Industrial Automation and Control
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Lecture - 37
The Fieldbus Network – I

Welcome to lesson 37 of the course an Industrial Automation and Control of NPTEL. In this lesson we shall be talking about computer network or a rather I should say a network of intelligent devices, which are used for industrial automation. So, it is a network, it is a digital computer communication network; however, the various devices which talk on this network are the devices used for automation for example, it can be a sensor or it can be a controller or it can be an operator station. So, we will see how this sort of a network can has been proposed it is standard has been proposed and what kind of functionality and benefits it can bring for a factory wide control system.

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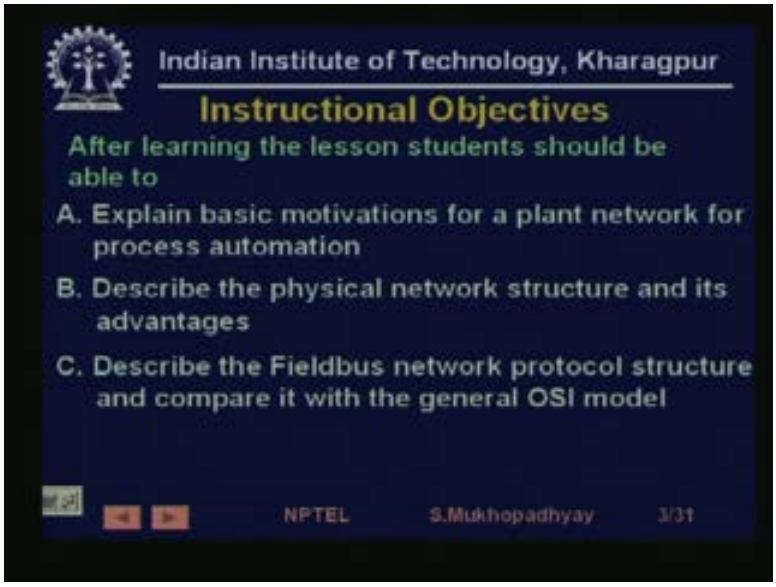

So, we start with the instructional objectives, so the instructional objectives are firstly, the student will be able to explain basic motivation for a plant network, how it actually helps to have a network for process automation. They will describe in the first part of this lecture, which will be followed in the next lesson will describe the physical network structure, how the various wires are connected and what kind of advantage is it brings in terms of you know installation commissioning.

Secondly, it will the field bus network protocol overall network protocol structure, as we know that computer communication is actually a complex protocol, where layers of software exist and they talk with each other to finally, realize the communication between two geographically far away devices. So, first we will take a basic look at the structure and compare it with a general there is a general computer communication model which is very popular and well known, that is called the open system interconnect model. So, it will compare the protocol model of the field bus with the OSI model and you will be able to describe the mechanism of coordinating communication among the devices on the bus, actually the lower two layers of this communication will be discussed in this part of the lesson.

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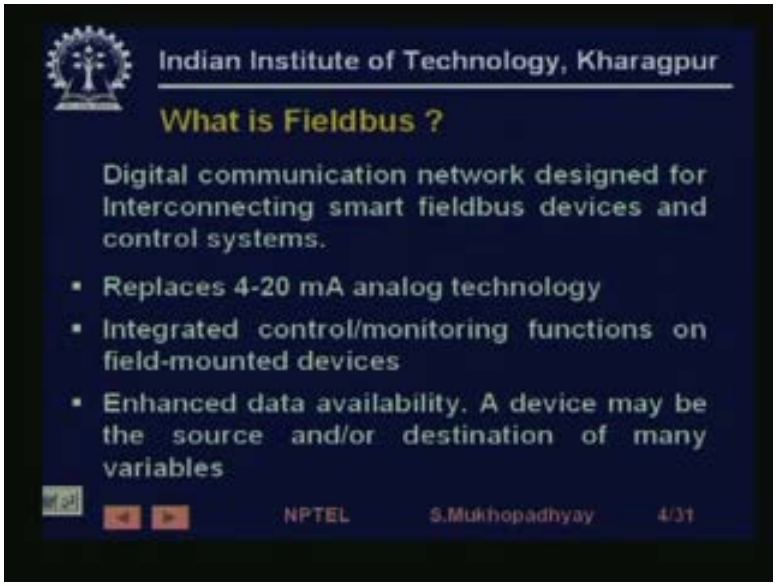

So, first of all we need to know what is a field bus actually a field bus is actually a digital communication network, which is designed for interconnecting smart field bus devices and control systems for plant wide control and automation activities. So, previously also you know you could connect a remote sensor, a sensor which is somewhat far away to a particular let us say a controller. So, for that people use to use various kinds of communication technologies for example, people use to use 4 to 20 milli ampere analog technology, where you know I mean current transmission used to be employed.

Current transmission as we have seen, has you know certain benefits in terms of noise immunity. But, it is still a comparatively much more primitive technology, which has several limitations. So, the field bus replaces this 4 to 20 milli ampere analog technology

and it also provides integrated control and monitoring functions on field mounted devices, previously what used to happen is that the field mounted devices mostly use to when not able to perform computations.

So, in that sense they were not able to they were not intelligent, so they were mainly devices. So, devices which will handle the power and will actually create the physical effect may be in terms of flow for example, of valves may be a valve positioner will actually drive the valve shaft or it can be a heater. So, previously the field monitoring devices were unintelligent and therefore, all the control monitoring activities had to be situated at a host computer.

So, all the signals had to be carried away to the central computer incurring very large wirings and making the data noise prone. So, these defects will be removed if we can have some intelligent on the field mounted devices, so that some abstract command signals will actually come and the control signals, which have to be the low level control signals, where the feedback is taken and the controller actually generates the output such signals can be computed on the device itself.

And it one of the great advantages of having a digital communication network is that, it enhances data availability. So, now one can very easily implement plant wide coordination activities, so you can coordinate till let us say suppose you have one shop which is feeding into another shop or you have one assembly station which is feeding into another assembly station. So, if you want to coordinate the activity between these stations for more efficient production, then that is now possible because over a digital communication network, it is much easier to easier and faster to share large amounts of data from one device to another. And therefore, you can by using software, you can have much more intelligent coordination in your for efficient and reliable production, so these are some of the features which are available on a field bus.

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And naturally we have, so one of the why field bus one of the advantage is that you have high speed and reliable communication. So, you both increase speed and you increase reliability, reliability comes from digital communication, reliability comes from various kinds of special kinds of media, like fiber optic cables used in the field bus system compared to wires, which were used in the older systems.

So, because this is an important here for two reasons, the first reason is that the industrial environment is actually very harsh. So, there are lots of you know here somebody may be doing electric arc welding, there are large power current carrying conductors around. So, you have lot of magnetic and electric interferences, so the environment is very noisy, so the chances of data getting corrupted and or actually very high.

And second thing is that, the consequences of having corrupt data because, it is a control application as we have stressed many times over this course, that this is industrial automation is a critical kind of computing and is necessary here. So, here if data is corrupted, then that can lead to a lot of you know devastating consequences in terms of money, in terms of human safety and things like that. So, therefore, reliability of communication is actually extremely important, so using field bus you increase both the speed of communication.

So, you can exchange large amounts of data over small times and you can exchange them reliably. So, then enhance data availability we have already talked about them, so you can actually because of this network which you have you can actually exchange

large amounts of data from devices, then can have a larger can have coordination's over larger areas, you can do monitoring, you can do whole production process optimization.

So, such functions you it is now possible to do in an automated fashion and in a much more timely fashion, then it was possible before. Then, easy configurability and interoperability of system component, this is actually very, very important a process automation system contains hundreds and thousands of various kinds of electronic components.

So, if you want that each one will actually talk to another, in a language will actually exchange data in a format which is acceptable to the other and will make meaning of the data which is received from the other. Then, you need to configure them properly and configuring hundreds of thousands of devices on a network is not a simple task firstly, secondly I mean devices always get added. So, every time you add a device you have configuration problem, second thing is interoperability, interoperability means that two devices are interoperable when they talk seamlessly with each other.

Now, previously what used to happen is that, because of the proprietary nature of the technology which was not standard. So, you know company A will actually company A's controller will probably talk to company A's operator station, but it will not talk to company B's operator station. So, every company is to have their own standards, now when you have that once you by certain parts of the equipment from a given company, then you actually get tired to that company.

Because, if you by anything else from another company, which may have better functionality, which may be cheaper. But, still you are always start because, it would not talk to the controller which you already have, so that means, that these devices are not interoperable. So, that problem has been removed because, now it is demanded that all field bus compatibly, if any company manufactures a device and it is declared to be field bus standard compatible, then it will be interoperable with any other field bus compatible device from whatever company it is manufactured.

So, therefore, the option for the customer have increased many fold this will faster, competition and will bring in products of improved quality and functionality at cheaper costs. So, this is a huge consequence, so this is why you actually standardize equip it is just like the PC market you know, so if you, you can always buy a let us say a network card from company B and a hard disc controller from company C and a motherboard

from A and if you put them onto a PC cabinet they are going to work without any problem.

So, we want that kind of interoperability in the case of industrial automation also, so that is offered by field bus. Then, there are huge wiring advantages that is because it is a network on which devices are hung, you have huge wiring advantages and remember that wiring although it just means cables. But, these wires are these are data cables, they are not only expensive they have to be laid, installed, commissioned and they have to be maintained. So, that is a huge task and therefore, the advantage of wiring is also nontrivial in the case of industrial automation project.

