Introduction to Internet of Things
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Lecture – 42
Sensor - Cloud – I

In this lecture, we are going to get introduced to a very fine technology, the sensor cloud technology which has become popular in the last few years. It is popular particularly for IoT environments, for the development of IoT environments.

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So, sensor cloud as the name suggests is about integration of 2 technologies sensor i.e. sensor networks and cloud technology. So, the whole idea is through the integration of sensor technology or sensor network technology with cloud. We offer sensors or sensing as a service, in the same way as in the traditional cloud computing platform which we have gone through in other lecture.

So, in cloud computing, people are talking about offering computing facilities as a service infrastructure, computing infrastructure as a service; software as a service platform as a service and so on. So, this is what we have gone through during the cloud computing lecture. So, here in censor cloud, we are talking about can we have a model where sensors or sense data or sensing can be offered to end users as a service, a very

fine technology, a very nice idea. That can basically revolutionize the way we look at IoT today.

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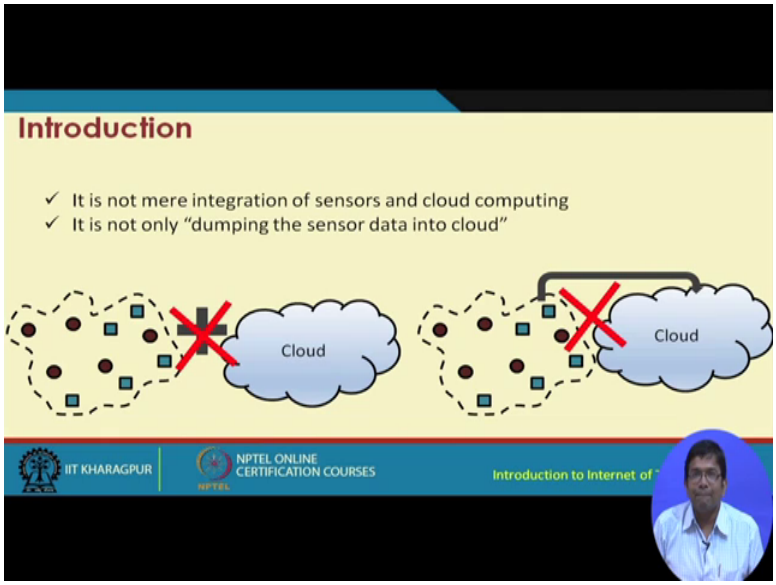

So, let us look at it further. So, in sensor networks we are primarily concerned about sensing of a particular region, where the sensors are deployed in cloud computing. We are primarily talking about storage of the data processing of the data and so on. However when we talk about sensors and cloud together, we are talking about how we can basically integrate the benefits that are obtained from each of these 2 technologies, but those benefits are not nearly about getting the sense data to the cloud, dumping the sense data to the cloud or it is not about the simple virtualization of the sensors the way; we have seen that computing platforms are virtualized in cloud. So, here also it is not a very simple integration of sensors and cloud computing technologies. So, it is not a mere integration of sensors and cloud computing technology and also, at the same time, it is neither the integration and at the same time, it is nor the dumping of the sense data to the cloud. Neither of these 2.

So, we can think of it as both of these plus some additional attributes, neither of these alone, both of these together plus several other benefits that we can get out of this integration.

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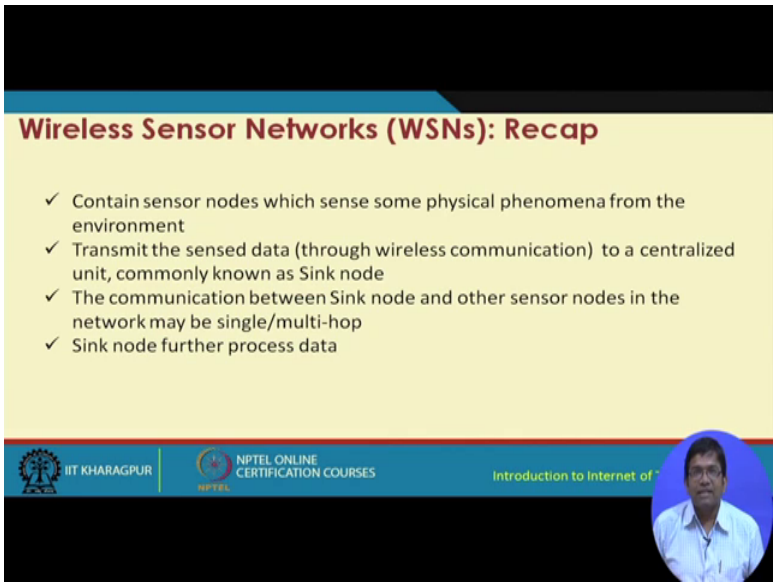

