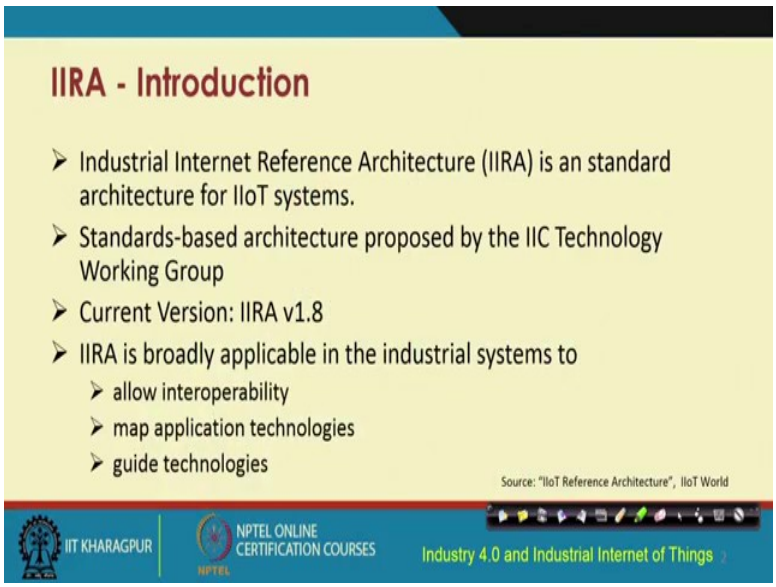
Introduction to Industry 4.0 and Industrial Internet of Things

Prof. Sudip Misra
Department of Computer Science and Engineering
Indian Institute of Technology, Kharagpur

Lecture - 24
Business Models and Reference Architecture for IIoT: Reference Architecture – Part 1

In this module, we have talked about the business models that could be used for Industrial Internet and Industrial IoT scenarios. In this particular lecture, we are going to talk about the difference architecture. In the context of the business, we have talked about the possible business models, that could be used in the previous lectures in this particular module, but we should be also able to use the different architectural platforms for transformation of the business for the adoption of Industrial IoT. Let us look at the IIoT reference architecture.

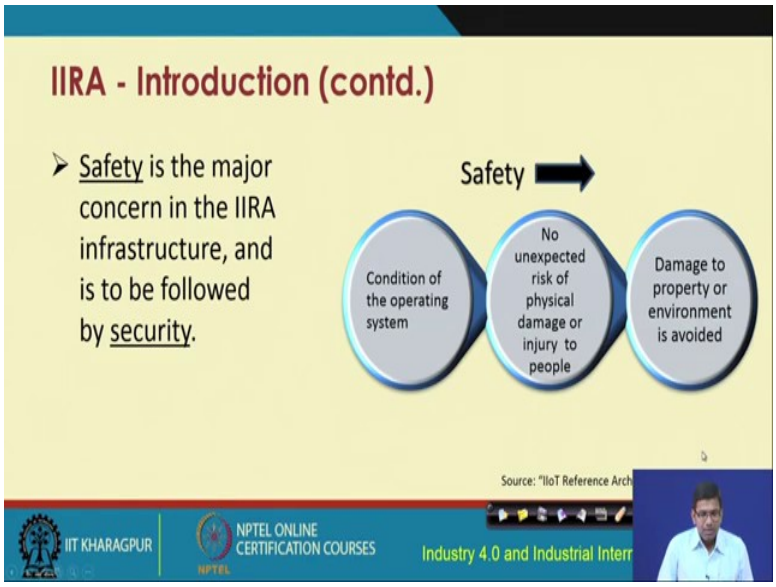
(Refer Slide Time: 01:07)



IIoT reference architecture is governed by the Industrial Internet Reference Architecture. This is sort of a standard architecture that IIoT systems globally tend to use and tend to follow. IIRA - Industrial Internet Reference Architecture is the architectural standard, that is used for most of these IIoT applications in these industries. So, it is a standard based architecture, which was proposed by the Industrial Internet Consortium – IIC, their technology working group came up with this architecture. The current version of it is

IIRA v1.8. So, 1.8 is the current version of the Industrial Internet Reference Architecture. And this architecture broadly applies in the industrial systems to allow interoperability, mapping application technologies, and in guiding the use of these technologies by different application users.

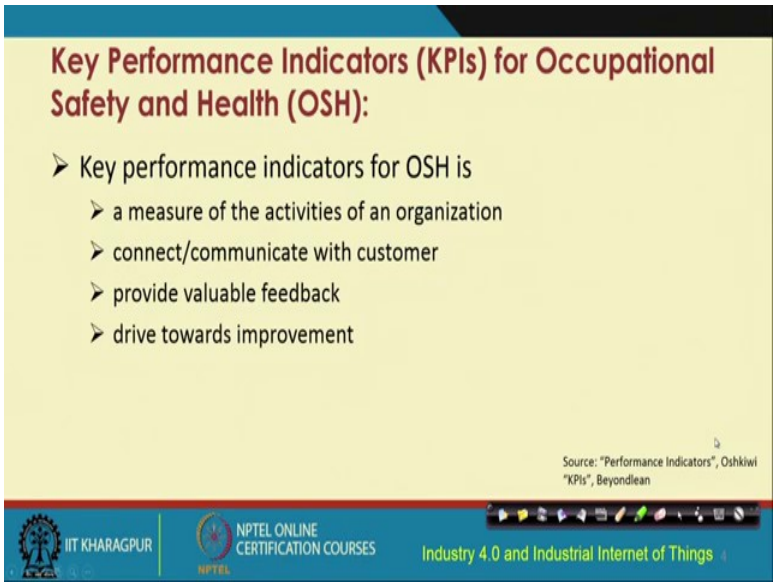
(Refer Slide Time: 02:14)



So, for the IIRA one of the central thematic concerns is the safety. And many of these architectural elements basically have been designed in such a way that safety has been kept in mind. IIRA safety concern is important and after safety is the issue of security. Security in terms of everything, security of information, security of data security of the systems and so on. Safety and security are paramount and central thematic considerations while coming up with the IIRA architecture for use with IIoT industrial applications.

