Communication Networks
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Module - 06
Data Networks
Lecture - 30
Introduction to Data Networks cont'd

So we have started discussing our Data Networks. So, in that particular thing, we have actually talked about how the circuit switch network traditionally changed towards a data network. So, there was an initiative in DARPA they have started connecting machines and all those things we have already discussed. So, from there what we have understood is that the core part of the network probably still requires a circuit switch network.

We have already discussed why that is required and all those things. And in the access part of this or where the user is getting interfaced with the network that is where probably statistical multiplexing is required and probably a new kind of networking, which is the data networks probably or the packet switch network we should say.

So, that is being initialized. So, let us try to understand a little bit more about this kind of networking. So, what is the requirement and all those things? So, let us try to see in a data network we have already seen that it needs to be done with packets.

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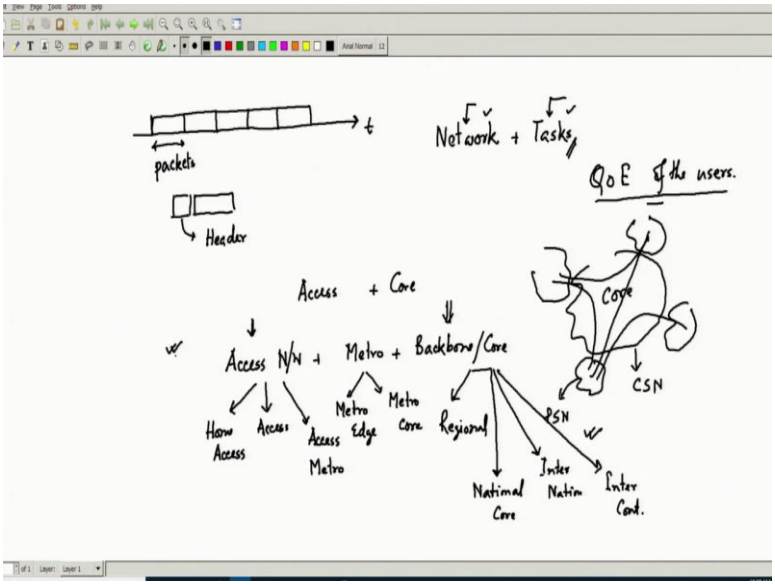

So, what essentially means that I have a continuous if even if I have continuous streams of data. So, in time let us say it is just initiated over here and it is continuously sending some amount of data. But what I will be eventually doing because of this packet switch network. So, I will first divide the data into smaller chunks we call packets later on you will see that this is actually termed as PDU or protocol data unit. So, that is why that terms we will come to that later ok?

So, this is where we will be constructing our packets ok. So, basically, this is the raw data and we have just segregated it into multiple segments we take those packets, and then on that packet, we actually add headers these are some redundant bits, that are required to fulfill some of the tasks of delivering the data from one end to another end ok. So, this task what is a network offering these days, ok, we have to understand those tasks and how they are linked to these headers.

How the header fields are specified, concerning how the tasks are being executed is what we will be mostly discussing in this particular part of the course ok. So, we need to understand these headers very carefully, but before that, we need to understand what is the philosophy of this, what should we do with these headers, and what is the task that we are talking about ok. So, that is something we need to understand and we need to also understand the corresponding network.

So, these two things, network, and the associated task, are the two things that we will be mostly discussing. So, the network that will be built, of course, should be consistent with the task and the associated task that has to be performed by the network. The major task is only one deliver the data, wherever it is requested from wherever it is injected, and wherever it is requested faithfully deliver the data ok.

So, when I say faithfully there are many parameters of this faithfulness. One is you should not have any drop another is you should deliver them within some time. So, timely delivery has to be occurring. So, all these things are part of the faithfulness sometimes the data order should be maintained so, all these aspects are the faithful delivery of data. So, all we are targeting for the major task is faithfully delivering the data whatever the faithful means to the user.

So, that is why it is always specified by the user. So, we say quality of experience by the user QOE quality of experience of the users. So, data delivery has to cater to this quality

of experience that the users are asking for. So, that is all the network has to do. Due to that, the network has multiple tasks to perform, this particular thing to be done is not that easy because there will be millions of users who will be connecting. They will be all asking for the same thing, you have to have a common infrastructure and they are all arriving randomly with a random amount of traffic.

