INDIAN INSTITUTE OF TECHNOLOGY
KHARAGPUR

NPTEL
ONLINE CERTIFICATION COURSE

On Industrial Automation and Control

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Topic Lecture – 48
The Fieldbus Network - I

Welcome to lesson 37 of the course on industrial automation and control of NPTEL.

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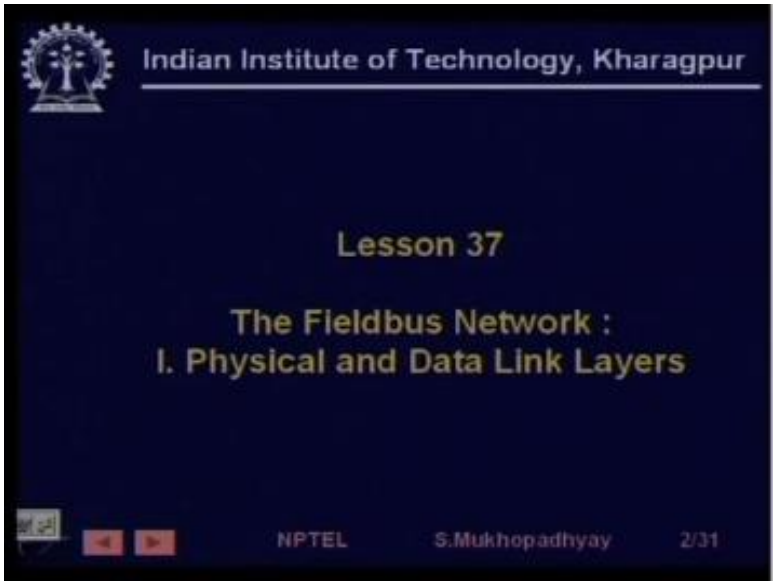

In this lesson we shall be talking about a computer network or rather I should say a network of intelligent devices which are used for industrial automation. So it is a network, it is a digital computer communication network, however the various devices which talk on this network are

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 its standard has been proposed and what kind of functionality and benefits it can bring for a factory white control system.

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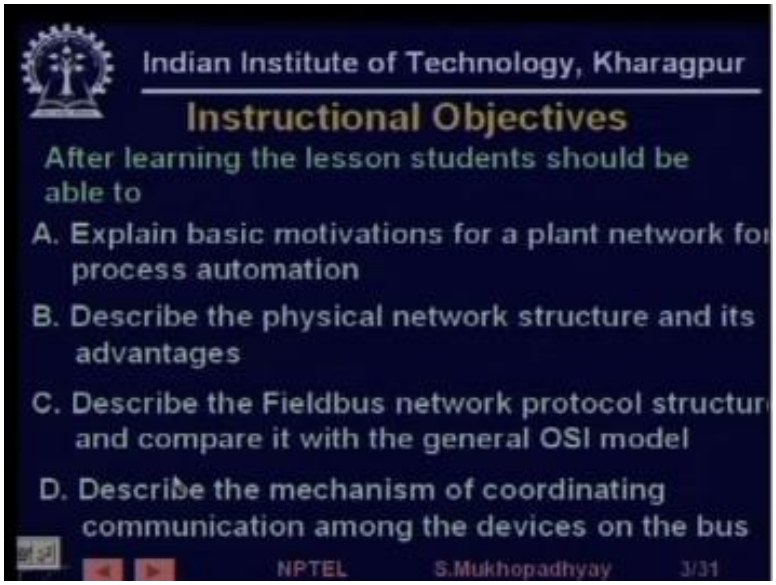

So we start with the instructional objectives. So the instructional objectives are firstly the student will be able to explain basic motivations for a planned network how it actually helps to have a network for process automation, they will describe in the first part of this lecture which will be followed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

So we will first, we will take a look at basic look at this structure and compare it with the general and 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 fieldbus 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 the fieldbus, actually a fieldbus is actually a digital communication network which is designed for interconnecting smart fieldbus 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 used to use various kinds of communication technologies for example, people used to use 4-20 mA 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 fieldbus replaces this for 4-20 mA 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 used to, were not able to perform computation. 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 so flow for example a valve maybe a valve positioner will actually drive the valve shaft or it can be a heater right.