So, just a quick recap of sensor networks; we have already gone through it in detail. So, in a sensor network what we have? We have the sensor noses sensing the physical phenomena that are occurring in the environment of their operation. These nodes send the data, the sense data to the sink which is a centralized unit and the communication between the sink and the other sensor nodes in the network is typically multi hop which can also be single hop of the sensor node. That means, the source node and the sink are sufficiently close to each other and the sink node basically either processes the data itself further or it sends it to a server for further processing. So, this is what additional sensor networks does.

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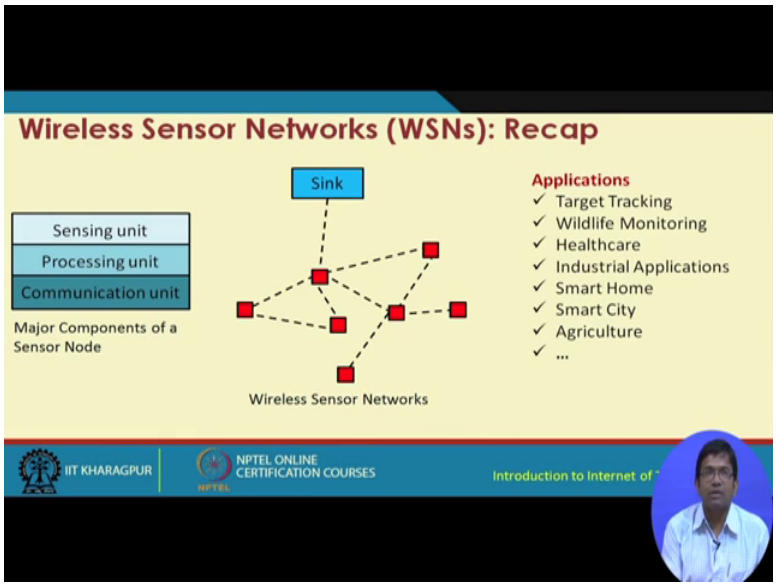

So, in a traditional sensor network, we are typically talking about such a scenario. We have the sensor nodes connected to the sink sensor nodes sensing the data, sending the data to the sink, the sense data to the sink. So, we have in every sensor node a sensing unit, a processing unit and a communication unit. Sensing unit will have to sense what is going on around it. Processing unit will do some processing; you know some basic processing and the communication unit will send it forward to the next top neighbor for final delivery to the sink. The different applications of sensor networks, we have already gone through; again target tracking, wild life monitoring, health care, industrial applications, smart homes, smart city, agriculture, vehicular networks, that means, connected vehicles and so many different types of applications of sensor networks cloud.

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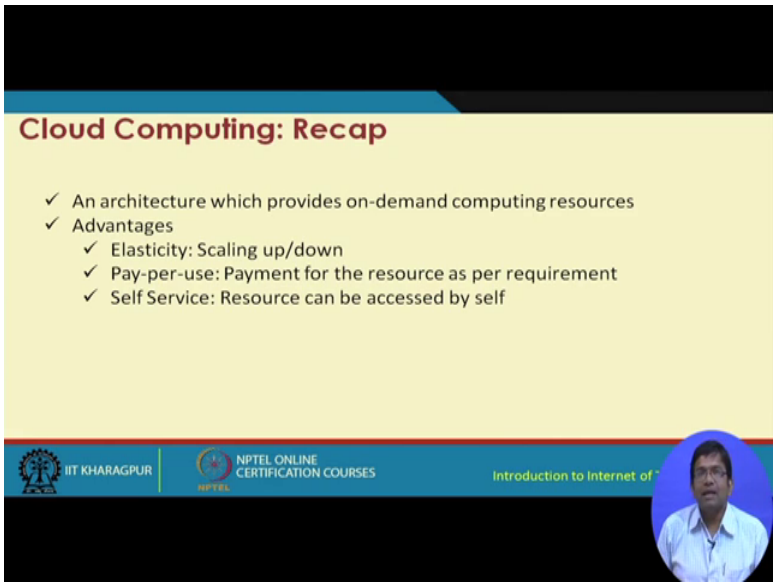

