Communication Networks
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Module - 07
Data Networks
Lecture - 31
Layered Architecture

Ok, so in the last class, we have already discussed means we have started doing the introduction of data networks and then we have started discussing region-wise networking architecture and the way we realize the network-associated protocols that will be different. And even the technology of networking like whether it will be circuit switching or means packet switching, so that also gets differed.

So, this is something we have already discussed. Then we have started discussing so, there is a regional wise means different kind of that is why network inception is there or the perception of network is there like core network, metro network metro also there are different segregation, so we have discussed about those segregation. So, you will later on see that all these networking when we will be actually discussing they will have different different realization.

And they their overall technology, architecture, associated protocols will be completely different, so that is something we need to keep in mind. The second thing that we started discussing is specifically in network there are two things one is the actual architecture and the other one is what are the task that we will be doing.

So, how the network is perceived and what are the task that we will be trying to do because any communication requires some task we have also started listing and started putting analogy between our verbal communication and networking ok. So, it is anyway exchange of information.

So, there must be some task that has to be done which are outside just the data transfer. So, we will have to just to make it fulfilling the experience fulfilling and to satisfy users experience through the network.

So, we need to do some tasks. So, that task we will be discussing in detail those protocols, how the tasks are segregated, which particular protocol handles which particular task how they are being means by implementing simple protocols and putting additional headers to the packet that is generated, how we actually get those task done by the network or by the connected machines.

So, that we will see that we will appreciate that is one part ok. So, that is one thing and we have also started discussing about the topologies there are multiple topologies like bus, ring, star what is the relative advantage disadvantage of them, so that also we have discussed.

So, now we will probably once we have got little bit of idea of course, the idea will be more cemented as we go along our journey. But now, because we have discussed a little bit about the regional segregation of network and their associated topology we will later on see how those topologies in each region which one is predominantly used and all those things why it is used some initial discussion we have already done because of network protection. So, you have an alternate route and all those things.

But, what now we will be trying to do is we will try to see all those tasks. What are those tasks? Very basic discussion we have started with the analogy of human communication or verbal communication probably. We will try to see in networking what are the tasks are there, how do we segregate those tasks and how do we organize those tasks that will be the major functionality of today's discussion.

And that is where the data networks has been designed as a layered architecture you see it is a virtual layering ok. So, that is something we will be discussing there is a 7-layer architecture which is from OSI and then there is the most popular one which is the TCP IP architecture which is the 5-layer architecture.

So, we will be mostly discussing about this 5 layer architecture because from the network perspective probably this is sufficient. So, we will discuss about these things that particular thing. So, we will try to understand how with this basically layered architecture all the tasks are being performed how in the network they are being realized, and how they work with each other. So, that is something which we will be targeting today. So, let us try to see what is this task ok.

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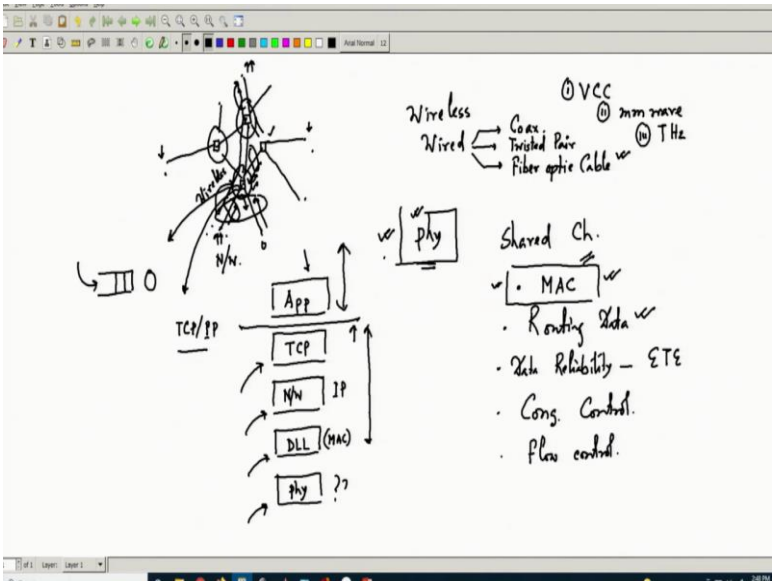

So, if you have to do a networking. So, let us say if I have to do networking. So, it is like some nodes are there which wants to communicate in between we also put additional nodes which are like our circuit switch network which are associated with the networking task only.

