Broadband Networks

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Lecture - 32

Metro Ethernet Access Networks

So, in today's lecture we will talk about an important topic in broadband access networks which is actually called as as metro Ethernet based access networks. Now, metro Ethernet, they are going to be, a metro Ethernet based access networks are going to be one of the major next generation broadband access deployment networks and today we will review some of these access networks.

So, the outline of our talk will be that we will talk first about the legacy metro access architecture. So, we will talk first about legacy metro access architectures.

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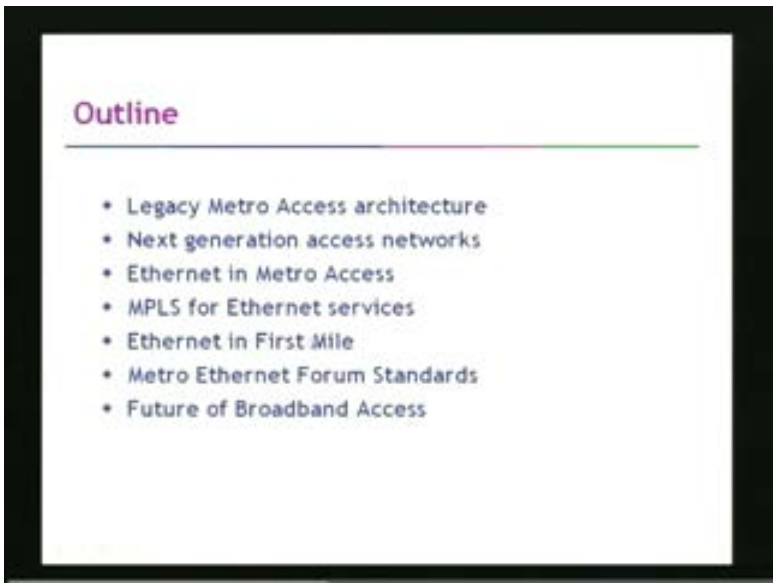

Then we will talk about the next generation access networks, then we will talk about ethernet in the metro access, we will see what is the role MPLS for various Ethernet services, then we will also talk about ethernet in the first mile. There is a new forum which is called as the metro Ethernet forum which is actually defining the standards for the broadband access networks and then we will talk about what is the future of the broadband access that is going to be there.

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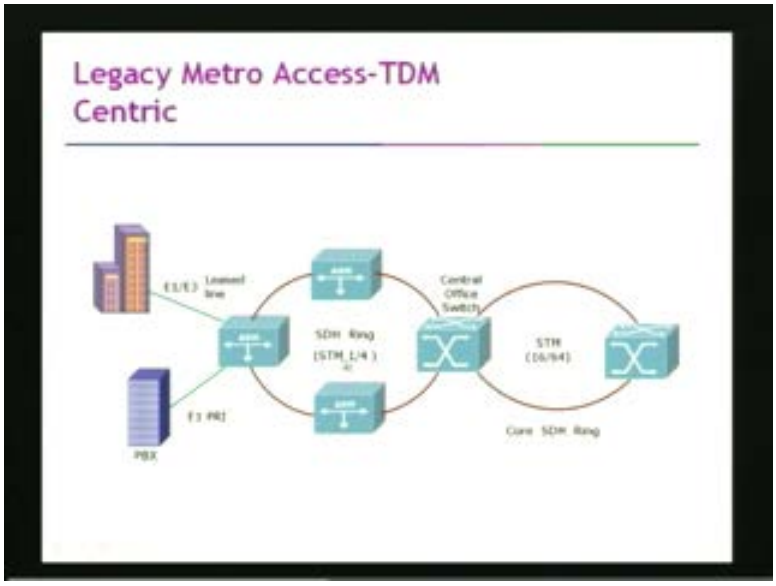

Now, let us look at first about the legacy metro access architectures. So, if you look at the legacy metro access architectures; now traditionally, the legacy metro access architectures were TDM centric. Now, what is meant by TDM centric? Basically, in the TDM centric architecture, you use a circuit switch technology to carry the IP traffic or the packets. So, it is basically a circuit switch technology and all the broadband services to the enterprise, they are provided using this kind of legacy metro access architecture.

So, if you look at the legacy view, then this it looks like something like this that there may be a primary SDH ring or a SONET ring, so SONET SDH ring made out of STM 1 or 4. So, this is this ring is more like an access ring and in India for example, this may be based on STM 1 or STM 4 which is about 155 megabits per second is STM 1 and 622 megabits per second is STM 4.

So, these are add-drop multiplexers which are connected together to form a ring and several of these add drop multiplexers are then aggregated at a central of a switch and this may be connected in another core ring which is an SDH ring either STM 16 or SDM 64.

So, from these add drop multiplexers, from this SDH add drop multiplexers, typically these ADMs will have E 1 lines or E 3 lines as their inputs and the SDH or the SONET as the output. So, you can then drop an E 1 or E 3 based leased line to an enterprise for providing broadband services or for providing voice connectivity you can give E 1 PRI line which can be connected to a PBA EPBX of an enterprise.

So, this was typically a legacy view. This was legacy metro access architecture. You had these SDH rings which are there deployed over the citywide networks and then you drop E 1 E 3 lines and provide broadband access to the enterprise customers.

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So, now what are the advantages of this view? This offers guaranteed quality of service. Since it is TDM centric, it is a circuit switch based technology and therefore it gives you a guaranteed quality of service.

Moreover, an SDH based ring will give you a fast protection and restorations capability and also the reliability. In terms of fast protection and restorations, it gives a typical 50 millisecond protection. So, if the ring breaks, then the nodes can store themselves in a time period of 50 milliseconds. So, this 50 millisecond was a very crucial number for providing the voice connectivity and for a longtime this SDH networks were really deployed for carrying predominantly the voice traffic and when the internet evolved or when the need for the data traffic came, then this primarily circuit switch networks was used to transport the IP traffic as well.

So essentially, a packet switch network was overlaid over this circuit switch based networks which was the legacy metro access architecture for the TDM centric view.

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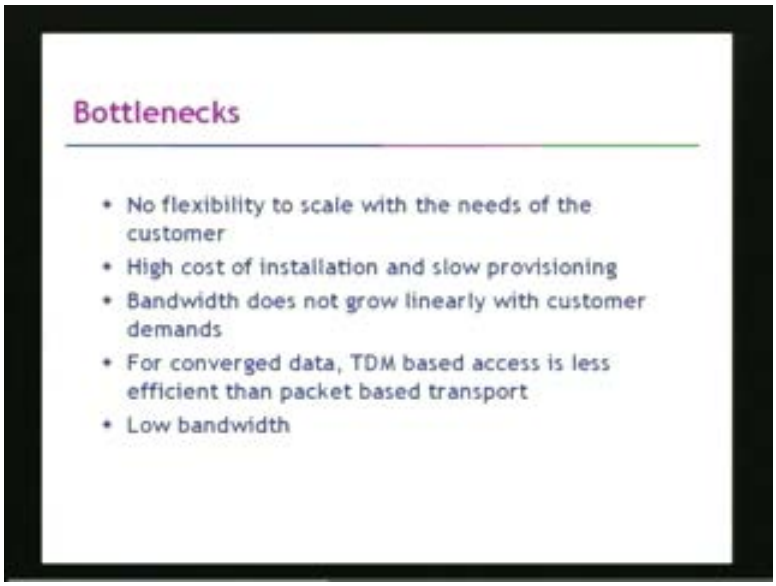

Now, what are the bottlenecks? If you look at from the next generation's broadband access perspective, then what are the bottlenecks? Then there is no flexibility to scale with the needs of the customers. So, what do you what do you mean by no flexibility to scale with the needs of the customers?

If you can look, if you can see from this ADM, you can only have the drops from the ADM in terms of E 1 lines or E 3 lines. E 1 is like 2 megabits per second and E 3 is 34 megabits per second and so on. So, you can only have bandwidths at those granularities. If some customer wanted let us say a 4 mbps, then he will have to be given 2 E 1 lines and so on. There was really no flexibility in terms of bandwidth granularity to scale with the needs of the customers.

So, let us say if some customer has taken today an E 1 lines at 2 mbps and if he wants to upgrade it to 4 mbps; then he cannot use the same existing infrastructures, he will actually have to take for another E 1 lines and so on. So, that flexibility was not there and with the changing needs, the customer wanted really that kind of flexibility.

Another bottleneck was there was this high cost of installations and the entire network was really very slow to provision. The high cost of installations means whenever a customer needed to upgrade its line or so, then it has to install those equipments at the sites and so on. Bandwidth of course does not grow linearly with the customer demands as we have already seen, already explained. And for converged data, basically TDM based access is less efficient than packet based transports and also we had a low bandwidth.