Let us have a brief recap. Cloud basically provides architecture, some computational platform which can be used on demand to get access to computational resources whenever required, that means on demand on a pay per use basis. So, the advantages of cloud technology over the traditional server based technologies like server farms etcetera, one is elasticity and that means, we can very easily scale up or down as per the requirements. If there is increase in the requirement of computational resources, then you know without actually going about buying those additional resources, one can simply subscribe and pay for those resources and start using them through the click of a mouse button.

Self service, the resources can be accessed by this, by self. That means you know the resources can be accessed by themselves and themselves means the sensor nodes or the computing computational nodes.

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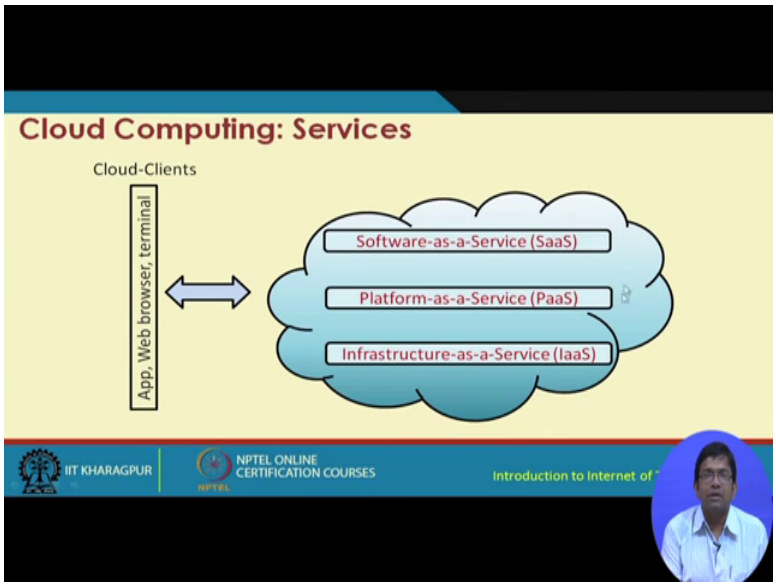

So, we are talking about 3 types of typically or traditionally 3 types of cloud computing services. Infrastructure as a service IaaS, platform as a service PaaS and software as a service is SaaS. Different cloud clients like different apps, web browsers, terminals etcetera are going to get access to the data and the services from the cloud.

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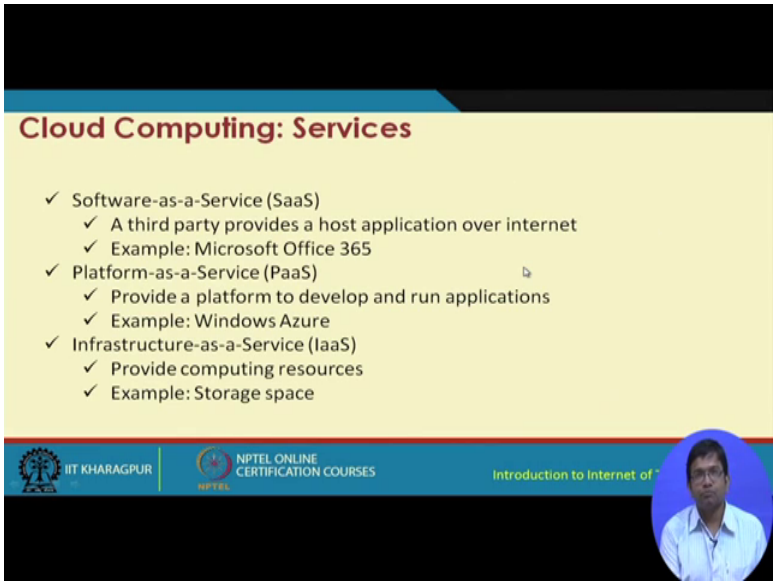

