Introduction to Industry 4.0 and Industrial Internet of Things

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Lecture – 40
IIoT Analytics and Data Management: Cloud Computing In IIoT-Part 2

So, in this particular lecture we are going to continue from what we discussed in the previous part on Cloud Computing for IIoT. So, if you recall that in the previous lecture we talked about the different examples of cloud computing platforms for use in IIoT scenarios and also the usefulness of the use of cloud; cloud computing what it is and what is its usefulness in the context of industrial automation IIoT and so on.

So, we are going to continue further in this particular lecture and we are going to look at few other examples of use of cloud and cloud-based analytics in fact, for IIoT. So, in the previous lecture we talked about the companies like General Electric, Siemens and Honeywell.

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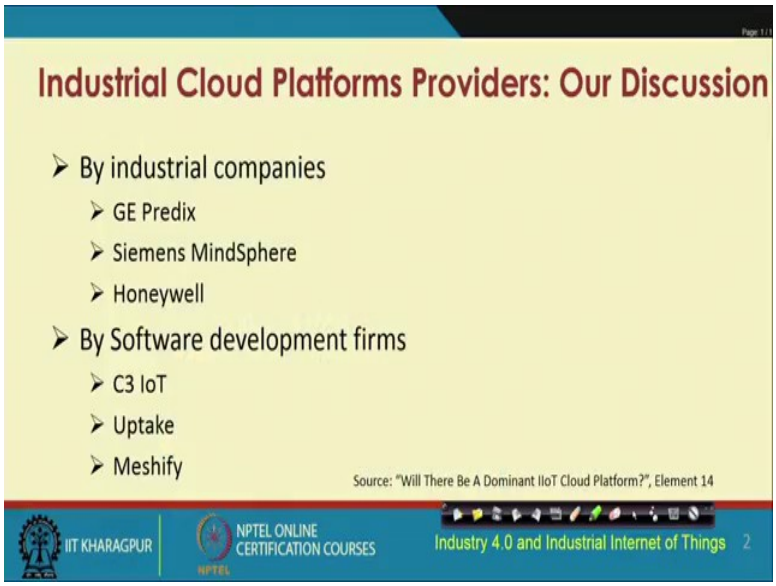

These are the different industrial service providers and their different solutions like Predix, MindSphere and the Honeywell solution we discussed in the last lecture and so there are many other company companies which have come up with their cloud-based platforms for industrial IoT solutions, but there are different other software development

firms who have also come up with their IoT solutions and particularly cloud-based IoT solutions and their integration with analytics.

So, examples of this would be the C3 IoT, Uptake and the Meshify. So, these are few of the other examples of the use of cloud-based analytics for IoT and these have been developed by independent software development firms. So, we will take up each of these and we will just quickly we will glance through some of their highlights or the features that they have.

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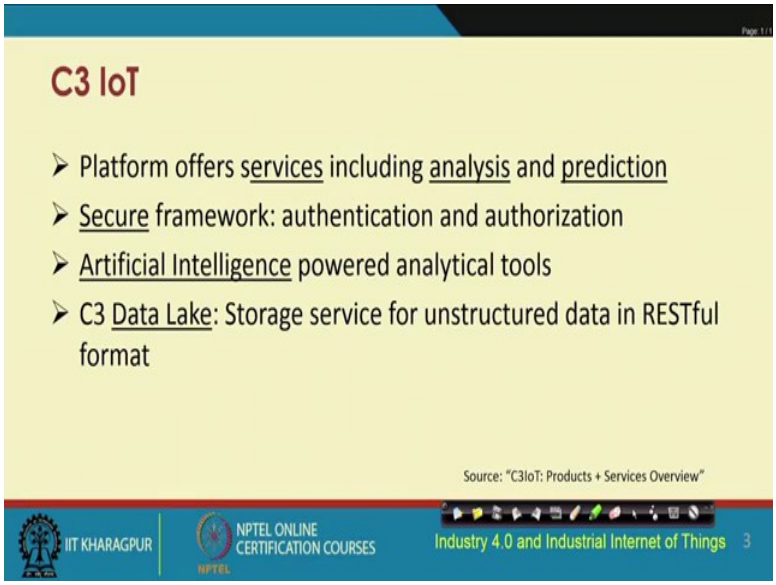

So, C3 IoT basically offers some kind of a platform that can help in different analytics and prediction and it is cloud-based. So, it is cloud-based services and including analytics prediction and so on and this particular platform is secured and there are appropriate authentication mechanisms, authorisation mechanisms etc., which have been implemented and these analytics that I was talking about in C3 these are basically AI-based, Machine learning-based analytics.

Different tools have been provided catering to the different requirements in the industrial setting and these data based on which the analytics have done are stored in something called the C3 Data Lake, which basically stores all this unstructured data that a typical of IIoT in using some kind of a format which is known as the RESTful architecture format.

So, this is how this all this data are stored, so the data stored in the data lake all these are unstructured data these are stored in the data lake plus there are different powerful AI-based analytics prediction and so on and everything together is a secured platform. And the security is offered in the form of appropriate levels of authentication authorisation and so on.

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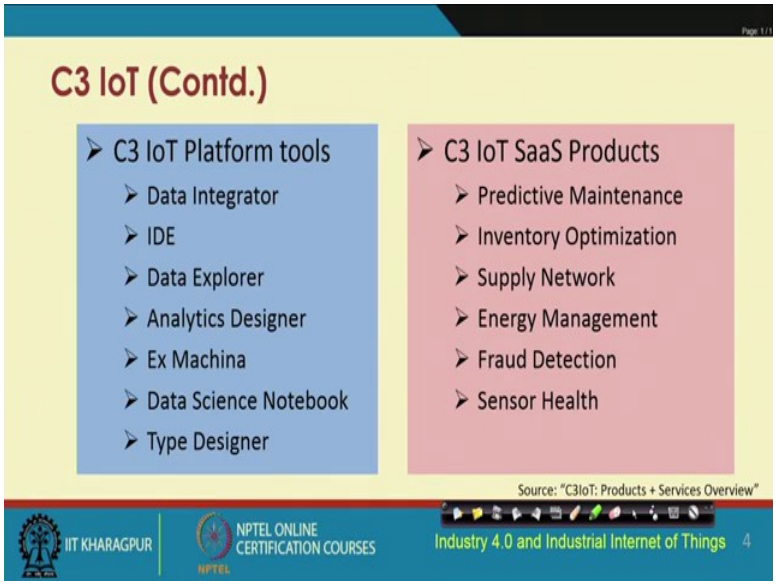

So, C3 IoT platform tools have different-different components such as the Data Integrator, IDE, Data Explorer, Analytics Designer, EX Machina, Data Science Notebook, Type Designer and so on. I am just naming these unless you are interested to know each of these tools.