So, it does not basically these are not source or destination, they do not generate any information they are not source of information they do not accept any information. So, they are not actually the one which is interfaced with human being who needs to access this information. So, they are not there for that purpose they are just there for the purpose of routing the data in proper way.

So, they are most of the times they are called switches in TDM already you have seen them, they are either switches or they are actually the network element. They might be multiplexer in TDM we have talked about that here they might be termed a switch, router and so many other devices which are generally put over there.

So, generally what will happen these things will be connected to those switches. So, all these end users will be connected to those switches and these switches will have connectivity among themselves. So, multiple users can be connected and then switches might have some connectivity among themselves.

So, some kind of connectivity they might have among themselves. So, this is the network let us say we have a very simple network which we have realized over here. Of course, the network can become much more complex, much more number of users, many more switches they might have very complicated connectivity. So, the connectivity we have shown among the switches is kind of a partial mesh.

So, it can be any arbitrary kind of partial mesh. So, some graph will be formed. So, this is our network ok. Now, let us try to see if somebody will be this is the originator. So, somebody will be generating data towards somebody ok and this data similarly others also might be generating data ok for another particular guy like in circuit switching whatever was happening ok.

Now, what network needs to do is faithfully transmit this data to this and this data to this without jumbling up any of these data. So, that somebody else's data is not being transferred to others and the data must be in order within time. So, all those user requirement that are there without any loss of data. So, in between some data must not be lost, so all these things should be happening. So, this is our overall task we have already discussed about that.

Now, that task if we now try to segregate it, what are the basic very important task that are there ok. So, let us one by one try to understand. So, first it is a data; data means it is let us take it as digital data. So, you have digital data whenever you will be transmitting you have a media over here. So, there are multiple kinds of media that might be there you might have wireless media, you might have wired media, and in wired also I might have multiple kinds of media.

So, I might have coax means coaxial cable, I might have twisted pair which was used for telephony earlier. So, it is just copper wire two copper wire twisted ok very thin copper wire with some insulation they are twisted. So, that is twisted pair you might have fiber optic. So, these are the possibilities even in wireless also you might have different different kind of things. So, you might have this means wireless at different frequency range you can operate them, it might be a satellite communication where you actually communicate to the satellite whether geostationary or non.

So, you communicate to them and then from there it comes back. So, it might be some other wireless other forms of wireless communication, which are there are multiple

frequency range which you will be using sub 6 gigahertz, then you can have a limited wave these days terahertz is becoming important then even optical signal also you can actually put it on air, so that is the visible light communication VLC.

So, you can have VLC, you can have millimeter wave, you can have terahertz. So, you can have multiple ways of communicating, of course satellite is another thing sub 6 gigahertz different bands are there in different bands. Of course, the technology will be different the way you use the band and the way the channel behaves it will be different.

So, anyway the purpose is that there will be a channel everywhere, whatever you put they might be a wire hyperoptic cable, they might be wireless whatever it is there is a channel. So, first task that you have to do is all the channels we already have studied in communication that all channels will be giving some impairments channel means it will have some negative effect.

So, its impairment it might be there. So, among impairments there might be many things like noise, the interference, distortion all kinds of things might be there ok. So, all we have to do is we have to combat these things. So, for that we do different things we do sometimes source coding, channel coding we also employ the channel effect cancellation like channel equalization sometimes we do modulation for different purpose also.

Sometimes we do modulation for even cancelling channel effect like OFDM we do that, but we also do means modulation for multiplexing ok. Whatever be the reason we will have to do all these task. So, these are some of the tasks which we have to do to combat the channel. So, whatever data we are transferring finally, that data has to be physically transferred.

So, we have to be concerned about in the physical layer What is there, in that physical layer how do I really transfer push the data to the other end ok. And it might be as you can see the physical layer might be hop by hop it is not that from source to destination you will have similar physical layer. It might be just the next hop up to next hop it might be wireless this is generally beneficial because of the mobility now people want.

So, if you have to have mobility to the user given to the user, so the last part which is the access part must be wireless because then you can freely move with your laptop with

your whatever device you have mobile or some other display device that you have. So, you can actually freely move.

So, that part might be wireless. So, that channel will be wireless, but that will go only to up to the access point ok. So, next access point it might be your base station it might be just your Wi-Fi access point whatever it is; it is just up to that wireless will be there, beyond that it might be different channel ok.

So, hop by hop there might be different different channel, it might be coaxial cable over here, it might be fiber optic over here, it might be again a wireless over here two wireless technology in both sides might not be same one side it might be let us say sub 6 gigahertz. You are using this 4G or 5G LT whatever it is or maybe Wi-Fi.