So, what are the services? SaaS, PaaS and IaaS and I will just give you some example once again. We have already gone through it and I will skip it. I will not skip, but I will go through pretty fast. So, software as a service, a good example is Microsoft Office 365,

platform as a service example Windows Azure and Infrastructure as a service you know several examples of inclusion of storage spaces, computational resources and so on.

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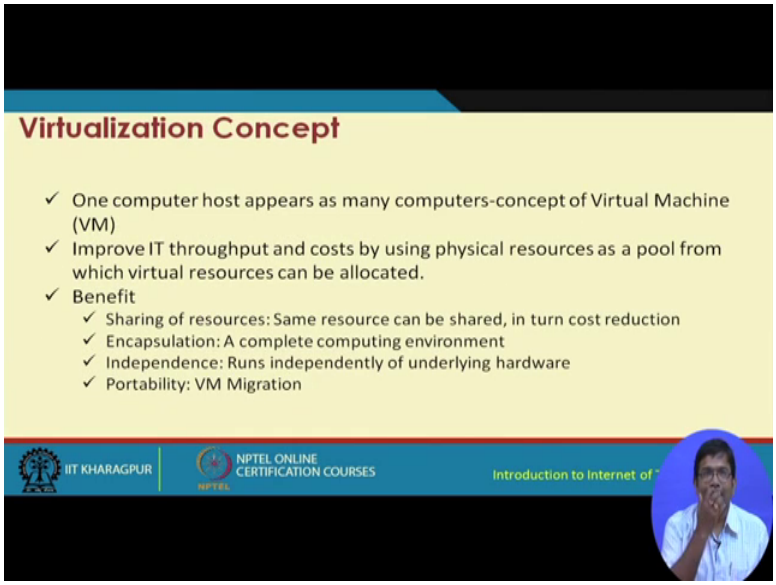

Now, let us come to the concept of virtualization which is key to cloud and sensor cloud. So, virtualization through the virtualization concept physically one computer might be holding on to the resources and to many computers. Those resources can be shared, they can used, those other computers can use those resources and can get access to the resources as and when required. So, overall the through put and costs are going to be increased and the benefit is that virtualization basically permits or enables this sharing of the resources which means that the same resource can be shared in turn through the reduction of the cost.

Encapsulation which is that virtualization technology basically provides a one-stop solution, a complete solution giving a complete computing environment. Independence basically means that it runs independent. That means, virtual terminal runs independent of the underline hardware and this virtual terminals are portable. That means, that a user might be using the computational resources through a virtual terminal and that resource where it is not used, those resources map to the actual physical resources and those physical resources can be made available to another user.

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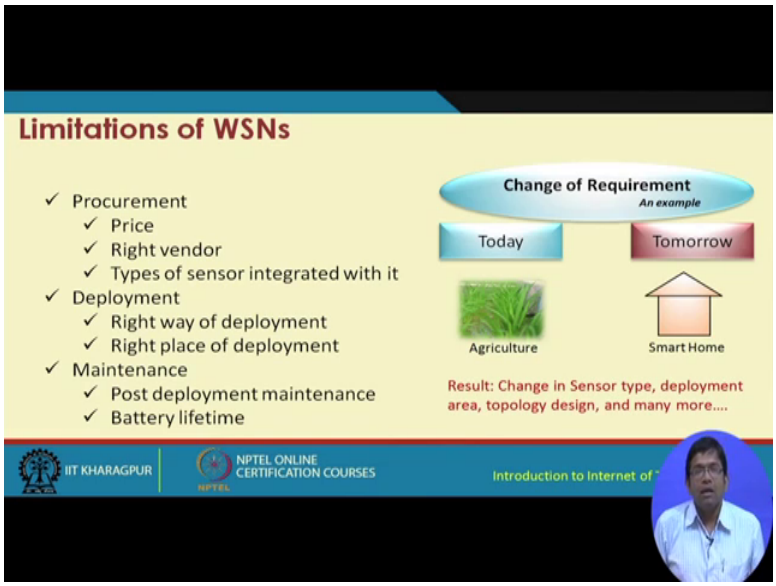

Now, the limitations of WSN networks; so, what we are talking about is the overall price of procurement is quite high. So, if we have some sensing needs, the only way to go about you know full filling those needs is to buy from the market sensors, sensor notes and sensor networks and then, go about deploying.