I think this is sufficient just to get an overall idea of what each of these tools do and what are their different component. So, that is why I do not get into the details of each of these components of these vendor specific tools. So, the other things are the different other tools like the SaaS tools for IIoT specifically performing things such as predictive maintenance, inventory optimisation, supply network, energy management, fraud detection, sensor health monitoring and so on. So, these are the two classes of tools that have been provided in C3.

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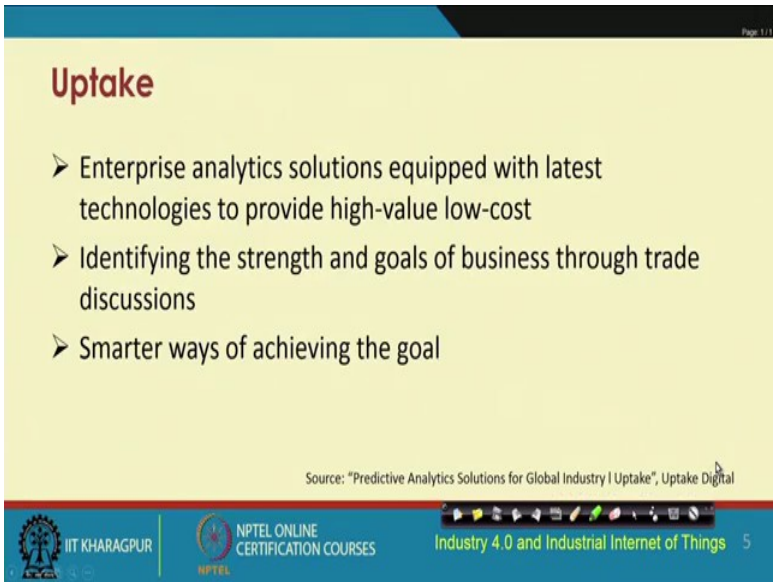

Uptake is another solution which is an analytics solution for enter catering to enterprise requirements and uptake basically gives high valued services at a low cost that is their motive their objective which is basically to offer high valued solutions at low cost and identifying the strength and goals of business through trade discussions; this is what uptake does.

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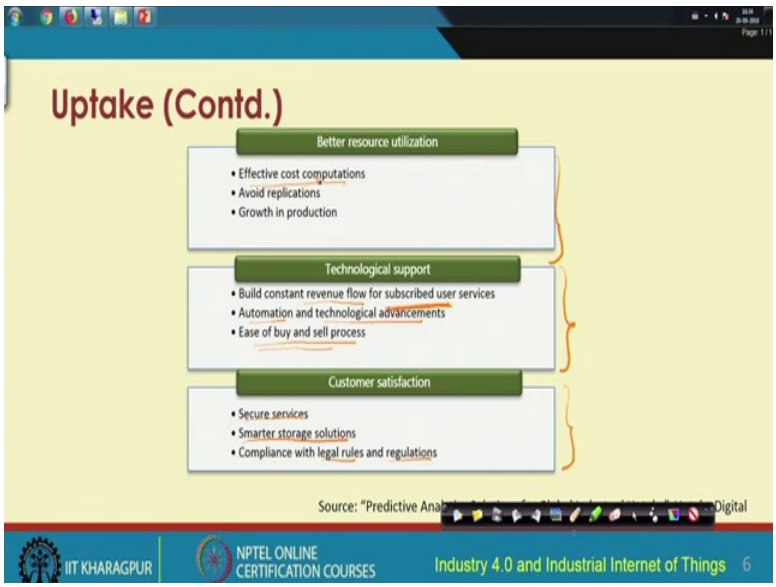

So, as we can see that uptake overall is talking about offering advanced analytics, catering to the requirements of the business or the enterprise and it is cloud-based and

targeting in the specific industry-based requirements that are there. So, these are this is the overall architectural view of Uptake. So, there are different layers one layer basically talks about the customer satisfaction, the bottom layer basically talks about the customer satisfaction which caters to requirements of securing the services, offering smarter storage, complying with legal issues, regulations and so on.

The second tier offers technological support talking about taking care of revenue flow for the subscribed user services, automation, technological advancement, ease of buying and selling and so on. And the third tier basically talks about improved resource utilisation, avoiding replications, growth in production, effective cost computation these are the different properties of this particular layer, so that was Uptake.

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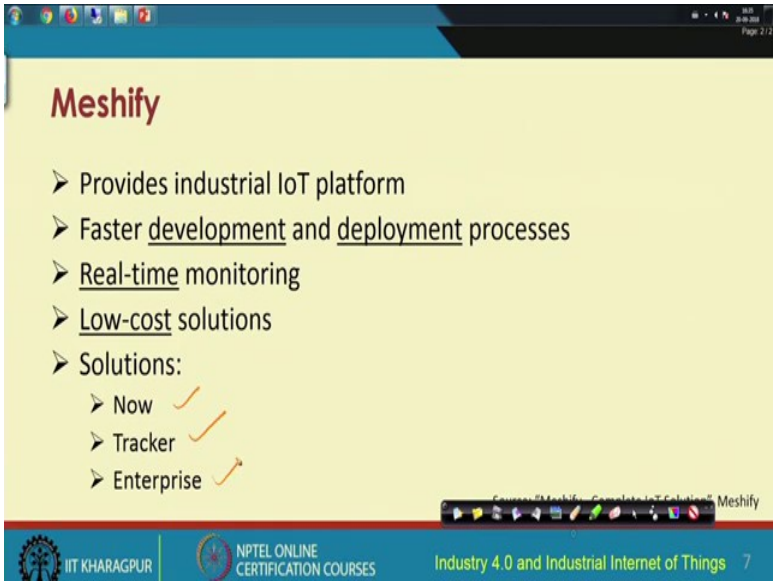

The third one is Meshify; Meshify is an IIoT platform that helps in faster development faster deployment of the processes, helps in real time monitoring of all kinds of machinery, processes, different instruments etc. The solutions that they talk about are of low cost and there are different components over here of Meshify, one component is this Now.

