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 - 44
IIoT Analytics and Data Management: Data Centre Networks

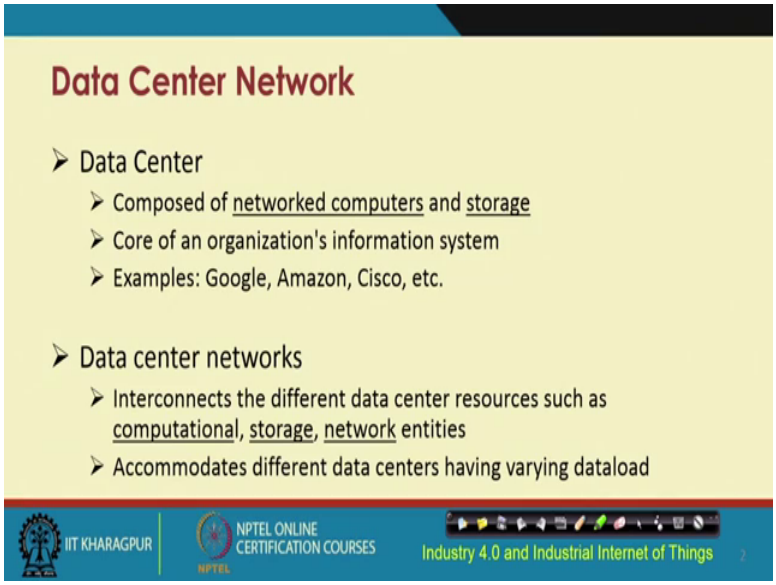
So, this particular lecture will focus on Data Centre Networks which is a very important concept a very important technology that is required for building large scale industrial internet of things. In the previous lectures I already highlighted the need for analytics, the data will have to be managed properly will have to be analysed thereafter. We have also seen that the data that we talked about in industry scale for IIoT scenarios. This kind of data has the properties of big data which have different different challenges of it is own. These are typically unstructured data having different characteristics of 3 V's, through 5 V's, through 7 V's and this is what we have gone through in detail in the previous lectures.

So, without getting into the characteristics of big data further; the question is that how do you handle the data? So, from an analytics point of view we have already seen that what are the different methodologies, what are the different tools and techniques that could be adopted in order to handle this kind of data, but where do you store the data, where do you process the data, that is very important. And if we are talking about large scale implementations we have to talk beyond single servers, low capacity servers, we have to talk about large scale not singular servers, but servers server firms, connection of different servers and so on. And this is known as the data centre network.

So, in a typical data centre what is a data centre? Data centre is basically a facility which has lot of high capacity computational facilities of all kinds high capacity, high performing computational systems having, high end processor, high end storage, high end memory and also high end computational or network facilities. So, everything has to be high end, but that gives you a data centre only, a single data centre is often not enough to cater to the requirements of most of the real life industrial IoT scenarios, in which case a network of data centres would be required. So, this is what we are going to talk about in this particular lecture.

So, we are going to try to connect to try to understand the requirement of data centre, data centre networks and how they bridge the gap between the origination of the data and the analysis of the data. So, analysis comes next, but then how do you handle the data that is coming so you have to store the data, you have to process the data in these data centres and the data centre networks and that is what we are going to talk about here.

(Refer Slide Time: 03:37)

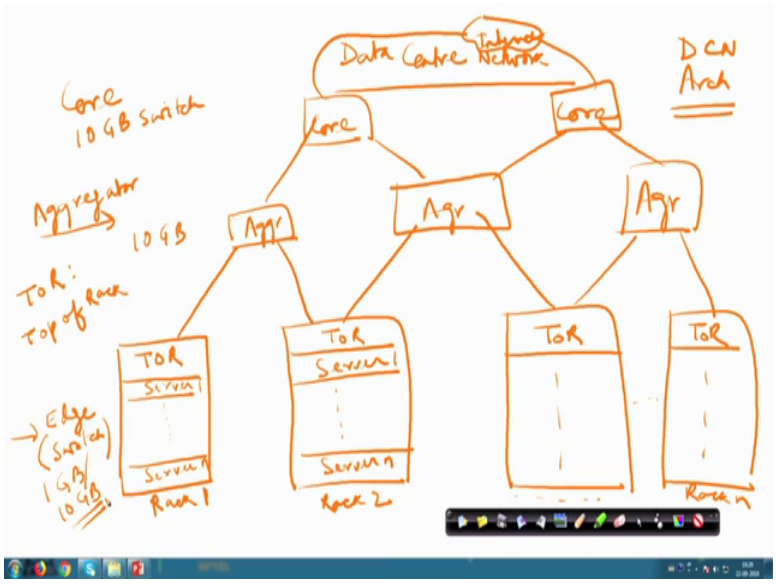


So, what is a data centre, as I was telling you earlier here we are talking about high end computational facility which are networked, networked computers, network servers high end servers which are networked together and also network storage. Most of these large scale enterprises their information systems are highly dependent on these data centres, it is these data centres as this name suggests which stores all this data.

Here there are different examples of data centres, data centres are quite widely available. Large scale companies such as Google, Amazon, Cisco they have their own data centres others rent the data centre facilities and so on. There are many other companies which also have their own data centres and maintaining the data centres is a different topic by itself right. So, we will not get into that, but let us try to understand beyond what is a data centre. So, here in this particular lecture we are not talking about a single data centre, we are talking about a network of data centre because that is what is more relevant and that is more used in the IIoT contexts.

So, in a data centre network basically we have all these different data centre resources involving computational, storage and network entities, which interconnect with one another. So, different data centres will be connected to one another and that will help in different ways including handling the varying data loads that are going to come over time. So, handling that kind of thing data loads and computational loads that are going to come over time that can be handled load balanced in a proper manner, if you have these network interconnected data centres. So, before we go any further let me just show you pictorially how a data centre looks like.

(Refer Slide Time: 05:44)



So, in a typical data centre so I am going to show you the architecture of a data centre; so, in a typical data centre we are talking about what in a typical data centre we are talking about the a single platform of different computational resources and servers etcetera etcetera, a network of servers not a network of servers, but a an interconnected you know platform of servers and so on. And, in the data centre network what we are talking about we are talking about these kind of data centres which are internet worked together right. So, let us talk about this data centre networks and how they look like schematically let us talk about that.

So, in a typical data centre we will have let us say that different servers: server 1, server 2 to let us say server n right. So, this is one edge device this is one edge device which could be like you know connected through some kind of a switch right. So, we are

talking about these kind of different servers which are placed together. So, this forms something known as a rack. So, let us say that this is rack 1 every rack has something known as a TOR, TOR switch it is basically a switch which will help these different individual servers in a rack to be interconnected together and also it has different other management and maintenance capabilities.

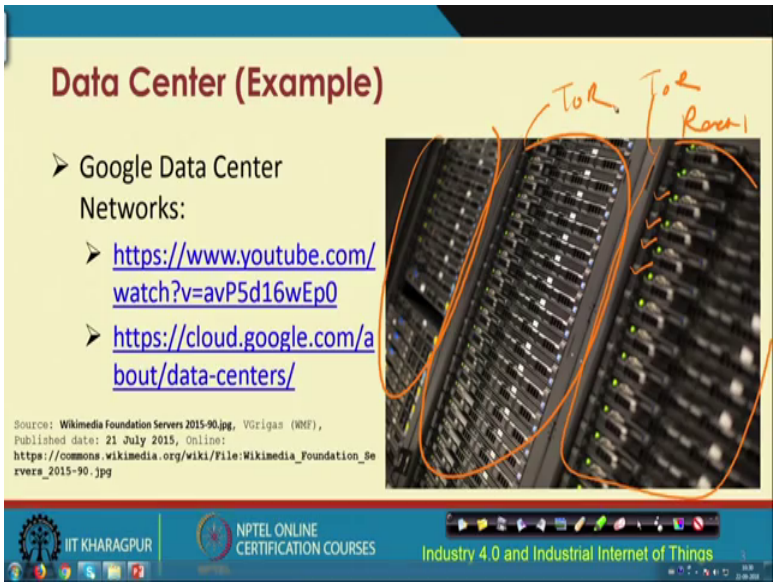
So, this is like a switch and this is known as TOR means Top of Rack. So, we have every rack having a switch and is controlled it controls basically number of different servers. So, we have one TOR, we have another rack with another TOR, server, server 1, server 2 to server n so, whatever be the n right. So, n may be equal to 5, 6, 10 or whatever depending on the type of rack, like this we will have other such edge devices in a data centre. So, we will have these different TORs and with different servers and this will be rack, rack n right, rack 2, rack 3, rack 4 and rack n. So, we will have all of these.