Then, the question is that we also have to be careful about procurement. We want to procure price, right vendor, types of sensors that are integrated to the platform. So, this is one limitation. Second limitation is about deployment. So, what is required is to have the right way of deployment and the right place of deployment. Right way means how it is going to be deployed and where it is going to be deployed and in terms of maintenance, most the deployment maintenance and battery life time are other limitations of sensor networks.

So, from an applications perspective, again what we see is when the application changes, the requirement also change. However, we will see that the sensor cloud technology can come to a rescue at least partially.

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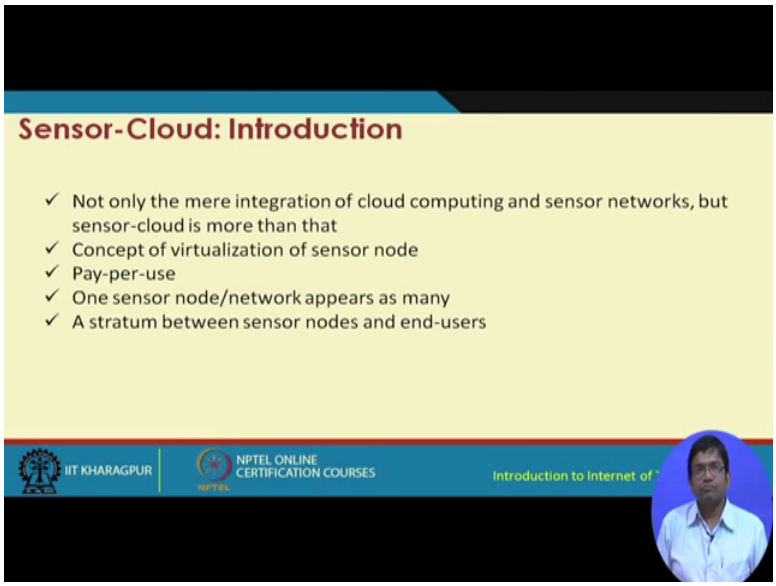

Through the introduction of sensor cloud, not only the mere integration, sensor cloud is not only the mere integration of cloud computing and sensor networks, but it is also about pay per use facility offering pay per use facility using the concepts of virtualization of the sensor node and introducing a layer between sensor node and the end user.

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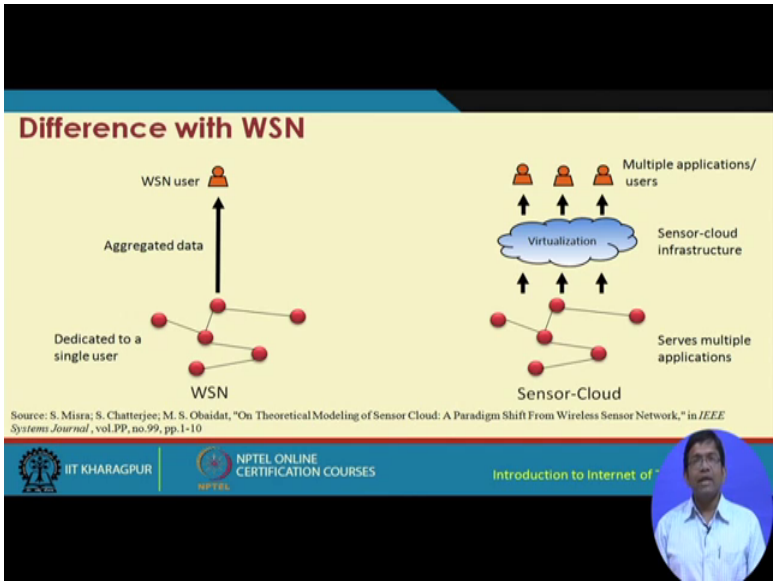