So previously the field monitoring devices were unintelligent and therefore, all the control monitoring activities had to be situated at a host computer. So every, 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 monitoring 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 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 fieldbus one of the advantages 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 fieldbus system compared to wires which were used in the older systems.

So because this is very important here for two reasons, the first reason is that the industrial environment is actually very harsh right, 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 that, so the chances of data getting corrupted are actually very high and second thing is that the consequences of having corrupt data because it is a control application as you have stress 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 we are using fieldbus, 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 and then can have a larger, can have co-ordinations over larger areas, you can do monitoring, you can do whole production process optimization. So such functions it is now possible to do in an automated fashion and in a much more timely fashion than it was possible before.

Then easy configurability and interoperability of system components, this is actually 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 you will actually exchange data in a format which is acceptable to the other, and we will make meaning of the data which it 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 a configuration problem. Secondly, 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 used to have their own standards. Now when you have that once you buy certain parts of the equipment from a given company then you actually get tied to that company because if you buy 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 fieldbus compatible if any company manufactures a device and it is declared to be fieldbus standard compatible, then it will be interoperable with any other fieldbus compatible device from whatever company it is manufactured.

So therefore, the options for the customer have increased manifold this will foster competition and will bring in products of improved quality and functionality at cheaper costs. So this has huge consequence, so this is why you actually standardized, it is just like the PC market, you know. So if you can always buy a let us say a network card from company B and a hard disk 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 right.

So we want that kind of interoperability in the case of industrial automation also. So that is offered by fieldbus, 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 all, it just means cables. But these wires are these are data cables, they are not only expensive, they have to be laid installed commission and they have to be maintained right.

So that is a huge task and therefore wiring is the advantage of wiring is also non-trivial in the case of industrial automation project.

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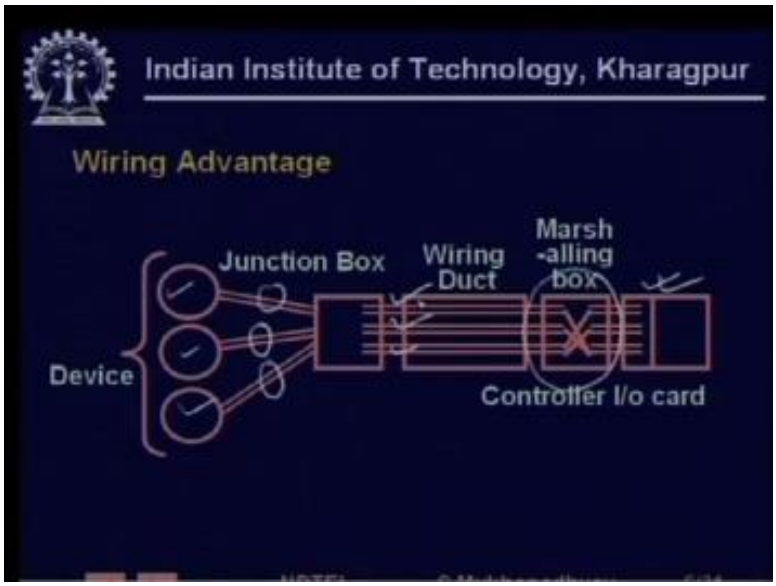

See the wiring advantage how it comes it comes because of the fact that if you have let us say 4-20 mA which means that a few number of devices have to be, can be connected if you directly connect point-to-point communication then for every pair of devices you have to connect two wires to actually another point where it will receive the data. If you have 4-20 mA 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 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 wiring so for three you need to run six three pairs of conductors.

