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 – 41
Analytics and Data Management Fog Computing in IIoT

In the previous lecture we looked at cloud, cloud based solutions, but cloud based solutions are typically centralized. So, you have all these different industrial machinery that are basically connected to the cloud, these industrial machinery they themselves are attached to different sensors, actuators, IoT devices overall and so on.

So, the all this data are basically over a specific communication channel which has a fixed bandwidth, all these data continuously typically for most of these industrial scenarios and the machinery. These data are sent through this particular fixed channel to this centralized entity called the cloud where lot of storage is existing and lot of processing can be done.

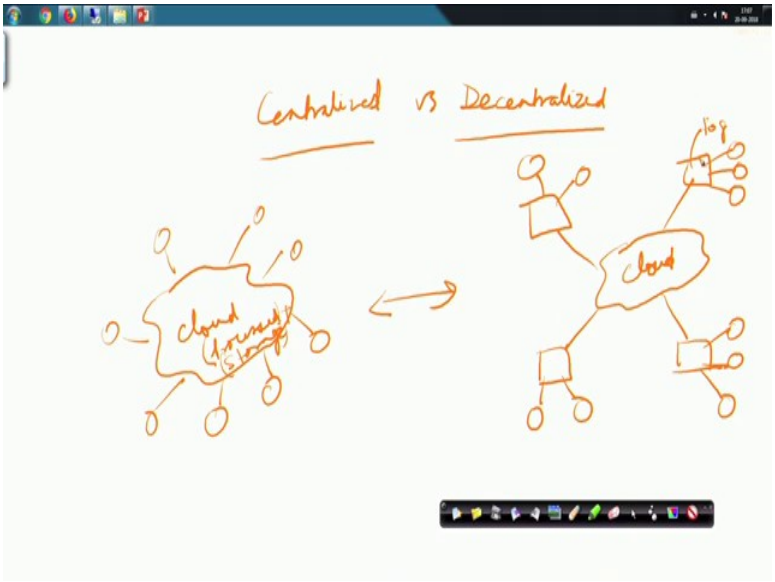
So, this data that are sent to the cloud are analyzed, lot of different types of analytics are performed, analytics to gather different meaning, analytics which will give you some idea about what is going on at present real time maybe non real time as well and analytics which will predict certain things that are going to happen in the future maybe the downtime maybe the time after which if certain machine or a certain part of a machine is going to go down.

So, all of these things are going to be predictive or current operational analytics can be done at the cloud. We have also seen that centralized models are not always good particularly in IIoT scenarios where real timing-ness is very important, where quicker response is very important, because you are talking about machinery operating at very high speed where safety of the humans operating these machines is very crucial.

So, IIoT solutions which are purely cloud based may not be ideal. So, we are now talking about a different approach which is called the fog based approach where we are talking about a layer of computation, a thin layer of computation performing some lightweight computation processing and so on, which will be done closer to the origination of the

data. That means closer to this edge devices and this particular layer is going to sit between this particular edge layer and the cloud layer and that is called the fog layer.

(Refer Slide Time: 03:11)



So, let us look at what we have just discussed so, we talked about this different centralized and decentralized models. So, centralized essentially is purely cloud based where you have all these different IIoT devices which will throw in lot of data and this data will all be processed and stored at the cloud. So, this is your centralized.

On the other hand you could have a solution which is a combination of your whatever you already had the cloud and some kind of you know these devices like these boxes over here which are representationally shown, which will be like your fog which will have reduced computational capacities than the cloud, but have certain capacities for doing some preliminary level filtering, processing, faster, decision making and so on. So, these are your edge devices and this is this fog layer that is sitting in between. So, now, let us look further at these different advantages of fog computing for IIoT.

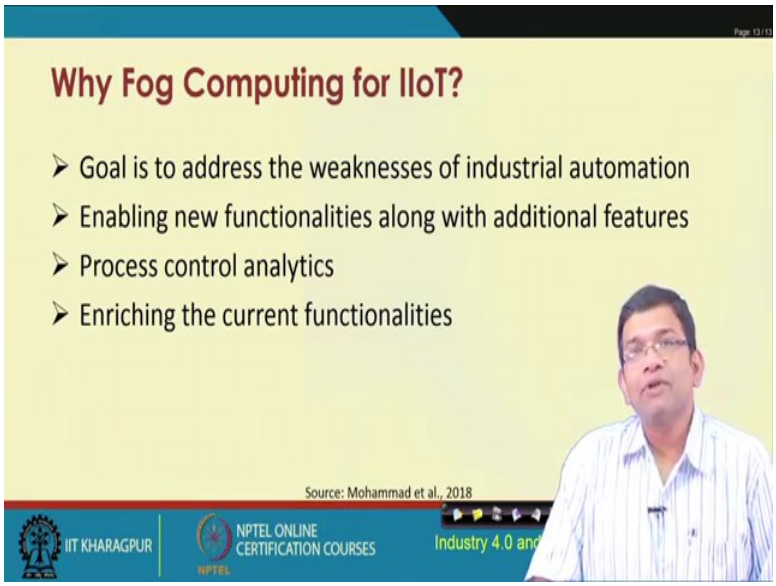
(Refer Slide Time: 04:42)

So, we already saw that in IIoT we are talking about scenarios where there are large numbers of different sensors, actuators, different devices, other machinery attached to these different other machinery and so on. So, all these machinery to machinery you know one machine connected to another machine and so on. So, all of these are connected and these machines are operating at huge speeds, not only that, but they are also sending data through their different sensors at very high speeds and many of this data are very time sensitive and could be critical.