So, then what we are going to have is the next layer over here in a data centre network will be some kind of an aggregator, this aggregator is another switch which is going to aggregate these different these different rack devices this is another aggregator. So, this was the edge layer, this was the edge layer here you have the aggregator, layer, aggregator, aggregator layer and so, like this you have all of these different aggregators.

Then you have the core layer you have the core layer where you have core level switches this is core 1, core 2 and so on, these are all core level switches which basically again aggregates at a higher level. So, these core level switches are even more powerful switches and then you have these core switches connect to the internet connect to the internet.

So, this is basically typical data centre network, architecture how it is how it looks like. So, core basically will be something like 10 gigabit switches will support this core, here also you are going to have at the aggregator level also you can have something like 10 GB switches. Whereas, in the edge you may have lesser like 1 GB or it can be even 10 GB depending on the resources that are available and the particular requirements of the client. So, this is a typical data centre network how it looks like right.

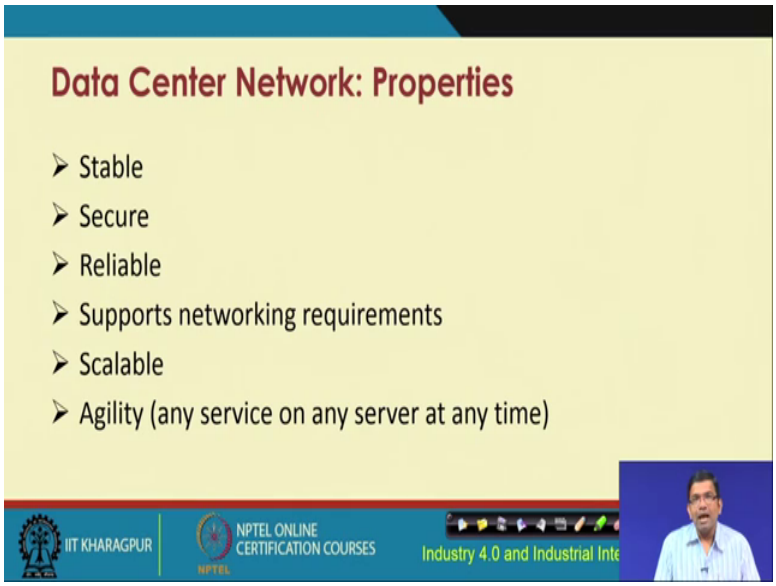
(Refer Slide Time: 11:02)



So, let us now go ahead and go further and look at the different characteristics of these data centres. So, on the right hand side what you see over here in this particular picture is and is a picture of a data centre network right. So, it is a network it is a data centre network picture and here as you will notice these are like different different servers, showing this different green lights these are these different servers that you have like this there are different servers. Each of these this is one rack this is one rack like that you have different other racks like this each rack has it is own TOR so, they have their own different TOR and so on right.

So, if you want to get little bit more idea about what is a data centre and how it looks like in real life etcetera etcetera, there are plenty of videos that are available if you search in the internet there are two different references that I have given you over here of a Google data centre how it looks like. So, this particular reference will help you to understand the Google data centre what is inside you know. So, they have their own videos I am not going to play it, but Google data centre and it is link is given in this particular slide.

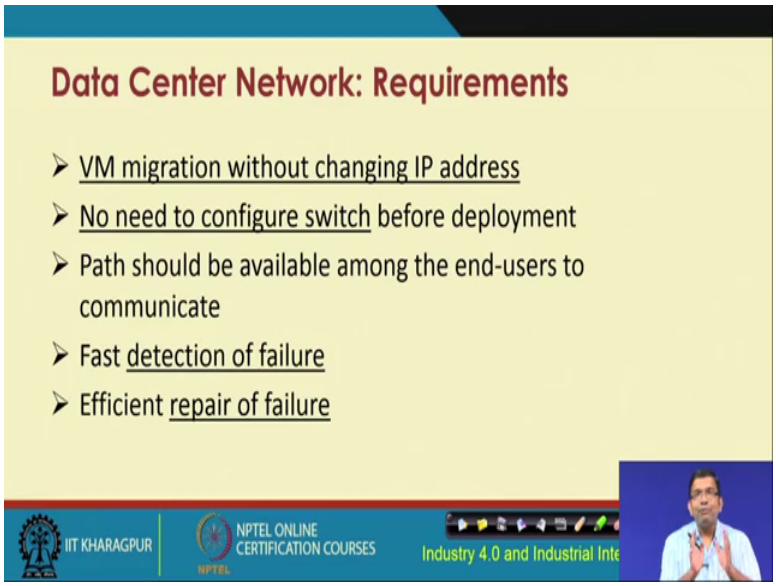
(Refer Slide Time: 12:24)



So, let us go further and try to have a look at the different properties of these data centre networks. I am not going to elaborate all of this because this is something that you will understand on your own. So, basically these are some of these desirable properties of the data centre networks a data centre network has to be stable, secure, reliable, should support different network requirements, should be scalable and should be agile.

So, out of all of these which are pretty much easily understood agility is something that I would like to briefly mention agility property means that a data centre networks should be able to provide any kind of service on any server at any time. This is known as the agility property of a DCN and the other properties as I said are easily understood and I do not need to elaborate further.

(Refer Slide Time: 13:13)



So, data centre networks have their own individual requirements VM migration without changing IP address should be supported this is very very important without changing the IP address, VM migration VM is the virtual machine. So, basically you know to the end user end user gets a virtual machine and is mapped to a particular physical machine ha having it is own separate IP. So, the end user has it is own virtual machine which has it is own IP.

So, even if the physical machine to which it connects to changes it is IP; that means it changes it is machine still to the end user this particular virtual machine and the corresponding IP address that it has got is not going to change. So, basically this IP address does not change in the case of the VM migration in the case of data centre networks. Second requirement is that there should not be any need to configure switch before deployment right. So, you deploy the servers first then you deploy the switches and thereafter you expand this particular thing further so you scale it up further. So, servers switch and you scale up further.

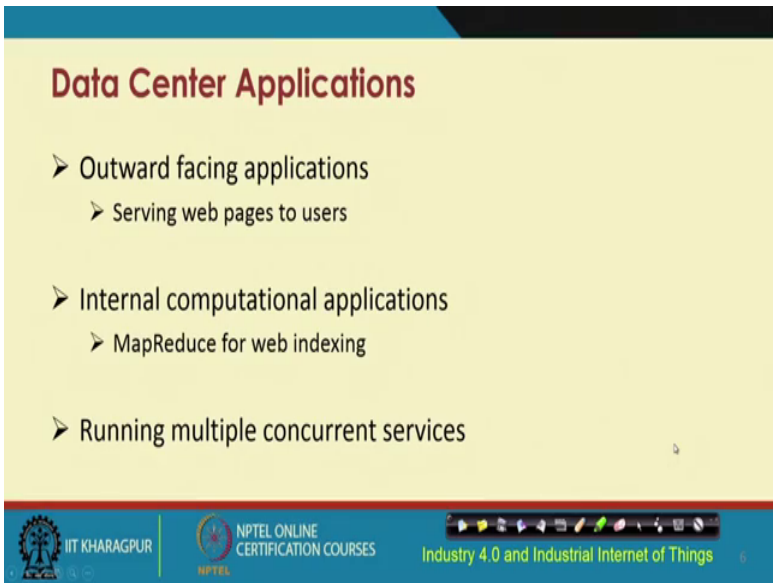
Say third requirement is that path should be available among the end users to communicate, end users should have different paths in the data centre network which will help them to communicate between different instances between different different users and so on. So, basically it has to be fully networked in add other words it is it has to be fully network this is very important fully network means then only you will be able

to have different different paths as per the dynamic requirements that are the that come up.