So, basically 4 major disadvantages: one is that the network does not scale with the needs of the customers and bandwidth really does not scale in that granularity. Then secondly, it

being a TDM based networks, it is anyway an inefficient networks for the transport of packets. So, in from that point of view also it is it is not efficient.

Moreover, the bandwidths are also low because today as you know that the enterprises are having the local area networks which can have 10 megabits per second as a minimum bandwidth. Ethernet today works at 100 megabits per second and some enterprises are also having 1 gigabit per second as their local area networks.

So, when you talk of the WAN links, when you talk of wide area network link; these links are coming like an E 1, E 3 lines like 2 megabits per second or 34 megabits per second and they were really perceived as the low. Even STM 1 is as you know is 155 megabits per second.

So, low bandwidth are also one of the reason and coupled with the fact that there was a high cost of installations and slow provisioning really made a TDM centric metro axis architectures not scalable and flexible with the needs of the next generation broadband access architectures.

So obviously, then there was the need to look for newer technologies and newer access networks for deployment of these broadband access network.

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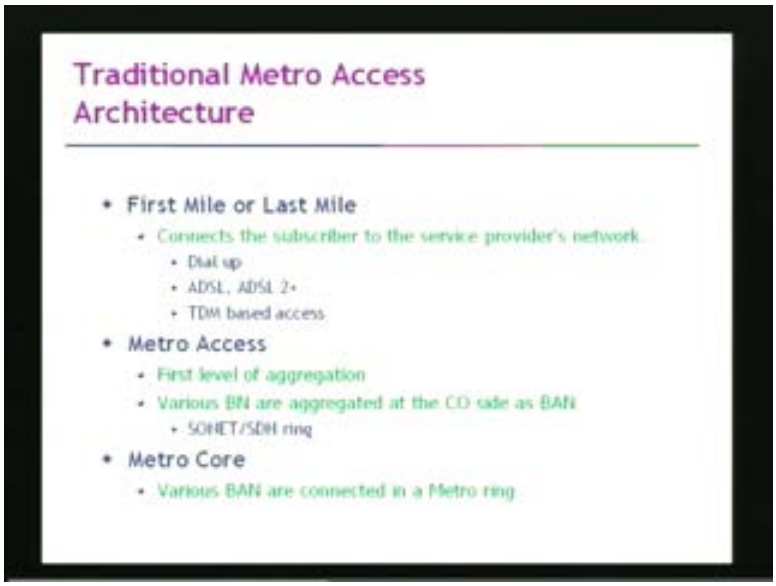

So we will see, what are the new technologies. So, if you look at a view of a traditional metro access, then the traditional metro access architecture actually comprises of 3 kinds of networks. One is the first mile which actually is near to the customer. So, it is used to be called as a last mile networks but in today's technology, we have a customer centric view. So therefore, we say that the network actually starts from the customer.

So therefore, the part where the subscriber connects first to the network: that is called as a first mile networks, then several of these first mile networks are aggregated to form a metro access networks and then several of this metro access networks are aggregated to form a metro core networks and then these metro core networks may form part of the nationwide backbone networks and so on.

So, there are 3 hierarchies; one is the first mile network, the second is the metro access networks and third is the metro core networks. So, there are three these kinds of 3 hierarchies exist in today's broadband access architecture. So, let us look at what are the technologies which are used in the first mile the metro access and the metro core.

So, if you look at the first mile network which as I said connects the subscriber to the service provider networks. So, there are three alternate technologies that have been used. Traditionally, as you know that the residential customers have always accessed internet using dial up technology which is also some kind of an overlay packet, overlay of packet networks over the circuit switch networks. Then we have the TDM based access networks which we had already talked of based on E 1, E 3 and SDH. The new packet based first mile networks could be based on either ADSL or ADSL 2 plus variants of ADSL.

Now, I will show about this ADSL network shortly. But the metro access networks then have these provides a first level of aggregation where these first mile networks are aggregated. So, various building nodes so BN, they are aggregated at the central of a site as the building aggregation nodes through either SONET or SDH ring.

So, typically in the traditional metro access architecture, metro access comprises of SONET or SDH rings and a metro core; in the metro core, various building aggregations nodes can be connected together in a metro ring. So, this is which I had shown earlier, this is traditional metro access architecture. This is like as a metro access, this is like as a metro core and these part forms of the first mile networks.

So, in this case, we have seen the first mile network is like a TDM based networks using E 1, E 3 lines. This network can also be a ADSL or ADSL 2 plus based networks.

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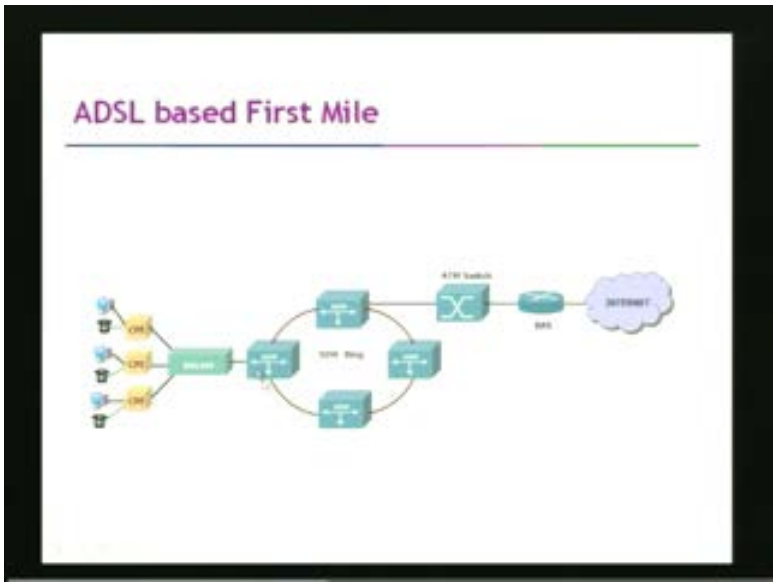

So, an ADSL networks would look something like this that in the first mile, you have a DSL access multiplexers which is called as a DSLAM. At the residential customers, you can have an ADSL CPE which is a customer premise equipments. These CPEs are connected to the DSLAMs and the DSLAMs can have an E 1, E 3 as an output and can get connected to an ADM in an SDH rings.

Now, as you can see, traditionally, for the ADSL, ATM technology was used as a transport mechanism. We have already studied ATM in our previous lectures. So, ATM was primarily used as a transport mechanism to carry the traffic and therefore an ATM switch was deployed in the back end to switch the ATM cells and then finally, we use the broadband access server to access the internet. So, this part forms the last mile networks and this form as as the metro access networks. Several of this SDH rings of course can be aggregated together to form as a metro core networks as well. So, this was a view of a traditional metro access architecture.

Now, there were several improvements that did take place in the ADSL based technology and one of the major improvements that has taken place is using IP based ADSL or IP DSLAMs as it is called. So now, these DSLAMs are actually IP aware and therefore the output of the DSLAMs can have an Ethernet as an input. So, that was one of the next generation kinds of DSLAMs that are currently being used.

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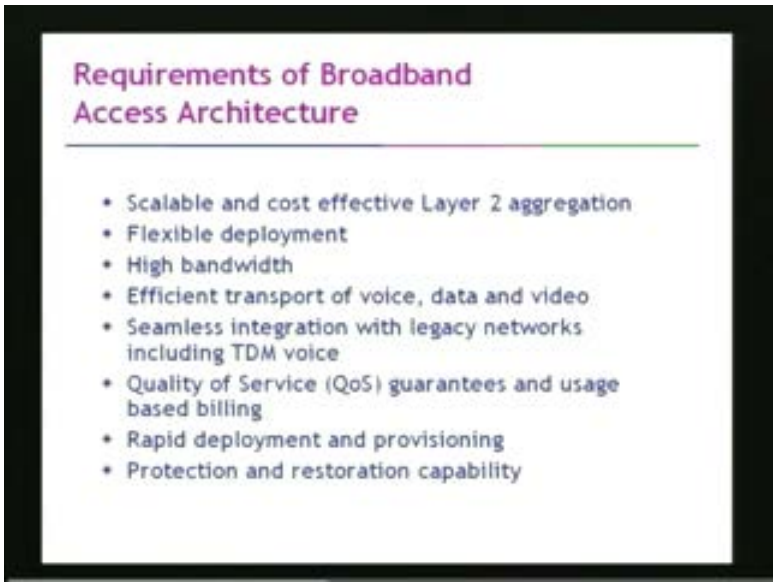

Now, if you look at what are the disadvantages of these metro access architectures, if you have to really understand what are the disadvantages of the metro access architectures; we need to understand what are the requirements of a next generation broadband access architecture. That is very crucial to understand that what are the services that the subscribers are looking for and what are really the bottlenecks which exists in the traditional metro access architectures.