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The second component is the Tracker and the third one is the Enterprise. So, let us look at a very high level what each of these components do and how they position themselves with respect to each other?

So, let us assume that this is our Meshify, this Meshify has these different components Now; Now is 1, which takes care of issues such as asset tracking, asset tracking in real-time because that is what is important for IIoT asset tracking in real time, then this Enterprise talks about full stack IoT solutions, fixable configuration support custom notification facilities and so on.

And the third one is this Tracker which takes care of faster deployment, real-time monitoring and visualization. These are the three main components of this platform Meshify which has been developed for higher IIoT requirements.

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Now, let us come to this cloud which is the focus over here of this particular lecture, cloud is very important, cloud helps in doing number of different things.

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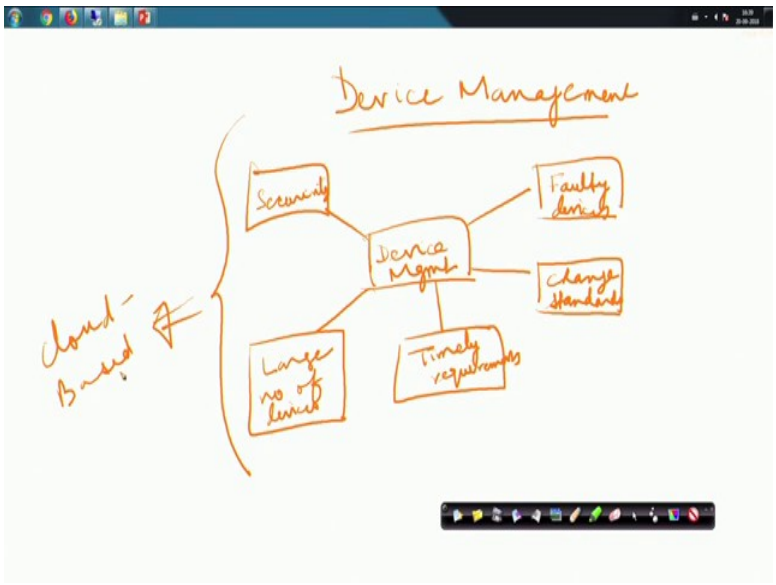

So, cloud basically will help in doing number one; device management, now what is this device management? Device management basically talks about managing the devices. So, let us now look at why this device management is important? So, we have this device management and why this device management is required? There are number of reasons why it is required.

There may be faulty devices; there may be change in standards that might happen from time to time, there may be a need for catering to some requirements in a timely manner. Device management is also required for several other reasons for example, taking care of large or other huge number of devices together which is typical of Industrial IoT solutions and also last, but not the least over here that I can think of is this security.

So, security offering so whatever the device management that we do securing the overall devices and the platform is the most important thing. So, catering to all of these is what is required and that is where device management is helpful. So, for this device management, cloud-based solutions are going to be useful. So, why do we need cloud-based solutions? Cloud-based solutions will help us in doing a number of different things.

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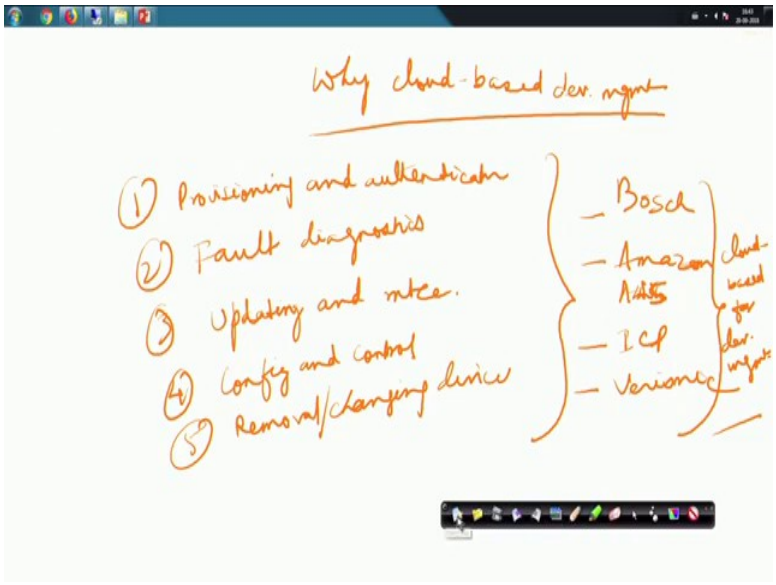

So, why cloud-based device management? Cloud-based device management has different features; number 1 is, it is going to help in efficient provisioning and authentication, efficient way of doing it authentication. Cloud-based device management will help in efficient fault diagnostics because if it is cloud-based then we are going to run the analytics in a much more efficient manner. And that can be done in the cloud so cloud will give us ample processing whatever is required processing power plus storage etc.

So, running this real time analytics etc. for fault diagnostics etc., are going to be much more do able if it is cloud-based. So, cloud-based device management for fault

diagnostic. Number 3 is efficient way of carrying out updations and maintenance, number 4 would be the issue of efficient way of configuration and control, number 5 would be if it is required sometimes to remove a particular device, to add a device, to change a device, to remove a device and so on.

So, that will be also facilitated, so removal or rather changing a device much more efficiently can be done with the help of this cloud-based device management IIoT device management. So, there are different companies which have come up with their solutions companies such as, Robert Bosch they have their solutions, companies such as Amazon they have their AWS and also the specific solutions creating to IIoT requirements, then we have ICP, then Verismic and so on. So, these are the company, this is some of the companies like this. There are many other companies which do cloud-based which offer cloud-based solutions for device management.