The third the fourth and the fifth properties are quite understood. So, you know data centre networks should be able to detect any kind of failure and should be if should offer efficient repair of failure. So, self healing behaviour; that means, that the data centre network if anything goes wrong should be able to heal on it is own should be able to repair the particular component that is there I mean whatever has failed or is going to fail should be repaired on it is own that is basically the self healing property of a data centre network.

A data centre network should be as much autonomous as possible and that is why all these different expectations and requirements are coming up. So, data centre network are huge you know you can abstract a data centre network like a huge computational resource which has huge processing, huge storage, huge computational resources, you know which can be offered to end users as per requirements and so on. And so they have to be yes fully autonomous they have to repair on their own and whenever there is some kind of failure the detection of the failure should also be done by this particular autonomous data centre network system.

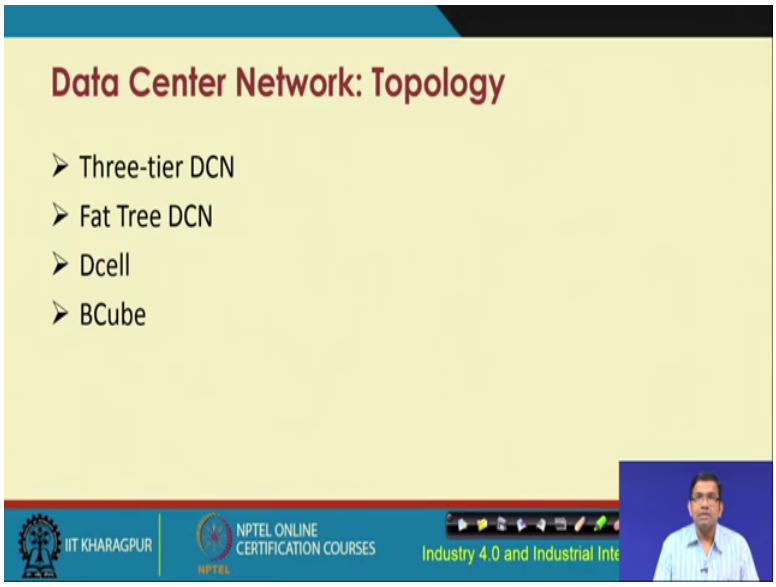
(Refer Slide Time: 16:20)



There are different applications of data centres, sub serving outward facing applications such as serving web pages to users, through internal computational applications such as

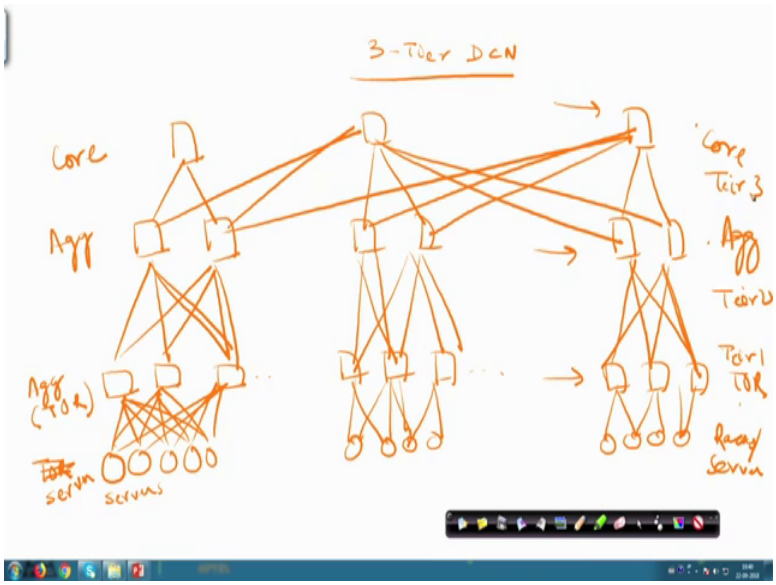
use of MapReduce for web indexing, through running multiple current concurrent services and many many more these are some of these different applications of data centre and data centre networks.

(Refer Slide Time: 16:48)



There are different topologies that are supported of a data centre network the common ones are the three- tier DCB that means, the three tier data centre network, the fat tree data centre network, the Dcell and the BCube these are the four different data centre network topologies that are available.

(Refer Slide Time: 17:15)



So, let me talk about some of these. So, we will start with the 3 tier, 3 tier DCN architecture. So, essentially at the outset when I discussed or when I explained the concept of a DCN the architecture that I had showed you consisting of different servers in a rack having TOR etcetera etcetera that is basically 3 tier architecture. So, you have the edge, you have the indicator layer and then you have the core, but let us look at it look at it from another viewpoint.

So, what we are going to have at the very bottom at the very bottom what we are going to have are let us say different different servers right different servers, these servers will be interconnected with each other to these devices known as the aggregator device. So, this becomes your aggregation layer, this becomes your TOR so, servers in a rack each rack having a TOR.

So, let us say that this is the TOR layer, this is the aggregation layer and then on the top you will have let us say this can be even like this and so on and then you have over here something like this becomes another level of aggregation or in other words let us do it like this that let us say that we have all these are like the different different individual racks with servers, this is we can call this aggregation layer had like a TOR layer kind of thing.

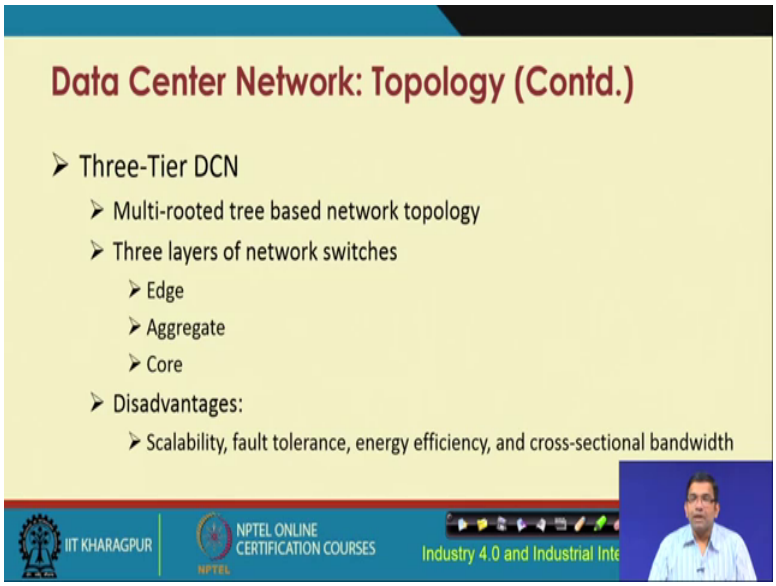
And this one we can think of another layer up which is the aggregation layer which has it is own aggregated switches and then for this one again we will have this core this is the core right. So, exactly I mean this is something that I had shown you in the at the outset when I talked about the data centre network when I explained to you the architecture typical architecture of a data centre network.

Now you can basically what you can do you can have something like this repeated once again right. So, this becomes one data centre, this becomes another data centre and so on so, you can have another like this. So, this is your to TOR and these are your different servers. So, then you have like this your aggregator and then you have your core this is your core. So, this can be like this, this can be like this, right and similarly over here as well.

The beauty of a 3 tier DCN would be to have connections of this sort right you could also have something like this and so on. So, this would be possible. So, you are going to have a huge data centre network with racks and servers at the very bottom layer, then you

have this tor layer, then you have this aggregation layer and then you have this core layer. So, tor aggregation and core these are the 3 different tiers so this becomes your tier 1, tier 2 and tier 3 so, this is how a 3 tier DCN looks like. So, let us go back once again and have a look at the properties of a 3 tier DCN.