So, to understand that first let us look at what are the requirements of a typical broadband access architectures. So, the requirements of the broadband access architecture are that the architecture needs to be scalable and should achieve a cost effective layer 2 aggregation.

So, why we are saying layer 2 aggregations because as that subscribers may want to get connected many of its corporate offices through a broadband access infrastructure provided by the service provider and these various offices of that corporate networks may have a layer 2 networks and the subscriber may want that these layer 2 networks may look like as a single common layer 2 networks to the subscriber and therefore the broadband access infrastructure should provide a mechanism of aggregating these layer 2 packets in a scalable fashion and give a view to the subscriber of its own layer 2 network as an integrated common layer 2 networks. So, we will talk, see more about this later.

Also, the deployment needs to be flexible and a deployment which should be flexible with the needs of the customers and of course we are looking for high bandwidth. Today we are talking of providing multimedia services like IPTE over broadband access architecture and therefore the bandwidth needs to be very high compared to the traditional metro bandwidths of 2 megabits per second leased line and so on.

At the same time, we want the efficient transport of voice data and video. This is to enable the triple play services over the broadband access architectures. Now, while many of these things can be achieved with a pure packet based with the next generation packet based architecture; at the same time, we should not forget that the legacy networks having the traditional TDM quality voice will continue to exist and therefore whatever architecture we come out with a packet based networks, we need to provide a way to have a seamless integration with the legacy networks and at the same time the packet based networks, we want quality of service guarantees and of course features like usage based billings and we want some circuit switch networks feature like protection and restorations capability as well.

So, there are as you can see that the requirements which are there for a next generation broadband access architectures are like having the best of both worlds like having the best of a circuit switch networks which are the features like quality of service protection and restorations which are the features available in a traditional circuit switch networks on the one hand. At the same time, we want features like efficient transport of voice data in and video high bandwidth effective layer 2 aggregations which are the features may be available in a typical packet based networks.

So, we really want the best of both worlds in order to evolve to next generation broadband access architectures. So, let us see what are the technologies which are available and what would be kind of a next generation access networks? So, we just reviewed briefly the traditional metro access architectures. We will now look for the next generation access networks. How the requirements which we have just outlined, how they can be met in a next generation access networks?

Now, in the next generation broadband access, what has been seen is that there is a move to go for Ethernet based broadband access. Now, as you know that Ethernet has been the dominant technology for the local area networks and Ethernet can come at a speed of 10 megabits per second or 100 megabits per second or 1 gigabit per second. Ethernet today can be made available at 10 megabits, 100 megabits and 1 gigabit and it is the dominant local area networking technology today.

Now since, it has a high bandwidth and since it provides scalability and flexibility; the question really is that can we move this ethernet into to provide broadband access in the wide area networks? That is really the proposal that we will evaluate in today's lecture. We will see how far it is possible to take ethernet to provide broadband access networks.

So, we are saying ethernet in the first mile, so you are saying ethernet in the first mile; so, which is like ethernet in the first mile network.

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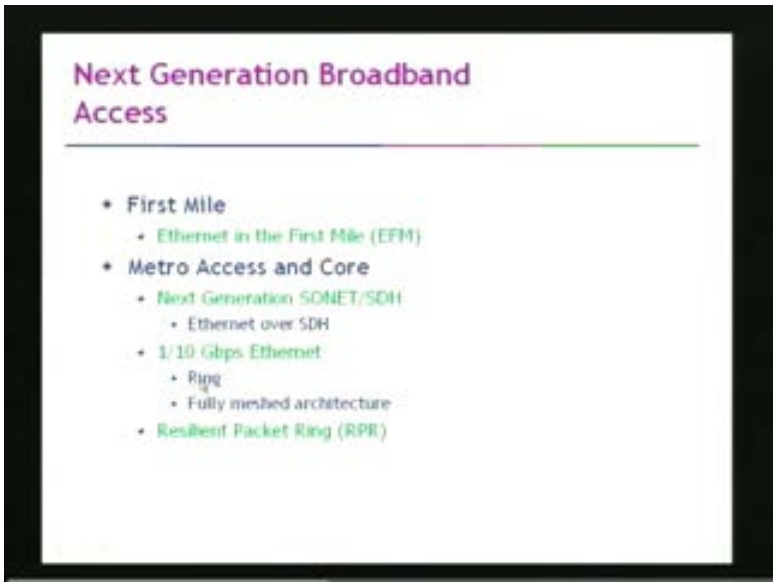

So, instead of using the traditional ADSL based or TDM centric architectures, we are proposing that ethernet be used in the first mile network which is called as EFM. As well as in the ethernet be used in the metro access and core. Now, in the metro access and core, there are 3 ways in which these Ethernet can be used.

One way is to go for next generation SONET and SDH. That means you have Ethernet over SDH, you run Ethernet over SDH. So, this is like an evolutionary step from the traditional SDH networks to go to the next generation SDH networks.

The other alternative is to have replace these SDH rings by a pure 1/10 Gbps Ethernet. So, you do not use the SDH or STM rings, you use a pure ethernets either in a ring form or in a fully meshed architectures. Either of these two technologies can be used.

The third alternative is to use for a new technology which is called as the resilient packet ring or RPR. Now, RPR is a protocol where the MAC is very similar to an Ethernet but it has certain features which are somewhat similar to SDH in terms of providing protection and restoration capability for Ethernet based rings. There are basically 3 alternatives that are available in the metro access or core networks.

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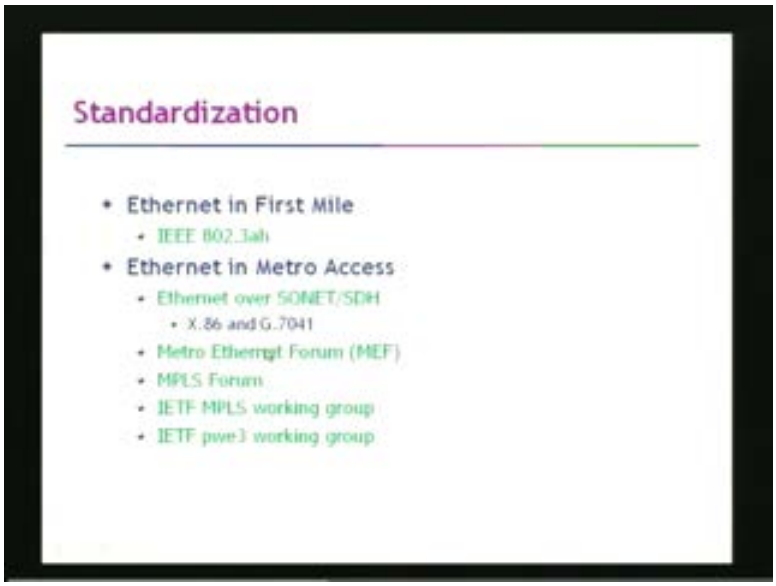

These proposals have been standardized ethernet in the first mile is currently being looked after by IEEE's 802.3ah standardization committees which is looking at standardizing ethernet in the first mile a kind of network. So, we will review what are the activities of the IEEE's 802.3ah shortly.

As far as the Ethernet in the metro access is concerned, the Ethernet over SDH is being standardized by X.86 and G.7041 by the Internal Telecommunications Union - ITU. The other standard bodies are which are looking at standardizations of ethernet in the metro access are Metro Ethernet Forums, MPLS forums, IETF MPLS working groups and IETF pseudo wire emulation edge to edge working group. We will see shortly how MPLS and pwe3, they come into picture in providing the metro Ethernet kind of services; we will shortly see and how ethernet over SDH really sort of works.

So now, let us look at one by one how these ethernet based access networks can work in the broadband scenario. So, let us see let us look at the next generation SONET or SDH based networks.

