Communication Networks
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Module - 01
Introduction to Communication Network
Lecture - 04
Circuit Switching Network

Alright. So, far, I think we have covered a little bit about Packet Switch Networks and Circuit Switch Networks, and we have seen the difference, the basic difference between them. So, we have already understood that a packet switch network basically is where we do hop-by-hop switching. So, it is the switching is done means there is something some information being carried along with the packet, and with that, we do switching basically.

And circuit switch network is where we actually first establish the circuit, and through that, we will be actually flowing the data stream. So, this is the basic difference. And the technology that is being used for the circuit switch network is basically statistics sorry, the time division multiplexing, and in packet switch network its statistical multiplexing. So, we have also seen the basic difference between these two, and we have seen the relative advantage, and disadvantages of these two things.

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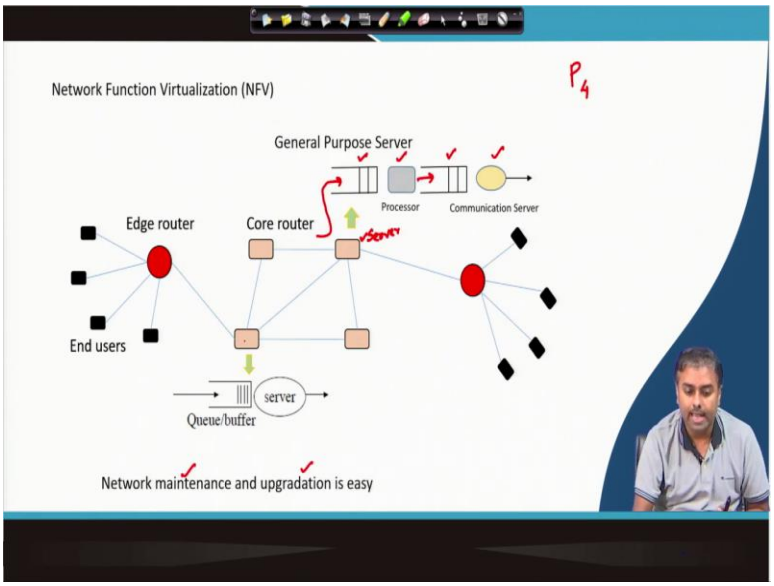

Now, what is happening now, we are probably seeing a new era of networking now. So, from packet switch network has become a little bit more popular compared to the circuit switch network these days. So, IP networking is the most important probably technology through which data is being carried out. So, it is all packet switch network now. And circuit switch network which is the telephony probably that is getting shrinked over the years.

But what now we are seeing is probably the new kind of applications, like augmented reality, and virtual reality, so automotive vehicles for them, whatever traffic they are generating. So, these kinds of or even industrial automation industry 4.0 massive machine-to-machine communication.

So, these kinds of applications, they are really demanding a different kind of quality of experience from the network. So, that means what kind of quality we want to demand from the network is becoming really challenging.

And packet switch network, we will discuss in detail, which is not capable of handling those challenges so, because there is a shift in the traffic. So, we are now also seeing that people or network engineers are coming up with a new era of switching. So, that is generally called means virtual circuit switching. We will talk about that. This is not a very new concept. This has been there over the last 30 years, but it never become popular probably.

And now it is with a revised definition it is actually coming back. So, we will try to understand this basic methodology of virtual circuit switching. But before introducing virtual circuit switching, let us try to see there is another shift, paradigm shift that is happening in the networking.

So, what people are saying is that means these days, you might have seen that let us say, different kinds of centralized processing like cloud service or they are calling it cloudlet mobile edge computing or fog computing, these kinds of processing services, centralized processing services are becoming popular.

So, it is like people are giving processors as a service. So, they store or keep a lot of processing in some centralized location, and then users can actually lend processing. So, this is something which is becoming popular these days. You are seeing all these Google drives and all these things. These are actually part of that. So, and you people are also taking this cloud storage, cloud processing, so all these things.

So, once this has become popular, now, from the networking perspective, people are also thinking that why not leverage this. So, that means the network also will take processing as a service.

So, for networking, whatever processing needs to be done, earlier it use to be in a particular dedicated box, which is called network equipment, or they were actually some intelligent switch or router. So, they use to do all these processing. So, it was it was not general-purpose; it was a kind of specialized architecture that we use to do all the network-related processing.

So, now what networking people are thinking that why not take the leverage of these processors which are distributed all over the world. So, take them and then try to do all network processing over there. What is the advantage of that? So, let us try to see what kind of extra benefit we will be getting. So, the extra benefit is now no longer we have to actually generate some specific networking equipment.