So, here is a side by side comparison of traditional sensor networks with sensor cloud. So, typically in the traditional sensor networks, we are talking about single user in sensor cloud. The benefits would be experienced more when we are talking about multiple

users. Then, in sensor networks, the data are aggregated and send to the sensor network user and in sensor cloud, the infrastructure basically takes care of it. The sensor cloud infrastructure basically is tasked to aggregate and send it forward and at the device level, these devices are dedicated to a single user in sensor networks and this can be improved by serving multiple applications by the different sensors. So, these are the different advantages of sensor cloud over sensor networks.

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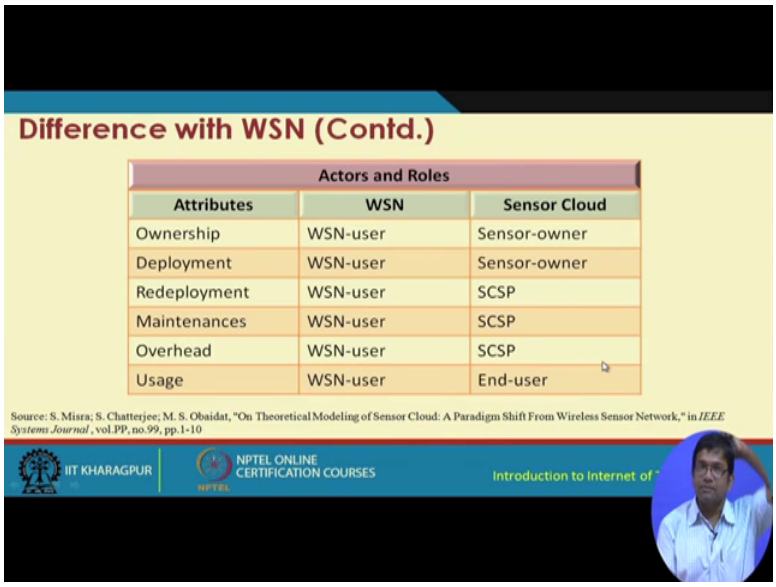

Now, in sensor cloud we are talking about not a single user or a single actor or a single role, but we are talking about different types of roles, different types of actors, we are talking about sensor owners who basically own the sensor, we are talking about SCSP sensor cloud service provider who may not be the owner, but is separate from the owner and is simply you know the service provider, sensor cloud service provider, the sensing service provider and when we have this maintenance with respect to maintenance, again the service provider does it overhead and usage. So, we see that we have diverse types of sensor cloud, we have diverse types of sensor cloud actors and in the traditional sensor network, we use to have only a single type of actor which is the WSN user.

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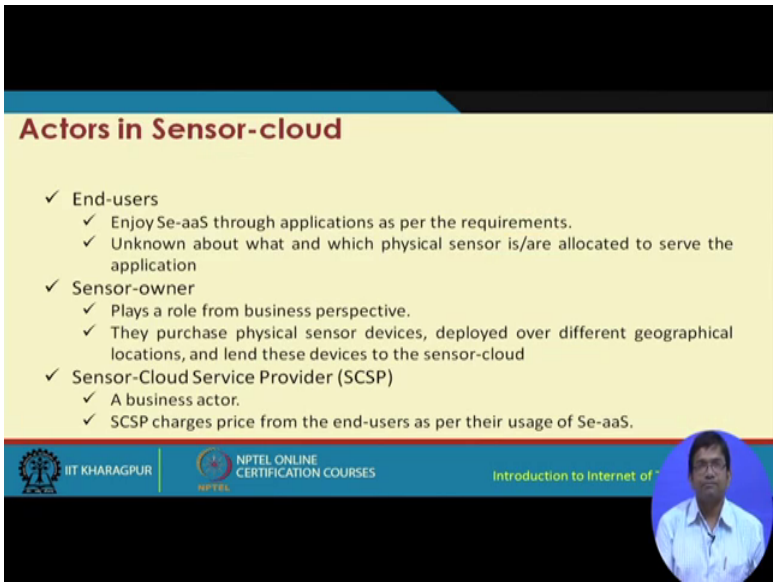

So, we have end users, we have sensor owner and the sensor cloud service provider, 3 different types of actors.