So, there is a need for immediate action or quicker response. So, it is not quite desirable to have any delay in sending the data from the point of origination to the cloud processing it over there and sending it back because the whole thing will add to the delay and that might lead to certain hazardous situations because we are talking about machines being operated by different people, different hazards will happen even if your data reaches the intended destination after maybe even a millisecond or a microsecond by that time maybe the hazard will happen, because everything is moving very fast, lot of data are getting generated and so on. So, we have a different very highly dynamic kind of scenario.

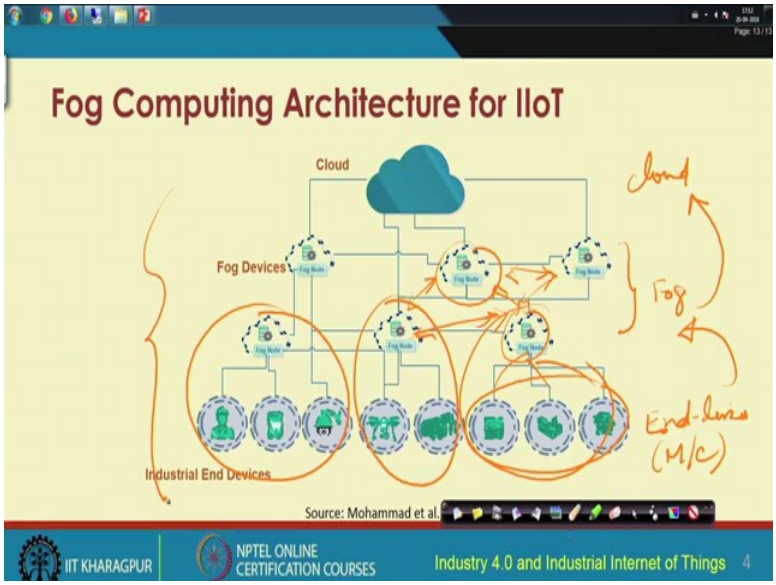
So, the major challenge is to handle the diversity of the data in real time and as close as possible and as fast as possible to the point from which the data are originating.

(Refer Slide Time: 06:41)



So, the goal is to address the weaknesses of industrial automation, that have been there and that is why this new technology which is called the fog computing technology will help in this particular regard. So, why fog computing? -- Taking care of existing weaknesses of industrial automation the cloud based solutions and so on. Enabling newer functionalities to be implemented along with the additional features and also enabling real time efficient process control mechanisms with the help of improved and faster analytics, and enriching the existing functionalities overall. This is how fog computing is going to help.

(Refer Slide Time: 07:26)

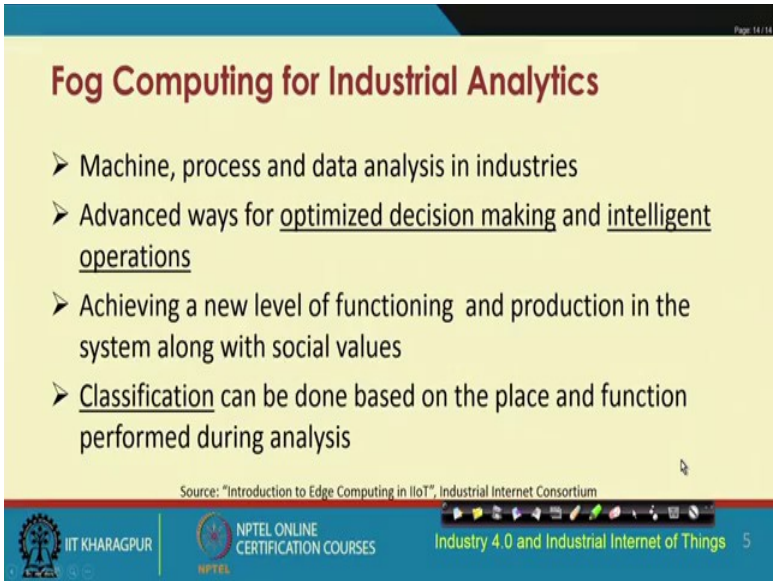


So, this is how this fog architecture looks like, as I told you earlier we have these different layers. We have these layers of this end devices that are the ones which are basically fitted to your different machines. Then you have this fog layer and this is your cloud right so, we have these 3 tiers.