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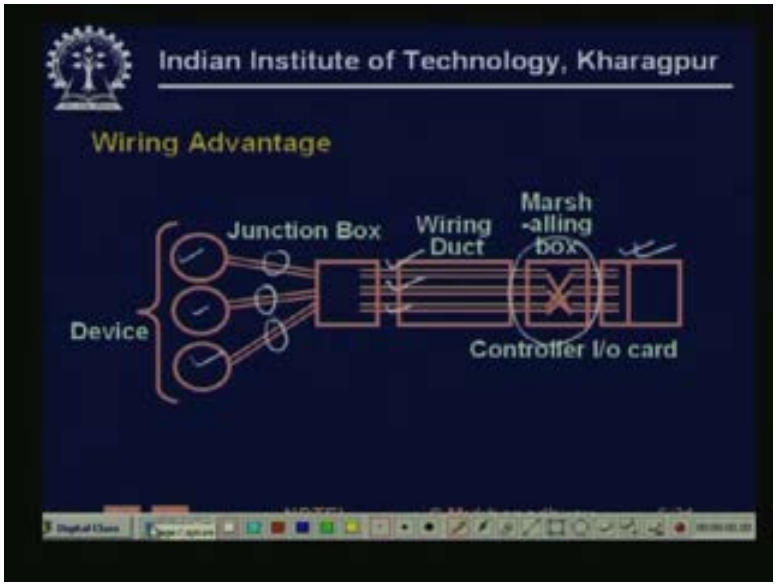

See the wiring advantage how it comes, it comes because of the fact that if you have let us say 4 to 20 milli ampere, which means that a few number of devices have to be can be connected if you directly connect point to point communication. Then, for every pair of devices you have to connect two wires to actually another point, where it will receive the data.

If you have 4 to 20 milli ampere technology, then on the same pair of on the same current loop, you can connect a number of devices true, but that number of devices are very less. So, what happens is that you make for example, see this diagram that here you have a number of devices, so from each device you run a pair of wires and these are get connected to the junction box and from there they run through a wiring duct. So, for each device you have a pair of wires, then they get into a marshalling box and then finally,

connect to a controller I/O card. Now, this look at the amount of wirings for three you need to run six three pairs of conductors.

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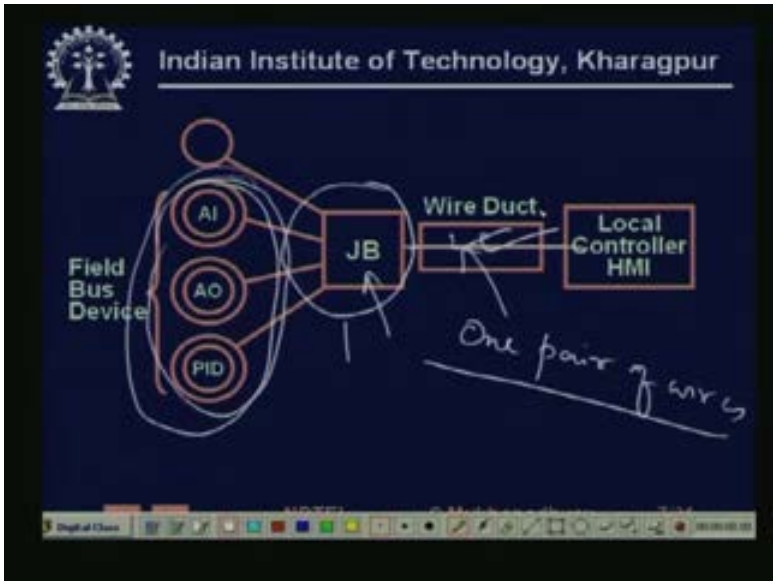

Contrasted to that, look at a this is here see what happens is that here you have these field bus devices. So, the field bus devices can be locally connected to a junction box or let us say a remote I mean some kind of a data concentrator, that is if they cannot be directly hung from a network, if they can be directly hung from a network that is even simpler. And then from this junction box actually starts the network, we will see this physical configuration just now.

So, here you have only one pair of wires, over which digital data is transmitted either in base band or by using modulation. So, for all these devices you actually need to run just one pair of wires to the controller, so the controller, so either this data that you have or actually time multiplexed. So, the either the time multiplex or if you use a some kind of a carrier, then it will be frequency division multiplex.

So, let us say in the case of time multiplexing what is going to happen is that different devices are actually communicating high speed digital data on the same pair of wires actually at different times. So, and the controller which is here is actually receiving that stream of data and then from data that data it is actually able to understand, that is which data is typically organizing to what is known as packets. And from by examining each packet it actually understands that from which device this data packet is coming and to which device it should go.

So, this done all digitally using digital electronics within the local controller, so as far as wiring is concerned you actually run only one pair of wires, this gives a biggest wiring advantage. There is of you know having digital communication, but there is a further advantage which comes, because you have a network bus, so we are going to look at that.

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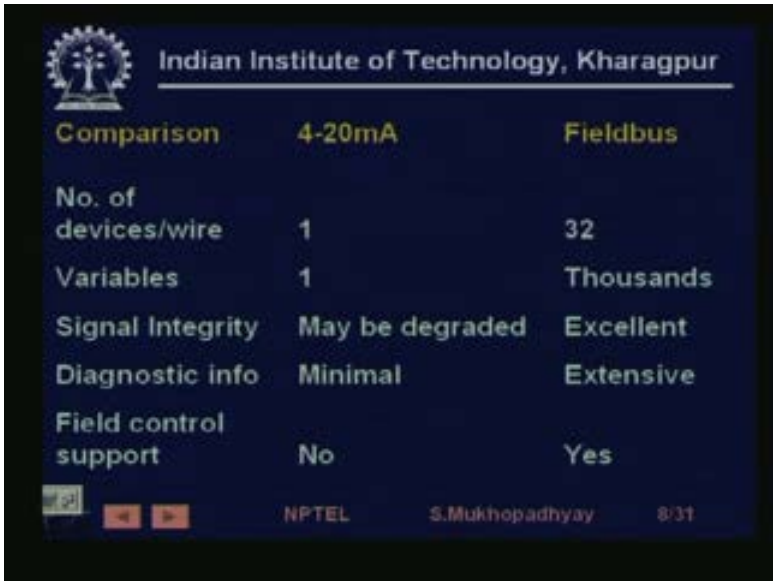

So, before we do that, so we the here is a comparison between 4 to 20 milli ampere which is a pretty old analog technology with field bus. So, in a here you can have number of devices per wire is 1 sometimes you can connect some devices in series, in a field bus you can connect large number of devices and then these devices can be further increase by using repeaters and other things, like on one device at a time since you are sending a current. So, you can actually send only one current because it ((Refer Time: 16:36)) continuous all the time it is coming.

While you can have thousands of variables can be transmitted over the same pair of wires in the field bus. Signal integrity, because it is analog communication although current communication is more immune than voltage communication, but still it is much more prone to degrading, while the immunity of field bus devices. Because, it is a digital data it is quite excellent, then diagnostic information because in the field bus, because you have intelligent devices.

So, therefore, these devices the intelligent devices means, these devices can actually examine their own signals. And can do computing to actually understand whether the devices working nicely or not properly or not or whether some fault has developed, so

such information is actually called diagnostic information. So, you know controllers can actually need a lot of diagnostic information because, otherwise even when things are running in an automated fashion one needs to know whether, you know all actuators, sensors are actually giving you the right data or is it that the sensor has failed and the data that you are getting is actually not proper.

So, in this case the field bus devices themselves being intelligent, they themselves can evaluate their diagnostic state. And then send information to the top level controllers, based on which these controllers can take action and extensive diagnostic facility is provided for the field bus. There is also support for field control, that is PID like controllers can be mounted on the devices and they can be commanded from a host station, they can be configured. So, such field level control support exists in field bus while none exists in the 4 to 20 milli ampere loop.

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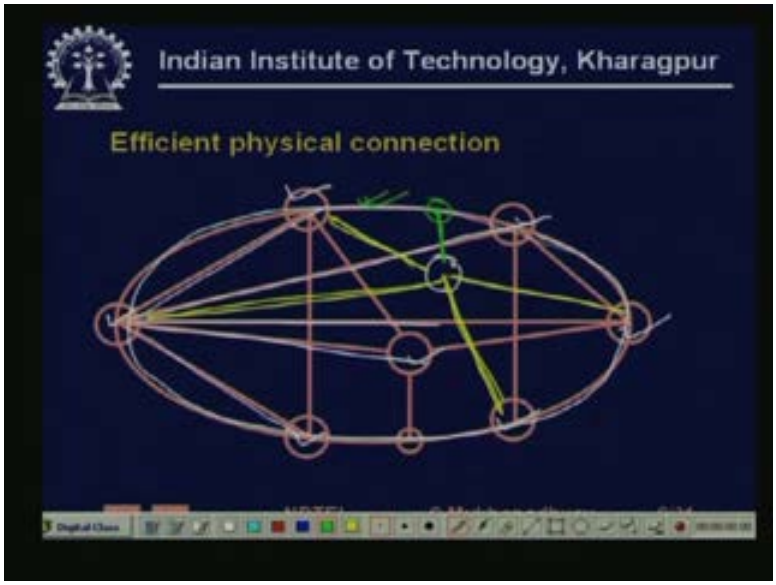

So, these were the advantages coming back to this efficiency of physical connection, you can understand this. Let me, suppose you already have these nodes and they need to interact with each other, so if you have point to point communication, then you need to connect all these wires. So, you see the number of physical connections that has to be made across the plant actually these distances can be quite substantial and if you have a point to point communication system.