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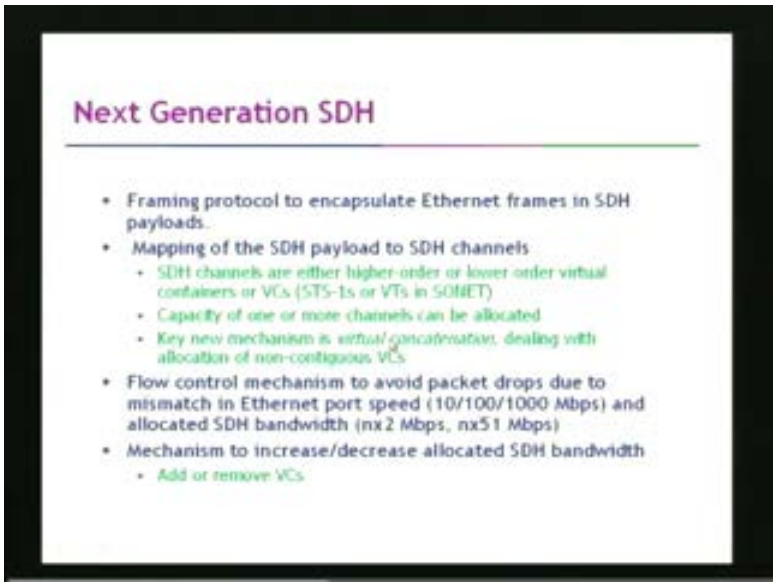

Now, next generation SONET or SDH is like a one step forward from the traditional SDH based networks. Now, next generation SONET SDH is basically is really a framing protocol which allows to encapsulate ethernet frames in the SDH payloads. So really, next generation SDH provides you a mechanism of encapsulating ethernet frames in the SDH payload and then tells you mapping of the SDH payloads to SDH channels.

Now, these SDH channels are either higher orders or lower orders virtual containers or what is called as virtual tributaries in the SONET. So, they are called virtual containers in the SDH. Now, capacity of one or more channels can be allocated and then there is a new mechanism which is called virtual concatenations which deals with allocations of noncontiguous virtual containers.

So, basically there are virtual containers in the SDH and one or more virtual containers can be allocated and you can use a virtual concatenation technique; so it is not necessary to allocate contiguous virtual containers, you can allocate noncontiguous virtual containers as well and this is achieved by using a technique called virtual concatenations. So, this way, SDH payloads can be mapped to SDH channels in the next generation Ethernet over SDH.

Then there is a flow control mechanism which is used to avoid the packet drops. Now, this is important because as you know that the Ethernet works at speeds of either 10 megabits per seconds or 100 megabits per second or 1 gigabit per seconds and the SDH typically can operate at either at 155 megabits per seconds or 622 megabits per second or 2 Gbps.

So, if you are connecting 100 megabits per second or 1 Gbps Ethernet to a SDH and you are giving only the SDH bandwidth that is available is only 34 megabits per second or some small fractions of 100 megabits per second; then you have to go for a flow control

mechanism, some kind of a back pressure based mechanism which will convey to the Ethernet to reduce the incoming rates.

And of course, you need a mechanism to increase and decrease the allocated SDH bandwidth that is add or remove the virtual containers. So, this is the brief outline of a next generation SDH. So, next generation SDH are basically ADMs. The next generation add drop multiplexers with ethernet with Ethernet inputs and E 1, E 3 also may be the inputs and SDH as the output and basically this protocol provides you a mechanism of encapsulating ethernet frames into SDH payloads mapping the SDH payloads to SDH channels and then having a flow control mechanism to control the mismatch between the ethernet speeds and SDH bandwidth that has been allocated to a particular flow. So, that is really the crux of the next generation SONET or SDH.

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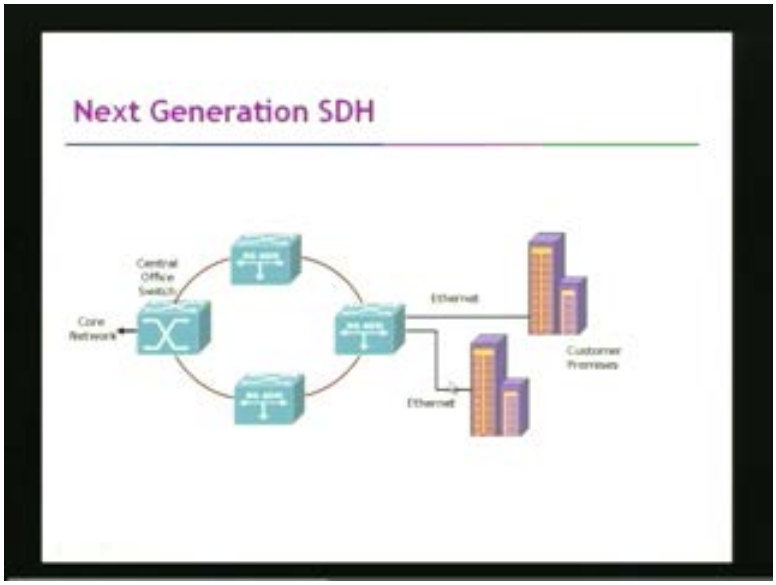

Now, this is like looks like as I pointed out, the next generation SDH, this is like a metro ring which is deploying the next generation add drop multiplexers. You can give a Ethernet based circuits to a customer premises. Actually, you can put this next generation SDH in the basement of the building itself and which has an ethernet as an input and this can be connected to a router or a switch in that customer premises building.

So, this how a next generation SDH can work and you can give bandwidth of 2 megabits per second or 34 megabits per second or whatever and one can do a flow control between this the Ethernet flow and allocated bandwidth in the next generation SDM.

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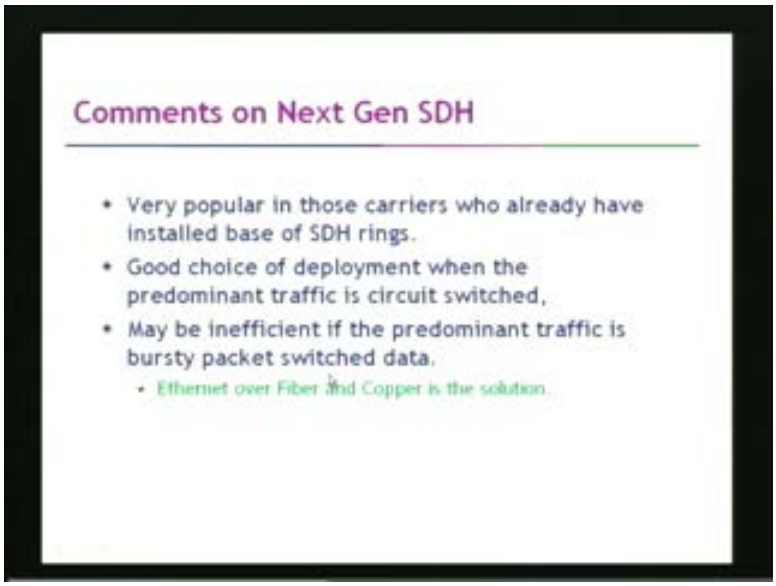

Now, some comments on this next generation SDH. Now, as you can see here that it is very popular in those carriers who already have installed base of SDH rings. So, one advantage of the next generation SDH is that it provides you an evolutionary step to the next generation broadband access networks. So, if some carriers if they already have installed base of SDH rings, then next generation SDH provides a convenient way to move into the next generation architectures quickly. So therefore, it is very popular in those carriers.

But at the same time the next generation SONET SDH is efficient if the predominant traffic in the SDH is the voice and only some small percentage of the traffic is the data traffic or the Ethernet traffics. So, it is a good choice of deployment when the predominant traffic is circuit switch but it may turn out to be inefficient if the predominant traffic is the bursty packet switch data.

So, as long as 80% of the traffic is going to be the voice traffic and only 20% of the traffic or 10% percent of the traffic is going to be the data traffic, then going for a next generation SDH is a very good solution for the broadband access architectures, for service provider. The reason being that the SDH has several advantages in terms of protection and restoration capabilities and reliabilities and so on; so therefore it would be preferred techniques for transport of voice traffics.

However, see in some portions of the data traffic is also there, one can you make use of next generation add drop multiplexers for providing voice plus data services. However, if the predominant traffic, if 85 to 90% of the traffic is to be carried in the service providers network is going to be an IP traffic or is going to be a data traffic, then a good choice for next generation broadband access networks would be to carry ethernet over fiber or copper. That would be the solution.

So, we would then look at what are the challenges that are there for deployment of ethernet in the metro access architectures, how Ethernet based metro access architectures can be evolved and what are the issues which are going to be there for ethernet based metro access architecture. So, let us look at some of these issues today.