So, as I told you earlier that the idea is to have certain executions done at the fog layer at the fog node and the rest being sent to the cloud for further processing. So, as you can see over here these different fog nodes they basically are fitted to different end devices. So, every fog node essentially takes care of a few end devices. In fact, as you can see from this also these fog nodes may also be interconnected they might be interconnected with one another.

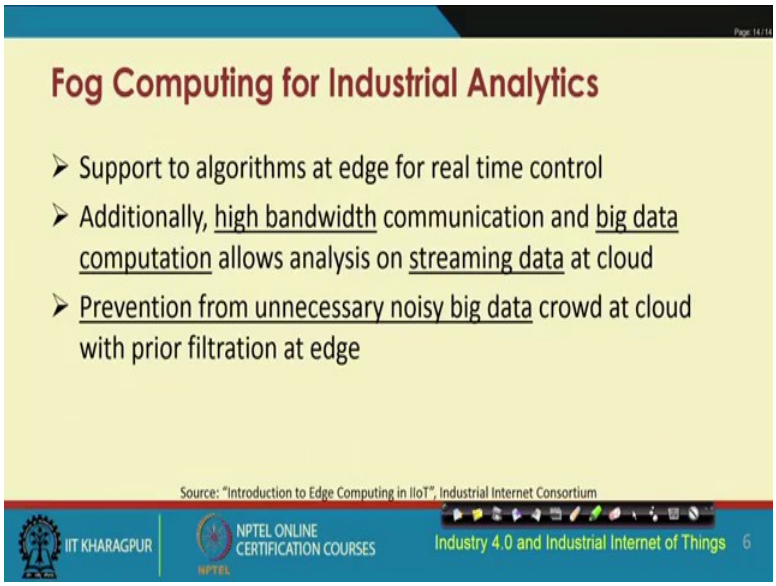
So, these are the different clusters of these fog and end devices in this manner and these fog nodes they themselves could be interconnected like this. So, this is this overall architecture of fog computing for IIoT.

(Refer Slide Time: 09:13)



So, fog computing helps in improving the performance of machines, processes the data analytics and so on, helps in optimizing decision making. Intelligent operations can be performed with the help of fog computing and different features such as data classification, i.e., classification of the data coming through from the same source maybe and trying to segregate that kind of data can also be done with the help of fog computing.

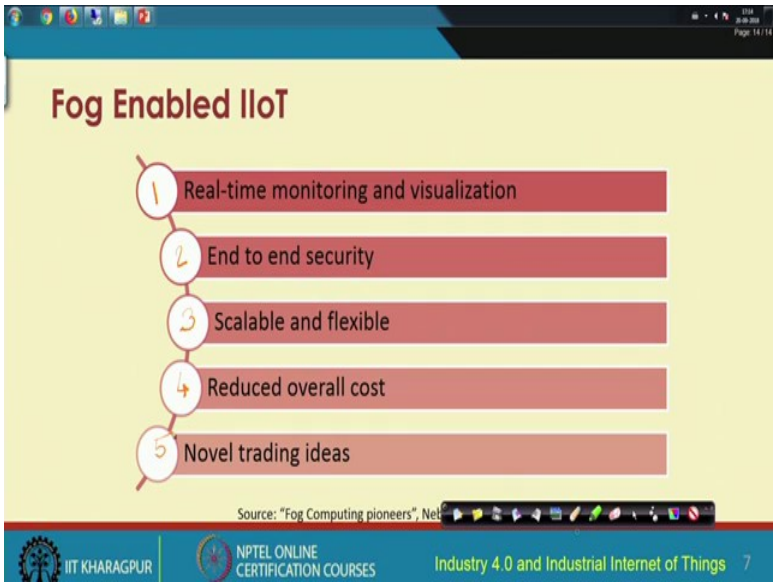
(Refer Slide Time: 09:54)



Fog computing has support for different algorithms that can be executed at the edge for real time control, for industrial scenarios there is a requirement of all these devices connected to each other and sending the data and this data are sent continuously in real time in large volumes and so on they are streamed.

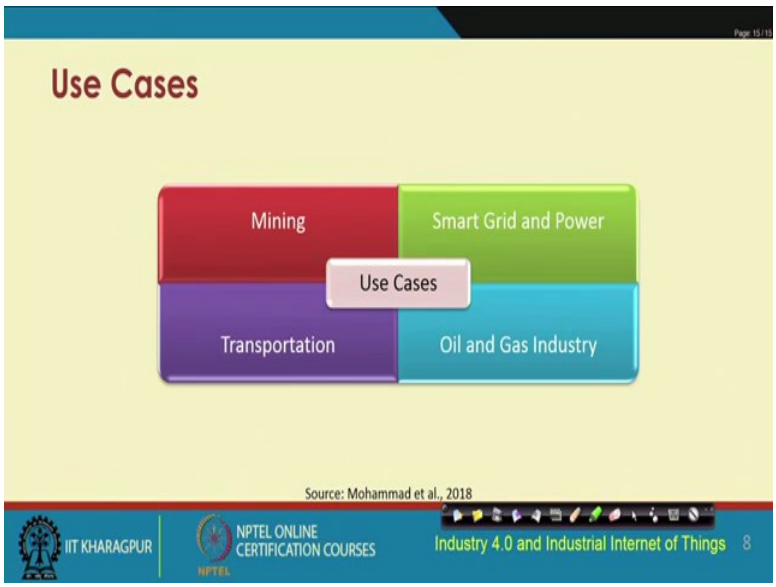
So, high bandwidth requirements are also there in the industrial settings and also it is required to prevent as much as possible the unnecessary noisy data from the crowd through some kind of filtration process so this filtration can also be done at the fog. So, taking care of all of these requirements and the density of doing certain computation filtration, basic analytics and so on could be done at the fog layer.