On the other hand, if you have a network then you are actually running a network all along the periphery of the plant. Now, for example, suppose you want to add another

device, so you put another device and suppose it actually talks to four other devices. So, you have to now connect all these four wires, if you had point to point communication. On the other hand, if you have a network then what you will do is, that you will simply hang the simply connect this to the nearest point in the network.

So, it will simply be hung on the network and then it is on the network bus, so it can communicate with any other device on the network bus. So, you can understand that if you compare even in this diagram, if you compare the length of the yellow lines with those of the green lines. Then, you will understand that what is the kind of cabling advantages that you can get, when you have a bus or ring kind of network running all across the plant. And this diagram itself shows the picture, but when you have thousands of such devices at that time this advantage becomes I mean predominant.

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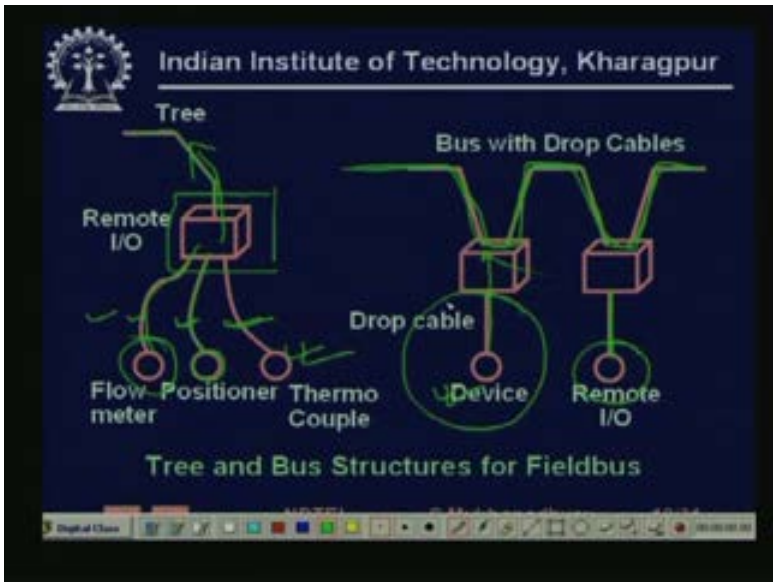

Here in this diagram you see how devices can be connected on the field bus, so you can connect them either you know like a tree. So, you can either have a separate branch from a tree, so for example, here you see that this is main network bus running from that network bus, you can hang a line which is a remote I/O, remote I/O means that it is a special electronic device, which actually accepts data from a number of devices, which are connected in a point to point fashion, so this is a control device, which is connected by a pair of wires to this remote I/O.

This is a positioner which is valve positioner, suppose which is connected, so similar now this device is actually a network device, these are not network devices. So, this

device will actually accept the data and then this device will transmit on the network after you know making packets out of it. So, you can connect a number of point to point devices to the network, either directly like here, so here you have a device which is directly connected on to the network bus, this is the main network bus running. And either you can connect that or you can connect devices, which are not directly network connectable with the help of what is known as a remote I/O block, so these are the two ways that you can connect devices on the field bus.

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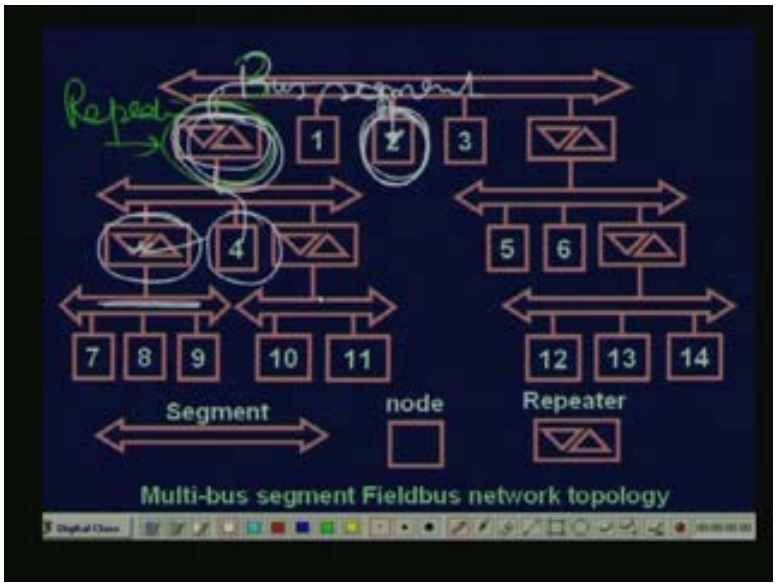

For example, this then shows that if you have a really you know very wide plant area network which actually can run into you know kilometers, if you have seen big factories you will know that. For example, if you go to Telco or if you want to go to Tisco or some big steel plant, then you will see that this factory is actually a several square kilometers. So, they are very large factories in therefore, if you want to have a plant wide network, then you actually have to have very large long distances are involved.

So, this figure shows that over such long distances still you can actually configure a network. So, you know this is by using bus segments, so there are several bus segments which can be directly connected over a cable, and then several bus segments can be connected by actually what are known as you know bridges or repeaters. So, you know this is a repeater, so a repeater actually is you see connects this is the bus segment.

Let me try a better color, so this is a bus segment and this repeater actually talks to, so whatever data. So, now, suppose this number 4 device, one should talk with number 2, so

it will transmit this data on the bus, it will go to the repeater and then the repeater knows, whether this is actually meant for it will go to this repeater it will also go to this repeater, so now this repeater will know that it is meant for it is a device on it is own segment.

So, it will retransmit it on the bus, while this repeater will know that it is not meant for a device, device number 2 does not exist on it is segment. So, therefore, it will not transmit it, so actually you can transmit data over from one segment to another using such repeaters. And therefore, you can configure a very, very wide network or network which actually scrolls over kilometers using a local area network technology.

So, this gives us an idea of how an industrial network is physically connected, so there is a bus, which is running all over the factory, this bus may be segmented using repeaters, etcetera. And then you have actually have to hang devices on this segments and then they will talk to other devices in that segment or in other segments. And using you can see that the field bus supports all kinds of devices, devices which are directly connectable on the network or which are not connectable on the network as well.

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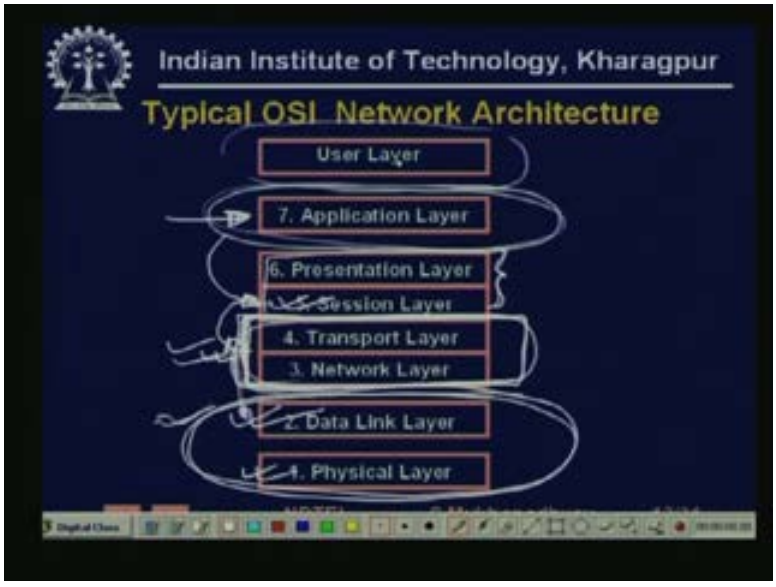

So, now having understood the connectivity the actual physical connectivity, let us come to the OSI network architecture. A typical a very general purpose network, these are very general purpose model and in the various special networks, you have some sort of an adaptation of these network architecture, in all networks it adapts this generic OSI network architecture in certain ways.

So, in the generic standard you have actually when over a network, when we when one computer talks to another it need not know what is the network connectivity, what is the address you just you know you really when one person chats with another person, over a long distance sometimes over the globe. So, it is a actually a virtual communication, but actually physically these data or the text, suppose which you are typing has to physically travel from your network, across various communication channels and physically reach the other computer, which may be thousands of miles away.

So, this is achieved through a layer of protocols, each protocol gives a service to the protocol above. So, that the protocol above and hide certain unnecessary details from the from the protocol above, so is the protocol above always sees it is own communication as across some virtual channel and is freed from several you know technical details. Otherwise, it would have been I mean absolutely impossible for us to do any communication over a network.

So, the communication is actually goes is whole system is actually organized in layers and any message, which is generately at a top layer will come down across the layers. Finally, reach the communication channel and the electrical communication, then it will travel across various, you know nodes and then finally, will go up and reach the top layer of the destination process. So, you have typically you have physical layer, which is actually the electrical layer, where the actual electrical communication takes place modulation communication, over any medium fiber optic, radio, wire, whatever.

Data link layer is the next layer, which actually provides increases the reliability of the electrical communication. So, here the data is not it is still treated as in a binary data, packets are assembled, error codes are attached, so that during transmission if some data error occurs that can be detected, these transport and network layers actually take care of the networking problems. So. Firstly, it does things like routing, so if you are sending an email message from here to Japan, from your say your host to whom you will send where should it go.

So, this kind of routing information is routing is done by network layer, then there are sometimes you know they do you know things like congestion control. So, some particular channels may be down, they may be choked, so if data is not going through these channels, there are mechanisms by which people can do things like flow control.