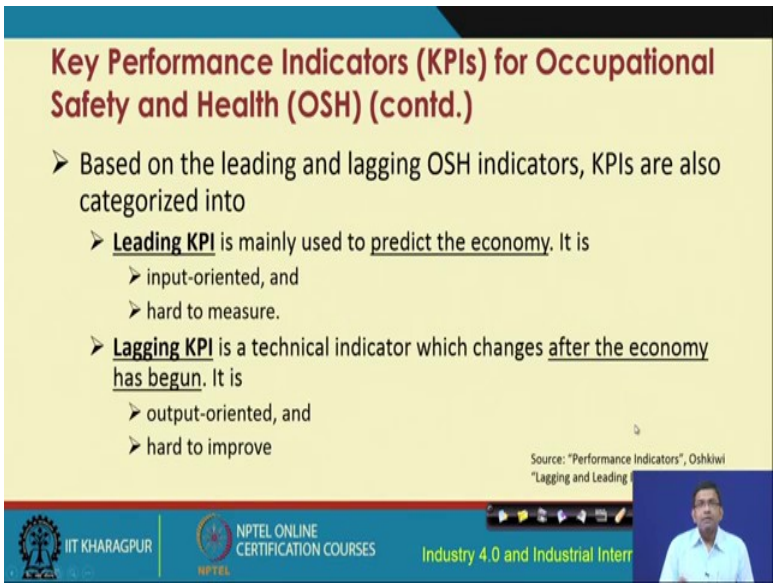
In terms of safety, it is important to know for the system that is operating, what is the condition of it. It is also important to ensure that there is no unexpected risk of physical damage or injury to people due to some malfunctioning or potentially malfunctioning systems in the future. And third safety concern is to ensure that there is no damage to property or environment, due to any kind of malfunctioning now or in the future.

(Refer Slide Time: 03:51)



These are some of these KPIs for occupational safety and health. These KPIs are basically a measure of the activities of an organization. These KPIs also help measure the connectivity and communication with customers, providing valuable feedback to the customers, and driving towards further improvement; there are different KPIs.

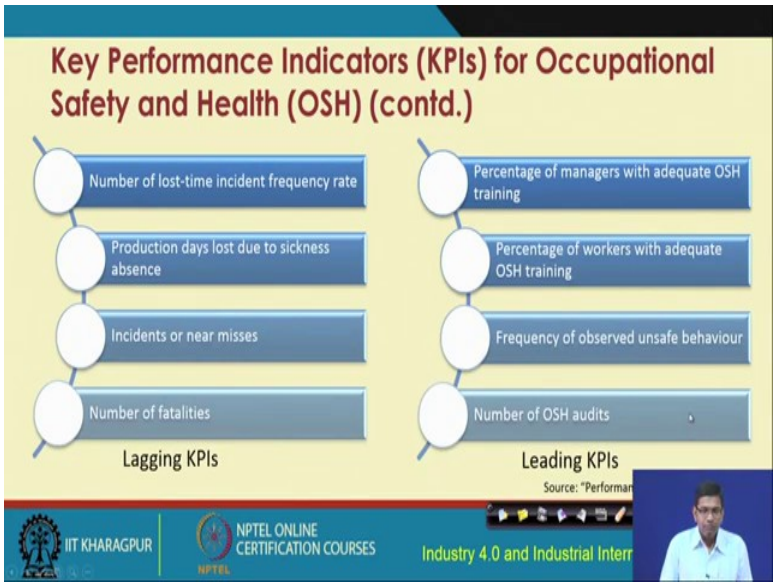
(Refer Slide Time: 04:20)



So, these KPIs based on their types can be categorized into two types. One is the leading KPI, and it is mainly used to predict the economy, it is input-oriented, and is hard to measure. And as the name suggests the latter category is the lagging KPI, which is a

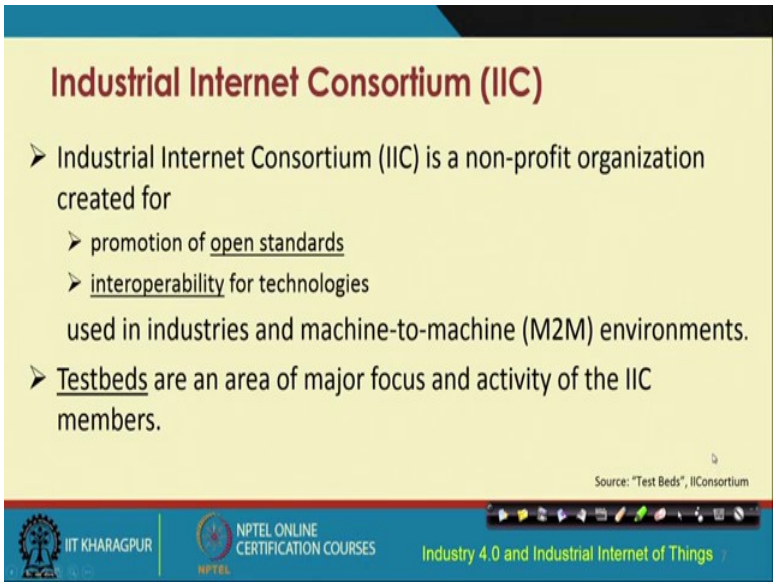
technical indicator, which changes after the economy has initiated. So, unlike the leading KPI, which is input-oriented, the lagging KPI is output-oriented, and this is hard to improve. Leading KPI talks about predicting, predicting the economy. And lagging KPI talking about after the economy has started to improve. So, basically these two perspectives are different. Leading KPI and lagging KPI are the two different KPI categories for OSH.