So that we do not have to do. What will we do? We will actually borrow some all leverage, some of these processing units, and then we put all our networking means protocols or all the networking logic into those processors as some process, dedicated process.

So, this is called, as I have mentioned over here, this is called actually network function virtualization. So, you can see over here. It is called network function virtualization. So, you are actually virtualizing all network functions, or you in a way softwarizing all the network functionalities.

What is the advantage of that? As I have told the first advantage is you do not, means you do not need any longer, any kind of very specific specialized network equipment. So, that is one of the advantages it has. The second advantage that is there is that any time you want to actually upgrade the network, earlier what people use to do?

So, they use to take the infrastructure out and then put in new infrastructure for the newer means version of protocols or specifications, or if you want to upgrade the network, that was the process, which is a costlier process, it is a time-consuming process.

So, it is not very efficient, but if you do this network function virtualization, then what will be happening you will mean in one touch you can upgrade that software and that is it. You have upgraded your networking. If you need higher infrastructure, of course, the processors will have to be changed. So, from time to time you can do you can upgrade your processors, so that is routine maintenance of the server that you do.

So, with that, you are sufficiently capable enough to upgrade the network from time to time. So, for that, you do not have to really root out all the infrastructure and then reinstall all the infrastructure. So, that saves the cost, and that also saves the timing of network upgradation. Not only that we can also see the era of automated or 0 touch networking. So, what will happen? Now, the network itself will understand through machine learning or artificial intelligence.

So, it will try to understand what is the upgradation need of networking and accordingly, it will actually make the network upgraded. So, this is a kind of self-organizing network or cognitive network that we are talking about; where the network will be, means it will have cognizance enough cognizance to actually upgrade itself. So, no human intervention will be required, nobody has to redesign the network, the network will design or redesign itself, and accordingly, it will upgrade itself.

So, this is the new era of networking. Of course, it is a very futuristic vision, but that can be possible if we try to do this network function virtualization. So, what will be done over here? So, as you can see, the network remains the same, the only thing is that instead of these core routers, earlier what used to happen, there used to be this communication server and there use to be a queue.

So, that is what we have introduced. So, this queue and this communication server that was there in the packet switch network. So, that is the introduction that we did from the circuit switch network to the packet switch network. Now, what are we trying to do? We are trying to put other things into this system. So, there is a processor, and there will be, of course, a processor queue also. So, this router or switches that will be now there will be no dedicated switches, it will be just a server, ok.

So, it is a general-purpose server, as I have written. So, it will be a general-purpose server where there is some amount of processing, so I can partition it, ok, through virtualization again. So, I can partition that server and some chunk of that server I can take; there would be, of course, a server queue.

And then, I actually take that thing, I put my network processing over there and whatever data that are coming that will be directly accessing those servers or those processing power to do whatever it wants to do.

So, basically, earlier, whatever things we use to do in the networking, all the processors that we use to do like routing that is one thing or let us say switching or some other things means generating populating the routing table, so all kind of processes now can be taken as some softwarized process, ok.

So, that is why people are now also introducing some network programming tools so that we can softwarize or encode these network processes. So, there is a language called P 4, that is becoming popular it is actually networking programming software, we can say.

So, our environment, where you can encode these networking processes. And that you can run in any general purpose processor or servers and that should be your networking. So, basically, what will happen, is all the routers now you will be replacing them with some processors followed by some, of course, communication servers, and there will be queues, processor queues, and this data

queue. So, it will be followed by, like, it will first any data that comes, they will be first going into the processor queue like this.

So, any data that comes through the networking channel, will go first to the processor, queue they will wait in the processor queue one by one, and they will be picked up by the dedicated processor, which will do the processing, whatever network processing is required over there, that will do. And then, it will give it to the communication queue, and over there the communication will be done through the communication server. So, it will go to the next hop.

So, this is how the network will look like, the futuristic network will look like. So, basically, it will be more virtualized. So, as I have told network maintenance and network upgradation will become very easy. So, not only that, this will facilitate the means this network virtualization will actually facilitate, how we can automate the network or we can make the network more intelligent. So, this is something that will be happening.