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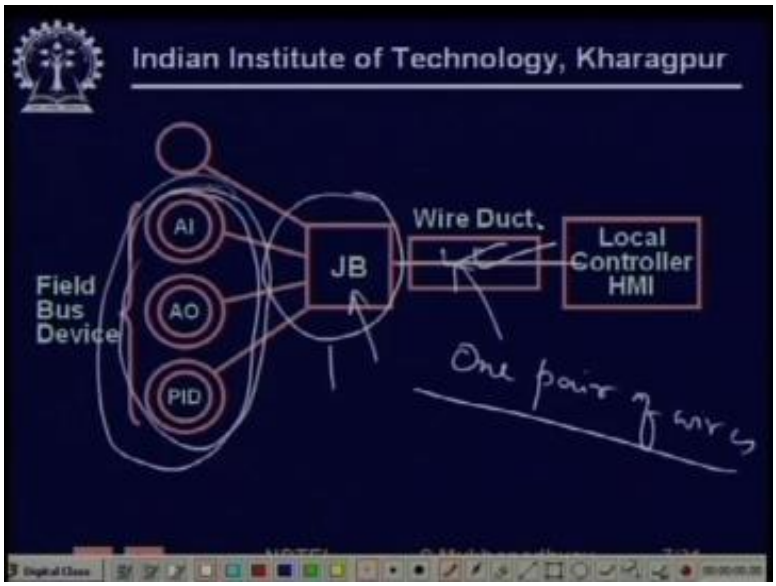

Contrast to that look at a, this is here see what happens is that here you have these fieldbus devices. So the fieldbus devices can be locally connected to a junction box or let us say a remote I/o, I mean some kind of, you know a data concentrator, if this, that is if they cannot be directly hung from 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 baseband or in, 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 are actually time multiplexed so either rather the time multiplex or if you use 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 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 organized into 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 right.

So this is 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 is the B, 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, here is a comparison between 4-20 mA which is a pretty old analog technology with fieldbus. So here you can have number of devices power wire is one sometimes you can connect some devices in C's in a fieldbus you can connect large number of devices and then these devices can be further increased 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 right because data is 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 fieldbus. 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 fieldbus devices because it is digital data, it is quite excellent.

Then diagnostic information because you have, because in the fieldbus 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 device is working nicely or not, properly or not or whether some falters develop.

So such information is actually called diagnostic information. So, you know controllers can actually need a lot of diagnostic information because otherwise 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 fieldbus devices themselves the 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 right. And extensive diagnostic facility is provided for the fieldbus, 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 whole station they can be configured so such field level control support exists in fieldbus while none exists in the 4-20 mA loop.

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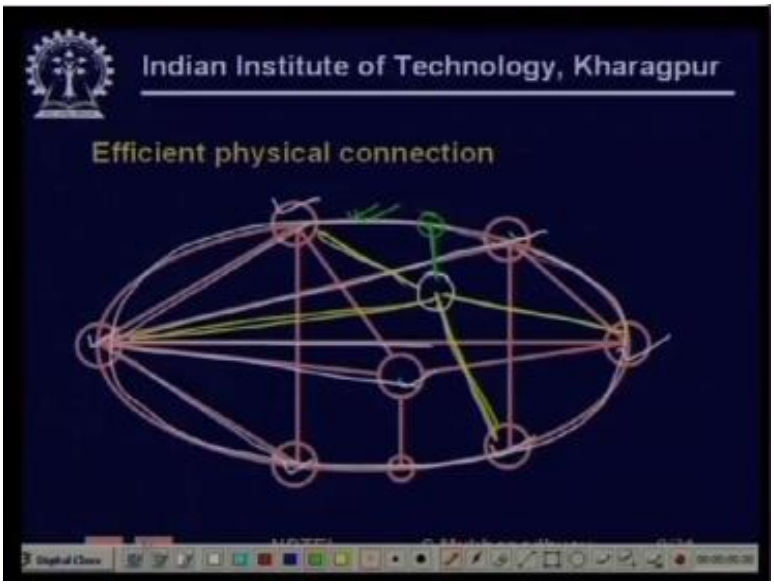

So this is, this were the advantages coming back to this efficiency of physical connection you can understand this. Suppose you have, let me suppose you have, you already have these nodes and they need to interact with each other right. So if you have point-to-point communication then you need to connect all these wires right. 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 this, simply connect this to the nearest point in the network right.

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 right.

And this diagram itself shows the picture, but when you have thousands of such devices at that time this disadvantage becomes, I mean predominant.