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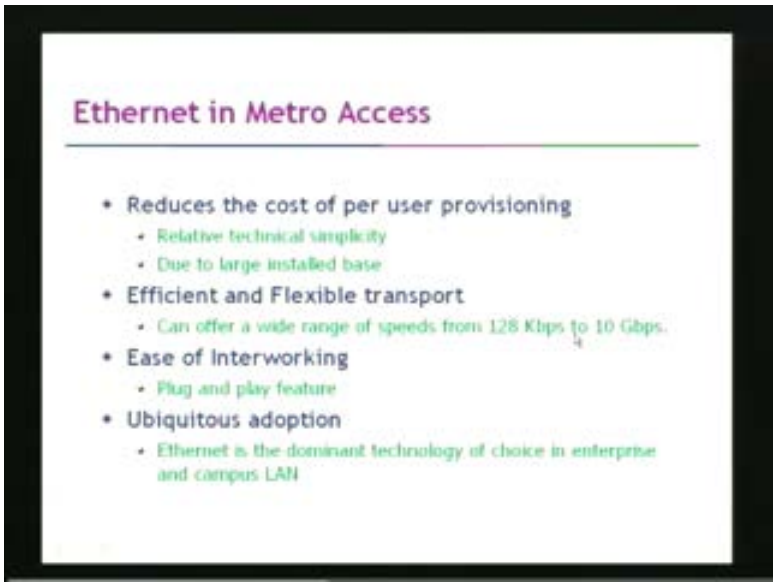

Now, what are the advantages of having ethernet in the metro access? So, one advantage of course is that it reduces the cost of per user provisioning in a significant fashion. The reason is being that it is relatively technically simple and Ethernet, we have a large installed base. Because of the large installed base in the enterprise wide networks or in the local area networks, the cost of the ethernet based system is significantly lower and also because of the relative technical simplicity compared to the traditional TDM based architectures, the provisioning is also simpler. So, that is one of the major advantages.

The other advantage is that it is efficient and flexible transport and it can provide you a wide range of bandwidth granularities, it can offer you a wide range of speeds from 128 kilobits per second to 10 gigabits per second. Remember that traditionally the Ethernet comes in 3 flavors; 10 megabits per second, 100 megabits per second or 1 gigabit per second, it comes only in 3 flavors.

But by doing appropriate rate shaping and by using ingress rate filtering, it is possible to give the bandwidth in granularities of 128 kilobit per second to 1 Gbps per second in Ethernet switches. So, that way by just software configurations, one can actually change the bandwidth for customer on demand. So, that is one of the advantages of having Ethernet based access networks.

Ease of interworking: it has a lot of plug and play features and of course the ubiquitous adoption, Ethernet today is the dominant technology of choice in enterprise and campus LAN. So, Ethernet is there in the enterprise networks. So, most of the traffics that is

generated comes from the ethernet and ends up at the Ethernet. So therefore, why not have Ethernet based access architecture in the core and the access also so that one can have a ubiquitous adoptions right from one enterprise networks to another enterprise network? So, that is also one of the arguments in favour of deployment of ethernet in the metro access architecture.

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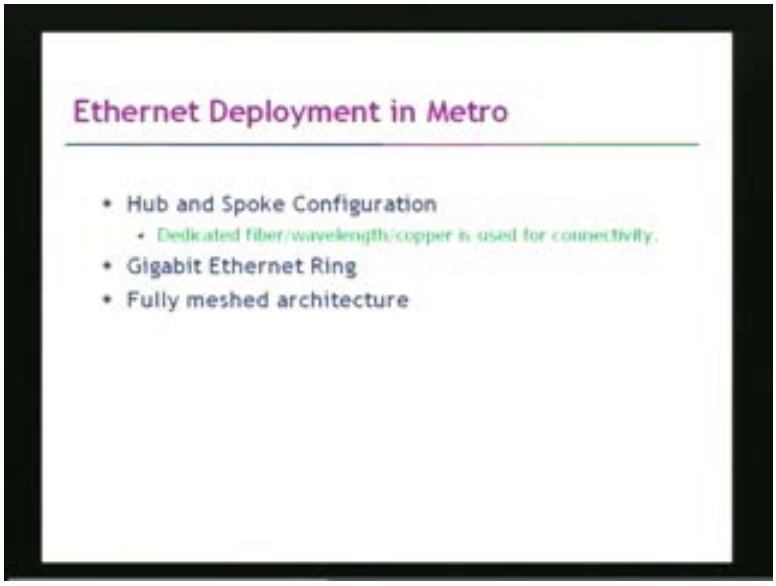

Now, Ethernet deployment in the metro can be done in various configurations. You can either have a hub and spoke based configuration. So, in hub and spoke based configurations that there is a switch and then you will lay out the connections to so you keep a switch there and then you will from the switch, you lay out the connections to the subscriber's home. One can make use of either a copper or a fiber based networks either of them depending upon the distances that is there which is possible to have.

So, one is like hub and spoke configurations, another one is that you can have a gigabit Ethernet based ring, you can have a Ethernet based rings also or the third one is that you can have a fully meshed architectures and one can have virtual ring over a mesh based systems so that is also... So, there are 3 possibilities of deploying ethernet in the metro access architectures.

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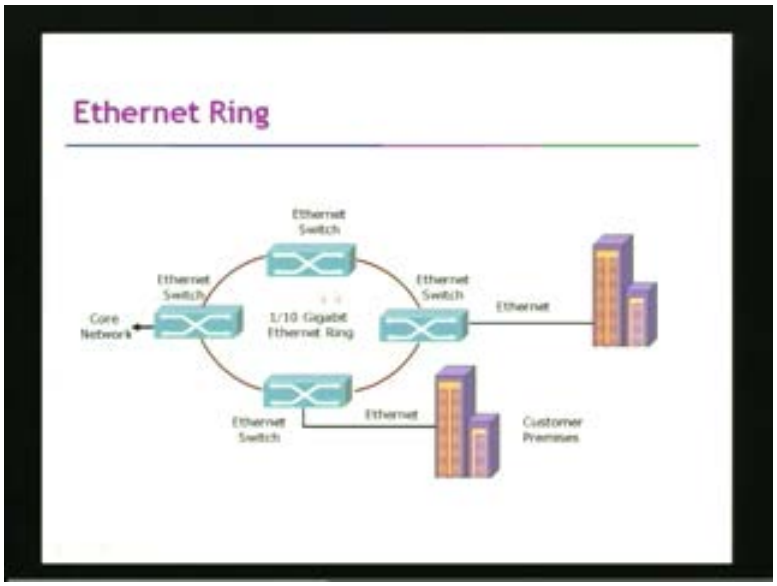

So, this is like an ethernet ring which is shown here. So, these are all Ethernet switches. These Ethernet switches are connected together in a ring form and these rings could be either 1 gigabit Ethernet ring or it could be a 10 gigabit Ethernet rings and from this switch, you can give ethernet based connections to directly to a customer premises and also from here.

So, instead of having this ring to be an SDH ring, you can have it as a pure ethernet based ring as well.

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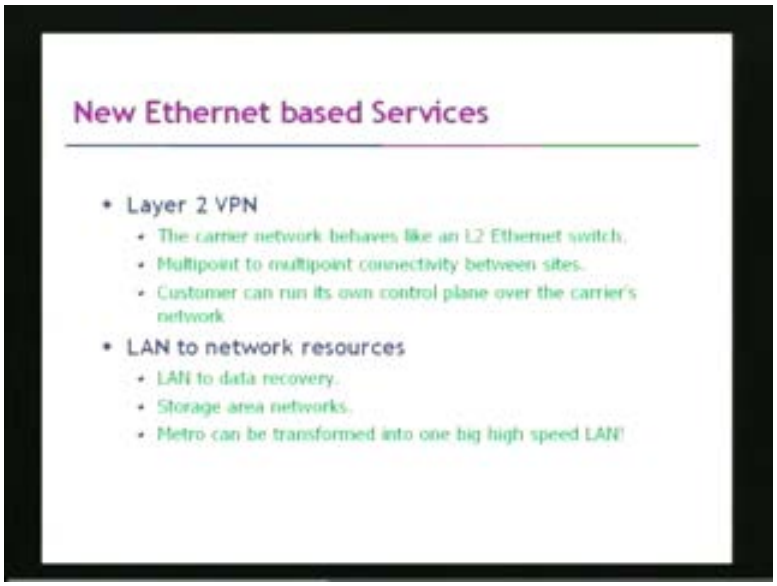

Now, with the Ethernet based access networks actually, not only we can provide the traditional broadband services but you actually have a new Ethernet based services also. Now, what are those new ethernet based services is what we will just review. So, apart from the fact that you can have traditional broadband services traditional broadband services, you can also have some of the new Ethernet based services.