So, this network and transport layers actually take care of the network topology, loading and network communication.

So, once you have taken care of these, from the session and presentation layers it appears as if you have a this is the physical communication, digital communication, this is the network configuration and network performance ensuring. So, once you have these two layers, these layers sitting on this and this actually sees a size some kind of a virtual session between two computers. So, it does not know it is completely oblivious of how through which path in the network, this particular message is going.

So, it does know it just knows, so it sets a session, presentation layers are generally rudimentary, then they not very strong. And it is the application layers are configured for typical kinds of application, like in you know want to have a remote terminal, so your you want your PC to actually work as a terminal to a server, which may be elsewhere on the network, so this is a remote terminal service, there can be an email service.

So, these various kinds of common kinds of applications various kinds of application TP service. So, file transfer, so such things are particular details of these are actually handled by the application layer and the application layer once, so then the application layer actually calls a session layer and says that you please set up a session for this particular application. And then the session layer gives those it is session messages to the transport and network layer, which decides how it will go.

And then they actually finally, puts all the addresses, etcetera and then finally, these get to the data link layer and then they actually are transmitted in the medium. The user layer normally this user layer in this is OSI network layer architecture actually a 7 layer protocol, which does not have the user layer, because for general purpose computing the user layer can be enormous variety. So, therefore, the user layer is actually not specified, but as we receive that in the particular case of industrial automation network, this is adapted.

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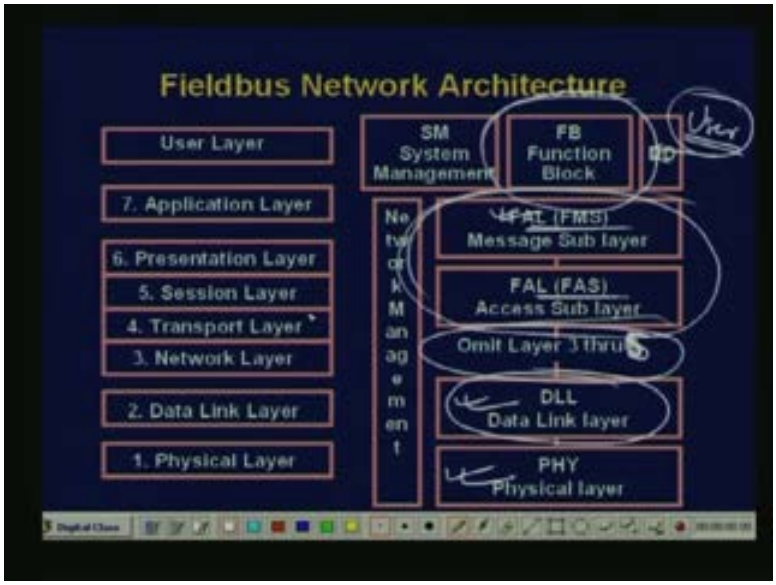

So, what is done is, we will skip these slides and see the field bus network architecture, so in the field bus network architecture there are certain differences. So, first difference is that the network in the factory is actually fixed it does not change, second thing is that the what kind of messages, there is the loading on the network, how many messages are coming frequency of messages arising on the network are also more or less constant.

Because, you know all the time I mean once it is designed it is fixed it is not that new processes are being, I mean large number of new processes can be suddenly generative, because we know what kind of computations are actually going on in this network. So, therefore, this you know this what I mean to say is that the transport and network layer functionalities nearly removed. So, therefore, it is good to remove the transport and network layer therefore, the field bus network actually does not have, actually has very rudimentary transport and network layer.

So, it has a physical layer it also has the data link layer, which you know does also part of the little bit of it actually puts the addresses, it actually ensures that is who will transmit when say the medium access protocol, etcetera for cyclic and acyclic communication is also handled in the data link layer. And this layer 3 through 6; that means, session presentation and application are actually application is there 3 to 5 I would say, physical, data link, network, transport and session layers networks no 3 through 6, networks, transport, session and presentation these 4 layers are actually removed.

Then, on top of that you have an application layer which application layer is, so you have field bus application layer, which is broken into two sub layers, one is called the field bus message sub layer, the other is called this the field bus access sub layer. So, the field bus access sub layer provides various kinds of addressing functionality and the field bus message sub layer actually configures the messages, which are coming from the user layers. So, in contrast the field bus network proposes an a major user layer, because here the computations are not of that much variety.

Number one, they are largely uniform they are all for process automation tasks and secondly, because of the fact, that you know it is necessary for easy configurability it is necessary that the, so enormous flexibility is actually not needed. So, you can create various kinds of templates and you can create a separate layer within which it will be easier for the application engineer for the process engineer to actually program this application. So, therefore, an user layer is proposed, so one layer is added and four layers are deleted, so you have a this is the field bus protocol structure.

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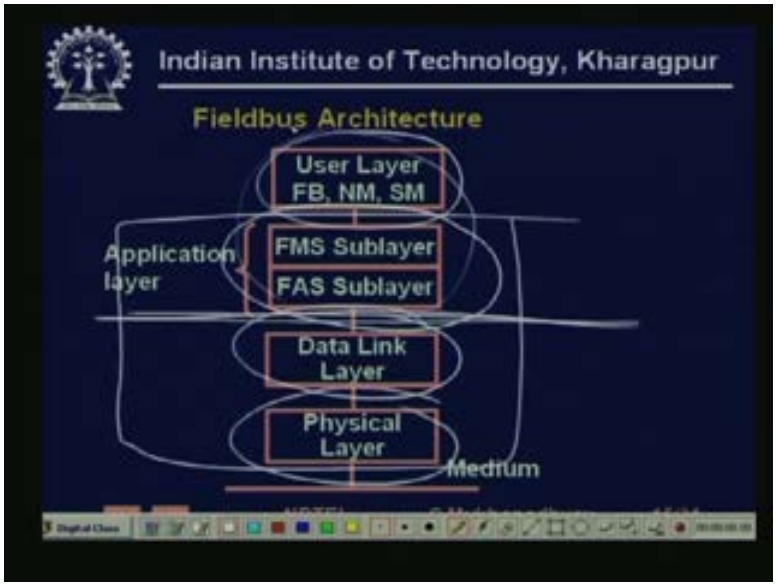

So, you have finally, the field bus architecture, so you have the physical layer, the data link layer and the application layer broken up into two parts. And then you have the user layer, which involves the function blocks which are you know abstract computing blocks which specify abstract communication. Let us, say between an analog input device and a process controller or a process controller and an analog output device.

So, it will just abstractly describe this in terms of function blocks and then the network communication through this, I mean among this function blocks will be automatically realized by this part of the network. So, this is the field bus protocol in this lesson we will be mainly concentrating on the data link layer and the physical layer, physical layer we have already discussed. And in the next lecture we will be talking about the user layer and the field bus application layer.

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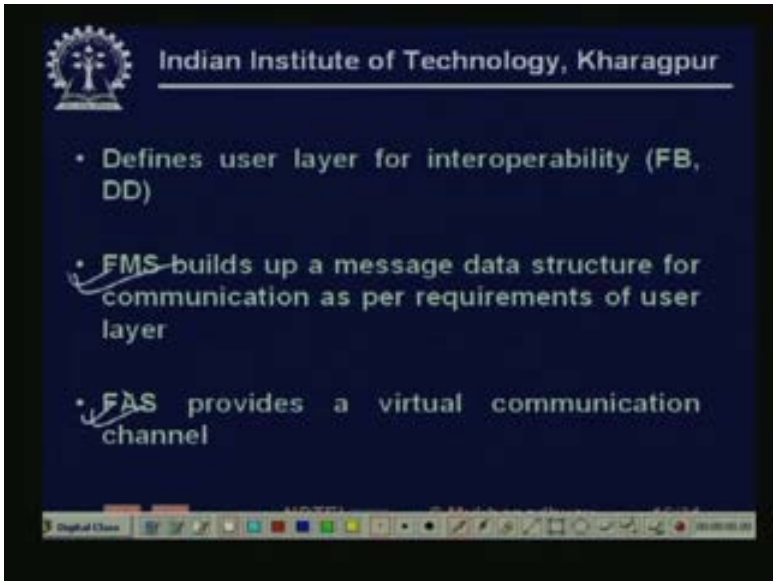

So, the field bus as I was telling it defines user layer for interoperability, so that you know every device. So, all the field bus devices are have to be of a certain standard as for as software interfacing or data formats are concerned, so those data formats have been already specified in the standard and any field bus device must comply with the standard. So, that they can be become immediately interoperable and these are defined in the user layer protocols, the field bus message specification.

So, the user layer just abstractly give, so may be an analog input block simply in it is user layer it simply generates a value. So, this particular temperature signal has to go to the PID controller it says, now for transmitting that to the PID controller, this has to be actually may be into the message and then a message has to be configured into a packet and then it has to be sent with after all the addressing, etcetera.

So, the field bus message specification, the field bus message specification builds up the message data structure for communication as per requirements and in fact there may be several function block processes within a device. So, all these devices frequently are

generating data, so they have to be put in the form of messages and then transmitted. And then the field bus access sub layer once it is gets the packet, this is to be transmitted then the field bus access sub layer adds, you know addresses and the networking information.

Such that, this can actually reach another device of the bus, you know each device has a unique address and unless you, since there is a shared media unless you transmit your unless your messages contain addresses. The device says will not able to understand whether a particular data that it has seen because, everybody is actually listening on the same bus, people are transmitting on the same bus and every device is actually listening on the same bus and picking of the data which is meant for it.