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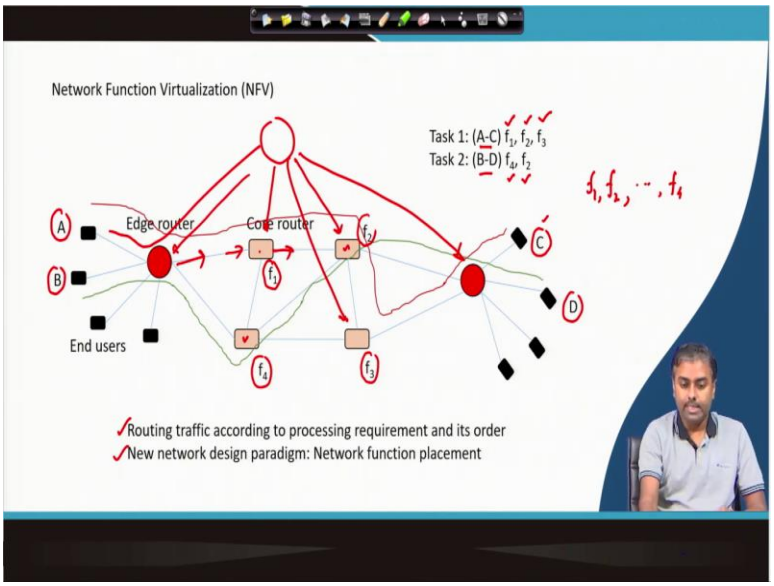

So, once we have understood this, now let us see how this will be done, ok. So, let us say I have a simple example I am doing. So, let us say I have two tasks actually; these tasks are now basically establishing a link from source to destination, and in the process, while it is going from source to destination it has to do some of the networking tasks.

So, networking tasks might include essential networking tasks which are actually routing or switching, that has to be done, and there might be some other extra job that or extra task that has to be done on those data, ok.

So, the data might be compressed, so that might be one networking task, that might be decompressed, and all other functionality that we can think of in the network. So, those functionalities might be required. So, let us say I need two connections one is A to C. So, this is one of the connections A to C and then another connection which is called B to D. So, these are the two connections that I will be needing to establish through this network.

So, A is over here, and C is over here, ok, and then B is over here, and D is over here. So, now, I have to give a path from A to C and B to D. So, this is something I will have to do. But I have to additionally also make sure that A to C, this particular traffic that will be generated from A and going to C. Before reaching C, it has to actually do these functions.

So, these are all network processing that has to be executed. So, let us say function 1, function 2, or function 3, I am just taking an arbitrary example, this can be anything. Some series of functions have to be done. There might also be ordering of this function, that function 1 has to be first done, then followed by function 2, followed by function 3 before it reaches the destination, ok.

So, this ordering might be there, or there might not be also ordering, but in most cases, there will be ordering, so that is why they call it a service chain. So, basically, you have a chain of service that needs to be executed before the data is delivered at the destination, ok. Similarly, task 2, which originated at B and went to D. So, also might require some function let us say f 4 and f 2 that is what it is requesting from the networking, ok.

Now, all these functions, let us say f 1, f 2 up to f 4, so these are the functions which you have to actually sorry, these are the function which you have installed within the network.

So, all these new switches or routers that we wish to talk about have now become all general-purpose servers. So, it might be a cloud processor, it might be a fog processor, whatever it is, so all those processors are now my router or switches. So, there this function has to be installed.

So, let us say I have installed those functions in a random fashion. Let us say f 1 I have put in this particular processor, f 2 has been put in this processor, f 3 has been put in this processor, and f 4 has been put in this processor. Now, while doing my routing so, the routing decision now also depends on the service chain. So, if I see task 1, I have to go from A to C, now f 1, f 2, f 3 has to be executed. So, I can see f 1 over here, f 2 over here, f 3 over here.

So, this route, whatever it happens, has to go to these 3 links. So therefore, the route root has to be something like this, this red curve that I have drawn. So, from A to C, I have to while processing my or while generating the routing, I have to also decide which path it should go, so that service chain exactly in order being processed in the, means along the path, ok. So, this is something I will have to ensure.

Similarly, if you see task 2, which requires function functionality 4 and functionality 2, so, there also you can see that I have done is I have actually routed it through this because f 4 is installed over here and f 2 is installed over here. So, that is how I have done the routing, ok. So, the routing will be heavily defined by the service chain it requires, accordingly, we will be doing routing. So, now, routing has to be decided accordingly.

How; who decides this routing, and how is this being decided? We will discuss that in the next slide, ok. So, that is also another interesting part, so where this network has been shifted, I mean, or the paradigm shift has occurred over here. But this is the first concept which is the network function virtualization. So, now you can understand that this routing has to do with the kind of processing it requires.