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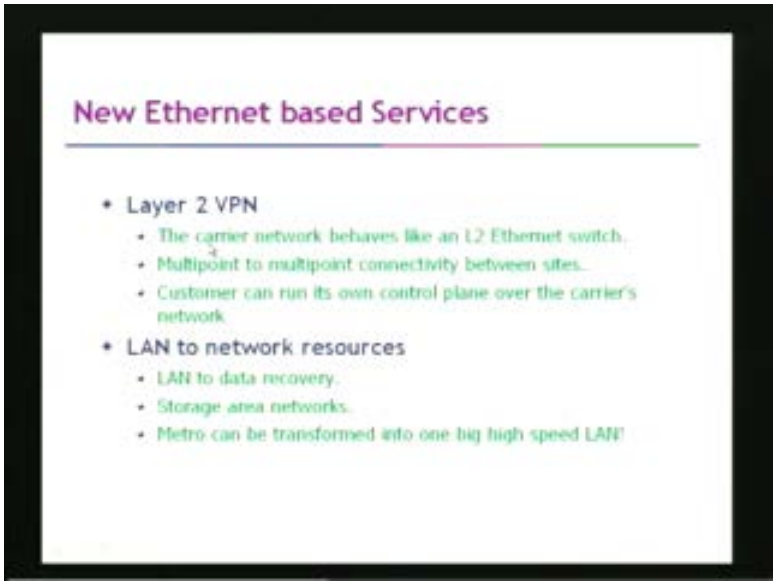

And, those new Ethernet based services are: one can have a layer 2 VPN, so the layer 2 VPN is like, so we can see that we have seen that a virtual typically, the corporate offices of a particular networks, they get connected through a service providers network at a layer 3 level and form a virtual private networks.

But if our metro access networks itself is an Ethernet based networks, then we can actually provide a layer 2 based virtual private networks. That means if the customer is having separate offices spanned over a city, then those layer 2 networks, those Ethernet networks can be connected together to form as a one layer 2 networks.

So, the carrier networks actually behaves like an L 2 Ethernet switch and one can actually provide multipoint to multipoint connectivity between these sites and customer can actually run its own control plane over the carrier's networks. So, these are actually the major features of the layer 2 VPN. Remember that the layer 2 VPN that is a virtual private network at the layer 2 level is not possible to have if we do not have the metro access networks based on Ethernet.

The second service that is possible is the LAN to network resources. One can have a LAN to data recoveries, storage area networks. Actually, as a matter of fact, the entire metro can be transformed into one big high speed local area networks, the entire metro can look like as a one big single Ethernet where these various corporate offices are sort of connected together. You can connect together a storage area networks, you could sort of

have a disaster recovery systems where your LAN is posting data to this disaster recovery system through this high speed big local area networks.

So, these are the new services that become possible when you actually deploy ethernet in the metro access networks.

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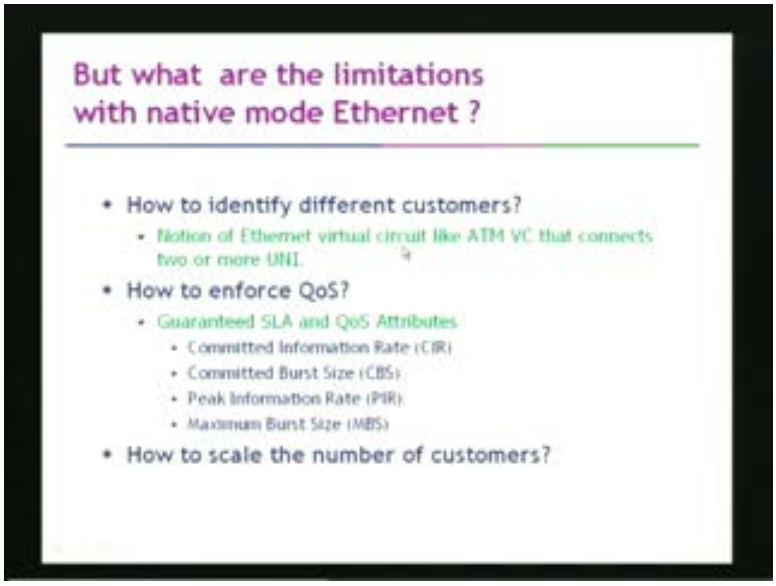

The question really is that and that is the most important question is that but are there limitations with the native mode Ethernet? Can we take this enterprise class ethernet networks and simply start deploying it in the broadband access networks? Is it possible to take this enterprise class networks and deploy it in the wide area networks just like this? Are there limitations and what are the problems and issues that are involved in deployment of the ethernet in these wide area networks? So, what are the challengers that are there?

Now, the first challenge is of course as you know is that how to identify the different customers. That is one of the important challenges. As you know that in an ATM based networks and that is why that was the preferred network by the service provider; there is a concept of virtual circuit that connects 2 or more UNIs. There is no such notion of Ethernet virtual circuit. Ethernet was primarily not was not designed to provide any virtual circuit mechanism and therefore Ethernet switches did not have this concept of virtual circuits in the traditional way. So, the question really is that how we can identify and isolate different customers? Do we have the notion of Ethernet based virtual circuit?

Secondly, Ethernet was actually like a best effort local area networks. It was not providing any quality of service guarantees and there was no way to enforce the service level agreements. Now, for example you cannot provide quality of service QoS attributes like committed information rates, committed burst size, peak information rates, maximum burst size. These are the typical quality of service attributes that would be

available in an ATM based networks. But in Ethernet based networks, being a best effort networks; these, it was not possible to give quality of service guarantees.

Then the last question of course is that how we can scale the number of customers? How we can say, how can address the number of customers using an Ethernet based networks? And finally, the protection mechanisms were not there in an Ethernet.

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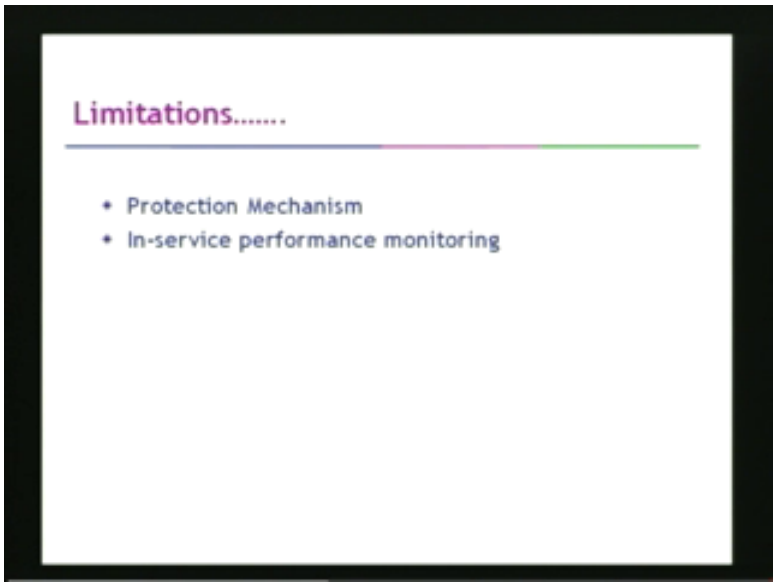

Protection mechanisms are not there in an ethernet based networks and there is no mechanism for in-service performance monitoring. Remember that in a SDH based networks, we have an inbuilt protection mechanisms and also some kind of performance monitoring. But this is not there when the ethernet is deployed as an Ethernet rings.

So basically, these are the challenges. How we can identify different customers, how we can introduce the notion of virtual circuits, how we can enforce the quality of service guarantees, how we can make the networks scalable, how we can provide protection mechanism and whether we can have some kind of in-service of OAM capabilities built into the Ethernet?

So, there are possibilities. We will see how some of these limitation which are there in the native mode Ethernet; by native mode ethernet we mean that ethernet in its native form is used to provide broadband access.

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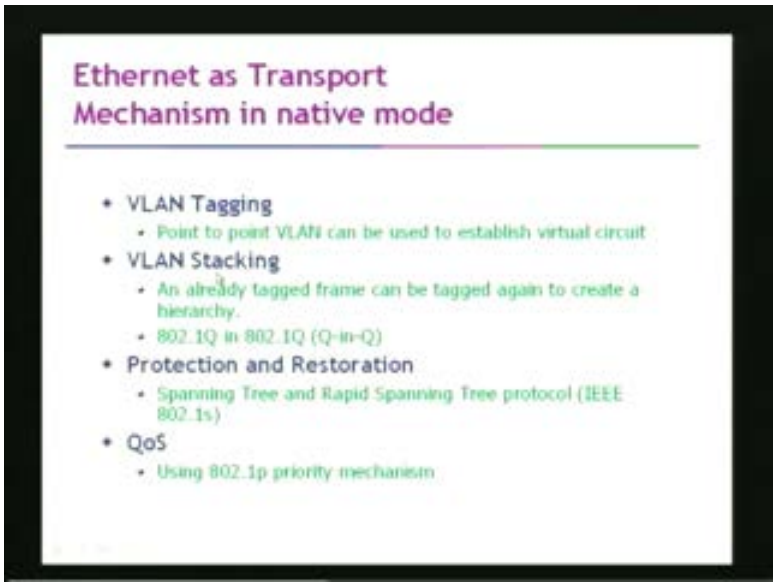

So, there are some mechanisms which can be used to address some of these limitations. So, when these Ethernet switches are being deployed to provide broadband services, we can use some of these mechanisms. So, one mechanism as I said; how we can introduce a notion of a virtual circuit in Ethernet. So, it turns out that the notion of virtual circuits in ethernet can be introduced by using some kind of a VLAN tagging. Now, a VLAN tagging is like we can have a point to point VLAN, we can establish a set of a point to point VLAN and this can be used to establish a virtual circuit.