(Refer Slide Time: 05:25)



So, leading KPIs for example, percentage of managers with adequate operational and safety, health safety training, percentage of workers with adequate operational and safety training, then, frequency of observed unsafe behavior, number of OSH audits, these are some of these different KPIs under the leading KPIs category. Under the lagging KPIs category, we have number of lost-time incident frequency rate, how many times the different incidents have occurred, and we have lost time due to those incidents, and the frequency of occurrence of those incidents. Production days lost due to sickness absence, incidents or near misses, and number of fatalities, these are the lagging KPIs.

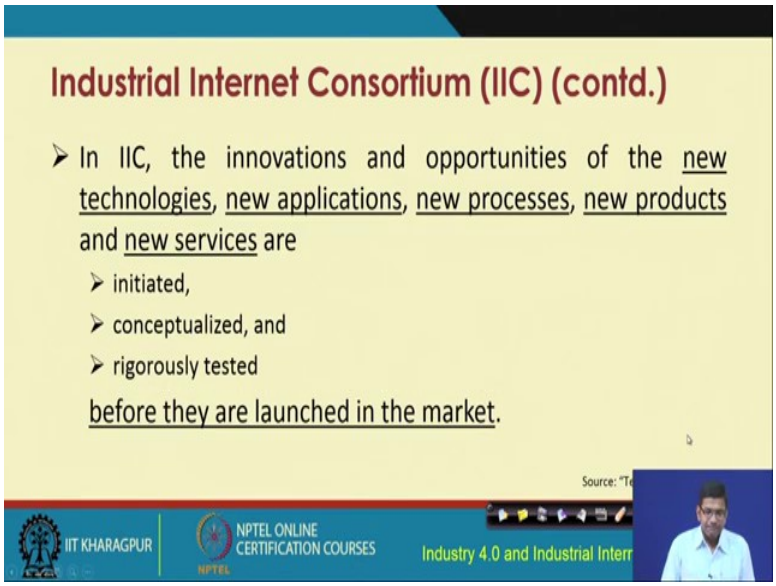
(Refer Slide Time: 06:22)



So, I was talking about the IIC, which is the Industrial Internet Consortium, which is a non-profit consortium doing different things promoting open standards, standards for interoperability, supporting architectures for promoting interpretability across different technologies. And these technologies open standards, interoperable standards these are used in industries and for M2M communication, in these industries.

IIC is the one which came up with that the Industrial Internet Reference Architecture, IIRA architecture. Industrial Internet Consortium - IIC has also among its focus areas and activities has the development of Testbeds for different trials also a major concern. So, testbeds are an area of major focus and activity of the different IIC members.

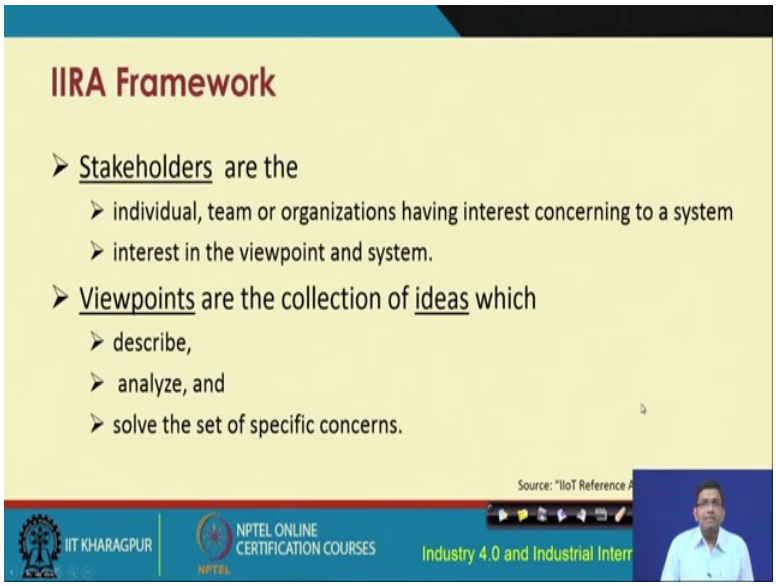
(Refer Slide Time: 07:33)



So, Industrial Internet Consortium continues to do different activities, tasks and so on, they have their different working groups. So, these working groups do different things they innovate, they come up with different opportunities of the use of new technologies, new applications, new processes, new products, new services, etcetera, which could be initiated, conceptualized, and could be rigorously tested, in the different testbeds that I just talked about a while back.

And these could be done before they are actually launched in the market. These are the ones these are the different activities that are promoted by the IIC.