Now, let us go back to what we were discussing earlier. So, we have understood that device management is very important because we are talking about in IIoT scenarios large number of devices taking care of large number of devices in a typical IIoT deployment scenario and you have to take care of different requirements starting from their configuration provisioning faults security and so on and so forth.

So, the ecosystem overall is highly complex and you need some kind of a solution, the solution if it is cloud-based we have seen that what are the advantages of doing it and overall cloud-based device management solutions are going to be helpful to offer different attractive services to the clients.

So, these are the needs for device management we have already seen and their different functionalities and why it is required to have this cloud-based device management solution?

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So, these are some of the features that clouds platform service providers should offer for device management; provisioning and authentication which we have seen already, fault diagnostics and monitoring, updates, security patches, maintenance, device decommissioning, configuration, control these are different things that cloud-based device management solutions will offer.

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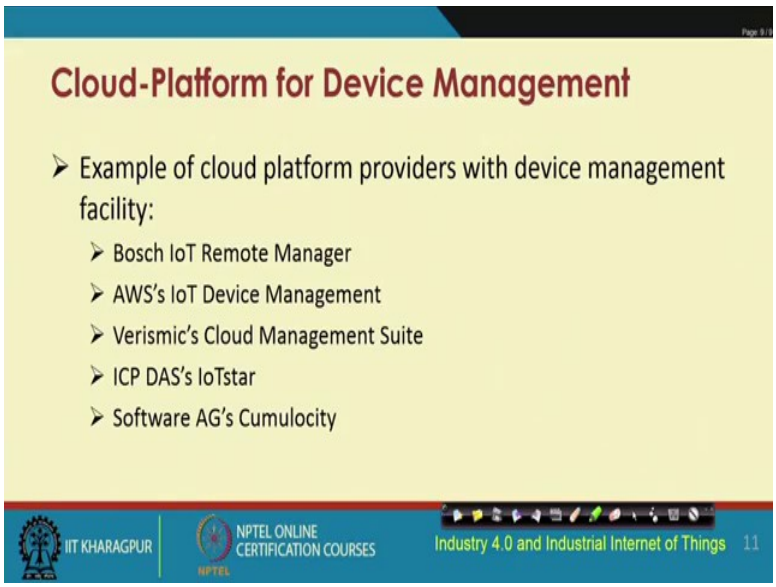

These are some of these companies that I mentioned Bosch's IoT Remote Manager, Amazon's IoT Device Management for AWS, Verismic's Cloud Management Suite,

ICP's IoTstar, Software AG's Cumulocity and so on like this there are many different other cloud-based device management solutions out there.

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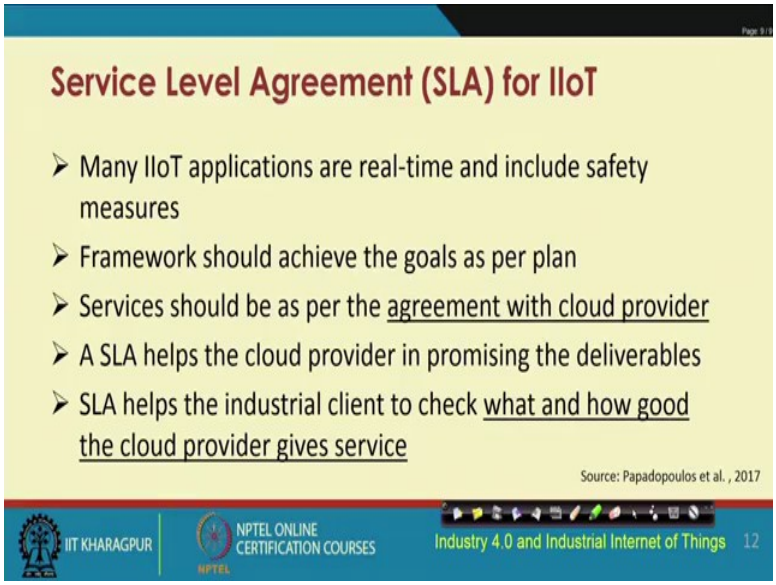

The next thing is that Service Level Agreement. So, Service Level Agreements or SLAs are very important particularly when you are talking about cloud. So, SLA is Service Level Agreement between whom, between the provider about what services are going to be provided and the consumers of the service. So, cloud service provider and the cloud service consumer who are basically this companies which are using these different services the IIoT solutions which are cloud-based and so on.

So, there are many IIoT applications that are real time where safety is very important. So, you need to have some kind of SLAs which will catering to the specific requirements that are there and the services should be offered as per the agreement with the cloud provider. So, it is some kind of a promise; promise of delivering something through some formal agreement which is often legal in nature. So, SLAs basically help the industrial clients to check what and how the cloud provider gives as services.

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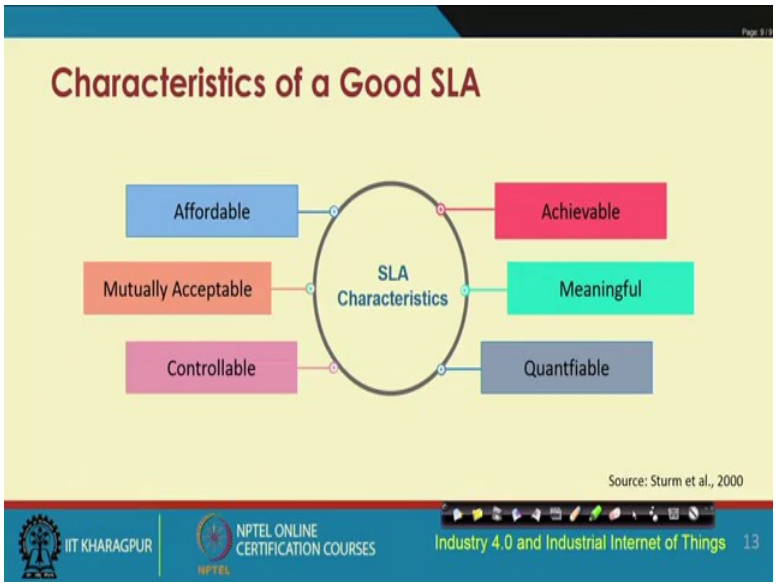

So, how good these services are this is what this SLA and the measurement of these which is important. So, SLAs have different features SLAs can be very simple, naive, and so on, but meaningful SLAs will have certain good characteristics certain characteristics which are desirable. So, these are some of the different characteristics that you see in front of you, a good SLA should be achievable something that can be achieved not something that is a dream and so on which cannot be done in within the required span of time and so on.