Not only that now while actually installing the network, you have an additional task. What is that task? Beforehand, this functionality where you will be keeping that also is now your decision. So, where should I put these functions or these virtualized functions which particular fog processor or cloud processor should I keep them, that is, this processor placement actually becomes the integrated part of the network designing.

This is the very important part. And this is not a very rigid part, basically, these processors, I can also that is where the network becomes more programmable, that I can later on if I think that now the network has to be reorganized, then I can actually shift these processors from one place to

another. Because these are just piece of software which has to be taken from one place and it has to be installed in another place. Immediately, the processors or processes will be shifted.

So, as you can see, this gives a very nice flexibility to the whole networking, and it is possible to continuously reorganize the network, and that is why people are thinking that maybe we can make it 0 touch network. That means, network will understand what is the requirement of it; who, which part of network will understand that we will discuss later.

But the network probably will understand which processor has to be kept where; accordingly, he will actually take a decision on when to shift some process from some processor to another processor. So, this is something which can be done, ok.

So, as we have now probably discussed, the key points are routing traffic according to processing requirements and its order, so, this is something we have already seen through that example so, that we have to do.

And the second point key point that we have told the new network design parameter, is this network function placement. So, where I will be placing them, how I can dynamically shift those placements, and how I can reorganize and redesign my network by means of these things, which can facilitate more cognitive or more interactive and flexible networking. So, that is something we have understood.

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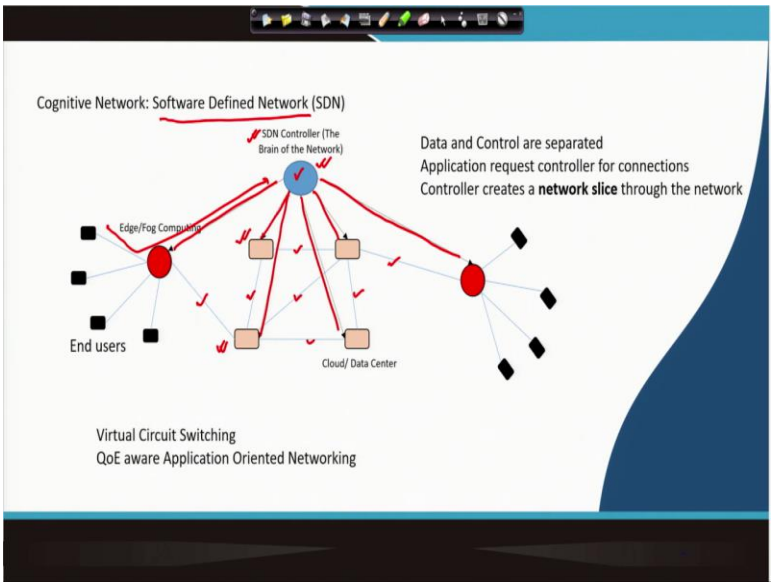

So, now, the next thing which we have been talking about that who will be taking this decision. If the network has to be intelligent, somebody should be there who should be the brain of the network, ok. So, that is where the new concept of software-defined networking is coming into the picture.

So, already we have softwarize the network function, now the whole networking or the network decision-making that also will softwarize. So, for that software-defined networking, this is a new concept that is being conceptualized.

So, let us try to see what is this, this software-defined networking, what we mean by this. So, basically, what is happening in this softwarization, the network has generally, if you see two functionality, even if you see in circuit switch network, so we have seen first you have to establish the circuit, ok.

So, that is actually the control part of the networking, so how do I establish the circuit? And then followed by the data flow through that constructed circuit, whatever circuit you have constructed through the entire network, so how do you flow the data?

So, basically, there are two parts of the networking, if you see, very, very crude discrimination. So, if you are classification, so two parts of networking; one is the control part, where you control

the networking. In IP also, there are two things, one is actual data routing and how the routers actually maintain the routing or how they facilitate routing. So, these are the two parts, actually.

So, one is the control part, we will discuss about these things in detail in the course in the due lectures of this course. So, we will see that the control part is there, and there is a data part. So, these control and data part in packet switch network or these are these days IP networks it actually means they follow an almost similar structure and the same path they follow same communication means facility they follow. So, they are mixed actually, data and control are mixed.

So, what we are trying to do over here is we are trying to actually separate these two things. So, essentially control and data are being separated among themselves. So, one part is controlled, the other part is actually the data part, ok. So, in the control part, there should be then controller, which is probably what we are talking about in the brain of the network.