(Refer Slide Time: 10:51)



So, a fog enabled IIoT solution can help in, real time monitoring and visualization, offering end to end security, taking care of scalability issues and making the architecture flexible overall, reducing the overall cost and novel trading ideas. So, these are some of the different features of fog enabled IIoT.

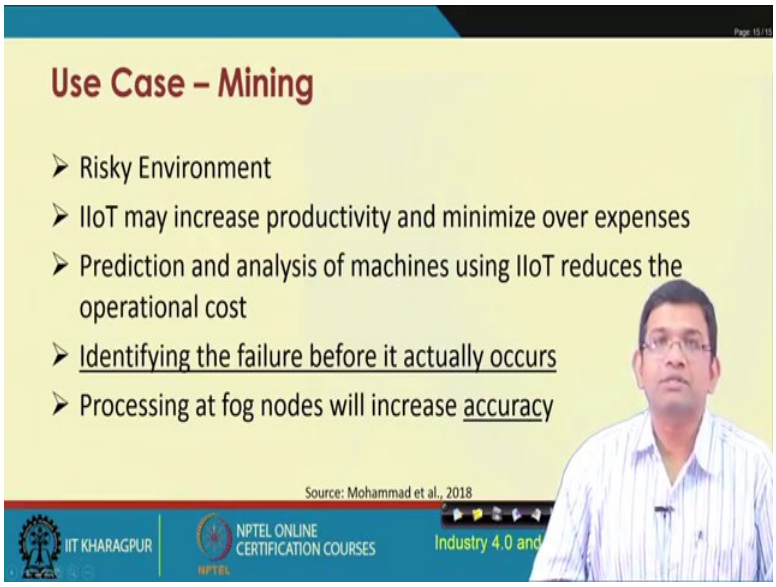
(Refer Slide Time: 11:31)



There are different use cases fog computing: could be used in mining industry, in the power sector, smart grid, in transportation sector, in oil and gas industry and so on.

We ourselves have been using fog based solutions for certain mining projects that we have in the underground coal mines we are deploying fog nodes, fog architecture overall for doing some basic analytics in the mine itself right close to the point of origination of the data. So, like that for smart grid also fog is very important transportation, oil and gas industry and so on. So, this is not the only list there are many other different applications of fog.

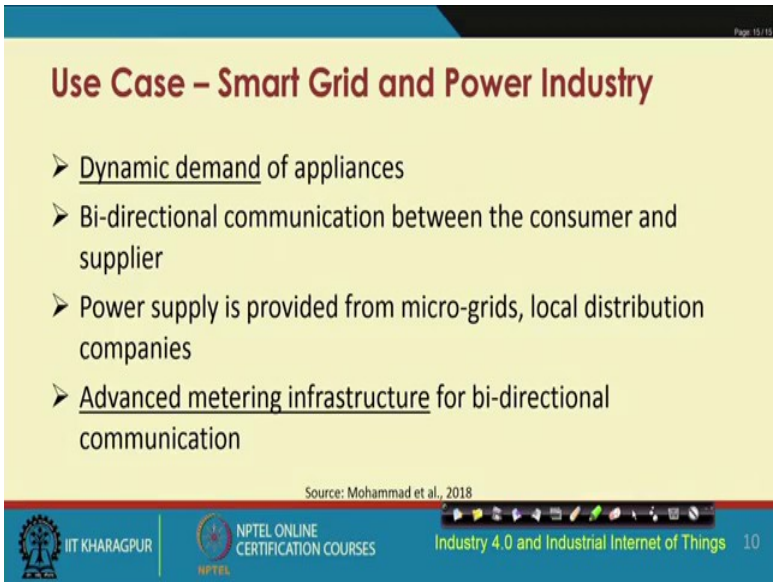
(Refer Slide Time: 12:12)



So, take the case of mining, as you know that mines typically are risky environments where productivity is indeed important, but overall safety is also very important. There are different mining machinery that are basically operating in huge speeds and working continuously. So, hazards are quite common due to mining machinery, monitoring of these different underground mine gases that are harmful. So, all of these different issues are there.

