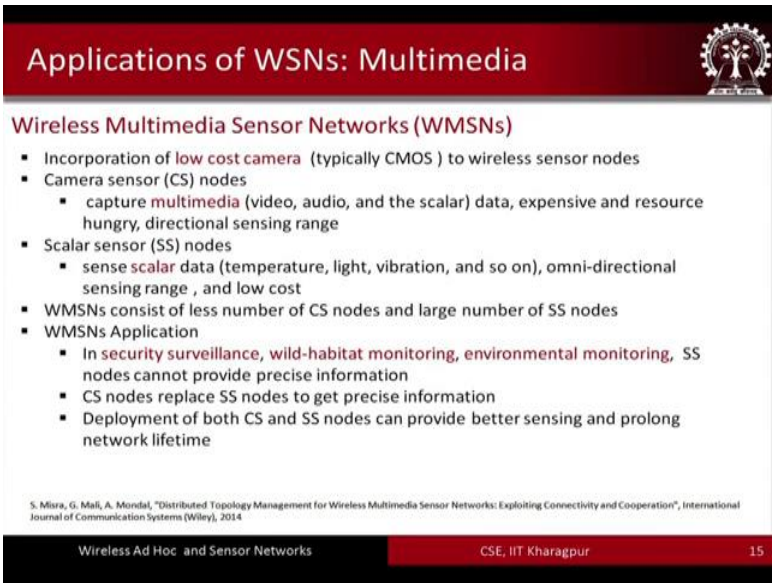

So, this is the layered architecture that is followed in our specific implementing this is what as I told you what we have actually implemented using real hardware in the field and this is the architecture the (Refer Time: 25:56) layer architecture that we have adopted in this particular example.

There are other applications of wireless sensor networks surveillance is a very important application. So, surveillance using cameras, cameras more specifically multimedia, you know cameras can be used to have something called well is multimedia sensor networks, well it is multimedia sensor networks have 2 types of nodes one is called the scalar node which measured data such as temperature light vibration and so on. And in addition to the scalar sensor nodes, you have the camera sensor nodes, which capture multimedia such as video audio scalar video audio data and so on and because of the fact is that these camera sensors are more expensive and more resource consuming.

So, more number of camera sales scalar sensors are used and lesser number of camera sensors are used in order to optimize the overall energy consumption and greater coverage and so on. So, as I said that the multimedia sensor networks comprising of

video sensors, camera sensors plus the scalar sensors like temperature, light, etcetera, all of them together can be used in order to servile a particular region and so on.

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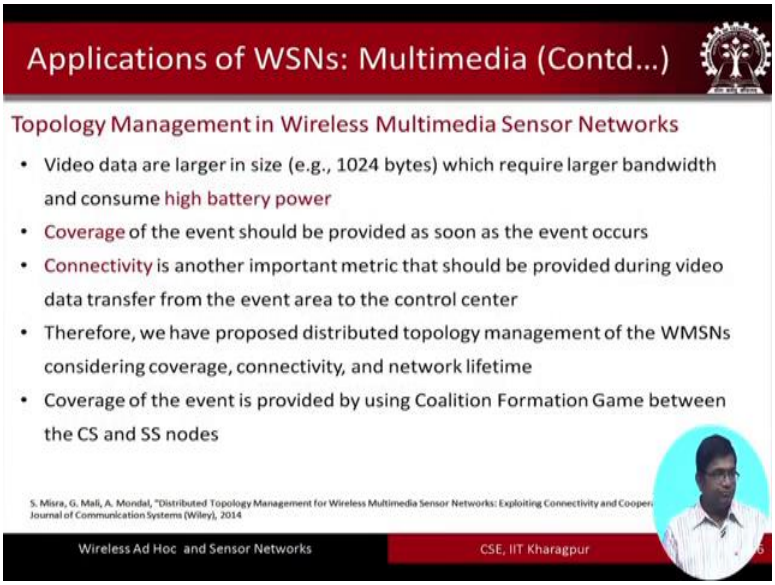

Topology management is a very important concern when we are talking about multimedia sensor networks consumption the video basically you know when we are using camera sensors or video sensors is video sensors they not only require large bandwidth for communication, but also they consume very high battery power and how you are going to power them. So, coverage of the event should be provided as soon as the event occurs and connectivity is another important metric that should be provided during video data transfers from the event area to the control center.

Therefore what we have done is we have proposed a distributed topology management scheme for wireless multimedia sensor networks considering coverage connectivity and lifetime.