Second is that the good SLAs should be meaningful, it should not be vague it should be precise meaningful quantifiable because only if it is quantifiable then it can be measured and you can enforce certain requirements and legalities etc. based on these different measurable quantities. Fourth is that a good SLA should be controllable, fifth is that it should be mutually acceptable which is also quite will easily understood and should be affordable.

So, these are the six different characteristics of a good SLA when we are talking about cloud particularly in an industrial setting IIoT-based setting. So, let us now again take a look and take a recap of what we have discussed.

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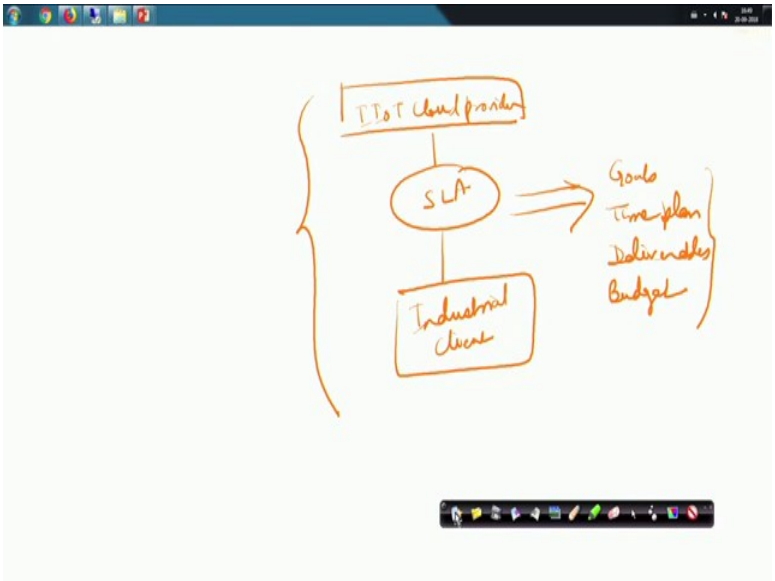

So, let us say that we have this IIoT solution, so we have this IIoT cloud service provider. So, this cloud provider is going to sign up an SLA with the industrial client. So, this SLA basically as we have seen will have different goals, time plan, list of deliverables and the specificity about the budget. So, this is what should be done in a cloud-based IIoT solution that is offered to the industrial clients. So, SLA should be there catering to these different requirements and the features.

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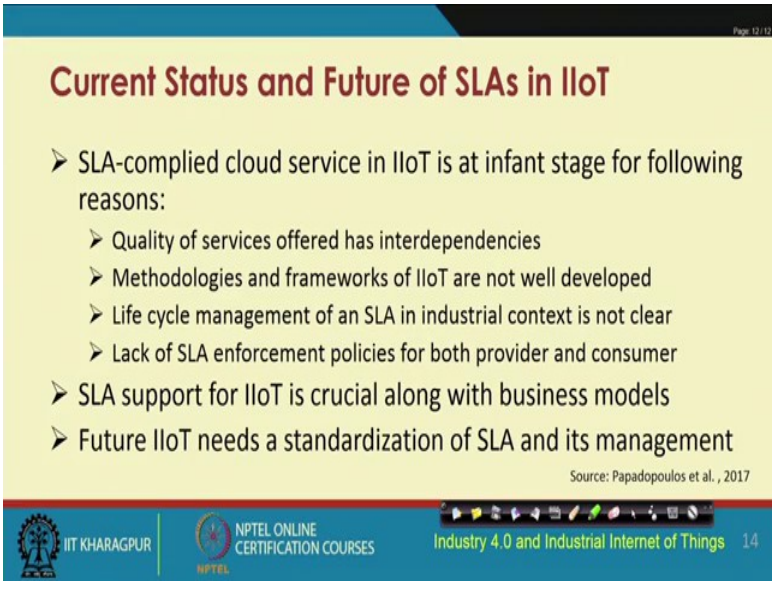

So, let us go ahead and look further, so the current status and future of SLAs in IIoT. So, SLA complied cloud service in IIoT is still in an infant stage because IIoT itself is in its infancy although there are bits and pieces that are already implemented particularly from an automation point of view, but cloud-based this kind of solution particularly SLA complied, you will find that it is not much matured at in most of the cases.

So, quality of services offered at this point has lot of interdependencies that is why it is still in its infant stages. The methodologies and frameworks of IIoT are not well developed, lifecycle management of an SLA in the industrial context is not clear, and the lack of SLA enforcement policies for both the consumers and the providers is also quite evident at present. So, there is lack of SLA enforcement policies.

So, SLA support for IIoT is crucial particularly from a business model point of view. So, whenever we are talking in the future of IIoT standardization of a SLA etc., we have to take all these different lacuna into account and try to address them in the future so that it becomes a very important necessity in the business negotiation process.

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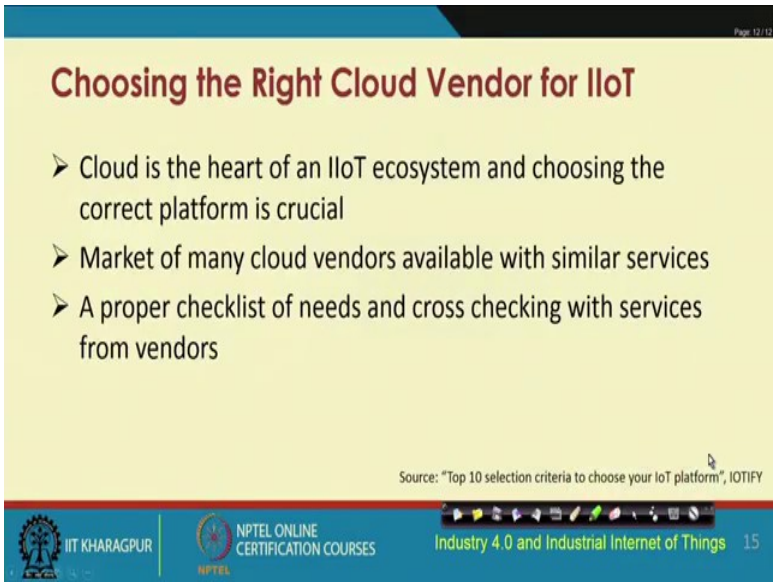

So, it is required to choose the right cloud vendor for IIoT, there are different cloud-based IIoT, cloud-based solution providers that are already there. So, it is very important to look for the correct vendor that will cater to the specific requirements that a particular industry has. So, a checklist will help in basically trying to identify the right cloud vendor for IIoT.