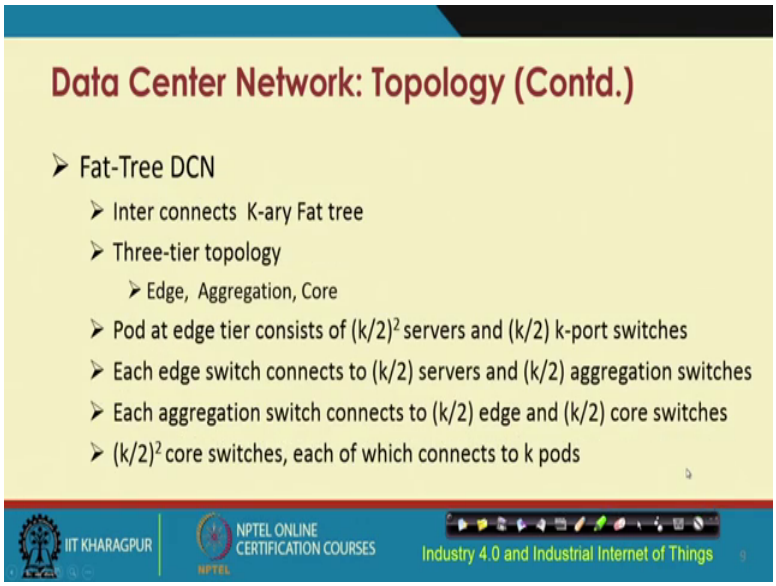
(Refer Slide Time: 21:53)



So, a 3 tier DCN as we have seen has a tree based network topology and there are multiple roots in the tree topology. So, multiple trees with multiple roots networked together this is your 3 tier DCN. There are these different layers of network switches core aggregate and edge and then there are different disadvantages that are also listed over here, disadvantages of scalability, fault tolerance, energy efficiency, and cross sectional bandwidth, these are some of these different limitations or the disadvantages of the 3 tier DCN.

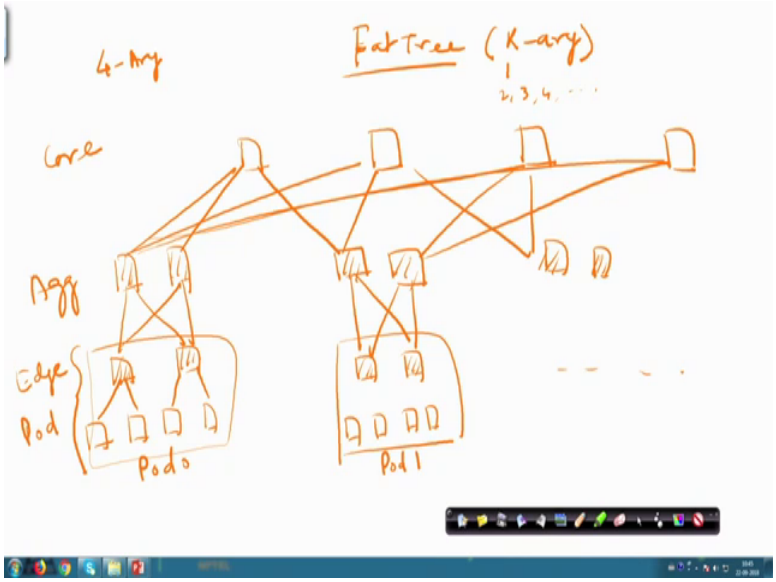
So, we are not going to elaborate on this different disadvantages rather let us use our time to understand the different other network topologies that are supported in the DCN.

(Refer Slide Time: 22:46)



So, the next one that we are going to go through is the fat - tree DCN. So, let us try to understand this particular fat - tree DCN architecture.

(Refer Slide Time: 23:01)



So, we have in a Fat Tree we have fat tree DCN architecture very quickly I am going to show you what it has. So, it has you know you can have a K- ary, K ary tree architecture in fat tree architecture. So, K can be any integer it could be 2, 3, 4, whatever. So, you know K- ary so it could be 2 ary, 3 ary, 4 ary and so on. So, I am going to show you an example of a 4 ary fat tree architecture of DCN.

So, in a 4 ary fat tree architecture it will be something like this. So, there are concepts of something known as pods so, there are different pods. So, let us say that you have these different servers or computers or whatever. So, these are going to be connected to some switches let us say that these are your switches, these switches together with your end devices these computers etcetera this one is known as a pod this is known as a pod. So, this entire thing over here this is your pod this is one pod.

So, this pod will again be connected to some other switches in this manner and again this becomes your aggregation layer, this becomes your edge layer and finally, you will have also the core layer like before where these are going to connect. So, you are going to have another you are going to have another one another pod like this. So, you will have another pod and these are your server so these are the, these are, these are the switches and these are your different servers or computers etcetera.

So, you will have another pod, pod 1. So, pod 1 also like before is going to be connected to other switches in this manner right and again it also will be connected to these core so, this is your core so, like this is going to continue. Now what is going to happen is, you will have each of these pods each of these pods and the corresponding switches to which it connects, this will be let us take up this one, this one will be connected to this core switch, this will be connected to this core switch. Again this one is going to be connected to this one it will be connected to this one and so on and so forth this is going to happen

And so, what this pod tree or the K- ary or the 4 ary tree does is that it ensures that every switch in this aggression layer is connected to at least one core in all of these so, from here to here, again here to here, again here to here and so on. So, it is very similar to your 3 tier architecture, but here there are certain properties. So, what are these different properties is what we are going to look at.

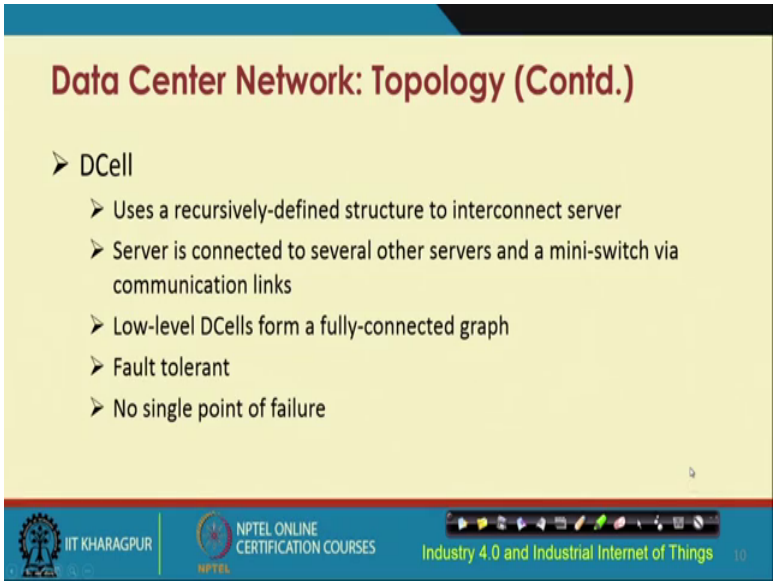
So, in the fat tree DCN we have a K- ary fat tree, there are 3 tiers like before which are basically the edge tier, the aggregation tier and the core tier. So, the pod which I explained to you earlier at the edge tier consists of k by 2 square servers. So, k equal to 4 so, 4 by 2 is 2, 2 square servers; that means, the 4 servers that I had shown you at each of these different pods and correspondingly there are going to be 4 divided by 2; that means, 2 to 4 port switches are going to be there. So, each of these edge switches are going to connect to k by 2 servers which are basically the 2 servers that I had shown you

and k by 2; that means, 4 by 2 equal to 2 aggregation switches. So, 2 servers, 1 below and 2 aggregation switches above.

Each aggregation switch in turn will be connecting to 2 edge switches and 2 core switches and that is what we have seen in the previous diagram that I had shown you and k by 2 that means, 2 square core switches; that means, 4 core switches each of which will connect to each of these different key pods. So, this is basically how the concept of the fat tree DCN looks like it is centred on the concept of this pods and these properties that I just enumerated just now these are the properties that will have to be held for a fat tree architecture which is again a tree based architecture having these three different tiers etcetera. But, there are certain specific constraints that I just mentioned this enumeration of constants makes this particular fat tree architecture a specific 3 type 3 tier architecture.