So, the field bus access sub layer provides in this way by providing addresses provides a virtual communication channel. So, that nobody the top layer should not need to worry about how it is device is actually sensing and then picking up the data meant for it, so it need not bother about that.

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The data link layer actually manages the communication protocol it takes care of the digital communication details, error coding, parity checking, etcetera. And the physical layer provides a the electrical and medium dependence, so if you have wire, if you have RAF, then it has to be radio transmission, if you have fiber optics, then there has to be optical communication. So, all these details are handle by the physical layers and levels to 3 to 6 are dropped for efficiency.

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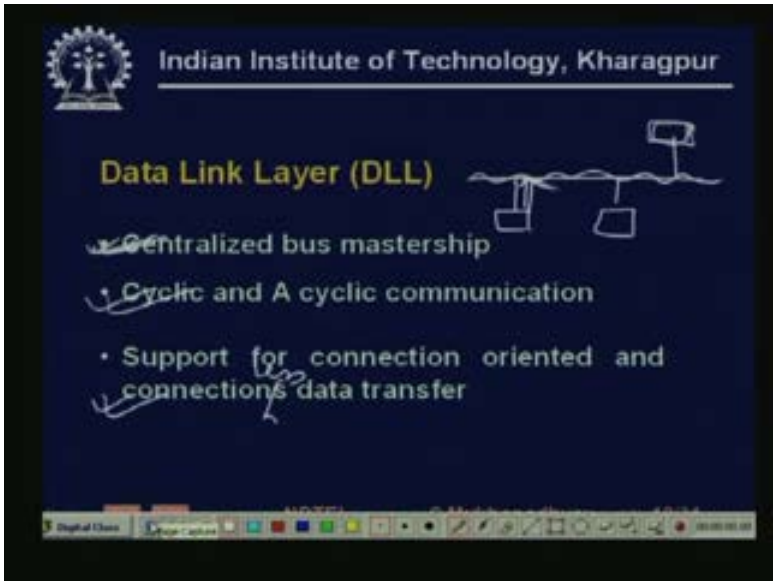

So, without going into the physical layer, because that involves a lot of you know electronics basically and generally communication electronics, so we do not want to get into that in this course. So, rather we look at the data link layer in the data link layer the features are, that you have centralized bus mastership, this is very important to understand, because you are having a bus on which everything is hanging. So, if you talk if a particular device transmits on this bus, that is signal existing everywhere on this connector.

So, all the other devices can get it and it is very important that no two devices never transmit data on at the same time on the media, because then the data is going to be garb let. So, therefore, there has to be a device will decide who will speak at what time on the bus, so this is achieved by what is known as bus mastership. So, the bus master distributes the right to transmit among the devices, depending on their needs and depending on how you have configure it. Communication can be cyclic as well as cyclic that is some devices will every say one second, they will send a packet.

So, they require cyclic communication, there some may be acyclic who have which we have been suddenly require may be due to some all on condition or things like that. So, these two kinds of communication are supported by the data link layers and sometimes you have features for connection oriented as well as connectionless data transfer, this is connectionless. So, you can have broadcast where you are not giving addresses or you can have a connection oriented, this meant for only this node only.

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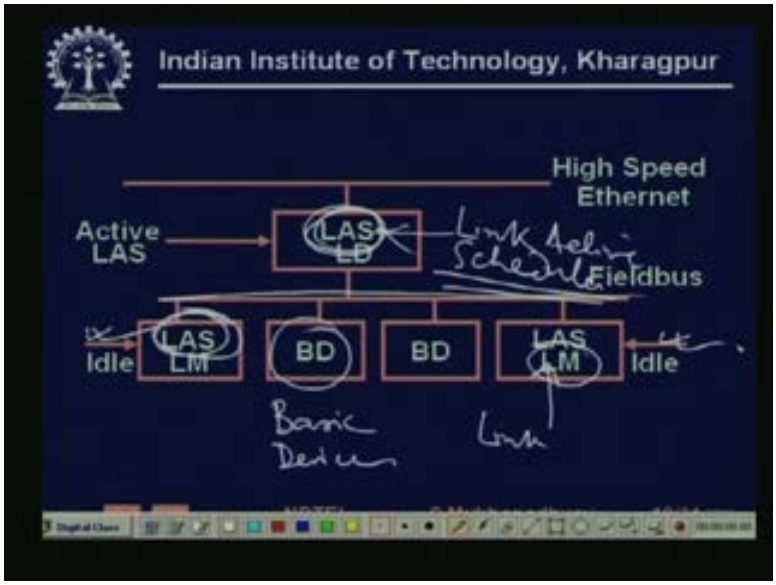

So, these are supported by the data link layer, so pictorially it looks like this on the bus, this is the field bus, there are various devices these are basic devices BD Basic Devices and these are Link Masters. So, LM is a kind of device which is capable of becoming a link master and there is among the link masters, there is a particular device which is called the link active scheduler. So, at this time this link master can also become the link active scheduler, but it is at this time ideal.

So, these are idles sometime you provide more link masters, because if by for some reason this link master fails, then who will ensured the communication. So, there are some other link masters, which are always kept in hot standby, so that they will they can immediately take over the communication and the control and coordination will continue, this is very important.

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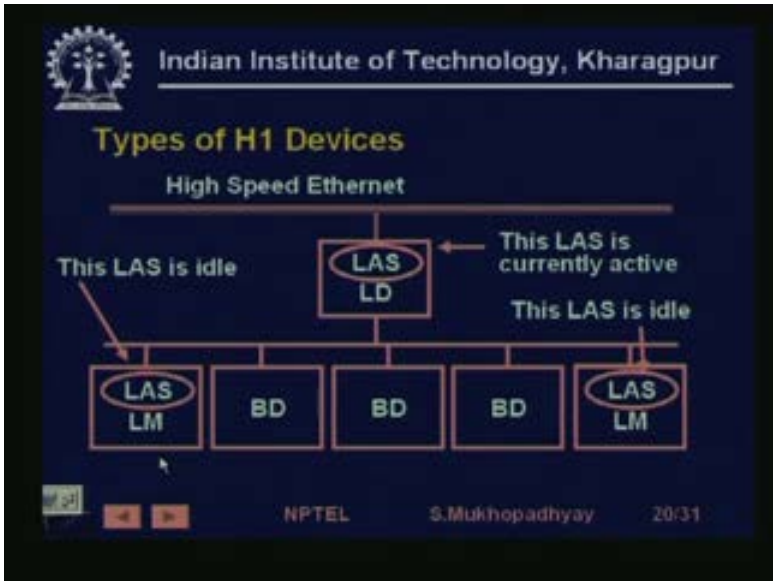

So, exactly same diagram which is repeated, so these are the link master and they are basic device, basic devices are not capable of becoming link masters or link active schedulers, while link masters are capable of becoming link active schedulers.

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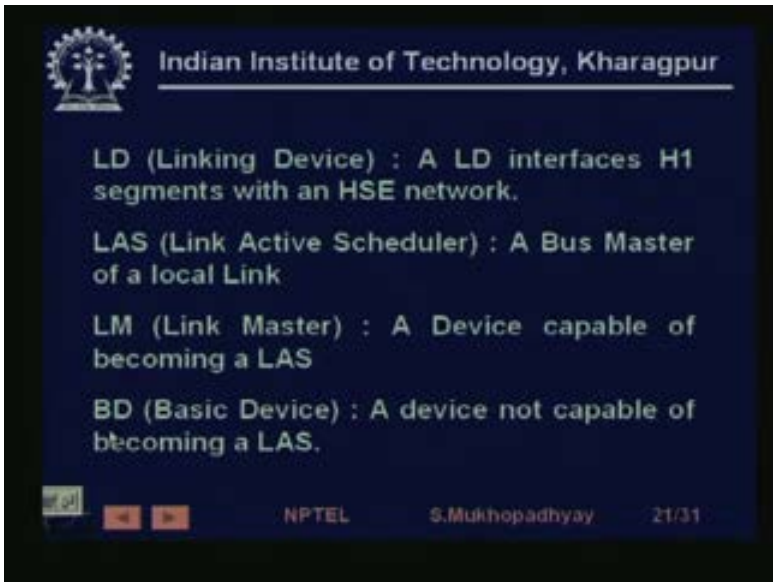

So, LD is a Linking Device as LD interfaces each one segments with an HSE or I do not know what HSE means, link master that is what I said, BD is basic device, a device not capable of becoming a link master.

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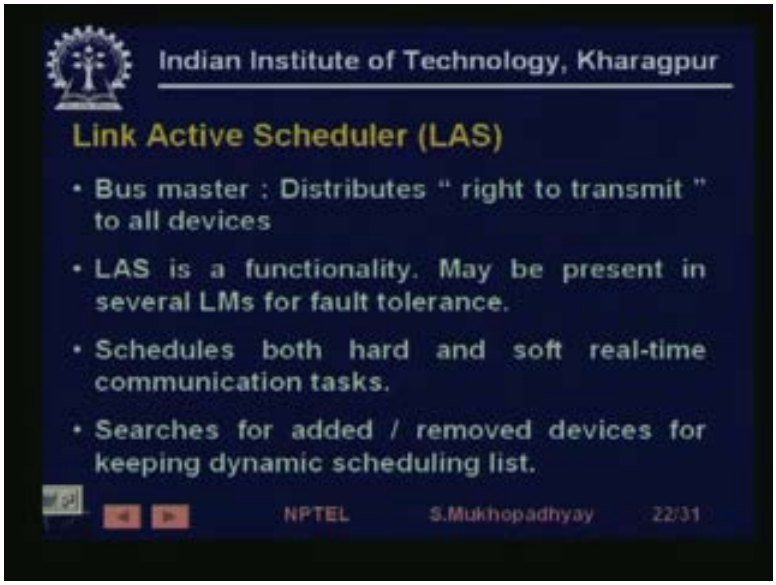

So, link active scheduler is as I said it is a bus master, which distributes right to transmit to all devices. It is actually a functionality some software which may be present several link masters or fault tolerance and it actually does this scheduling of the various, you know soft and hard real time communication task. So, soft real time communication task are those, which also need to be finished in time, but even if they are slightly delayed there is not, so much of a problem.