So, there should be a controller, a dedicated controller, so we are now talking about a completely centralized controller. We will talk about that also. So, basically, we are now going towards the era of centralized networking from a distributed networking; we will also talk about how IP is more of a distributed networking. So, you should have a brain of the network, which is a centralized controller, which we call a software-defined network controller or SDN controller. So, that is the part, ok.

So, there should be an SDN controller, and of course, the brain, in our case, we have seen that through the nervous system, it actually controls all the body elements. So, similarly, networking is a similar concept. So, this SDN controller becomes the brain of the network, and then it must have connectivity. So, there should be a dedicated control network connectivity to all the networking elements, which are the switches or routers of the or any network element of the entire networking, mostly they are routers or switches.

But this particular control network that we are trying to put in, so that must be a dedicated network. So that whenever they wish, they can control these things. Now, the good part is these controllers are also now, according to our network function virtualization, they are actually virtualized servers; they are no longer any dedicated means kind of switch or router; they are also servers.

So, it is just this will be one server probably, which is a large processor probably with a lot of capabilities. And that should be connected to all the servers which will be actually now functioning as a virtual node, ok or virtual network equipment.

So, it needs to have some dedicated control channel to them through which they will be actually talking to each other. So, basically, that happens to be the control network. So, this link, this link, this link, this link, and this link, and this link, that is the control network. It is kind of, as you can see, it is a kind of star or tree kind of topology, so where the centralized controller you have and that is connecting to everybody over a dedicated path, ok.

As you can see, the actual data path, which are this link, this link, this link, are completely separated out now. So, that is what I was talking about. So, the data network and control network has been completely separated out. These two are now no longer on the same path.

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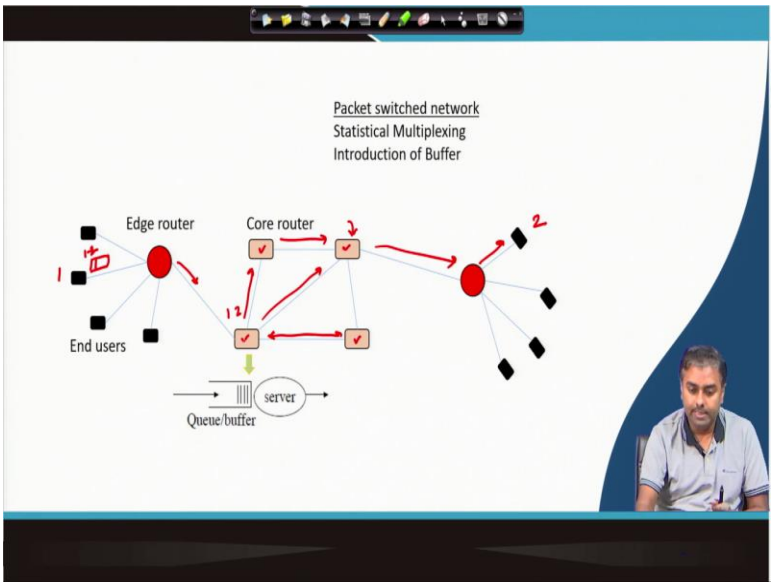

So, earlier, what used to happen if you just give one analogy, one simple example. So, let us go back to earlier routing. So, over here, what is to happen? So, this was the packet switch network. So, basically, these routers were the sole controller. So, they use to exchange messages among themselves through the data path only, ok.

So, though, there were specific messages which are to be called control messages. So, they use to exchange messages among themselves to control themselves, and it was a distributed controller because every router is a controller. So, they use to, in a distributed fashion they use to exchange messages, then they use to decide what needs to be done. So, that used to be the fashion of the packet switch network, where it was all in the same entity network entity, where the controller itself, which is not happening now.

So, same entity will be the controller and they there are multiple controller over the network, all the switches, all entities are controller actually and in a distributed fashion they use to behave like a controller or they use to actually exchange messages among themselves over the data path, that was the case. So, data and control packets were actually superimposed and they were carried over the same link. This is actually getting shifted in the new paradigm, ok.

So, that is the major change that is happening. I now have a separate dedicated data path and a separate dedicated control path, ok. So, once I have these two separate dedicated data and control paths. So, over the control path, what we are trying to do now this, SDN controller or brain of the controller or brain of the network. So, this will control all these things.

So, this will actually decide which function should be where, and who should have what kind of functionality installed, how they will be actually handling the traffic. So, all those decisions have to be taken now by the SDN controller. So, does anybody wish to now get connectivity what they have to do?