So, there are different advantages and disadvantages of each of these different architectures.

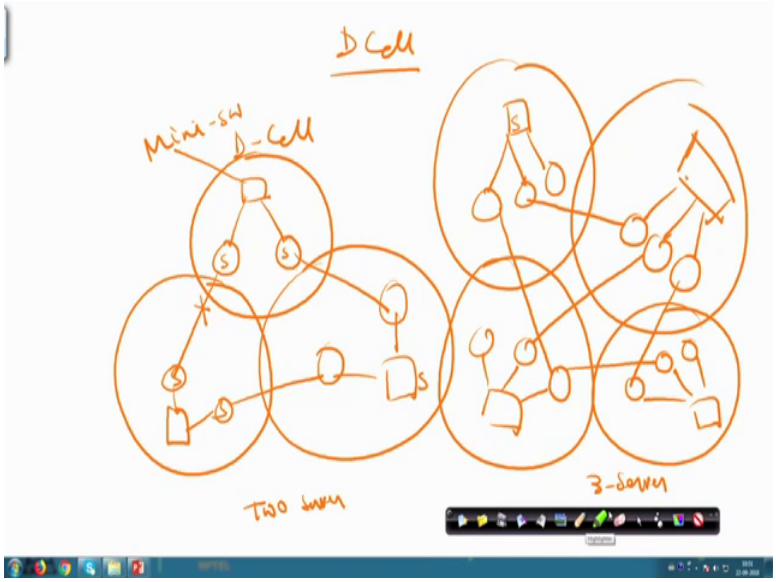
(Refer Slide Time: 28:59)



So, let us look further there are there is this another architecture which is known as the D cell architecture which uses a recursively defined structure to interconnect the server. The server is interconnected to several other servers and a mini switch via communication links and a low level DCN sorry a low level D cell will form a fully connected graph and there would not be any single point of failure in this kind of

architecture this is the advantage and also this kind of architecture is fault tolerant. So, let us now look at this D cell architecture how it looks like.

(Refer Slide Time: 29:34)



This D cell architecture in this D cell architecture as we will see in this D cell architecture we will have the concept of something known as the D cell we will have the concept of the D cell. So, in a D cell you have something called the mini switch mini switch and every mini switch has every mini switch has a server, this is a server, this is another server.

Every server in a D cell will connect to another D cell server, this is another server, this will be another server which again will be connected by a mini switch, this is another mini switch and this mini switch this mini switch basically connects to two different servers, again you are going to have something very similar you are going to have a mini switch with two different servers like this and these again will be like this and this is how basically this D cell architecture will look like if we are talking about 2 servers only 2 servers.

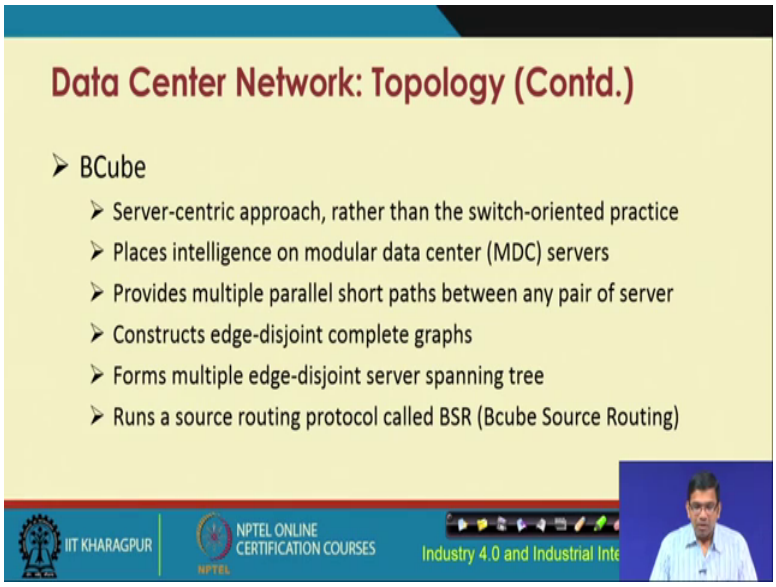
You can extend this particular concept is as you can see over here that this is more fault tolerant architecture let us say that if this link breaks and so, you will find another path between these servers through which the data can be routed so, this is a fault tolerant architecture. So, let us say that you take the case of a 3 server, 3 server architecture so,

here basically what you are going to have is one mini switch with three different servers 3 different servers this is your mini switch and 3 different servers to which it connects.

Then you are going to have similarly another mini switch with three different servers like this. So, this is one D cell this is another D cell, you can have another D cell with another mini switch and three different servers in the likewise manner. So, this will be your another D cell and you will have a mini switch with 3 different servers like this forming another D cell. So, essentially what is going to happen is one surfer from here is going to connect to another server over here, this server over here may connect to this one over here, this one may connect to this one over here, this one may connect to this one and this one may connect to this one and like this, this will continue. So, as you can see over here this is again a pretty elegant fault tolerant architecture of a DCN which is known as the D cell architecture.

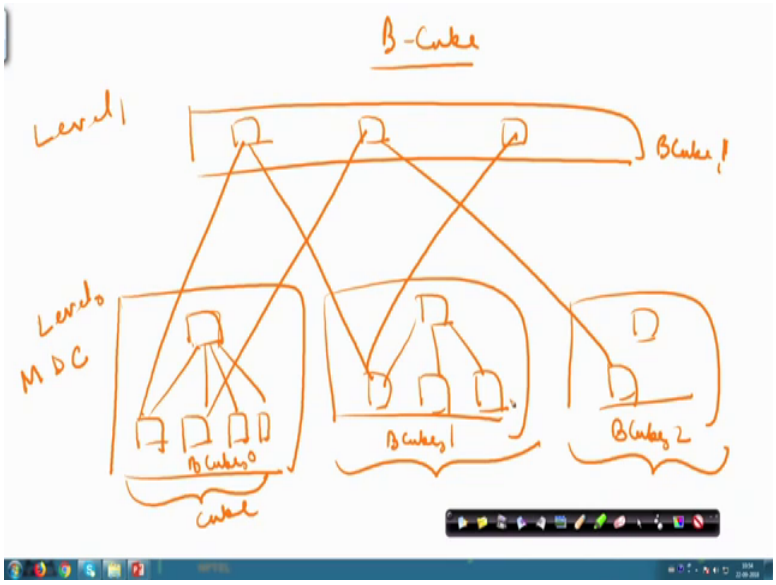
So, this D cell architecture has different different properties. So, these are some of these different properties that I am going to highlight now. So, a D cell basically uses a recursively defined structure to interconnect the server, where the server is interconnected to several other servers and a mini switch via different communication links and the low level D cells form a fully connected graph and there are these fault tolerant architecture that we have seen. So, these are once again these different properties of a D cell DCN architecture.

(Refer Slide Time: 33:08)



Let us look at the last one which is known as the B cube architecture.

(Refer Slide Time: 33:17)



Here in the B cube architecture I will show you that we have B cube architecture, in a B cube architecture you have the concepts of something known as the modular data centre MDC modular data centre. So, this modular data centre has different B cubes each of let us say that these are the different B cubes and this is one cube, like that you can have other cubes and so on. So, in the B cube architecture you have all this different switches and these will be connected to another level of B cube the let us say that this is your B cube 0.