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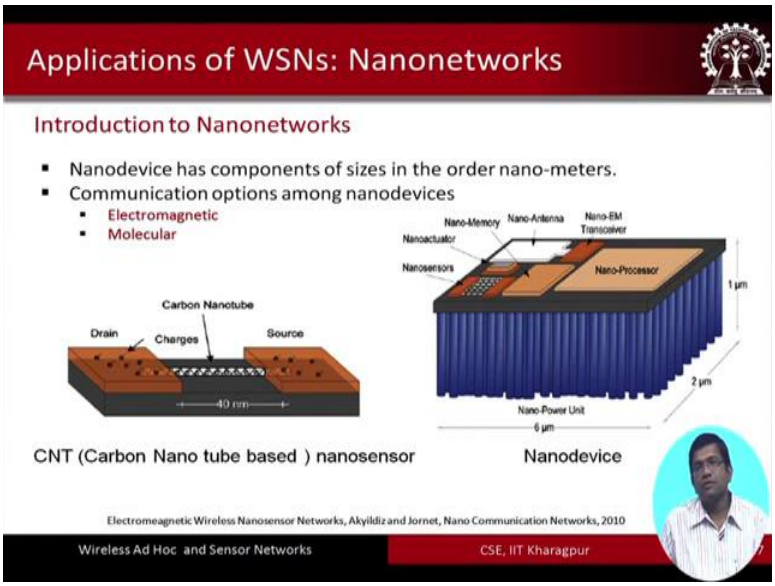

Finally we come to the nano sensor networks, nano sensor networks are basically the similar kind of concepts like the terrestrial sensor networks that we spoke about so far. So, these terrestrial sensor networks are large scale wireless sensor nodes main space typically main space wireless sensor nodes which are much bigger in size and they can be seen through regular naked human eye.

And on the other hand, nano sensors are nano scale sensor networks, they the size of a nano power unit is in micrometers and nanometers and so in a nano device like in a regular sensor node we have different; other different components of a nano device and the dimensions are in the micrometer range and the different components are nano sensors and this is an example of a nano sensors and the architecture the diagram of a nano sensor how it looks like, one of the very important things in a in the construction of a nano sensor is they carbon nano tubes. So, the carbon nano tube is used in nano sensors in the fabrication of nano sensors. So, nano sensors, nano actuators, nano memory, nano antenna, nano transceiver, nano processor and so on, so these are the different components of a nano sensor node.

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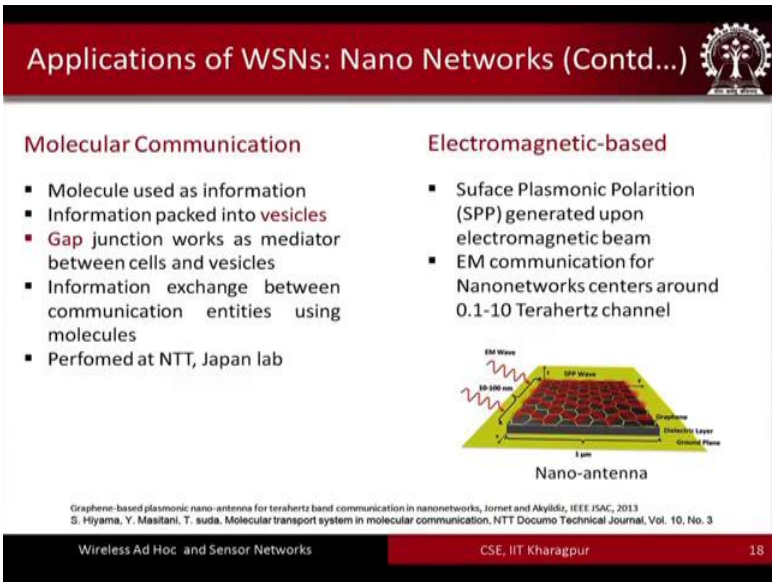

The nano sensor networks; they can communicate in 2 forms molecular communication and electromagnetic communication. In electromagnetic communication basically the similar kind of thing that happens with electromagnetic communication in the big scale terrestrial sensor networks those are basically brought down to nanometer micrometer scale and they are used they are used in the; so they are used for they are used in the; for as nano devices they are used as nano devices and electromagnetic mode of communication is used.

So, these nano networks they communicate in the terahertz; terahertz band and so electromagnetic communication based communication is one aspect. So, I have shown you how an how a nano antenna looks like this is taken from the reference that is given at the bottom plus there is molecular communication as well. In molecular communication it is a different type of communication where biochemical fluids then the body sensors are used to communicate between the different parts of the human body and molecular means of communication using these biochemical fluids and biochemical medium is used.

So, gradient gradients are set up and because of these gradients the fluid biochemical fluids are going to flow between the different points between through molecules and through different bio biosensors through three different biosensors on the human inside the human body. So, this is these are the 2 different modes of communication

electromagnetic communication and molecular communication which are the 2 different modes or of communications in a nano sensor network.

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So, these are a large number of different references that we have collected for you. So, just if you concluding points. So, one thing is that you must have noted that I have often referred to some of the works that we have done. So, remember that it is not required for you unless you are very much interested to go through these papers to understand if you are into research and you are interested in research on these particular aspects then it is fine. But as such you are not required to go through any of these papers in detail, it is not required to expose you to the specific research, but to understand the broad concepts the different types of applications of the sensor networks and the solutions targeted 2 serving the different applications so and because we have done, so me and my students; we have done lot of work, we have lot of contributions on wireless sensor networks that is the reason why many of these previous slides you have seen papers letter from research works that we have done in the past.

So, with this, I would like to thank you for watching the second part of the lecture on the introductory aspects of wireless sensor networks.

Thank you.