So, you need to handle all these things and you need to deliver faithfully. So, that the quality of experience is being satisfied end to end, from wherever the request has come from and up to where the request has to go. So, all these things have to be done for that we need to design a network properly and we need to see how those tasks can be optimally put forward. So, this is what we will have to see.

So, if we now try to concentrate on these two aspects one is the network aspect and one is the task aspect. So, let us first try to see the network aspect of it, and then we will go to the task aspect. So, what is the network aspect? So, network aspect already we have seen, that maybe the whole network does not behave similarly.

So, we have already identified that the, if the network has access which is the user interface, and the core part which is the in-between. So, basically, the core network this is the core part and then these are the access, which is actually connected to the core ok?

And they require service from one point to another point. So, this core part generally it is generally a circuit switch network. And this part access part we have seen that it should be a packet switch network. So, as we can see the requirement of a network in different locations of networking is also different. So, therefore, the network has to be segregated accordingly. So, what traditionally has been done is that just not access and core there are some intermediate stages also.

So, basically between packet switching and circuit switching, there are some intermediate stages also. So, that is how people have segregated the network. So, they call it the access network, of course, then the metro network, and then the core or backbone network again these also sometimes are segregated. So, in this part sometimes there are many names that come into the picture one is called home access, this is the network within the home ok?

So, these days even homes are becoming bigger and there are multiple users who and there are multiple also envision that multiple machines will be there will communicate with each other your refrigerator will communicate to probably your microwave, and all kinds of things your coffee machine will communicate with the alarm clock.

So, all kinds of things will be happening if that is the case then within the home also there should be networking. So, that is the part which is called home access. Then the actual access part and then the access, where it meets the metro which is called the access metro. Similarly metro also has two parts, one is towards the access one is towards the core. So, this is called the metro edge and this is the metro core. Again core network also it might be a regional core, then there might be a national core then there might be an international core even intercontinental.

So, there are so, many segments of the network and remember we will later on probably discuss in detail that each segment actually does different tasks. When once we go ahead with the task description of the networking you will see different network segments also actually do different kinds of tasks. That is also another part that will be apparently becoming interesting. Different network segment has varied networking architectures as varied kinds of means networking requirements are over there, and what kind of media they use to install also varies.

As you can see in the backbone the amount of traffic, because they are all getting aggregated. So, the amount of traffic will be very high whereas, access the traffic will be much lower. We have already seen that access traffic is more random whereas, backbone traffic is more smoother. So, therefore, circuit switching probably is more capable over there, but the traffic volume will be very high.

So, therefore, optical fiber is probably the only solution optical fiber with DWDM means dense WDM technology with a very high data rate sometimes it goes up to each wavelength you go up to 160 Gbps. These kinds of transmission also become essentially point-to-point links probably most of the time. So, that is why many kinds of technological differences will be there. Whereas, access is more like a common media is there. So, shared media you will be trying to access everybody is trying to access the shared media.

So, there might be a chance of data transmitted at the same time, either collision or if it is wireless then interference cancellation. So, all kinds of things come into the picture. So, as you can now see there are a lot of complex tasks, which are involved to make the network realizable. So, that task we will be also discussing that, but you can see that the network gets segregated along with the geographical location of the network ok.

So, this is something we will be discussing heavily with each segment of the network what is the specialty of that network, what task it does do, and what kind of architecture do you need to propose for this kind of network? So, this is one thing that you have to keep in mind so, that is one part of the network. The second part of a network which also comes hand in hand is the topology of the network.