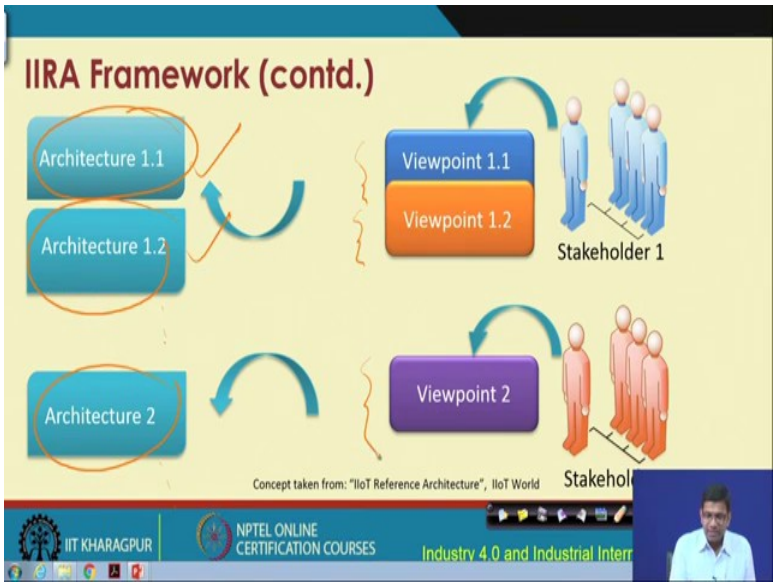
(Refer Slide Time: 08:16)



So, II Reference Architecture (IIRA) - Industrial Internet Reference Architecture, IIRA has different architectural components, which are part of their framework, number one is the stakeholder. So, we need to understand some of these different concepts. So, number one is the stakeholder stakeholders are individuals teams or organizations having interest concerning the system.

The next concept is linked to the stakeholders; these are the viewpoints. So, these stakeholders have some interest in the viewpoints and the system. So, viewpoints are from the stakeholders, which are basically the collection of different ideas from the stakeholder's collection, grouping of them, describing these different ideas, analyzing the ideas, and solving the set of specific concerns.

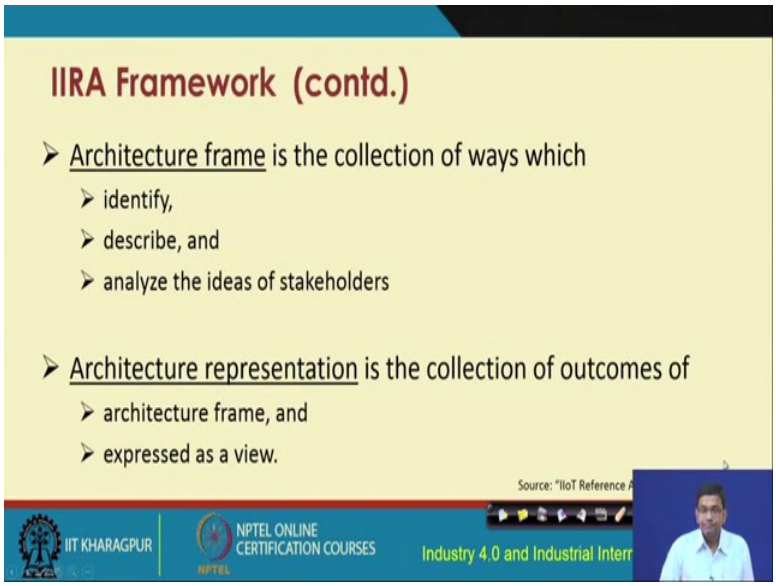
(Refer Slide Time: 09:13)



This is the IIRA framework. So, as you can see over here let me just explain it to you. So, this shows that there are different stakeholder groups--stakeholder group 1, stakeholder group 2. These stakeholders have different framework sorry have different viewpoints, viewpoint 1.1, viewpoint 1.2, etcetera.

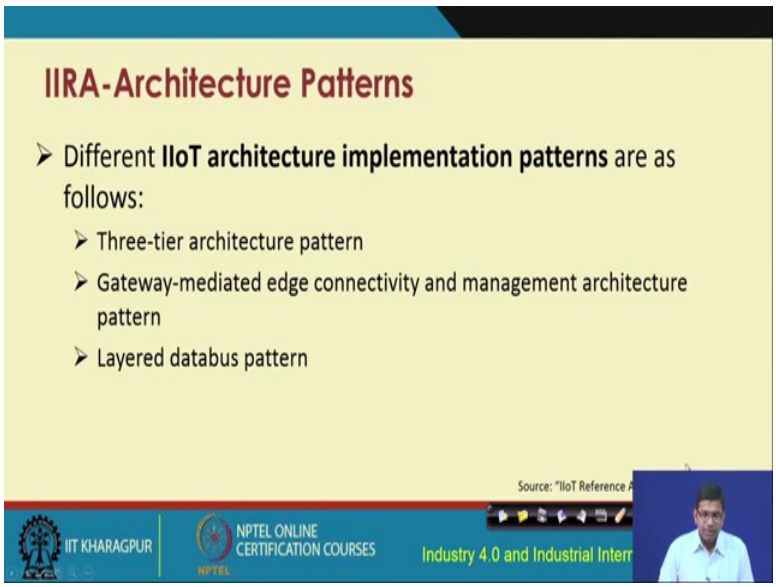
Similarly, stakeholder 2 would have their own viewpoint, which could be again classified as 2.1, 2.2 etcetera, as the case may be. So, that is the concept of the viewpoints, which is basically a, a collection of different ideas from different stakeholders. So, these step these stakeholders come up with different viewpoints and these viewpoints essentially help in coming up with these different architectural components architecture 1.1, 1.2 etcetera, and architecture 2, 2.1, 2.2 etcetera, mapping directly to these different viewpoints.