They have to first communicate with the controller. So, first, these things have to be done by this. So, it is almost like, as you can see, this is almost happening like circuit switching. So, first, you have to establish a connection. So, a similar thing is also happening over here.

So, what you do is you first go to the controller, you tell the controller what needs to be done, then the controller or you request something. Then, the controller will decide through his intelligence, or there will be software which will also now probably be more intelligent software like AI or machine learning will be enabled over there, so that controller can make his own decision. It will not be just protocol-driven; it will be learned by itself; it will try to means update itself, upgrade it selves, and all kinds of things it will be doing.

But whatever it is, it will be taking some control decision, and then whatever control decision he takes he will inform those switches and also to the source and destination that, ok, I have now reconfigured the network, and this is what you will have to do in the data.

After that, so once he reconfigures, so suppose let us say he reconfigures for this A to C, A has requested to the controller and through this path, so this is the controller probably A has requested that I need f 1, f 2, and f 3 functionality and I need this traffic to be routed to node C, then he will install all the logic of routing.

So, he will say, ok, he will inform this node that, ok, you have to route it to this path, then he will say inform this that you have to take this one, do the f 1 functionality, and then you route it over here. So, all these logic he will be actually instructing to all those respected servers or switches and accordingly the entire network will be properly constructed, ok. So, this flow will be constructed. So, this is something that is happening.

This particular concept is now actually called virtual circuit switching, ok. So, what is virtual circuit switching now? Let us try to just before finishing, let us try to understand this particular concept of virtual circuit switching. So, over here, what is happening? So, first, basically, what do you do? You give the control handle to the network controller, you say you establish a connection for me.

So, the network is actually now doing this connectivity. So, he is configuring all the switches, and all the routers, which are also virtualized. So, you actually make this configuration. After making the configuration almost like circuit switching, now you are telling the particular source that, ok now your circuit has been constructed. It is a virtualized circuit, statistical multiplexing will still be happening everywhere. So, we are not taking the facility out of packet switching network.

So, that will be happening. But it will be a more controlled one, and that is how now the data flow will be happening. So, it will flow through the network, we will see later on when we will be discussing what how this is happening. But this will be happening like a packet switch network.

So, all statistical multiplexing will be happening, all randomized things will be happening, and the packets will still have headers, but you will have more control over them, and routes are all facilitated by the controller only.

So, this is the new paradigm that is coming up. We will talk about this briefly also in the later part of the course, probably at the end of the course. We will start discussing these things in the new paradigm of networking. So, yeah, from we will next class onwards, we will probably start talking about the Circuit Switch Network. So, that should be our main goal, ok.

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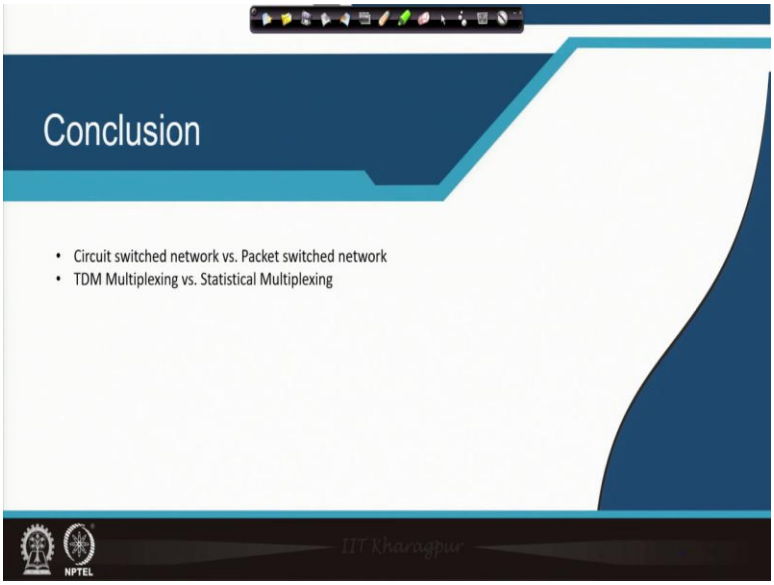

So, let us see in conclusion what we can say; in the introductory part of this course, we have learned about what is the difference between a circuit network and a packet switch network. And to facilitate that, we have also started discussing TDM multiplexing versus statistical multiplexing, what is the difference between that.

And we have also seen one extra part probably that is the new era of networking which is virtual circuit switching network. But that we will discuss more in the latter half of the course.

Thank you.