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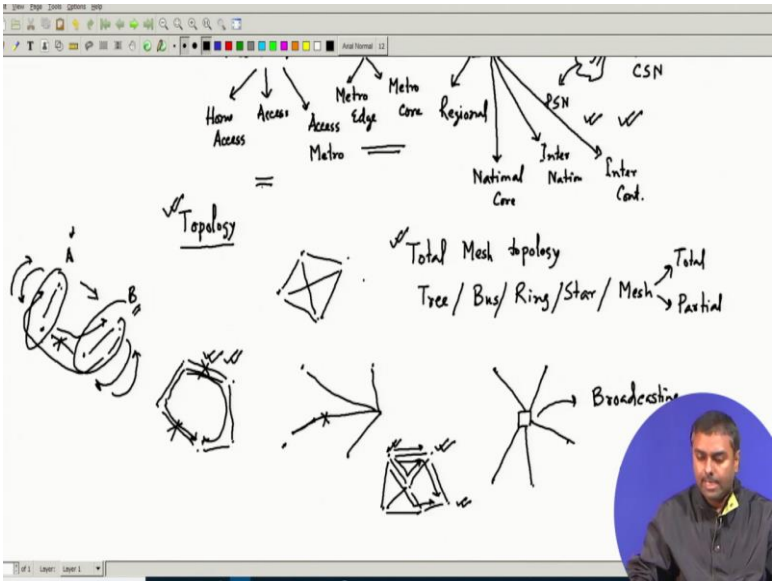

So, topology means it is like a graph you have some nodes, and networking is all about how we want to how do you propose to connect the graph or connect these nodes. What should be your underlying edge graph, which will connect these nodes ok.

So, of course, you do not want to lift leave-out nodes, but you also do not want to overdo it. In the first or second lecture, we were told, that if n nodes are there and everybody has to connect to every other node, then n c 2 connections are required and n can be prohibitively large over here in networking. So, it can be billions of users.

So, you cannot really propose to give that many links between users so, you do not want to do that so, therefore, there must be some technology. So, the worst technology that we can talk about, or probably we should say that is the in a way best also, because everybody gets connection. So, basically, you give connectivity suppose only these 3 nodes, if we consider you give connectivity to or this 4 we consider.

So, you give connectivity to everyone to everyone. So, all these 4 c 2; that means, 6 connectivity you provide ok. So, this is called this particular network is called graph theoretically it is called click ok. Or in networking terms, we call it total mesh, mesh topology ok. So; that means, everybody should be connected to everybody. So, this is not required so, often we go about it and do something else ok.

So, there are multiple topologies, I will list them later on we will discuss them. So, you have something called a tree, you have a bus you, have a ring, you have a star, and you have mesh, of course, the mesh can be total mesh like this one or it can be partial mesh. So, if we just try to see over here, let us say I give just 5 nodes over here and I want to connect. So, one might be a tree; that means, I go over here to a particular so, basically, I construct a tree.

So, let us say I go to from this node to this node from here I probably start branching out something like this so, that is the kind of tree network. So, from one particular node, I will be going to other branches from those to other branches. So, I keep doing that ok? So, this is a particular tree kind of topology. Whereas, the star is everybody is connected to I define a central hub kind of thing and everybody should be given connectivity to that hub.

So, everybody is connected to everybody and this hub is a kind of broadcasting. So, whatever comes to him he broadcasts to everybody ok. So, Star network means it can anybody can reach everybody. So, in general, in wireless media if we have a directional antenna, then it is a star topology I should say because I can reach everybody within the vicinity of course, it has to be within the listening range or hearing range two notes should be within that. If that is the case then it is a kind of star topology.

Everybody can connect to everybody or we can also say that is in a way that is also a mesh topology ok so, we can also term that way. So, that is the star. The ring is you just connect them like a ring, buses you connect them like a straight this one linear

connectivity. So, basically bus will just not have this link so if I just connect these four in a linear array, then it becomes a bus ok? Now let us try to think about the merit and demerits of these things and of course, we have all also talked about some partial mesh.

So, partial mesh means so, suppose I have few nodes. So, I will be connecting a few of them to others not all to all so, this is a kind of partial mesh. So, as you can see this particular node is not connected to this node directly, but he has via connectivity and he has multiple such via connectivity ok so; that means, he has the option to reach the other nodes in multiple possible ways even his neighboring nodes also he can reach in multiple possible ways ok.

So, that is called partial mesh; that means, I do not provide total mesh, I do not give everybody-to-everybody connectivity, but partially I connect them ok. So, that is one way of doing it. So, think about this partial mesh and ring topology, it has some inherent advantages. So, these topologies are somewhere means they have some different things. So, we will try to appreciate that part also.