So basically, we can use a point to point VLAN to establish a virtual circuit. We can also use the concept of a VLAN stacking. Now, VLAN stacking means that you are bundling some virtual circuits into a big, another big virtual circuit just like in the ATM network where virtual circuits were bundled into a virtual path. So, this is like tunneling. So, the same tunneling effect of virtual circuits can be created in an Ethernet based networks also by using the concept of VLAN stacking.

So, in the VLAN stacking, what you can do is that that you can attach a VLAN tag to an existing VLAN tag. So, this VLAN tag will become an outer VLAN tag which will identify the tunnel and the inner VLAN tag will identify various virtual circuits which are kept inside that tunnel. So, it is possible to do this nesting of these tunnels inside a tunnel by using the concept of the VLANs tagging which has been standardized in IEEE's 802.1Q which is called actually popularly called as Q-in-Q features.

We can provide an elementary protection and the restorations capabilities. The spanning tree, the original spanning tree protocol has been modified to what is called as the rapid spanning tree protocols and IEEE's 802.1s standards actually defines the rapid spanning tree mechanisms.

So, one can have protection and the restoration features through the help of a rapid spanning tree. As far as a quality of service is concerned, one can use the ethernet has a 802.1p priority bits which are 3 bits really and therefore 8 classes of services can be created in a Ethernet based networks. Traditionally, this field was never used in the enterprise local area networks. But if you want to provide ethernet based broadband access services, then perhaps this field can be used to create priority queues inside an ethernet switch and provide the quality of service guarantees.

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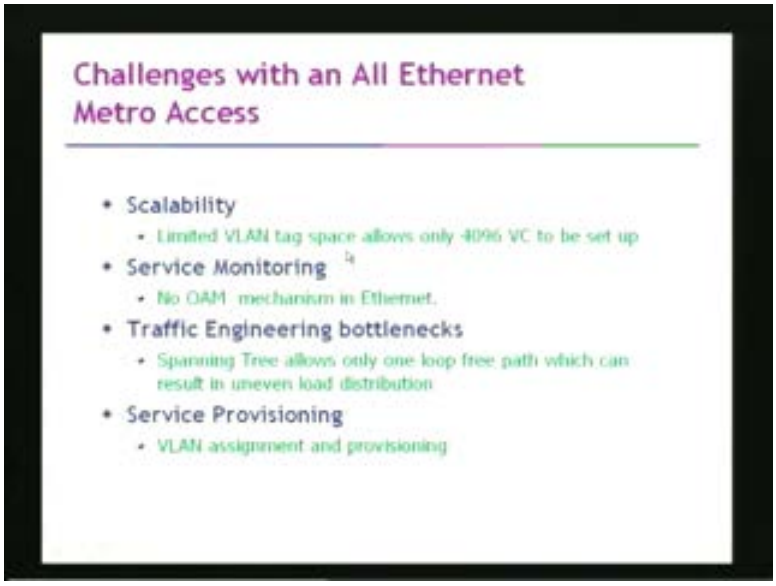

Now, if you see that if you consider ethernet based broadband access networks in its native form, so even though the notion of virtual circuits perhaps can be addressed by using point to point VLAN and VLAN stacking and by using some kind of priority mechanism, there are still challenges for the large scale deployments of such native mode based Ethernet broadband access networks. So, what are those challenges?

One of the challenges of course is the scalability. Even if you assume that we can provide the virtual circuit by using point to point VLAN, remember that a VLAN has only 12 bits and therefore you can actually have only 4096 virtual circuits to be set up in the networks. So, if you want to go beyond 4096 virtual circuits, then this will become a problem. The scalability will be a serious issue with the VLAN.

Service monitoring; no OAM mechanisms is currently available in the Ethernet. As far as the spanning tree is concerned, spanning tree allows only one loop free path which can result in uneven load distributions and therefore traffic engineering will become a serious bottleneck if a large scale wide area deployment of the Ethernet is done.

And thirdly, service provisioning; the VLAN assignment and provisioning still continues to be a major issue in the Ethernet based broadband access. So, these are basically the

challenge that exists when we take up this native mode ethernet for the large scale deployment of Ethernet based broadband networks.

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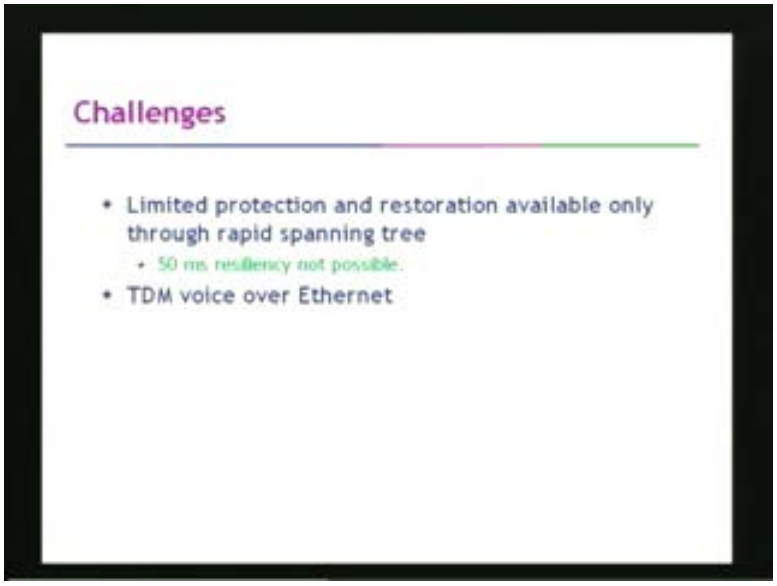

Then there is a limited protection and the restorations capability is 50 milliseconds, resiliency is not possible and finally we have the Ethernet based broadband networks typically cannot carry the TDM quality voice unlike in the SDH network, in the SONET SDH networks where it was possible to carry the TDM quality voice and as well as the packet data.

But however, in the pure Ethernet ring based architectures, it is not possible to carry the TDM quality voice. That is also a big challenge that needs to be needs to be addressed. So, then what is the solution?

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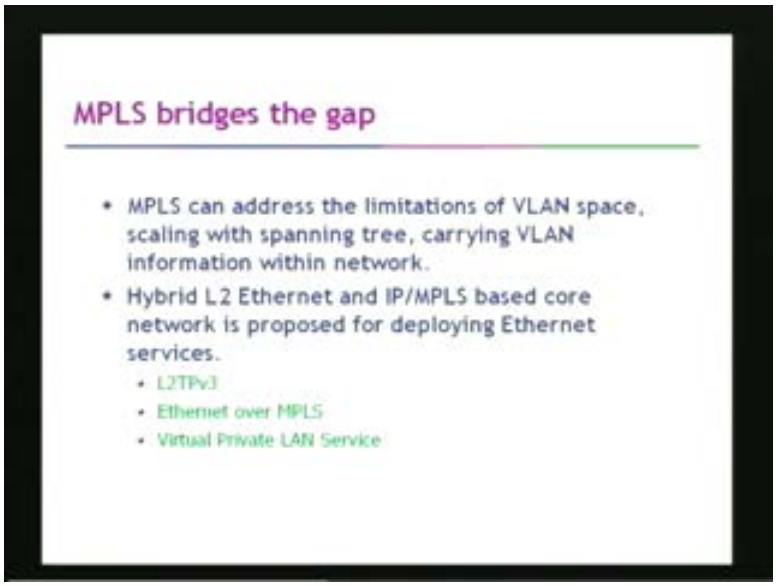

The solution it turns out is that the MPLS, the multi protocol label switching actually bridges the gap. We have already studied MPLS in our previous lectures and now we will see how MPLS can really be a useful device, can be a useful technology for addressing this challenge that we can have a ethernet based broadband access deployment using MPLS as the transport technology in the core of the networks.