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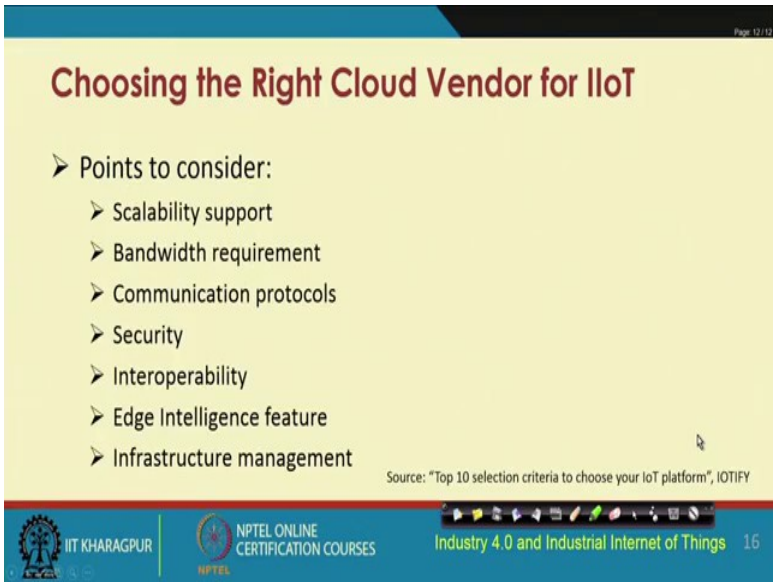

So, this checklist is given over here taking into consideration points such as scalability support whether the particular cloud vendor that you want to choose has support for scalability; that means, if you have dynamically if your requirements increase and so, on in terms of these different computational resources etc., whether the cloud vendor would be able to support that number one.

Number two is the bandwidth requirement which is well understood the communication protocols that are supported whether it is MQTT, AMQP, HTPP or the other protocols that are there. So, which ones are supported MQTT is more common, but then AMQP is also coming and so on. So, which ones are there that are supported by the cloud vendor and what will which of these protocols are going to help you cater to your specific requirements that you have for the IIoT solution that you want to deploy or is already deployed.

Security, I do not need to elaborate further, interoperability also the same, edge intelligence feature is very important. So, edge intelligence so whether this particular cloud-based solution has offers certain edge intelligence; that means, that wherever close to the point of collection of data; that means, the machines which have these IoT devices installed to them, whether all these data are sent to a remote cloud which will take lot of time etc., to send the data and also to process and give back the real sense own or some

of the analytics can be done at the edge; that means, at the local gateway or hub or whatever.

So, that will make the life faster, but at the same time not everything can be processed at the edge. So, ultimately some of it will have to be done remotely at the cloud. So, edge intelligence features infrastructure management these are some these different parameters that can be taken into consideration for choosing the right cloud vendor for IIoT.

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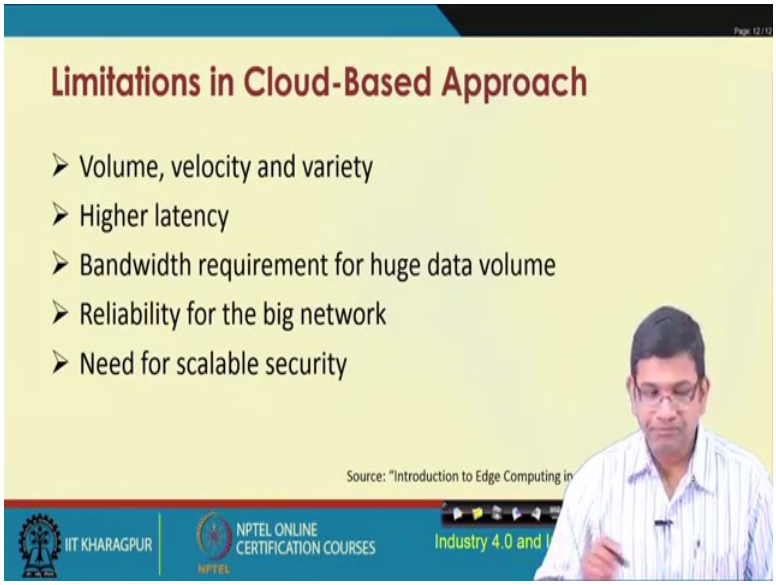

So, limitations in the cloud-based approach is that we are talking about a scenario in the case of IIoT we are talking about scenarios of machines large number of machines equipped with large number of IIoT devices, IoT devices and so, on sensors, actuators and so on and so forth. And supplying large volumes of data coming at huge velocity is having high variety; big data basically essentially big data characteristics are there and whether your cloud-based solutions will be able to cater to their requirements or not these kind of requirements.

So, if you are sending everything to the cloud; obviously, taking care of issues of volume is fine, but velocity particularly real-time processing faster processing etc., that may be difficult because there is going to be higher latency, you want to send everything to the cloud backend, which is maybe the server where it will get processed is located continent survey.

So, this is going to in turn impact the overall latency, propagation delay is going to increase of the packet that is sent from the device in the machine to that cloud and also processing it over there and then getting it back again the results to the user end that again will add to the time. So, higher latency is going to be there if it if everything is cloud-based. Bandwidth requirements for huge data volume will be there because you are talking about huge volume, high velocity, variety, and so on all this big data characteristics. So, you need the channel also to be of a high capacity high bandwidth.