(Refer Slide Time: 10:24)



Next comes the concept of the frame, the architectural frame, which is a collection of ways which identify, describe, and analyze the ideas of the different stakeholders. The concept of architectural representation is important; it is the collection of outcomes of architectural frame and are expressed as views.

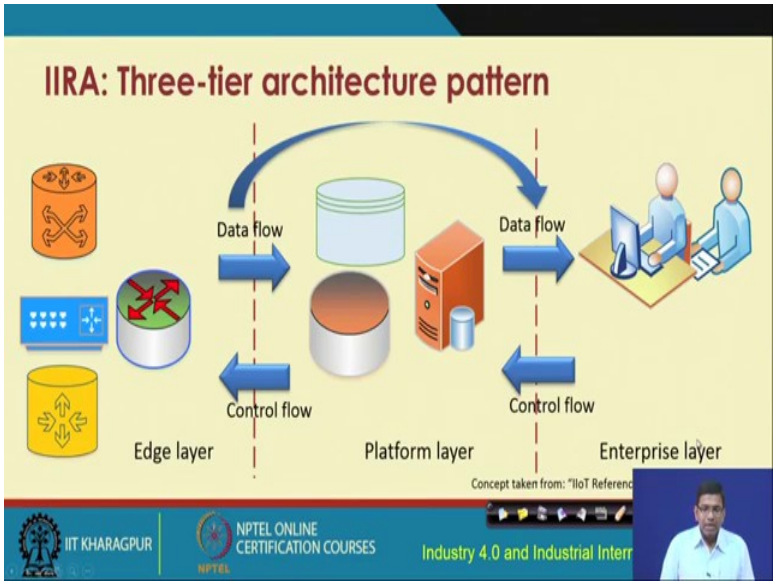
(Refer Slide Time: 10:47)



Different IIoT architecture implementation patterns are have been proposed. So, we will go through three different patterns, number one is the three-tier architecture pattern,

number two is the gateway mediated edge connectivity, and management architecture pattern, and third is the layered data bus pattern.

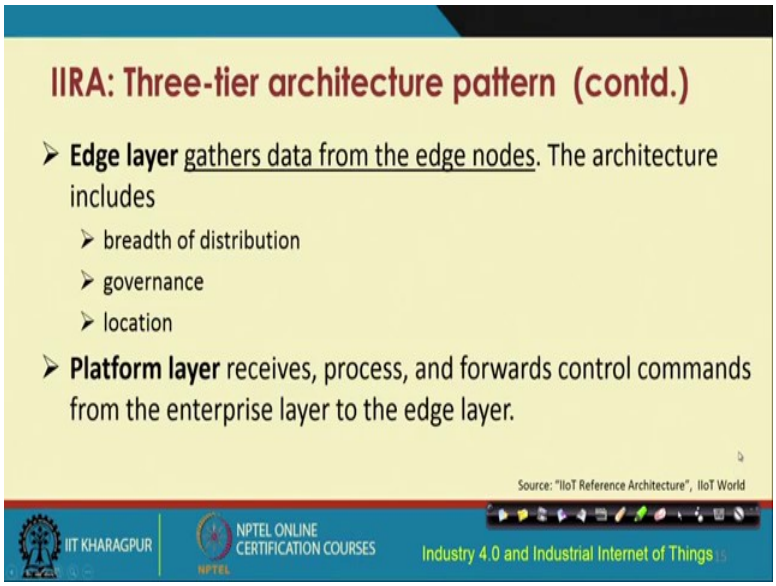
(Refer Slide Time: 11:10)



So, let us go through each of these, to start with we will first go through the three-tier architecture pattern. In this three-tier architecture pattern, we have three different layers we have the edge layer, the platform layer and the enterprise layer. So, edge layer basically talks about all these different edge devices, basically the device is connecting to these different gateways at the edge and so on.

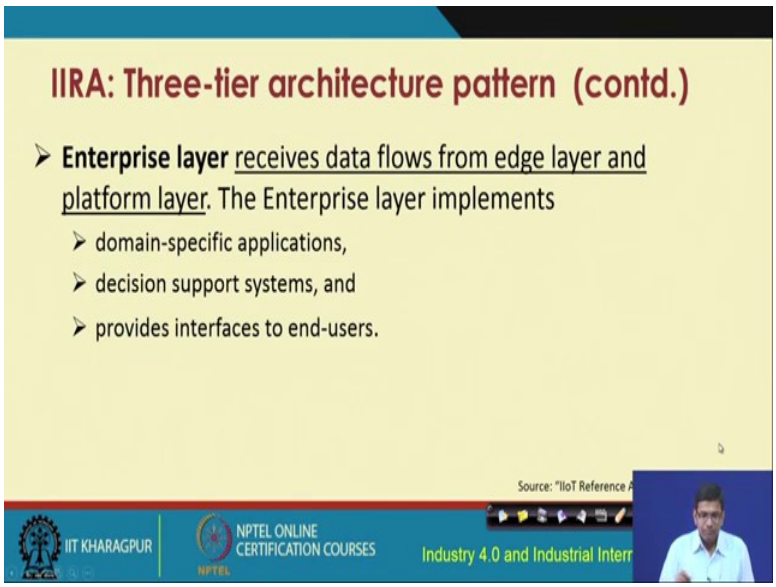
And these devices and the gateways etcetera are going to send the data to the platform layer, these are this is the platform layer, where the data are going to be analyzed, and so on. And further the data are going to be processed and sent to the enterprise layer. The control flow is in the reverse direction, data could flow from, the edge layer to the platform layer directly, or could directly also flow to the enterprise layer.