Now, MPLS can actually really address the limitations of VLAN space scaling with spanning tree because by using the concept of a MPLS label, we can actually address these limitations fairly easily. A hybrid therefore, it appears that a hybrid L 2 Ethernet and IP/MPLS based core networks is likely to be used for deploying Ethernet services like layer 2 VPNs, Ethernet over MPLS and virtual private LAN service.

So basically, what is going to happen is that as far as the first mile and the metro access are concerned; may be, we can run ethernet in the native mode but as long as the core or transport network is concerned, to provide Ethernet based services, MPLS will have to be used as a transport technology. So, let us look at the issues that are involved for MPLS for Ethernet services.

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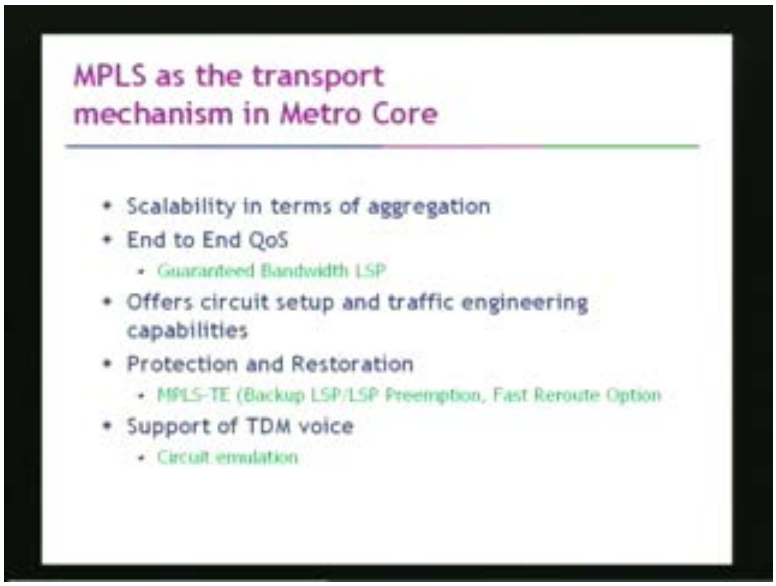

Now, MPLS as the transport mechanism in metro core has lot of advantages. It can provide scalability in terms of aggregation. MPLS can of course give you end to end quality of service guarantees in terms of guaranteed bandwidth label switch path, it can offers a circuit setup and traffic engineering capabilities.

Now, MPLS has recently also come up with protection and restorations mechanisms which are quite good in terms of MPLS traffic engineering and fast reroute options and also MPLS provides the support of TDM quality voice using circuit emulations. So actually, you can carry the TDM quality voice over MPLS based networks using circuit emulation of the voice over MPLS. So, that also somewhat addresses the problem of the transport of TDM quality voice over such packet based infrastructure.

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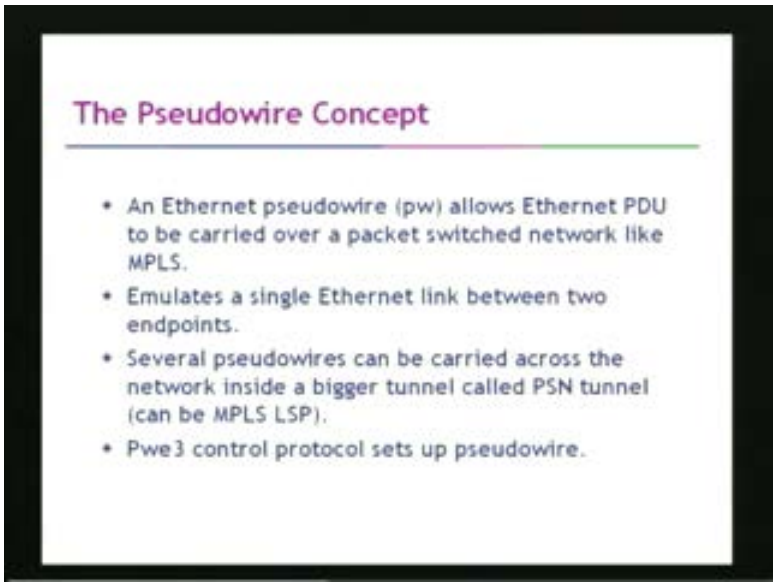

There is this pseudo wire concept; an Ethernet pseudo wire will allow an Ethernet PDU to be carried over a packet switch networks like MPLS and it basically emulates a single Ethernet links between 2 points and several pseudo wires can be carried across the network inside a bigger tunnel which can be called as a MPLS label switch path.

So, pseudo wire actually, it can emulate a single Ethernet link between 2 endpoints in a packet switch networks. So basically, when you have the metro access based ethernet networks and the first mile networks and MPLS based transport technology in the core, you need to define a mechanism of carrying Ethernet over MPLS, how to carry the Ethernet frames over MPLS.

So, the concept of pseudo wire, so pseudo wire will actually set up the tunnel and then the encapsulation mechanism of encapsulating ethernet in MPLS packets is provided by Martini draft.

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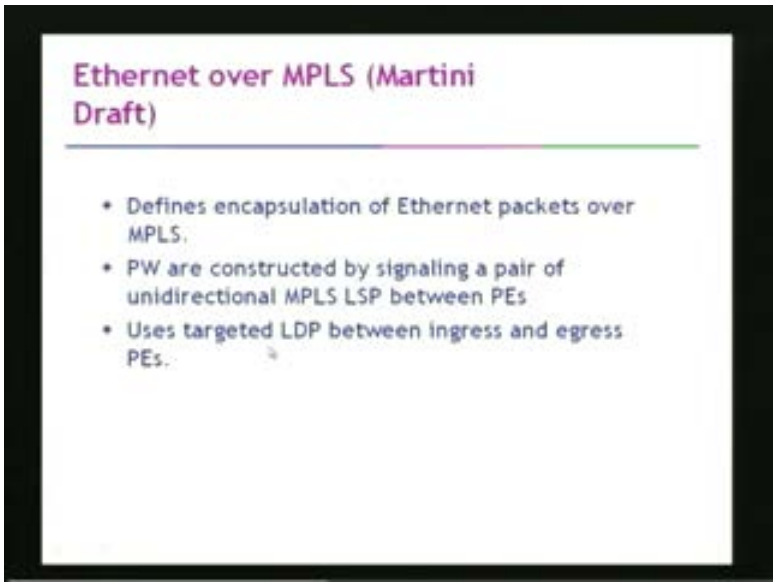

So, Martini draft actually defines the encapsulation of Ethernet packets over MPLS. Then pseudo wires are constructed by signaling a pair of unidirectional MPLS/LSPs between provider edges and then it uses target LDP between ingress and egress provider edge.

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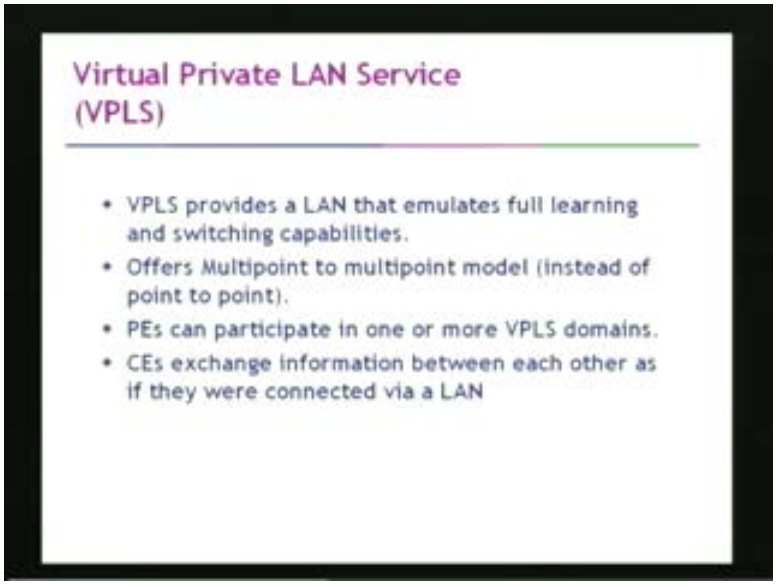

So, then we can have a service like virtual private LAN service which actually provides a LAN that emulates full learning and switching capabilities and offers multipoint to multipoint models instead of point to point. Providers' edge can participate in one or more MPLS boundaries and CEs exchange information between each others as if they were connected via local area networks.

Now, what we will do is in the next lecture, we will discuss issues which are related to what are the challengers that are involved for ethernet in the first mile and then conclude how ethernet can be used as a technology for the broadband access.