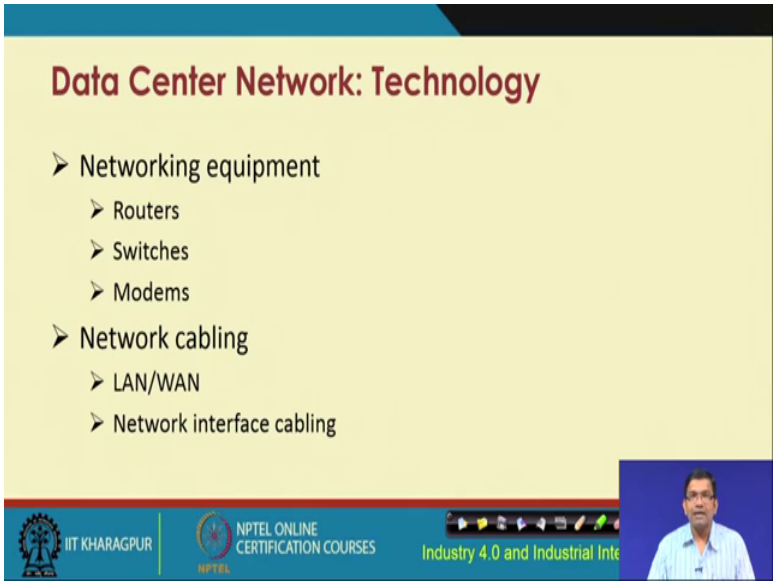
This will be let us say your B cube 0 1, this we let us say that this is 0 0, this is 0 1 B cube 0 2 and so on. So, you will have another B cube, another B cube and so on and this one will become your b cube 1 and you can even have 1 1 right. So, these are your different different switches at this particular level this becomes your level 1, this becomes your level 0 right.

So, these essentially from this mini switches they are not going to connect to the level 1, but from here these are going to connect right. So, this is how it is going to happen over here not to this one not to this one. So, only it is going to connect to these this is how your B cube architecture grossly looks like.

So, we proceed further and we try to have a look at the different properties of the B cube architecture it is a server centric approach rather than a switch centric practice and it places the intelligence on the modular data centre that I just showed you and it is corresponding servers provides multiple parallel short paths between any pair of servers. Constructs edge - disjoint complete graphs and forms multiple edge disjoint server spanning tree.

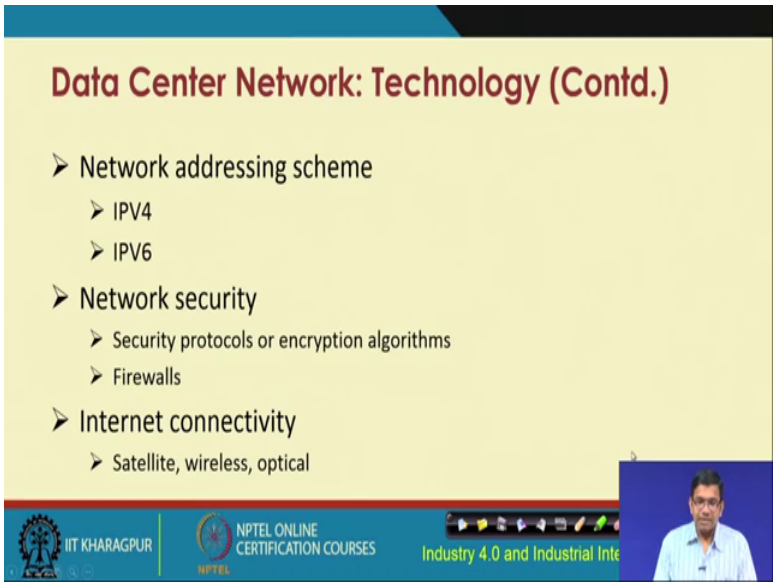
So, there is a specific type of routing protocol that is that supports these B cubes which is known as the BSR the B cube source routing protocol which basically helps in routing in this particular B cube architecture. These are some of these highlights of these properties of the B cube architecture that I had drawn and showed you how they look like.

(Refer Slide Time: 36:03)



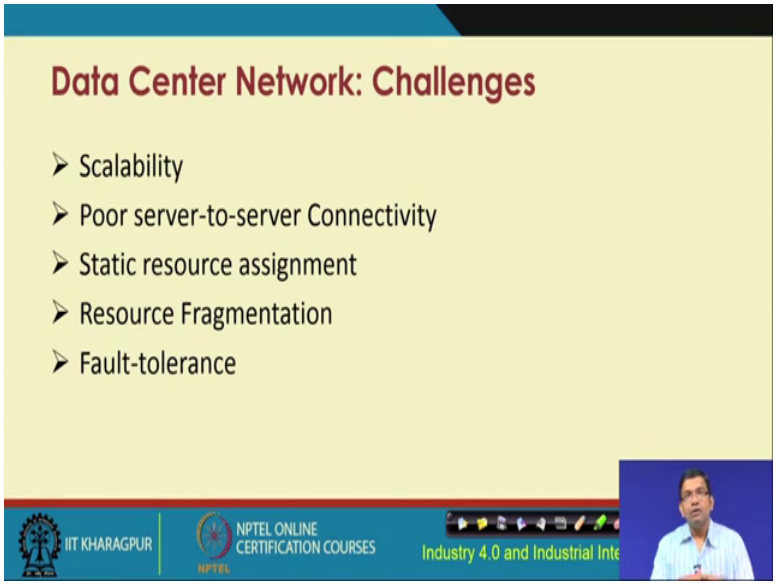
So, let us now quickly very quickly let us go through the different other requirements. So, a data centre network requires different networking equipment such as routers, switches, modems, supports cabling of LANs, WANs, network interface cabling and so on.

(Refer Slide Time: 36:20)



Has addressing schemes supported IP addressing scheme supported by IPV 4, IPV 6 or whatever is required these are the only 2 options at present if you are talking about the internet. So, IPV 4 or IPV 6 based network addressing scheme or supported network security protocols, algorithms, firewalls etcetera are already in place you in these data centre networks, internet connectivity is offered through optical wireless or satellite can communication.

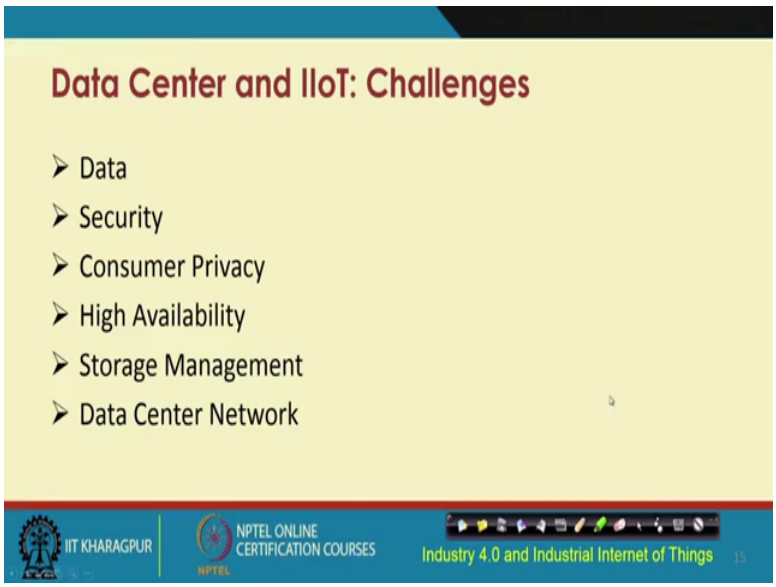
(Refer Slide Time: 36:50)



Different challenges of data centre networks include scalability challenges. So, if you want to scale up the you know the issues are not very trivial you have to deal with large number of different things and poor server- to - server connectivity can be a challenge because it heavily bases on fast connectivity between these different distributed servers and distributed D cells cubes and racks and so on um.

Static resource assignment is a challenge so dynamically you have to assign these different resources as per the availability and the requirements that are coming from these clients. Resource fragmentation some part of the resource lies in one location another part of the resource lies in another location so the distributed resources will have to be handled properly. Fault tolerance is a challenge so, if some part of the network goes down the system as a whole will have to be able to detect that and will have to recover from it.