So, mining industry finds lot of these scenarios where fog can help, because fog can help in reducing the overall response time. Accuracy can be improved with the help of fog, response time reduction, & improvement of accuracy all of these things can be done with the help of fog based deployment of IIoT solutions in the mining industry.

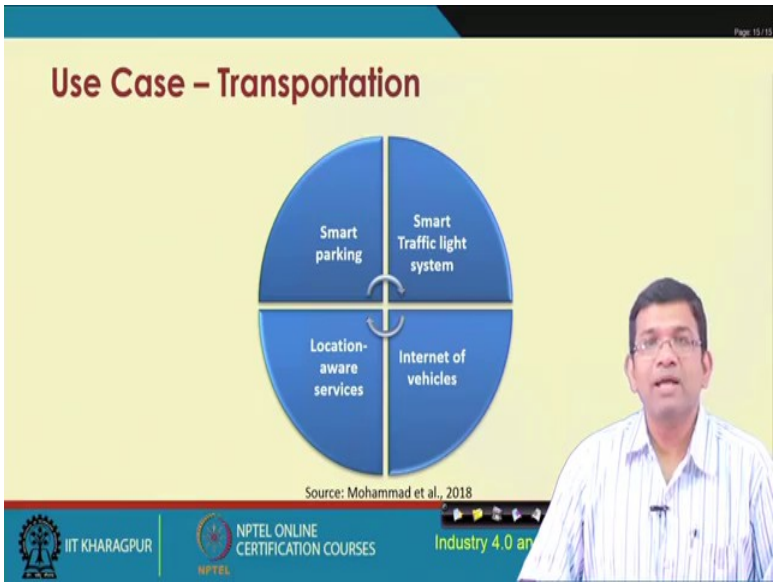
(Refer Slide Time: 13:22)



So, this is just in a nutshell that I have told you like this for other industrial sectors as well for smart grid power industry etc. fog is very important. In the context of smart grid now a days we are talking about dynamic demand scheduling of appliances (appliances dynamically will be scheduled). They will be programmed by the consumers depending on the specific criteria such as the time of the day and the pricing etc. different appliances could be scheduled.

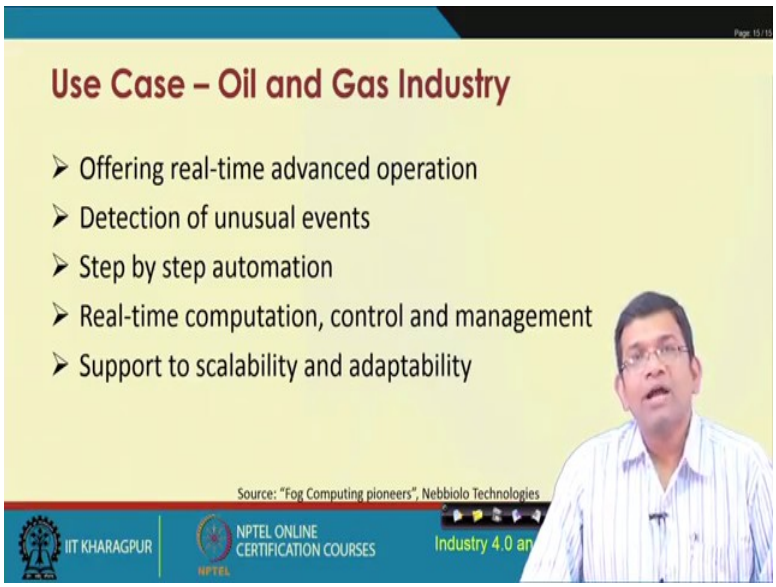
So, in certain cases what might be required is to basically implement these different solutions for dynamic demand scheduling and the others to be done as soon as possible. So that the responses can be sent to these end equipment and machinery quickly so, the response time could be improved. So, that is why in the case of smart grid and power sector as well the implementation of fog is very interesting and efficient.

(Refer Slide Time: 14:39)



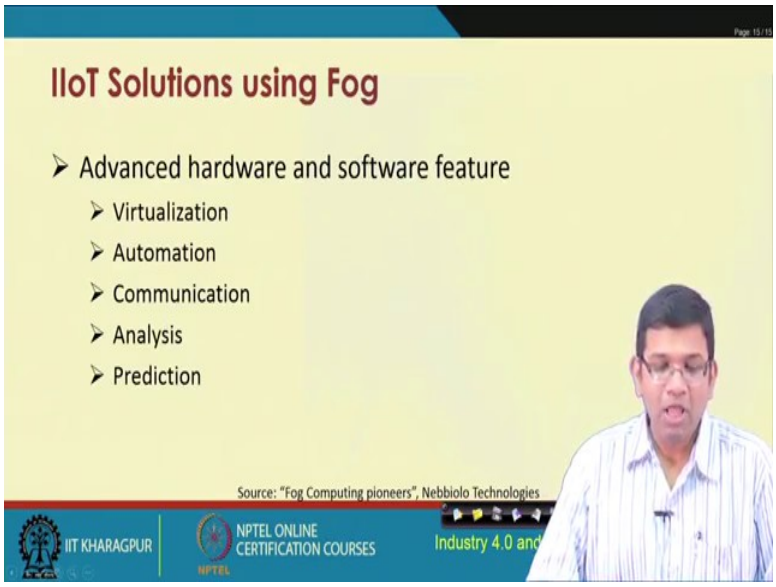
In the case of transportation, smart parking, traffic lights, internet of vehicles, location aware services to the vehicles and so on. All of these basically fog computing for the reasons that I mentioned earlier in the context of mine and smart grid, these are also applicable here. So, you can basically extrapolate those different benefits of fog computing that makes fog based mining, fog based smart grid attractive you could extrapolate those and try to think of a fog based solution for transportation which will be attractive as well.