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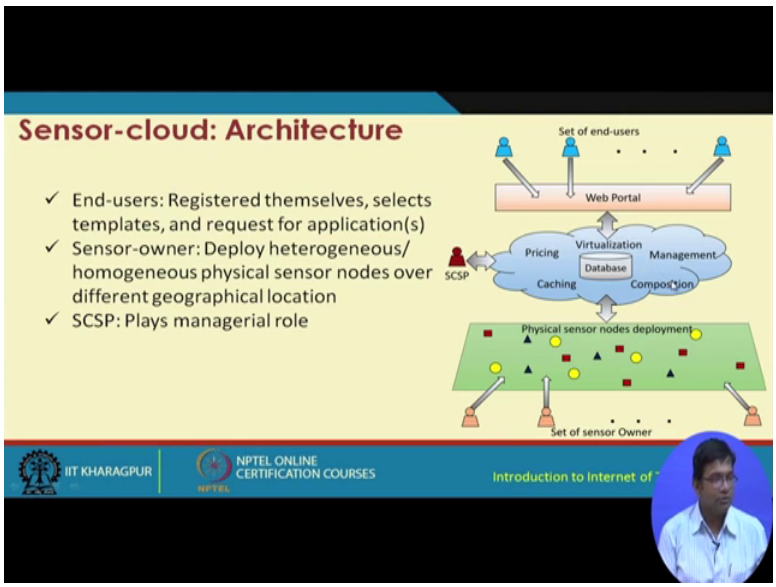

We additionally have end users and SCSP which is basically the sensor cloud service provider which primarily takes the managerial role. So, we see in this particular figure, we have a state of sensor owners, then we have through virtualization, pricing, caching composition management. We take care of servicing, the request from the SCSP and also,

sending the responses back and finally, the vertical communication over here with the weight portal.

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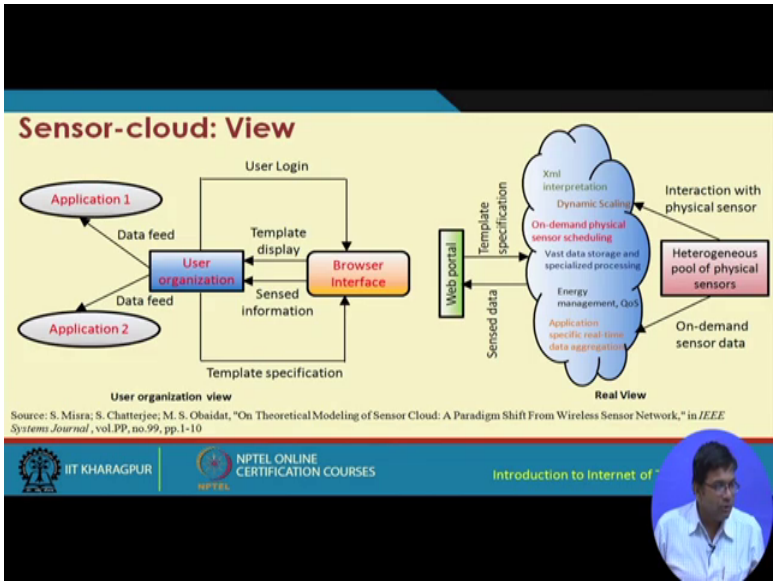

So, the left hand side figure basically shows that how the sensor cloud data is accessed through a browser interface. So, we have a browser interface and the templates as well as the sensed data are sent to the user organization, and this data from the user organization are basically fed as data feeds to diverse applications. On the other hand, on the right hand side figure, we see the real view of sensor cloud. So, here we see that there are only a few functionalities scaling, dynamic scaling, then on demand physical sensor scheduling, energy management, quality of service and application specific real time data aggregation.