But, hard real time tasks are those if you cannot finish those tasks, those computing and communication tasks in time, then the system may completely collapse. So, it must, so for you in a scheduling you have to take care, such that the hard real time tasks are definitely finished within time. So, the link active scheduler also has to you know these you can always keep on as we said that, there is easy configurability, so you can add a device simply to the network. And the link active scheduler also has to look for whether some new devices been connected and then has to configure them and then has to take care of their communication need. So, it also searches for added and remove devices, similarly if a device is removed it has to take it off from it is scheduling list.

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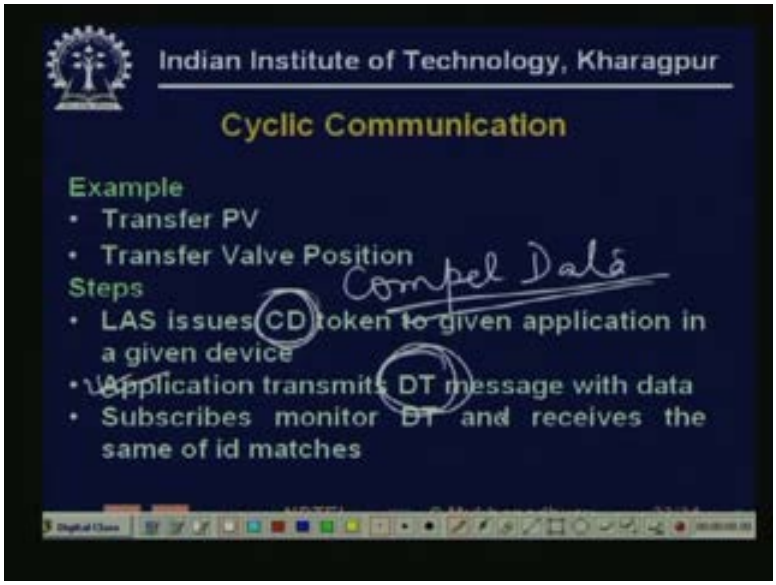

For cyclic communication, typically applicable in the case of control, so you know transfer process variable or transfer valve position, valve position is just an example. So, it continuously has to take the process variable, compute the controls and then output to an output device, so this goes on. So, this is an example of cyclic communication, so if there is cyclic communication, what the link active scheduler does is that it issues a CD or Compel Data token to a particular device.

So, once a compel data token is given this device to which this CD token was issued must respond with the data token. And then this it will send on the bus and then all the devices are actually all the time looking for the data, so the device which needs that data token will actually, will receive it and will take it and then use it.

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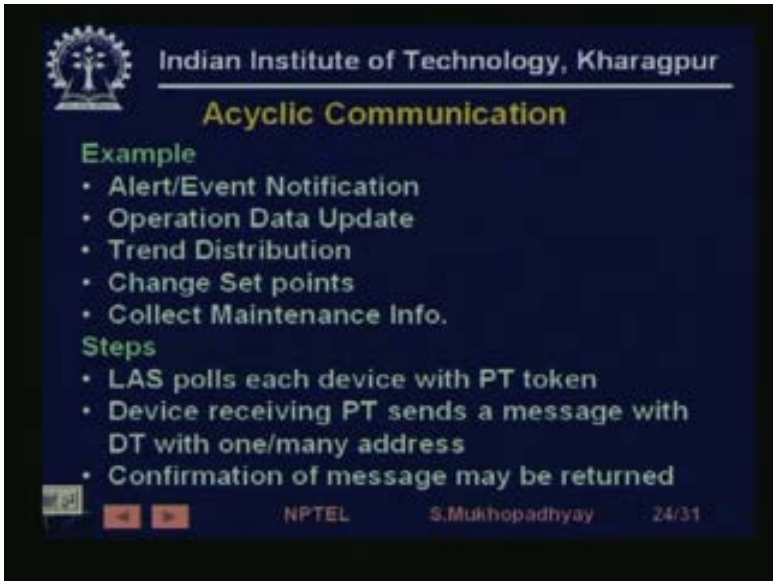

For acyclic communication, acyclic communication typically occurs when you have alert or event notifications, you have some operated data update, sometimes you like to see some trends. So, you can ask for some trend data, you can change set points or you can change if other kinds of commands to change operating modes collect maintenance information etcetera. So, these are not cyclic information's, but demand driven sometimes if they are invoked then that communication is to be obtained.

For this the LAS polls each device with the PT token, PT is a Past Token, so if a device has something to communicate it will take the past token and then will communicate, if it does not have anything to communicate it will simply pass the token to the next device, so whoever needs it will hold the token and then will transmit the data.

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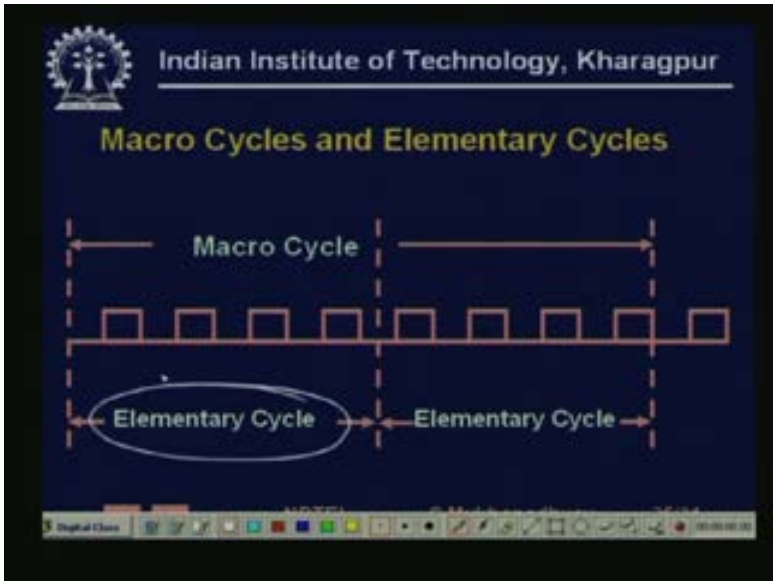

And the communication is actually organized overall into cycles called macro cycles and within each macro cycle. So, macro cycle is the basic cycle over which the communication is periodic and then within macro cycles you have elementary cycles. So, an elementary cycle is resided by the fastest by the device which needs to communicate the fastest, so let us see the next example we will understands it better.

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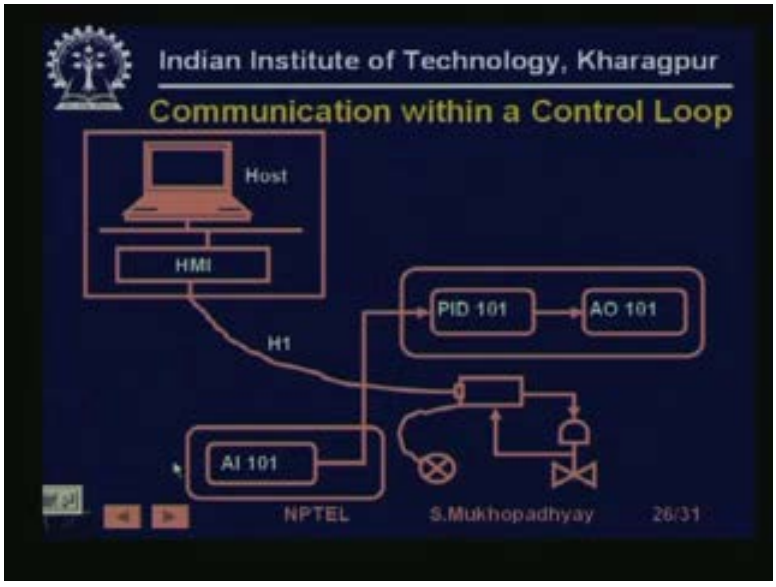

So, for example, take this loop this is a PID loop with say an analog input a PID and an analog output. So, these are you know actually you know on different devices and the analog input, so they are all on the network and the analog input this is the function

block representation. So, virtually this AI must communicate with PID and then PID here must communicate with AO and they are actually physically different devices.