(Refer Slide Time: 15:17)



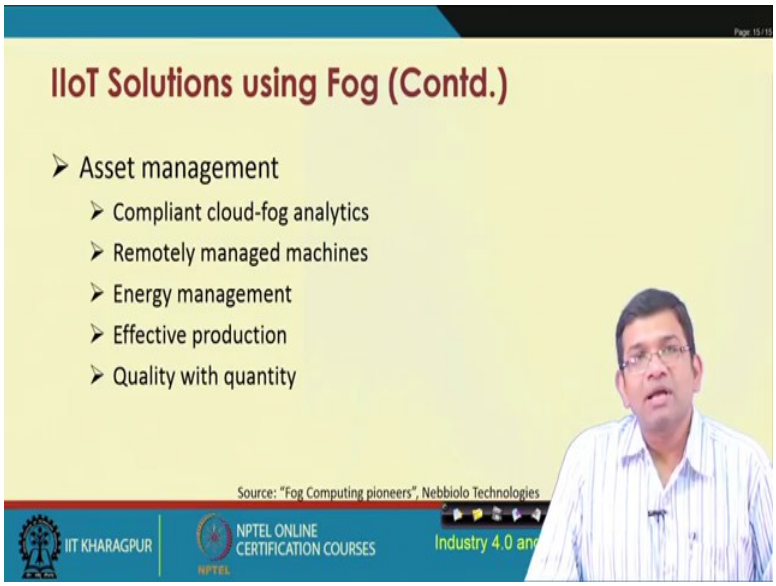
Oil and gas industry also finds lot of use of fog computing, offering real time advanced operations is very important in the oil and gas industry, detection of unusual events detection of leakages through different transmission lines (where this gas is being transported through pipes). Those gas pipe transmission lines, step by step automation, real time computation, control, management, support to scalability, adaptability etc. all of these are different things that can be done using a fog based solution.

(Refer Slide Time: 16:02)



So, using fog advanced hardware and software features such as virtualization, automation, communication, analysis, prediction, all of these can be done.

(Refer Slide Time: 16:13)

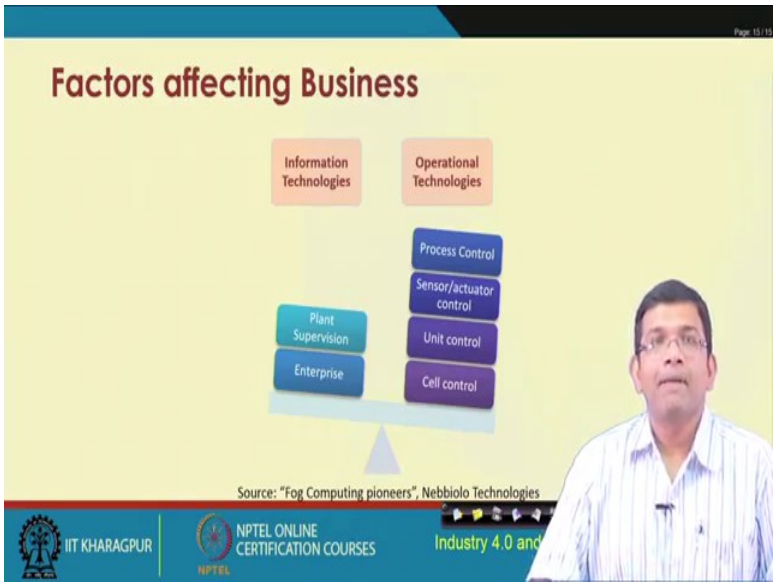


Asset management can be done with the help of fog based IIoT, where compliant cloud fog analytics can be executed, remote management of machines can be done, energy management can be done, effective production, quality with quantity all of these can be done for asset management using fog based IIoT problems.