(Refer Slide Time: 12:17)



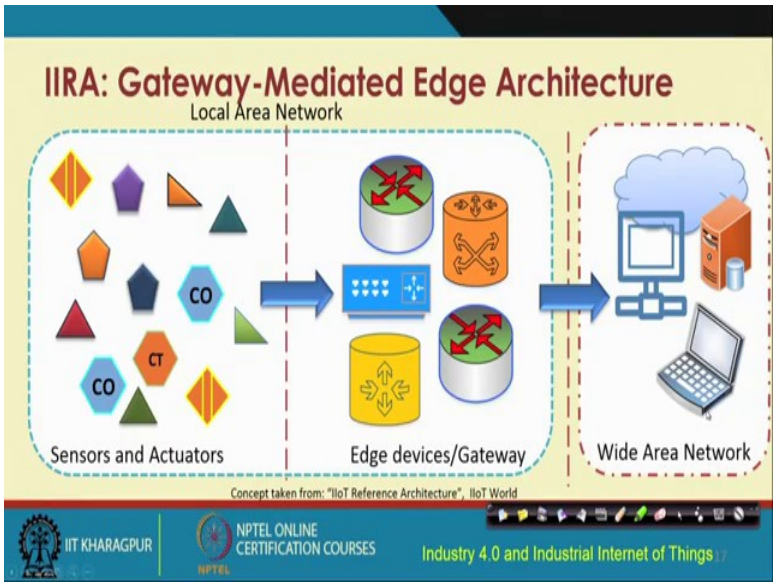
So, this three-tier architecture pattern let us go through the different components, in further more detail. So, we have the edge layer, which gathers data from the edge nodes, the architecture includes the breadth of distribution, governance, and location of the data. Breadth of distribution of the data, governance of the data, and the location of the data meaning that where from the data are coming from these individual devices. Platform layer basically it is concerning receiving, processing, and forwarding control commands from the enterprise layer to the edge layer.

(Refer Slide Time: 12:56)



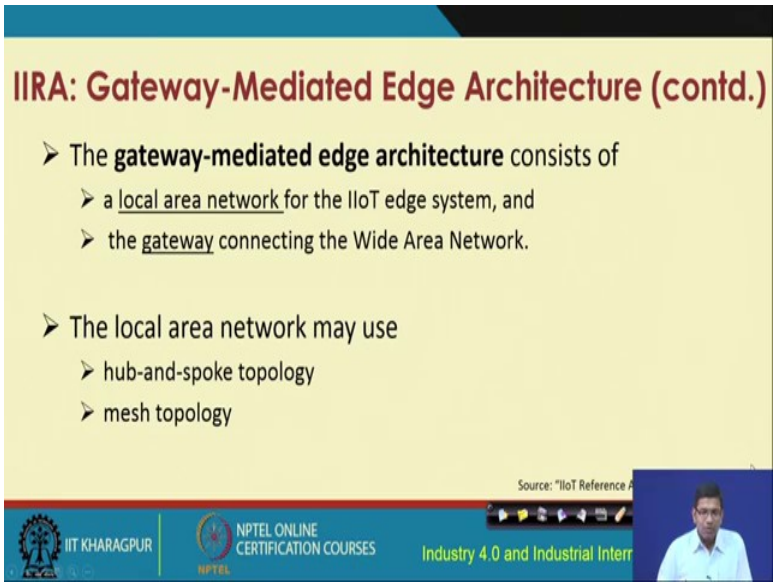
And finally, the enterprise layer concerns receiving data flows from the edge layer and the platform layer. So, I mean directly from the edge layer, the enterprise layer could be receiving the data or it could be from the platform layer, which again receives the data from the edge layer. So, the enterprise layer basically implements domain-specific requirements, decision support systems, and other requirements such as interfaces to end-users.

(Refer Slide Time: 13:25)



The next type of architecture is the gateway-mediated edge architecture. Here basically we are talking about incorporation of the, the gateway, gateway concept. So, we have all these different sensors and actuators, these sensors and actuators throw in lot of data. And through the different gateway devices, edge devices, gateway devices and so on the data are sent to the wide area network for further dissemination of different information and so on.

(Refer Slide Time: 14:04)

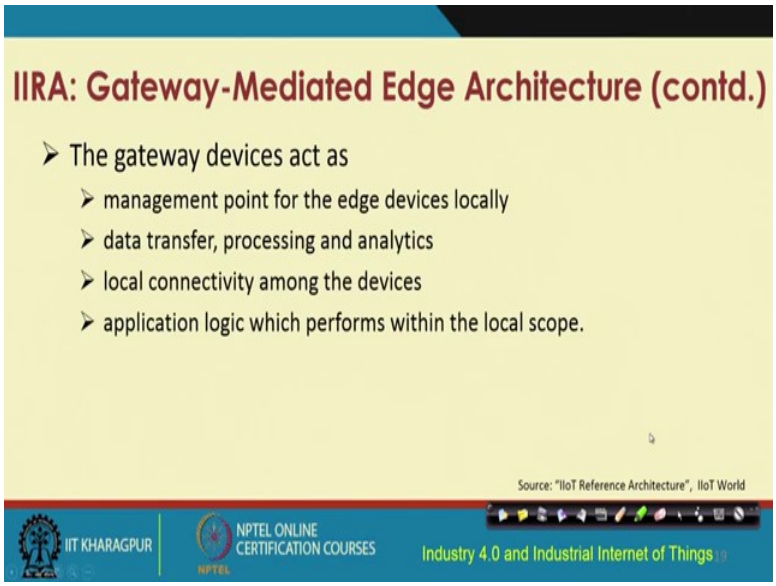


So, like the previous architecture here again let us go through each of these architectural components of the gate gateway-mediated edge architecture, in further detail. So, this gateway mediated edge architecture consists of a local area network for the IIoT edge system and the gateway connecting to the wide area network. The local area network may use a hub and spoke topology or, a mesh topology.