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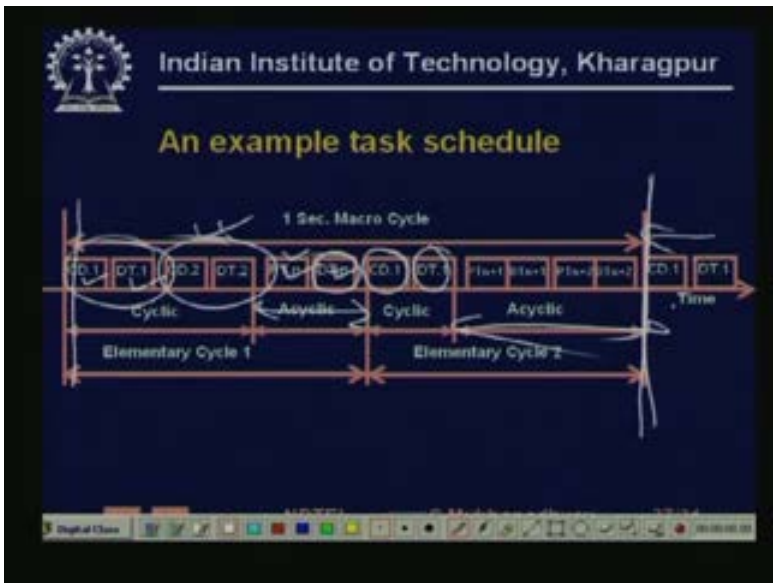

So, in this case you see that suppose there are, so this an example of you know several devices. So, suppose it can very well happen that one device needs to talk two times in one second both are cyclic, but another device needs to talk only once, so you see how it is organized. So, the macro cycle is actually decided by the slowest device, so see it is here the slowest device talk needs to talk only every one second, so therefore, you have a one second macro cycle.

On the other hand the elementary cycles are decided by the fastest device, so in this case the fastest device needs to talk twice in a second. So, therefore, in one macro cycle you have two elementary cycles, so first time what happens is that CD 1, DT 1. So, the first device talks, then CD 2, DT 2 the second device talks and then sometime is in this elementary cycle sometime is kept free, this time is kept for acyclic communication.

So, if there is any acyclic communication requirement, then this PTN and DTN suppose this some n'th device who needs do some acyclic communication. So, this PT will be passed and this DT will be transmitted, now in the next macro cycle you see that because CD 1 and DT 1 speaks. Because, it needs to talk twice in a second, while CD 2 and DT 2 is skipped, because the second device does not need to speak twice in a second.

And this whole time is actually utilized for acyclic communication and then the next two acyclic communication cycles go on and in the, so now this macro cycle ends and the

second macro cycle begins. So, the first elementary cycle of the second macro cycle is here, in which again CD 1, CD 2 and CD 2, CD 1, DT 1 and CD 2 and DT 2 will take place, so this is the basic way in which the communication goes on here.

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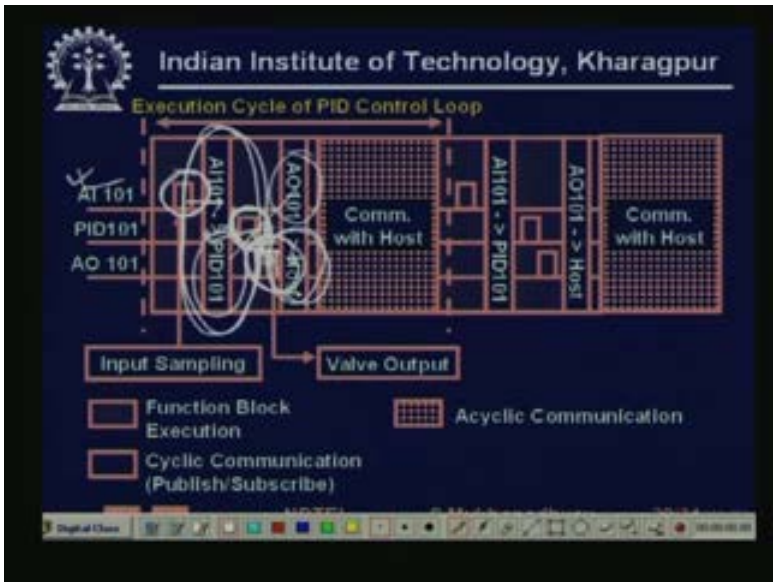

So, for example, see in that communication loop things are serialized also, so first in this communication loop what happens is that first the AI 101 to PID 101 takes place. So, the analog input gives feedback to the PID controller, then the PID controller, now the PID controller as we had seen in the previous diagram, that the PID controller and the analog output devices were on the same physical device. So, there is no need for communication, so this PID controller giving value to AO is there is no need for communication.

But, this analog output may also have to be transmitted to the host or some operator station, which wants to see what kind of outputs are going to the plant. So, for that you need a communication, so at this point of time, so the here the analog input process computes, input samples and then a communication is scheduled, after this communication ends the PID data has got the results. So, it will compute and then the PID will directly give and then the AI block will compute this does not require any communication, because the PID and the AO block are on the same physical device no communication is required. And then the AO block will communicate on the network with the host, so this is the way the this PID loop computation and communication will go on.

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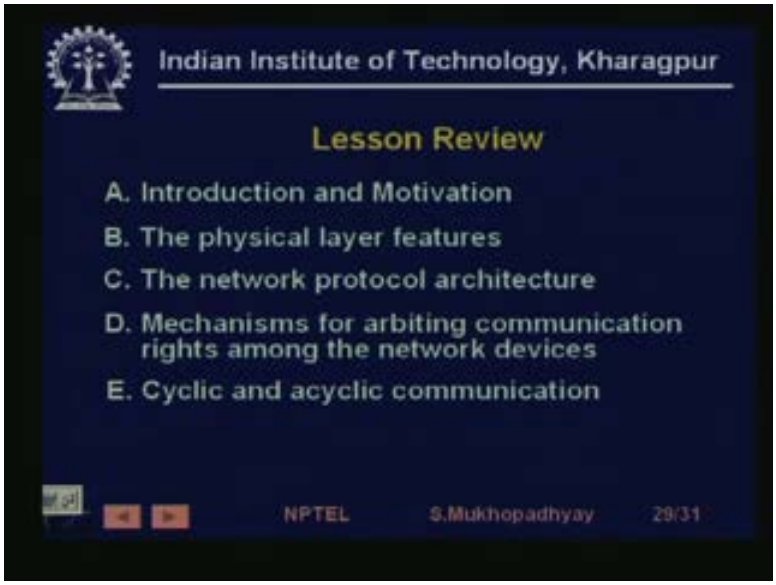

So, this brings us to the end of the lessons, so let us review it, so in this lesson we have seen the basic introduction and motivation of having a network. So; obviously, here I would like to make a comment that; obviously, there are advantages of having a network over in you know a simple analog or point to point digital communication system. But, one has to remember that the investments required for the field bus network, all kinds of software, the smart field bus devices all these things I mean the application domain must be large enough and must require enough quality and enough that is the cost of setting of this field bus network must be justified.

So, even if it is you know quite elaborate and gives lot of functionality, but one should have need for that functionality and using that functionality, I mean revenue should be returned this is another comments. So, introduction and motivation, then we have seen the physical layer features and we have seen that how these are connected, how these are to be connected and how using repeaters and then digital communication, you can have very large networks and you can have wiring advantages and you can have very reliable data communication.

Then, we have seen the network protocol architecture and we have seen that it is basically some kind of an adaptation for the special purpose of plant wide control of the OSI layers, and we have seen the what are the layers existing in the field bus architecture. Then, we have seen the mechanisms for orbiting communication rights among the network devices, so how cyclic and acyclic communication goes on by and

how centralize bus masters issue tokens to particular devices, which take them and then transmit data.

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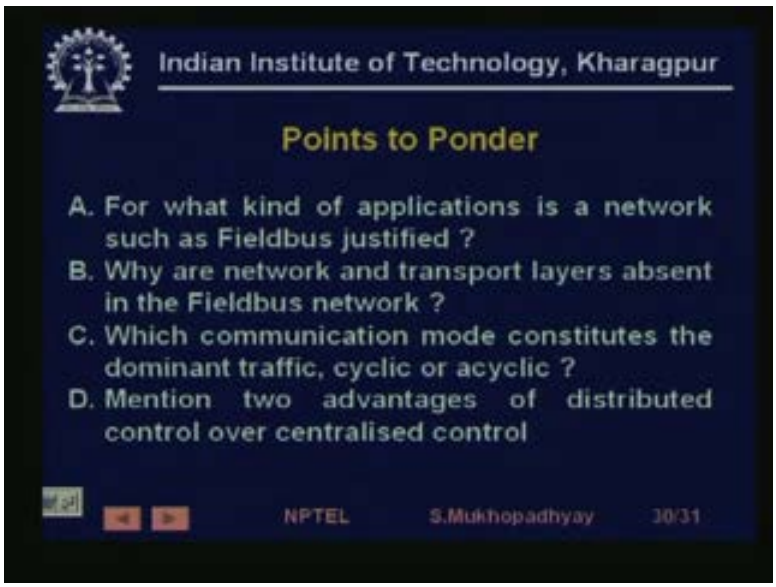

So, this brings us to the last thing points to ponder some questions, so for what kind of the application is the network such a field bus justify. So, I raise this point immediately, so you can think of some application where this will be justified, why are network and transport layers absent in the field bus network. This also has been discussed, which communication mode constitutes the dominant traffic cyclic or acyclic.

So, you can think of the various process automation tasks and then decide which is mention two advantages of distributed control over centralized control, so with this I would like to conclude today, thank you very much.

Industrial Automation and Control

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Lecture – 38

The Fieldbus Network - II

Welcome to lesson 38 of the course on industrial automation and control under the NPTEL program. In the last lesson we had been talking about the field bus network and we had seen the basic nature of the protocols, we had seen the bottom layers, the connectivity the data link layer, where basic cyclic and acyclic communication is realized. In this lesson we are going ahead and we shall take look at the two upper layers of the field bus network, namely the field bus application layer and the user layer.