(Refer Slide Time: 16:36)

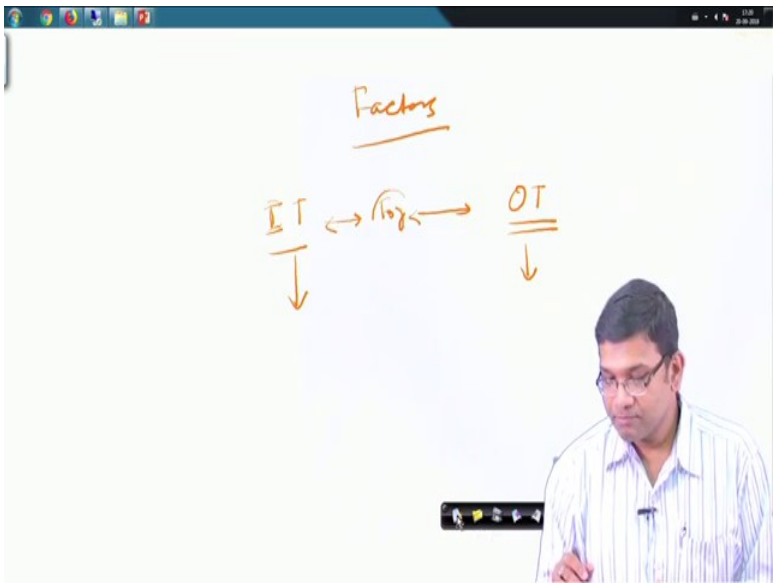
Futuristic monitoring and control systems for industries, they are also you know IIoT based solutions using fog are useful.

(Refer Slide Time: 16:51)



Now, the factors that affect business, if we talk about that, so these are the different factors that will typically affect the business.

(Refer Slide Time: 17:03)



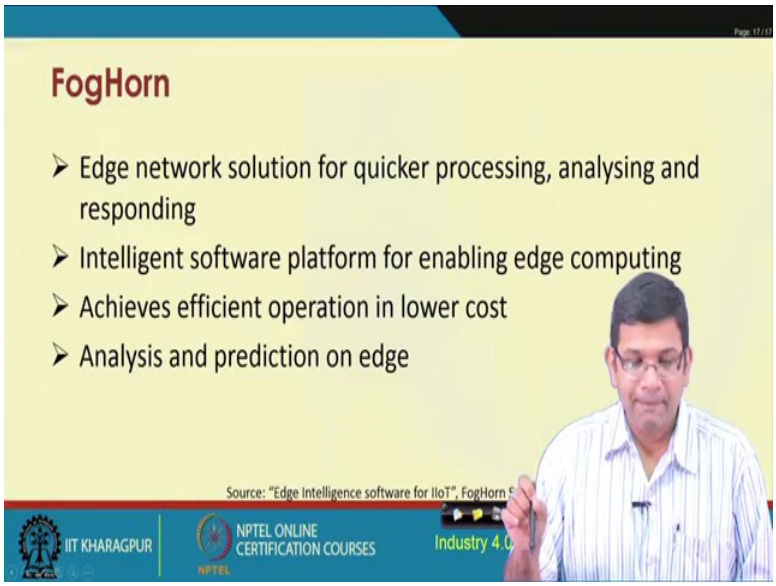
So, these factors if we look at can be classified in this particular manner, you have these IT based factors and the OT based factors, IT means information technology and OT means operational technology, these different factors with the help of fog can be implemented right.

So, different operation technologies factors and IT factors is what we are going to look at and how fog can help in addressing these requirements. So, IT factors include plant supervision, enterprise and so on whereas, the OT factors include process control, sensor actuator control, unit control, cell control and so on. So, these are the different OT factors and these OT operational technology factors typically in most of these industrial automation settings these outweigh the IT factors of plant supervision, enterprise control and so on and this is where this integration and handshaking of these IT and OT parameters for improving the business outcomes this is where this fog can help.

(Refer Slide Time: 18:42)

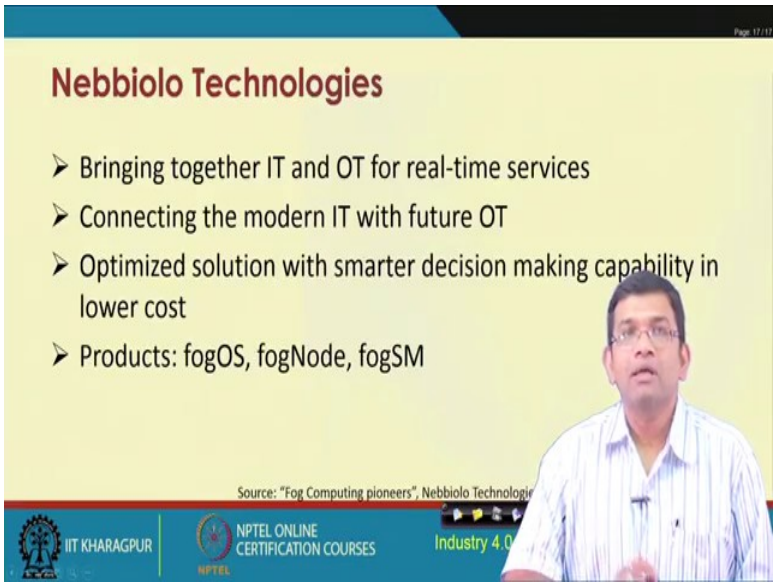
So, let us go ahead further. There are different fog platform service providers that are already there like the cloud service providers that I told you previously, for industrial contexts. So, one is the Fog Horn, say next is Nebbiolo, third is Crosser and fourth is Sonm. So, these are some of these fog platform service providers.