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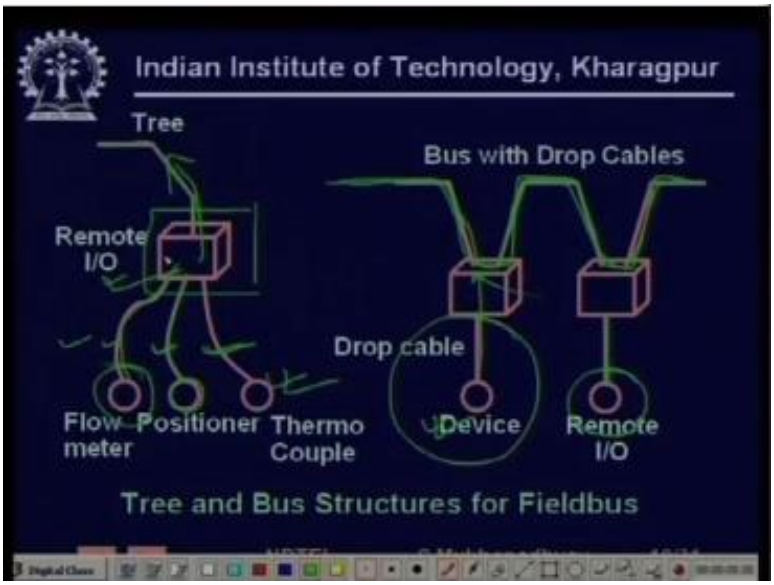

Now here in this diagram you see, how devices can be connected on the fieldbus. So there are, so you can connect them either, you know like a tree. So you can either have a separate branch from a tree. So for example, here you see that this is the main network bus running from that network bus you can 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 similarly, now this device is actually a network device, these are not network devices. So this device will actually accept the

data and will, and then this device will transmit on the network after, you know making packets out of it.

So this, 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 onto the network bus this is the main network bus running right. 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 right. So these are the two ways that you can connect devices on the fieldbus.

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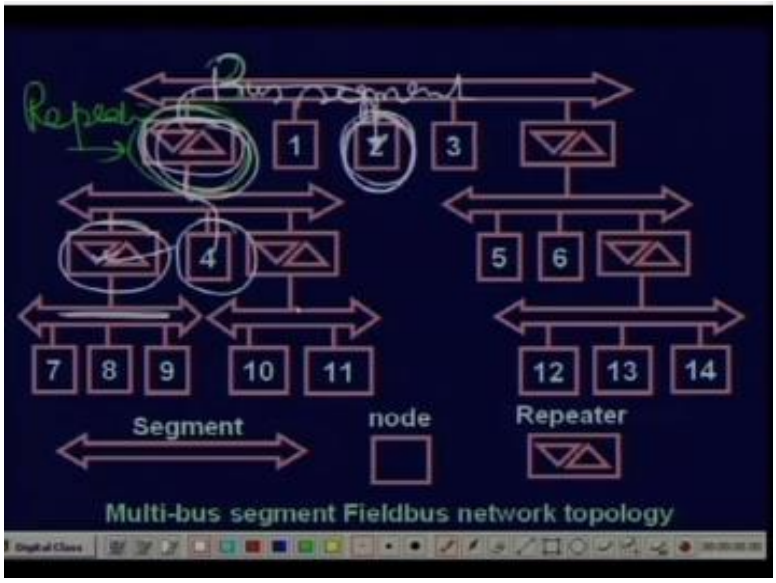

For example, this then shows that if you have a really, you know very wide plant area network which actually can run into, you know kilometers if you have seen big factories you will know that for example, if you go to Telco or if you want to go to Tisco or some big steel plant, then you will see that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

And therefore, if you want to have plant-wide network then you can have, 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 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 a 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 four device wants to talk with number two 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.

S now this repeater will know that it is meant for a device on its own segment so it will retransmit it on the bus while this repeater will know that that it is not meant for a device, device number two does not exist on its 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 sprawls over kilometers using a local area network technology.

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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 etc. 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 the, you can see that the fieldbus supports all kinds of devices, devices which are directly connectable on the network or which are not connectable on the network as well.