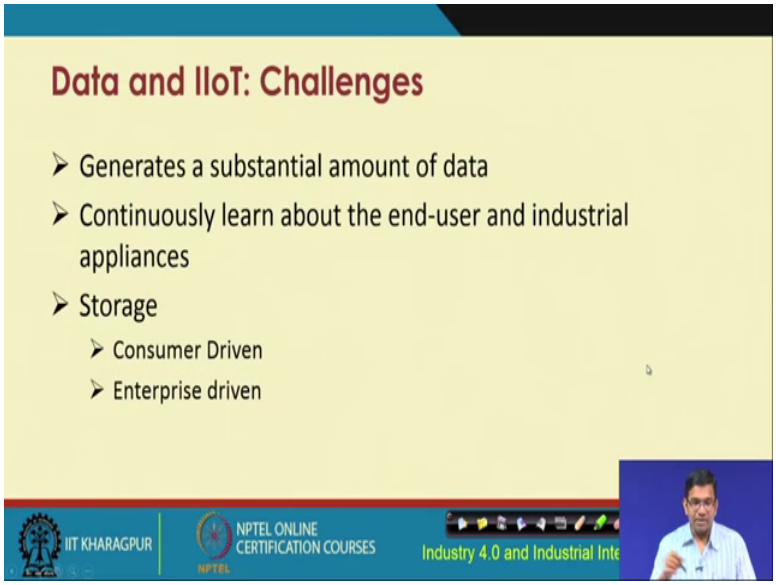
(Refer Slide Time: 37:46)



Other challenges are with respect to the data centre connecting to the IIoT, IIoT is data centric, security issues are there, privacy issues are there, availability is very important if we are talking about industrial machinery fitted with different different sensors, actuators, and so on. High availability of this machinery means that high availability of these different sensors which produce data. So, availability of this data at any time based on the different requirements is very important. Storage of the data is important and

building of the data centre network for catering to the requirements of IIoT is very important and is challenging.

(Refer Slide Time: 38:27)

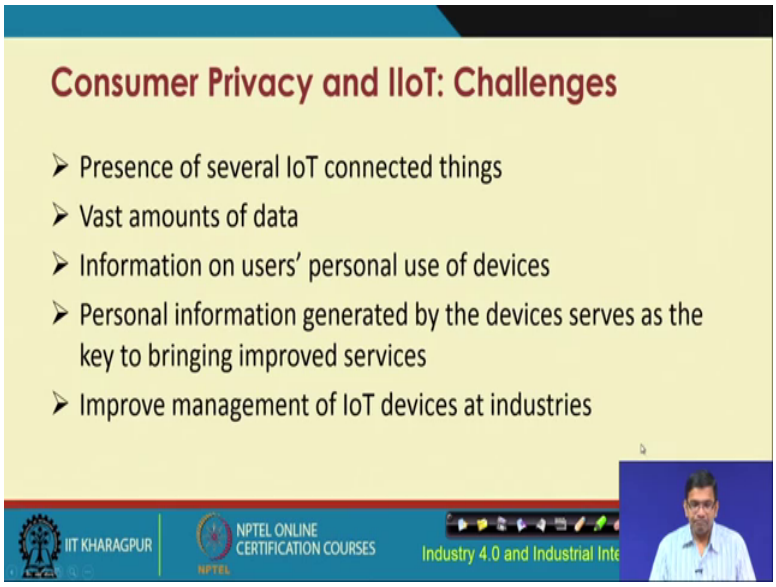


In the context of data IIoT generates lot of data substantial amount of data which will have to be continue continuously learnt from the end user is obtained from the end user and will have to be made sense out of using different algorithms, intelligent algorithms, machine learning algorithms and so on and different challenges with respect to the storage of this particular data. The storage could be consumer driven or based on the requirements of the enterprise so different different data and storage requirements and the challenges are there when we are talking about data centre with IIoT.

(Refer Slide Time: 39:07)

Security issues I do not need to elaborate further security issues are there in any network if you are talking about a data centre network and that too with resource constrain IIoT connections here security is a huge issue and will have to be dealt with adequately.

(Refer Slide Time: 39:22)



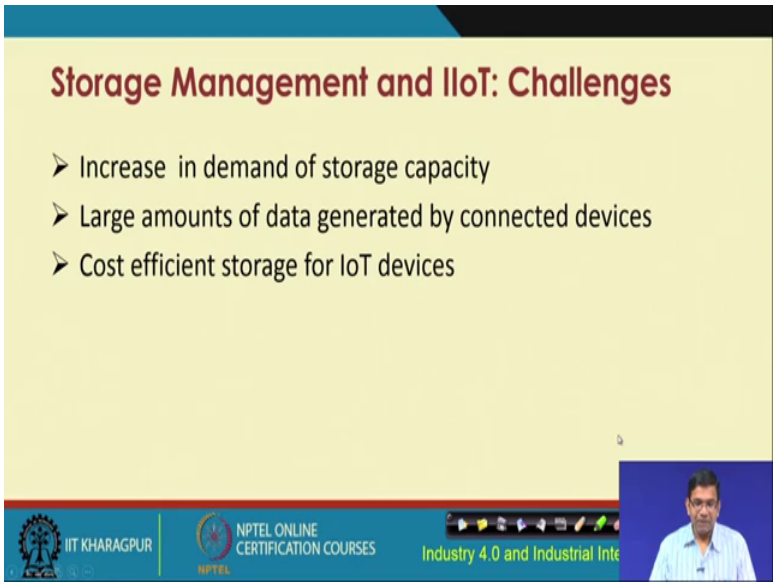
Privacy issues are paramount in IIoT data where this data going through and where this data is going and through which different parts of the network it is going through depending on that because, this data sometimes will have sensitive data the privacy of

this data are very important. So, privacy of the data privacy protection in the context of IIoT and it is interconnectivity with DCN is an important challenge.

(Refer Slide Time: 39:48)

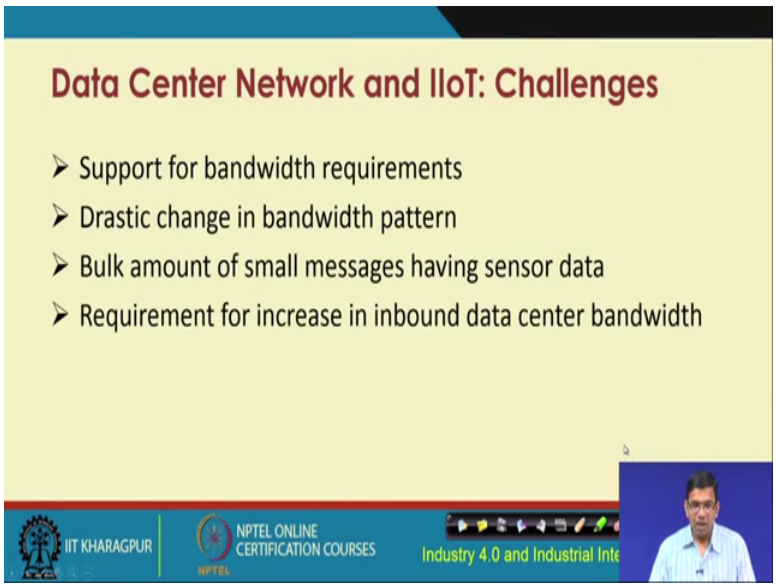
Availability of the data high availability of the data with IIoT will make the connectivity of IIoT with DCN very important, taking care of different requirements such as connectivity of in innumerable number of devices which are interconnected. Then increase in the complexity of security management, impacting impacts due to security challenges, real time business processes, personal data safety, etcetera are different challenges with respect to high availability and IIoT in the context of DCN.

(Refer Slide Time: 40:22)



Storage management is important here we are talking about large volumes of data coming from IIoT, how do you store the data in a cost efficient manner is very important.