(Refer Slide Time: 19:09)



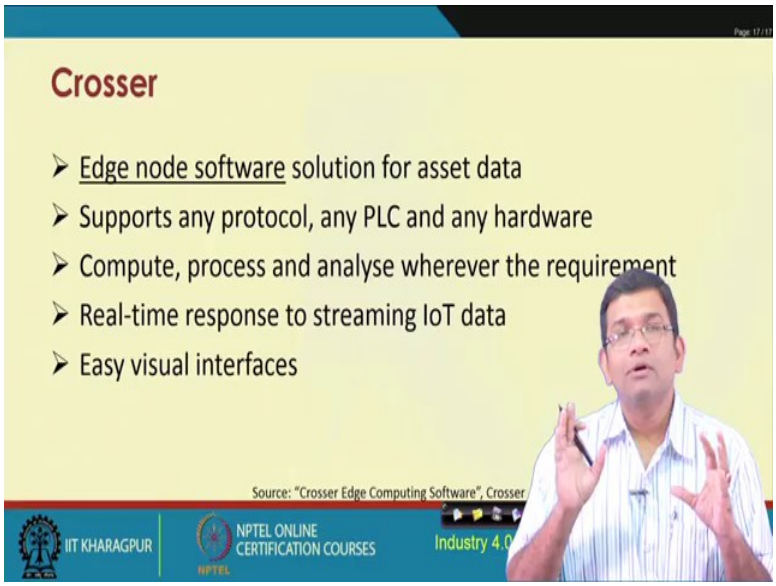
So, FogHorn just in nutshell offers edge network solution for faster processing, analysis and response. So, it is basically an intelligent software platform that is provided for enabling edge computing.

(Refer Slide Time: 19:24)



Nebbiolo, basically helps in this integration of IT and OT. Offering this integration of all these different components is done with the help of Nebbiolo, they have different products fogOS, fogNode, fogSM and so on.

(Refer Slide Time: 19:45)



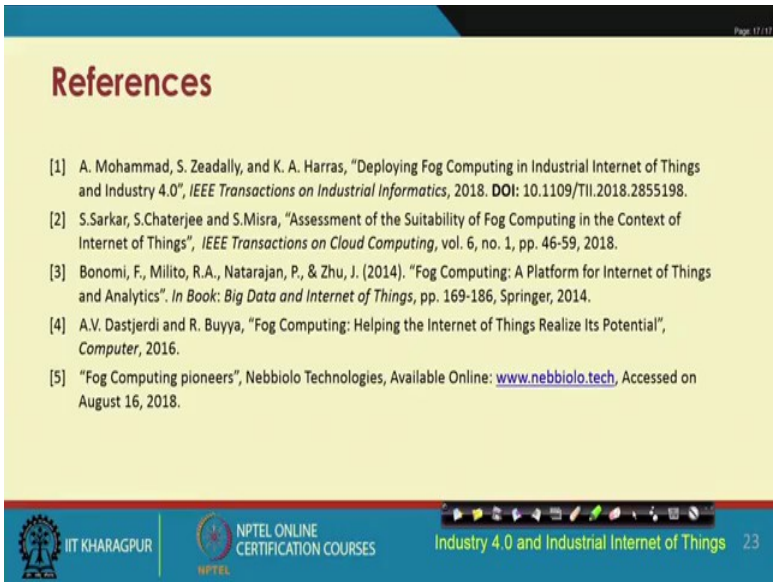
So, this connection between this IT and OT with the help of this technology is possible. Crosser is an edge node software solution for asset data. So, it basically runs on different machines PLCs, end devices, computer hardware and supports different varied types of protocols.

(Refer Slide Time: 20:10)

Sonm, is basically a distributed cloud service for customer hardware, this is basically essentially a fog solution and they have different components supporting block chain infrastructure, video streaming, machine learning, video rendering. Block chain probably

may most of you are already familiar with. Block chain is good for security, offering decentralized security particularly, but also the centralized ones. So, overall security of the infrastructure block chain based services, basically are useful and are quite popular at present.

(Refer Slide Time: 20:49)



So, with this we come to an end and these are some of these different references we have gone through in the last few slides, these different fog based services that are available and how they could be integrated with cloud and so on and these are fog based solutions for IIoT scenarios which we have discussed.

So, these are different references and we come to an end of this fog based solution. Fog remember is not the solution, fog is a complementary solution that can be offered along with cloud. In most of the cases fog does not stand on it is own. So, fog and cloud together a converse solution is what is typically found useful in most of these IIoT implementation or deployment scenarios.

Thank you.