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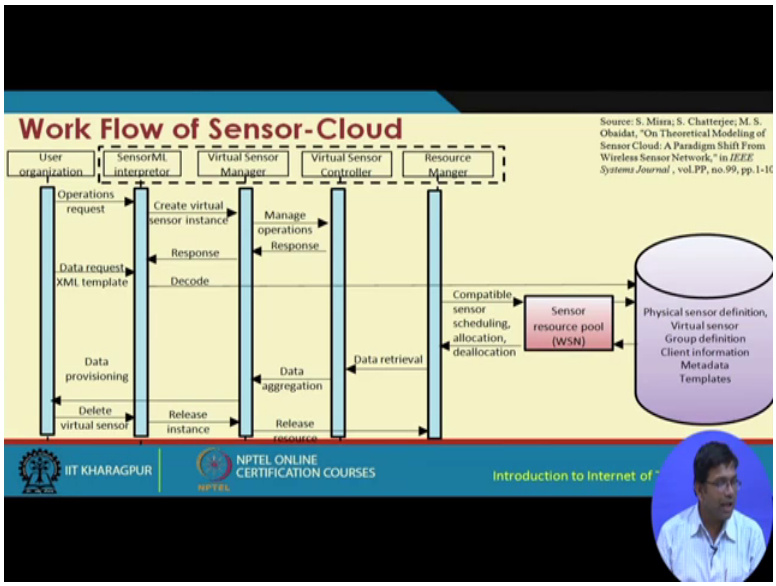

So, here is the flow diagram, the sequence diagram of sensor cloud. So, as we can see over here, the different actors or roles include user organization, Sensor ML Interpreter, Virtual Sensor Manager, Virtual Sensor Controller and Resource Manager. So, initially from the user organization, a operation request is sent to the sensor ML interpreter. This creates the virtual instance of the sensor, then this is basically sent to manage the controller to basically function on the controller. A response is received from the controller and the response is again transmitted forward further and then, this XML template is decoded like this. This continues. The data are stored in the sensor resource pool and different functionalities, such as service sensor, physical sensor, definition virtual sensor, group definition, client information, metadata and templates are used over here in this architecture.

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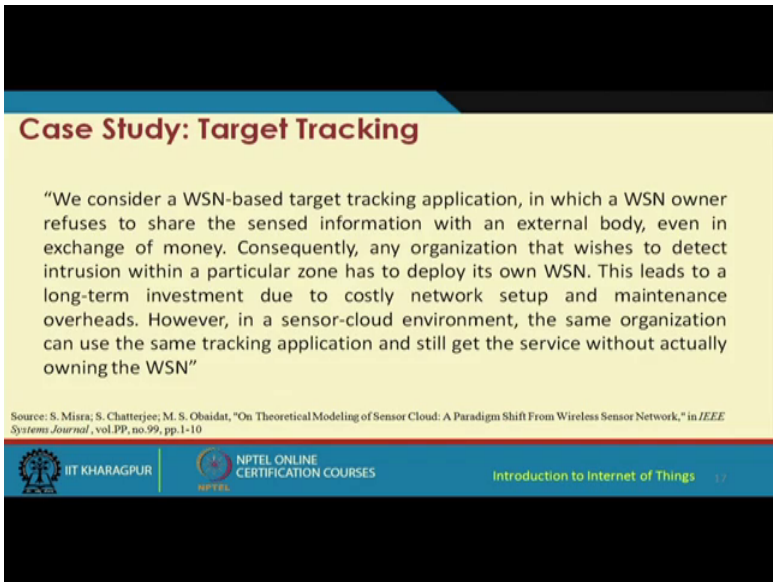

Let us now briefly consider a case study. So, we considered a sensor network based target tracking application in which a sensor network owner refuses to share the sensed information with an external body even in exchange of money. Consequently, any organization that wishes to detect the intrusion within a particular zone has to deploy its own senor network. This leads to the long term investment due to costly network setup and maintenance overheads. However, in a sensor cloud environment, the same organization can use the same written application and still get the service without actually owning the sensors. So, this is the whole advantage. You know we the users have sensing needs, but they do not have to really own the sensors in order to get access to the sensed information about the physical environment of operation.

So, with this we come to an end of the first part of the lecture on sensor cloud. The next lecture is going to be on the more advanced topics of sensor cloud. So, there we are going to learn about the different solutions as well about how to handle different solutions in sensor cloud.

Thank you.