So, the ring and the partial mesh have some advantages what is that advantage? The advantage is, in the network, there will suppose these links will be failing there is the possibility that links will be failing, it might just suppose you have a fiber and that fiber gets cut due to road work or due to some other things due to some natural disaster so, there is a cut in that. So, immediately what will be happening?

So, suppose I have a bus network so, it is like this they are connected. Now, everybody was getting connected to everybody else, because he could connect to him via these two nodes so, that was possible. He can connect to this guy via this node. So, everybody was connected in a way only they had to go and bypass some other nodes to reach the other node. So, connectivity is there.

But, now suppose I have this link failed then immediately you can see two islands are forming. So, this guy can communicate to this guy and this guy also can communicate to this guy and so, on over here so, they can communicate to each other. But none of them intermediate connectivity is lost. So, none of them from that is an island, island A and island B if we say from A island none of them can connect to B island.

This is the big disruption that one fiber card can any time. So, we will have a completely dislocated network and some of the guys cannot reach others. So, think about that your important server is residing over here and you are residing over here, you want to access that server you cannot do that because the network has got a single fiber cut. But if you have a ring or a partial mesh, then you have multiple all-in rings at least two alternatives are there. So, this guy earlier suppose he was connecting to this guy over here.

Now, this got lost you can still come over here. So, the ring has inherent protection, of course, but it comes with a cost nothing is free over here. As you can see in the ring you need to still put this extra link, which costs because you will be installing some physical infrastructure over there. You might install fiber, you might install coaxial cable, you might have to put a point-to-point wireless link, whatever you put that cost, but with that minimal cost, you are getting some service over here.

Partial mesh is even more protected because it has multiple paths from one node to another node to reach ok. The more actual connectivity you give more paths will be generated and the more protected it will be of course, definitely that is something that is very obvious. So, accordingly, you have to design your network. So, now you have understood that the topology is very important, you are more in failure failure-prone region where the data connectivity is huge means one link failure means a huge amount of connectivity gets lost.

So, there you have to provide protection because more number of if you go towards backbone probably one link failure means probably let us say it is a it is a link between Calcutta and Delhi. So, that link fails; that means, all the traffic all the users millions of users are connecting from Calcutta to Delhi all their connectivity will be disrupted. Whereas, in your local vicinity one link gets failed probably the subscriber loop, that is directly coming to your home that is getting disconnected or that fiber is getting cut.

You are the only one who will be suffering nobody else in the network. Whereas, that particular link is carrying thousands of people traffic. So, therefore, according to the importance of the network you need to also think about what kind of topology you should put where you will be having inherent protection. This is something you need to keep in mind ok. While designing the network so, as I was talking about. So, you have a

network and you have a task. So, this network design comes heavily with this topology design also.

So, what kind of you have multiple options of topologies, and what kind of topology we will be taking, that completely depends of course, you have options, but you need to now think carefully about which one I should put. So, everybody has their pros and cons a bus has a lower cost of installation whereas, it is not protected against failure. The ring has a little higher cost, but it is more protected at least it has a second degree of protection against failure.

Whereas, partial this one is more costly because you have to put some more connectivity, but it is more protected. So, accordingly, you have to make a decision ok. Again if you think about this tree it is also not fully protected because one link failure of course, only one of the guys will be suffering over here, But the tree also can be something like this so, it goes to this then it goes to branches out to multiple other things now where the cut happens.

So, if the cut happens over here this entire number of users we will be disconnected to this entire number of users. If the cut happens at the lower end of the branches or lowers this one level of tree then probably not many will be disconnected. So, it all depends ok sometimes in the upper part of the tree you try to provide some mesh connectivity if possible because they have to be protected.

So, accordingly, you decide actually your topology is your decision your networking decision. So, you need to decide what kind of topology you should be installing. So, now we have understood that there is regional segregation of network and also there is differentiation in topology. You will also see that many of these places have different topologies most of the time the core you will be seeing they are more like partial mesh.

Whereas the metro is more like a ring because you need to still give protection. This is more like a tree or bus sometimes because you need less protection over here. So, you can see also topology basically, is decided depending on the kind of network where you are kind of importance of each link so, if there is a failure what to do. So, all those things actually decide what kind of topology will be coming. So, accordingly, the network gets segregated and according to you take your decision ok. So, that is one thing.