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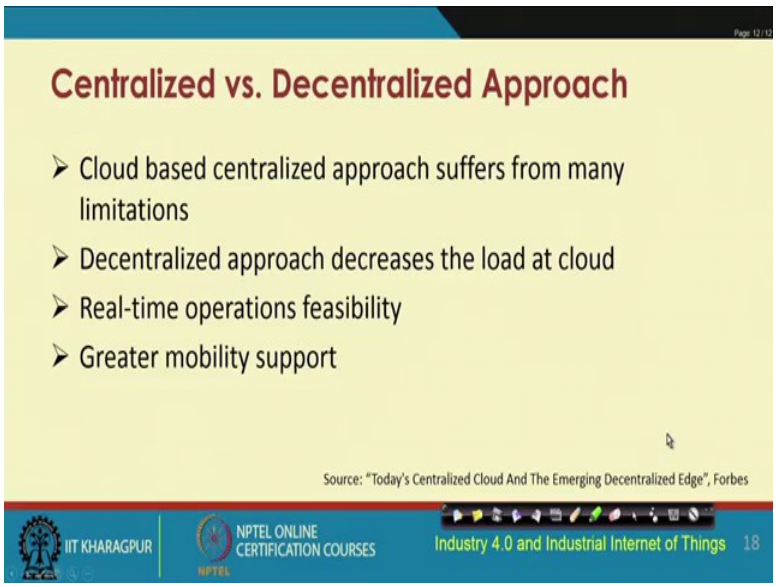

There is a requirement for the big network and need for scalable security, these are some of these limitations in cloud-based IIoT solutions, that is why there are these different other solutions people are thinking of. So, entirely centralized cloud-based solutions are the ones that we talked about and they suffer from many limitations which we have already seen. Now people are talking about decentralized approach that will decrease some of the load on the cloud and will also makes our lives faster by processing certain things at the edge.

So, it is sort of like partial cloud at the edge; that means, closer to closer to the devices from where this data are generated and real time operations feasibility greater mobility support, these are some of these cloud-based centralized approaches and how they suffer from these different elements and the different other characteristics, the desirable

characteristics mobility support operations real time operations feasibility those are required and so on.

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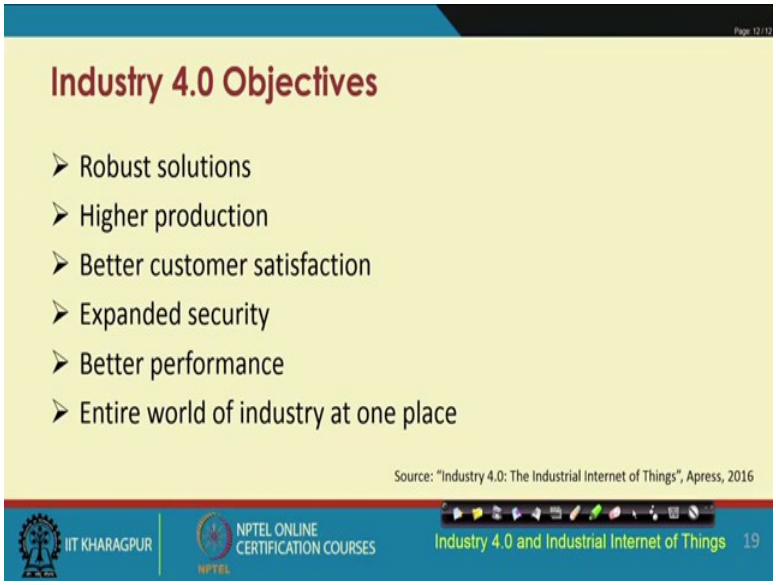

So, if we are talking about Industry 4.0, take a look at what we discussed earlier several lectures back we talked about Industry 4.0 having objectives of robust offering, robust solutions, higher production, improved customer satisfaction, expanded security, improved performance and so on and so forth, these are some of these different Industry 4.0 objectives.

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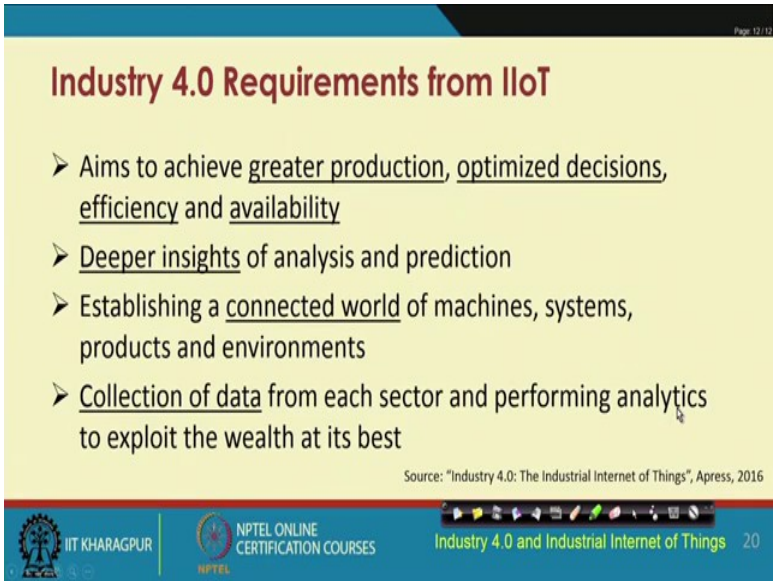

So, so from IIoT view point these requirements will aim to achieve greater production optimized decisions will be possible with higher efficiency and availability. It is also possible to have deeper insights of analysis and prediction, establishing a connected world of machines, systems, products, environments with the help of IIoT. Connected IoT, connected machinery, connected IoT devices on these machineries and so and the collection of data from each sector and performing analytics to exploit the wealth of its benefits, these are some of the requirements from IIoT perspective.