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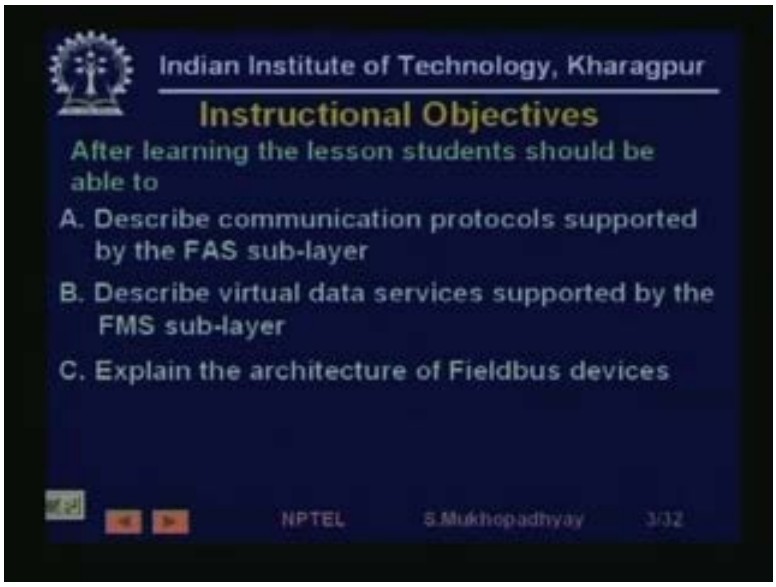

So, looking at the instruction objectives, describe communication protocol supported by the field bus access sub layer as we have mentioned before. The field bus application layer is actually consisting of two sub layers, one is the field bus message specification or field bus message sub layer. And the other is typically referred to as FMS and the other is the Field bus Axis Sub layer or FAS, so here we will describe communication protocol supported basic features of field bus access sub layer.

Then, the virtual data services which are supported by the field bus message sub layer, so we will basically take a look at access sub layer functionality and FMS functionality. So, that you understand the basic purpose of it, then we will go over to the user layer and after this you should be able to understand the basic architecture of the field bus device and how user computation is done.

And finally we will take a look at the various system network and time management functions that are essential to realize a virtual distributed control system. So, here we have communication within a control loop the same diagram, so we will skip it.

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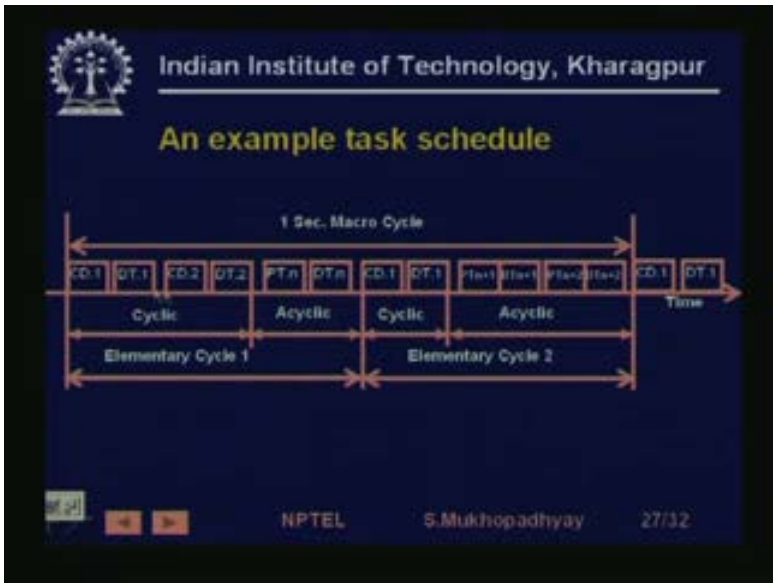

And we have already seen this that how we communicate using cyclic and acyclic communication over macro cycles and using elementary cycles.

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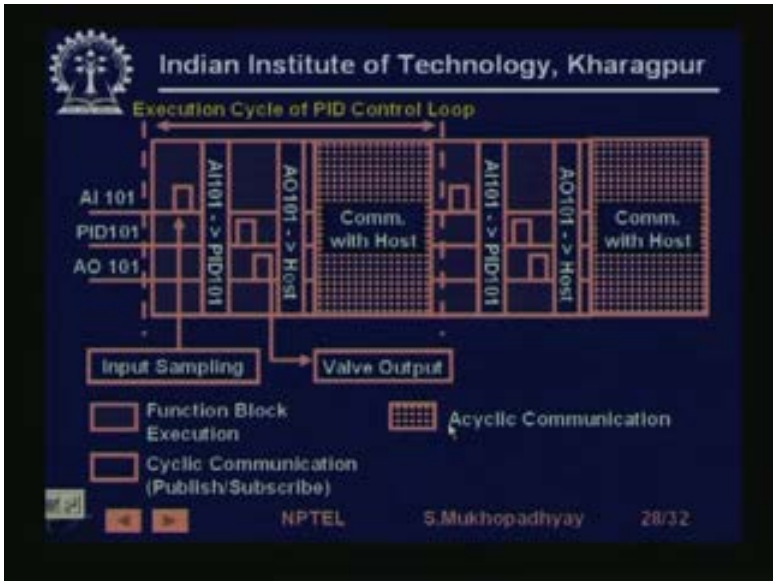

And we have also seen this is, so you see that is what I talking that the inputs will be sampled, then there will be there will be some communication, then the PID block will

execute, then the analog output block will execute, because they are on the same device no communication needed, then the output block will communicate to host. So, in this way communication will be scheduled by the system management, the rather the computation will be scheduled by the system management functionality for control.

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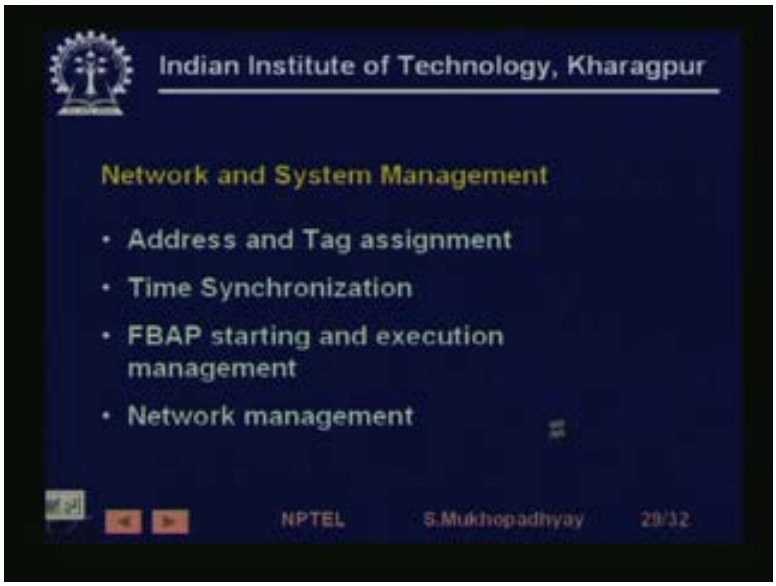

So, then again network and system management, so it basically involves address and tag assignments and maintaining them. And when a device comes on recognizing that device when the device goes out of the network, removing it from the scheduling list, so all these are network address and tag assignment and management. Then time synchronization, function blocks starting, execution management and network management.

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So, we have come to the end before that let us review the lesson, so we have looked at the FAS sub layer, which basically defines a virtual communication channel and provides three different kinds of communication channels. Then, we looked at the FMS sub layer which provides 42 or 42 is a number ((Refer Time: 57:35)) keeps changing. So, different kinds of information services and provides the message data of structures for those services.

And finally, we saw the field bus device architecture, which actually let us the manufacturers provide a standard interface to their computation, while maintaining their own proprietary flexibility. So, we saw the function blocks and their execution and the system and network and time management functions.

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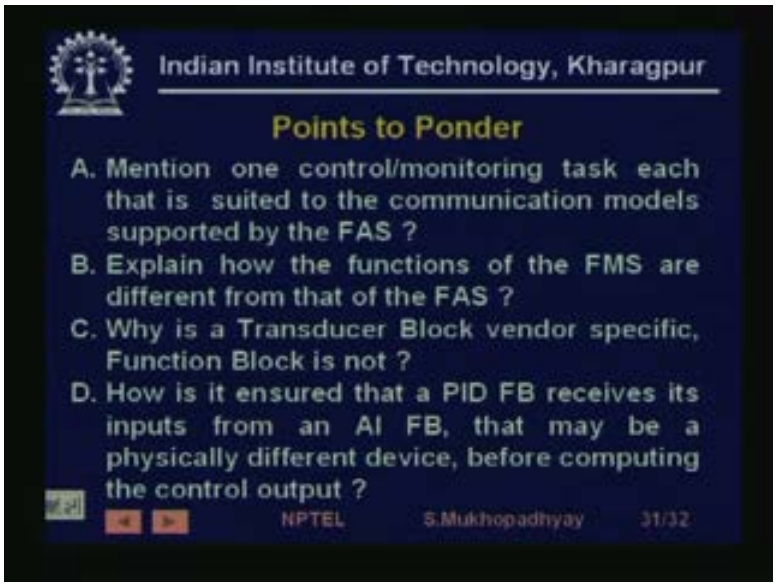

Before we end points to ponder, so mention one control monitoring task each, that is suited to the communication models supported by the FAS. So, QUB, BNU, QUE for each one try to find a task which can use that model, explain how the functions of the FMS are different from that of the FAS, this is clear. Why is a transducer block vendor specific, function block is not, this is also clear mention in the next lesson, how is it ensured that a PID FB receives it is inputs that's by scheduling done by the system management using link schedule time, that's all.

Thank you very much.