Mesh topology is one where the different nodes are connected to one another in the form of a mesh. So, there are lot of different links redundant and many different links are there. So, basically what happens is if one link has broken, still, then the different nodes may not be completely disconnected from one another, because there might be some alternate links directly or indirectly, which will basically handle the problem.

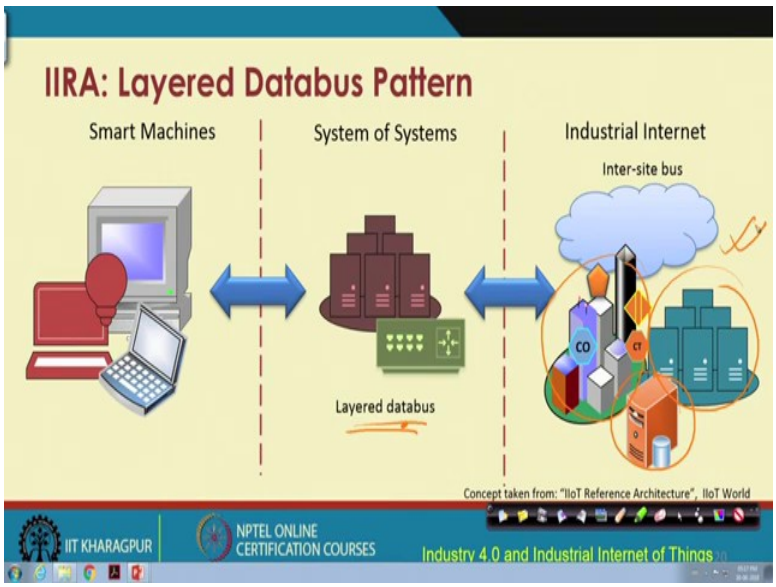
So, the other one is the hub-and-spoke topology, which is very similar to the star topology where you have the hub and there are different spoke are connected to the different other edge nodes and together, you have a central kind of hub device connecting to these different other IoT devices, other edge devices. So, this becomes a star kind of topology or a hub-and-spoke topology.

(Refer Slide Time: 15:30)



So, you have this local area network, which supports two different types of topologies, the mesh topology and the hub-and-spoke network topology. Then you, we have these gateway devices acting as the management points for the edge devices locally transferring helping in the transferring of the data, processing of the data, and analysis of the data.

(Refer Slide Time: 15:45)



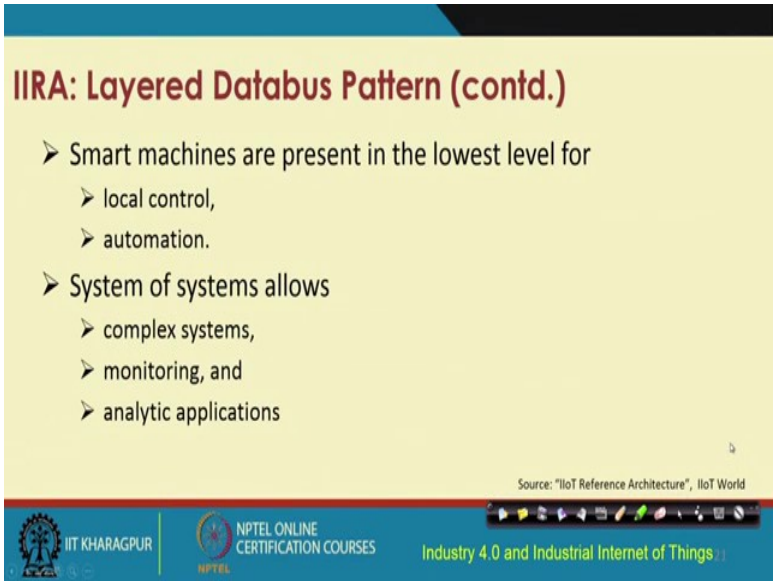
The third type of architectural pattern is the layered databus pattern. So, one thing I should mention before we go any further is all these different architectural patterns are

sort of like common templates, which could be used in order to, which could be used as reference architectures in order to deploy IIoT solutions in the industries.

So, now let us go through this third architectural pattern, which is the layered databus pattern. So, here we have three different tiers, we have the smart machines, then we have system of systems, and the industrial internet. So, a system of systems is basically a complex system consisting of different, different subsystems together working together generating lot of complex, executing lot of complex algorithm, generating lot of data handling to be handled, and processed to get lot of insights about what is going on down underneath. This is what is done by the layered databus.

And then you have the industrial internet. We have these different applications running on the industrial internet in different industrial application sites, same site, same site in the same industry different groups or different, different sites of the same company or it could be that different companies are interconnected together. So, this is the layered data bus layered data bus pattern, which is different from the previous two patterns that we have just discussed.