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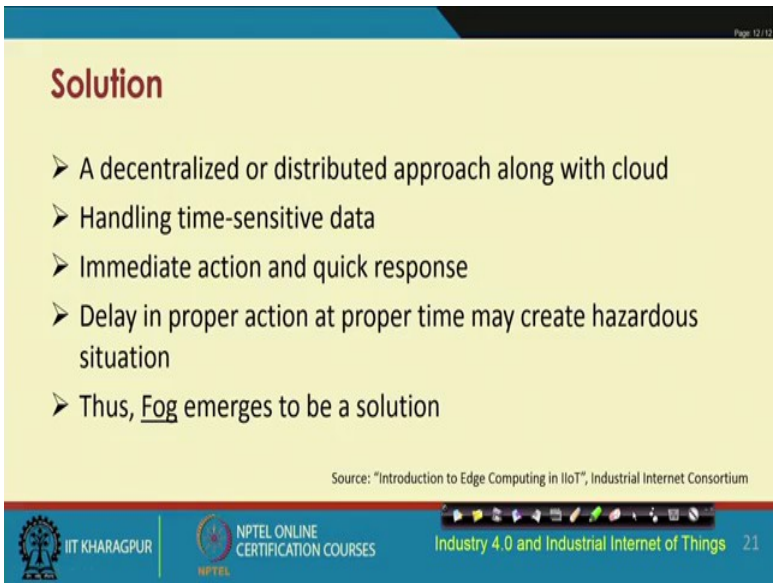

So, the solution is to have some kind of a decentralized or distributed approach along with the centralized cloud, which will help in handling some time sensitive data, where immediate actions will have to be taken some quicker responses will have to be taken and some processing will have to be done faster instead of sending everything at the cloud which will overall increase the latency.

So, that promptness in the processing at least to some level that can be done with something in your solution that is coming up which is the fog. So, fog is an emerging technology which will help to perform some of this processing closer to the point of origination of the data and the rest of the processing can be done at the cloud.

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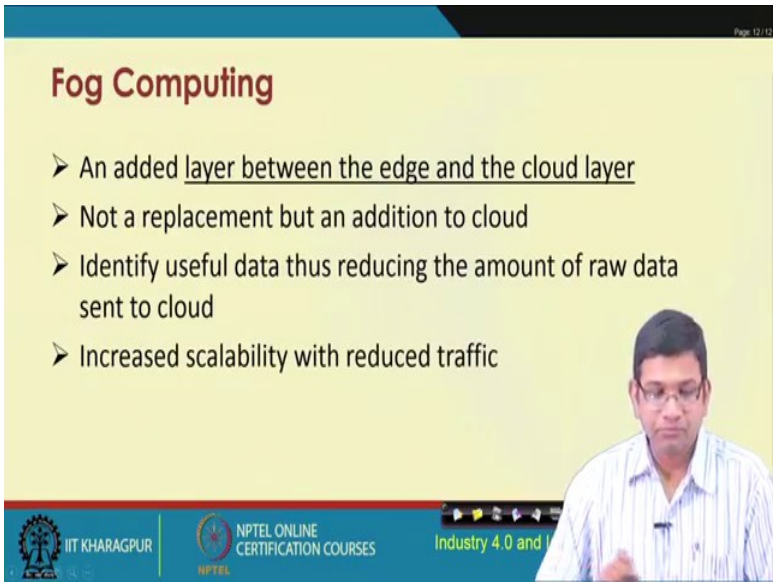

So, fog computing basically offers an added layer between the edge layer and the cloud layer. However, keep in mind that fog cannot do everything; it cannot solve all your problems it is not that fog layer can do all the processing, that would be otherwise done at the cloud. So, only some meaningful processing of some raw data, before it is actually sent to the cloud and also some processing, that has to be done quite fast will be done at the fog.

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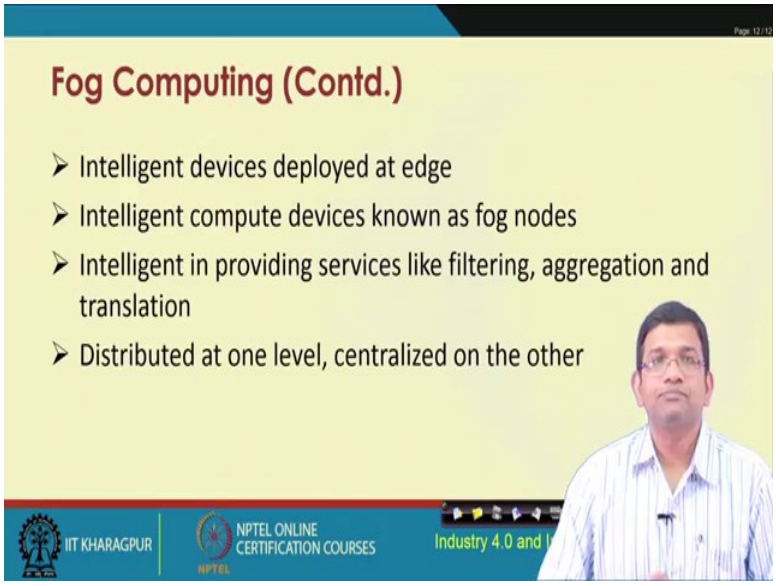

So, intelligent devices are deployed at the edge, intelligent computing or devices such as the fog nodes, which are known as the fog nodes would be would be deployed which can offer different services such as filtering of the data, aggregation of the data, translation of the data and so on.

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So, with this we come to an end of the lecture on cloud computing for IIoT, holistically previous lecture and this lecture included, we have seen the different features of cloud we have looked at the requirements of cloud why cloud-based solutions are required, why cloud-based analytic solutions are required and how they are useful and how this cloud-based solution is going to help in catering to certain real life industry 4.0 IIoT requirements that are there in the industries.

We have looked at certain specific solutions that are there some industry specific solutions, some independent software company based solutions and so and how they can help in addressing some of our requirements. So, with this we come to an end and these are some of these different references that are there and if you are interested you could go through these different references, I would suggest that you go through this particular paper that was authored by me.

So, Assessment of the Suitability of Fog Computing in the Context of Internet of Things which was published in the IEEE Transactions on Cloud Computing in 2018 and so the other papers and this one together will help you to get an understanding of 2

technologies; one is cloud; cloud for IIoT and also the newer upcoming technology fog which I am going to again discussing further depth in the next lecture.

So, fog and cloud together in all these references will help you to get a deeper insight and what is required to have is some kind of suitable cloud, fog-based solutions for catering to the IIoT requirements, with this we come to an end of this particular lecture.

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These are these are the references that are there.

Thank you.