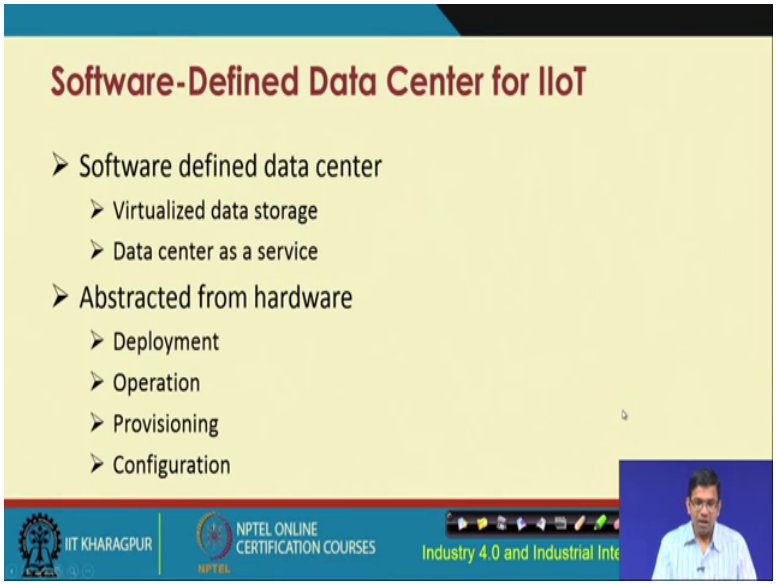
(Refer Slide Time: 40:33)



So, data centre networks support different bandwidth requirements are there, there could be because it is a network you know there could be dynamic changes in the bandwidth pattern availability of their bandwidth and so on. So, correspondingly the performance of the data centre network will also change and if we are talking about IIoT, IIoT is a fully distributed system and these different bandwidth requirements coming from the different

parts of the system might also change over time so, catering to this particular requirements are very important.

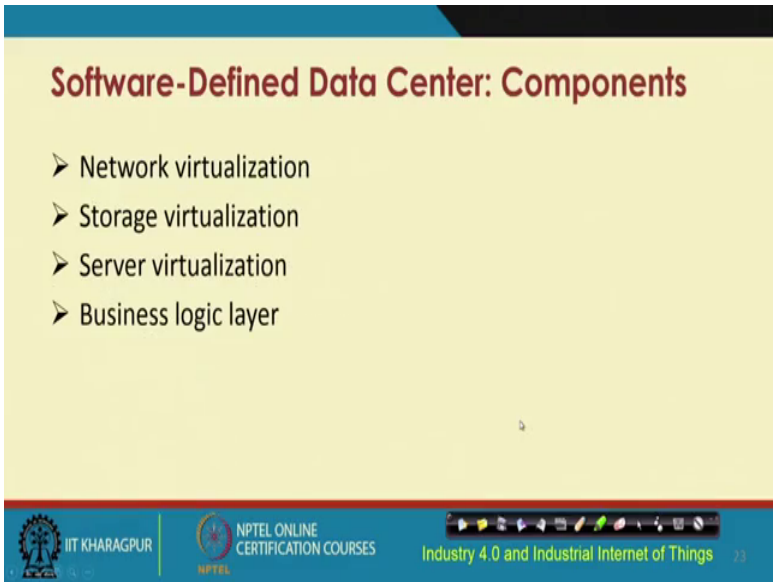
(Refer Slide Time: 41:05)



So, lastly I am going to talk about the software defined data centre network, in a software defined data centre network we are talking about virtualized data centres which are basically the physical instances beyond the sorry the virtualized instances the logical instances beyond the physical ones. And, how do you interconnect this virtualized instances and cater to the specific requirements is what software defined data centre talks about.

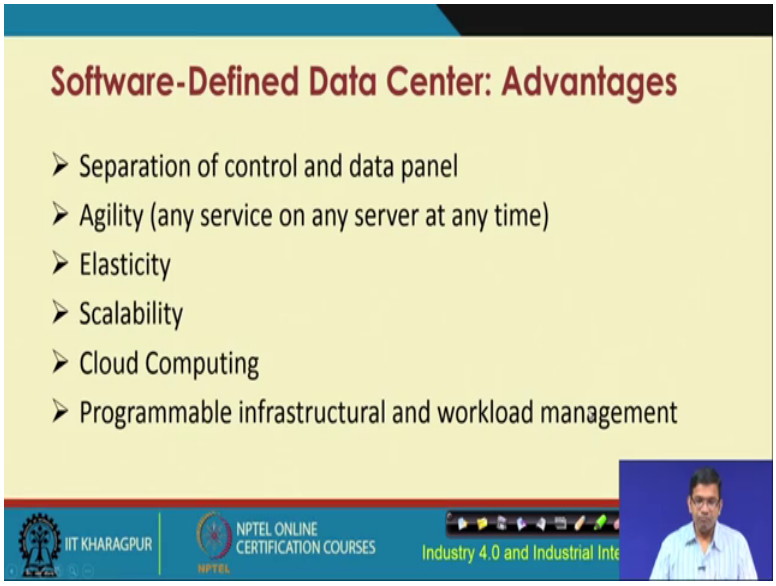
So, in a software defined network essentially we are talking about separating out the control plane from the data plane. So, data plane and the control plane traditionally were put together in a software defined architecture, a software defined data centre network we are talking about separating out the control plane from the data plane. So, that you can effect effectively efficiently in a centralized manner depending on the dynamic requirements changes in the requirements and so on, you can change the execution of different jobs in the different parts of the data centre.

(Refer Slide Time: 42:05)



So, network what network virtualization, storage virtualization, server virtualization and so on these are core to building software defined data centres and taking care of the business requirements business logic these also will have to be taken care of adequately. So, there has to be a separate business logic layer, in addition to the network virtualization layer, the storage virtualization layer and the server virtualization layer in a software defined data centre.

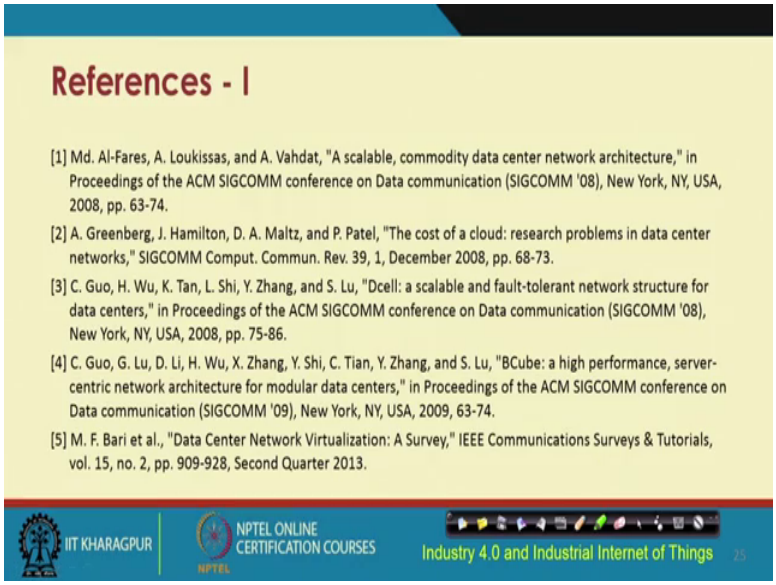
(Refer Slide Time: 42:31)



So, it is very important to separate the control and data planes and to cater to the requirements of elasticity; that means, dynamically depending on the increase in the requirements, scalability of the requirements and so on, the resources will also be elastically a elastically proficient and made available to the end users. So, agility is a very important property and this is something that I talked about in the context of get the property of a data centre.

In general data centre network in general and for software data centre as well agility is very important and should be supported. So, catering to agility requirements with respect to supporting any kind of service on any server at any time is a very important requirement of any data centre network and definitely for software defined data centre.

(Refer Slide Time: 43:18)



So, these are some of these different differences of data centre networks I would encourage you if you are interested to go through at least some of these different references to this basically this particular lecture has given you an overview of data centre networks and how it positions itself with respect to IIoT, what are the different challenges of data centre networks particularly when you are talking about in the context of IIoT and so on is what we have discussed.

We have also discussed in detail the different different architectures that are available for data centre network and how you are going to use them. So, this particular lecture focused on getting some overview of data centre networks and their corresponding

architectures and challenges and so on. And, this we have to keep in mind that this particular you know high level understanding of data centre networks will help us to also build IIoT systems holistically for scattering to the specific requirements of the industry segment that, this particular IIoT that you are building the system that you are building where is going to support.

Thank you.