Now, after understanding these things can we now go towards the task of the network? So, let us try to understand what is the task of a network let us try to understand that part. So, the gross task we have already understood now is just delivering faithfully or delivering with GOE Quality Of Experience, for the users that they have targeted or they have demanded. So, with that, you have to deliver the data into the end from one end to another end wherever the data has to be delivered.

So, that is the major task of networking, but for that task, the network has to do a lot of things. Let us try to understand this from a very simple analogy that we do often. So, let us say we talk right. So, this is also not one kind of communication basically the entire communication comes from keenly observing this particular thing, and our communication verbal communication lets us say ok.

So, in our verbal communication let us try to understand what are the things we do can try to characterize those things. So, whenever we talk you might be thinking that we can freely talk, but there are some protocols when you are talking to somebody else what are those protocols or some rules actually, that both of them should not be if two persons are trying to make a meaningful conversation they should not start talking at the same time, they should not be nontalking or they should not be silent at the same time.

That is the, that is the basic requirement of communication. So, one should talk, and then when he stops the other one should start talking or the other one should start responding. So, this is the simple mechanism that if I talk the other party should mean should not be saying anything ok at that point. How do we do that? Generally, whenever it is there is some gesture there are some rules to these things. So, you actually initiate a communication you tell that ok.

Can I say something then the other party gets he stop talking he will be listening to you and start telling then you can say that I have finished then the other guy can start initiating then he can again ask if should I start explaining my own thinking. So, like this, it goes on. So, there is a protocol and if you can see that the protocol is all about other than talking you are doing something some gesture or some verbal phrases also you are exchanging, that wait can I say something?

So, these are not part of actual communication. You might be discussing something about quantum physics let us say, but in between you are saying something that is not

part of quantum physics you are just telling others to stop and then you are trying to say something ok. So, this part is part of those almost like the header. So, that is where you need to insert some of the extra things to facilitate this communication.

And that is the part of protocol actually, where you are adding a header to facilitate these things in communication we do a lot of gestures. So, suppose somebody wants to ask the question what they do they raise their hand this is a gesture. Again it is part of the protocol it is part of the extra sign communication that you are trying to do to get attention sometimes in a chaotic situation multiple people are there in a crowd you want to talk to somebody.

So, you just say shout attention please everybody stops, then you talk to him when you talk to him you address by his name only he will know that it is addressed to him. So, all these things actually whatever you are talking about that has nothing to do with his name probably you are trying to give some instruction that ok you should prepare this document, but there you need to call his name because you need to get his attention in particular you need to give that task delegated to him only.

So, this is part of networking again as you can see, or part of a communication task. So, there are extra things, sometimes you have to do name calling, sometimes you have to do some signing sometimes in a crowd you have to stop others to communicate by doing some signing. You will see all these things are incorporated in networking in the access network if I just give one example, in the access network everybody is let us say this air everybody can communicate if there are 5 fellows over here who wants to communicate to each other everybody can at the time at the same time can communicate.

If they communicate simultaneously they will collide because their data will be jumbled up they will be superimposed and it will become garbage 1 0 will be all mixed up ok? So, if I am doing digital communication 1 0 will be all mixed up I will be getting garbage at the receiver end. So, I need to somehow do the mechanism. So, that somebody can capture the channel he might say all others stop I am communicating I will finish my communication then you can start.

How do I do this among the machines? So, whatever understanding we had as human beings while doing the communication same understanding has to be given or delegated to the machines. So, that they can do the same task that is part of the networking. That is

where we will see a lot of protocols are designed like all these wireless Wi-Fi you are using or Ethernet protocol you are using. So, all those are coming up with these protocols of collision avoidance CSMA CA, CSMA CD, these are all techniques of accessing the channel stopping others from communicating and doing the collision avoidance.

So, the two fellows are not communicating simultaneously and wasting the channel. So, all these things all these tasks are simply taken from a human understanding of human communication understanding ok. We will try to see and appreciate how this has been implemented, what kind of algorithms have been proposed for these things, and how the headers associated headers as we have talked about communication signs or some extra language that we use similarly we have some headers.

So, how those headers are consistent with the kind of rules that we will be implementing? So, that is probably the task that will be targeted in the next ok.

Thank you.