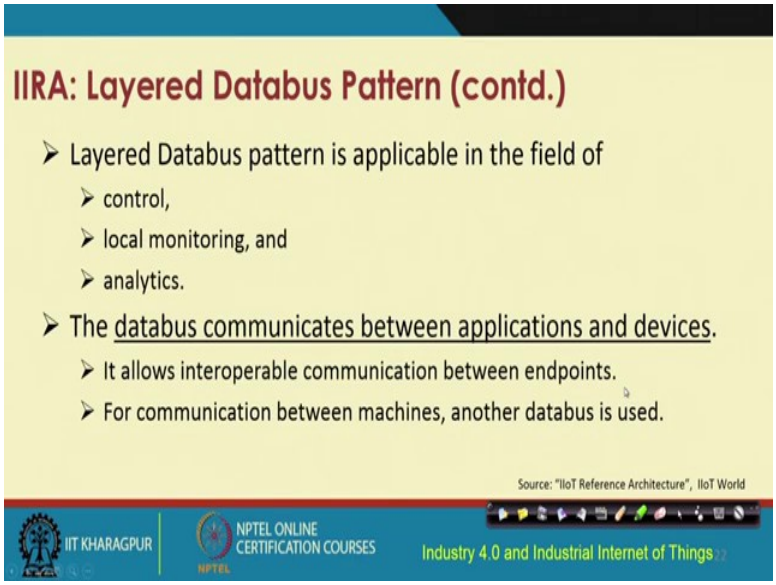
(Refer Slide Time: 17:30)



Let us go through this pattern also little bit, in further detail. So, here we are talking about use of smart machines. So, these smart machines at the lowest layer will help in local control and automation processes. System of systems layer allows complex systems

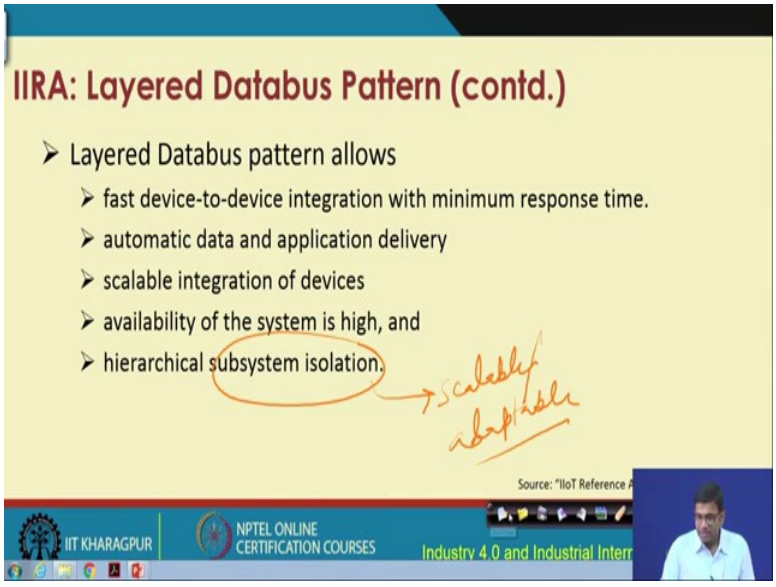
to be executed, complex monitoring, complex processing, and analytic applications, all of these things could be executed at this particular layer.

(Refer Slide Time: 17:52)



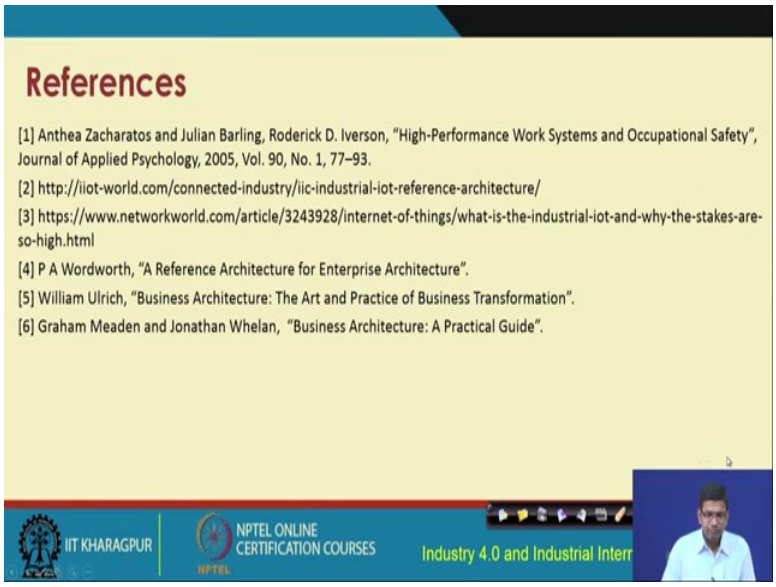
Then you have the layered data bus pattern, which is applicable in the field of control local monitoring and analytics, and the database basically communicates between the applications and devices through this communication is enabled with the help of the data bus. This communication will essentially help in allowing interoperable communication between different endpoints, between different machines.

(Refer Slide Time: 18:18)



Layered databus pattern basically allows first device to device integration with minimum response time, automatic data and application delivery, scalable integration of devices, availability of the system making, it higher and hierarchical subsystem isolation. So, this isolation part is very important subsystem isolation, because this will help in making the solutions much more scalable and adaptable, adaptable to what; adaptable to different changes.

(Refer Slide Time: 19:00)



With this we come to the end of the first part of the reference architecture. So, we have seen that this IIRA reference architecture is sort of like a de facto kind of standard being used for the implementation of IIoT in the industries. And this connects well with the business model of this particular unit in the business model, we have seen the different types of business models that could be adopted and this reference architecture is the one which takes it further technically. This reference architecture is sitting between the business issues and the technicalities. And it is trying to map the business requirements with the technical requirements by providing different, different architectural solutions, common architectural solutions, which could be adopted in order to deploy IIoT solutions in the industries. These are some of these references, which you could use and go through further. You could also dig on your own to find out more different other differences on this topic.

Thank you.