Whereas the other side you are using millimeter's wave probably. So, it might be completely different technologies that will be there every hop you will have this media which has to be come back in a different way depending on the media. So, that is something you have to ensure.

So, how do you ensure that you ensure with the task of doing modulation, channel equalization, synchronization all kinds of things ok. Means you do all these things to actually combat you might do source coding, you might do channel coding all these things you actually do.

Whatever you have to do for a point to point physical link you will have to do and that is a task that has to be done for data transfer ok and you have also appreciated now that this task has to be done differently at different hops of the network.

So, if I have a network from source to destination I might go to the next switch which is local access point, from local access point I might go to some means metro edge network where I can go to some egress point of that edge node means metro network, then I can go to a egress node of core network or gateway to the backbone network.

So, all nodes will be there in between and I go hop by hop from one node to another this is all about networking ok. So, we will have to do that and all the intermediate nodes which are we are terming as switch or router or whatever it is. So, those will be taking care of forwarding the data so that we will discuss later.

But right now what we can see every hop we need to do this task. So, that is the task of physical layer ok we still we should not talk about layer. So, these are some of the tasks which are associated with the physical data at the bit level ok. So, you we have to do modulation, channel equalization all kinds of things we will have to do.

So, that is something some task we will have to anyway do ok this is one task we will have to do it to faithfully transfer the data to the other end. Next what is there let us try to see if there is a media in the access part if you try to see ok. So, if there is a media sometimes what might happen it is a shared media. So, let us talk about this 5 G or 4 G access you are doing.

It is a shared media it is your AR where electromagnetically you actually take a same frequency electromagnetically you transfer the data over that frequency you modulate at that frequency and you transfer. But, when you are doing multiple other users present at that vicinity they will be also doing the same thing. So, how do you actually moderate this access of the channel, because it is a shared channel.

So you have a shared channel and you have to somehow devise a mechanism to moderate the access of this channel. So, we generally term is this as media access control or MAC media access control you will see later on.

So, this is another task we have to somehow do that, because if there is a shared media how do we really access that like over here I was talking about this general verbal communication if you have too many people you want to talk to somebody what do you do you before even starting to talk you actually shout somebodys name that ok.

I want to talk to this guy everybody else actually they stop communicating. So, you get free media towards that particular guy and then you say whatever you have to say, after you have finished your this one you release these things somebody else will be using it. So, similar kind of thing also we will have to put, so that the machines can coordinate these things.

Whatever we human beings are doing so similar thing can be done by the machines and we have to also make it very efficient. So, the common media that is being shared among users is properly being utilized and nobody is suffering that they are not getting access whereas the media is not being utilized properly.

So, this is where we will have to think about those tasks also this media access control. So, that is another task. The third task probably that comes to my mind is I have to deliver this whatever data I am transferring from the source to destination. So, all these switches has to do this delivering, he should not see suppose I want to deliver it so it must be delivered like this.

So, switch must know Switch must have that intelligence that he has multiple options he could have delivered it over there, but then it would have gone to the wrong person ok. So, he should know where to deliver every chunk of data that he will be getting he must be knowing that where I should deliver this.

How do I decide that delivery address, how do I actually decide which path I should take. So, this route selection or path selection that something has to be done by the network, because nobody else will be means standing there and taking the data and then saying that ok this data must go over there. So, nobody no human intervention will be required over there.

So, you need to have that mechanism that somebody does this job. So, that routing is another routing your packets or data that is another job ok. Now, when you do all these things you have to also keep in mind that user quality is of prime importance, user must be satisfied. So, what does that means? That means the data must be delivered on time that is one thing, second thing is it must be faithfully delivered it must be reliably delivered.

So, whatever I am generating over there that data must be represented over there otherwise it is I am emailing something that is being corrupted and some other things are going on the other side that are not good. So, we need to faithfully or reliably deliver the data.

So, this data reliability has to be somehow guaranteed. So, that is another task that data reliability. So, I am listing the task data reliability this must be maintained end to end ok. So, end to end data reliability has to be guaranteed not only that, see these switches are handling those data right. So, those data's are coming from multiple sources they are routing that. So, there will be we have already discussed about queuing.

So, there will be queuing because multiple data might come simultaneously then I will not be able to process all of them, because data requires some amount of processing to be delivered on the other side. So, that time I will have to actually this is where the server comes into picture. So, actually he that server is handling that data all other data must be waiting in a buffer. So, there will be buffer over here so there will be this one if I just make it bigger.

So, there will be that queuing and server kind of techniques. So, where data will be buffered and I have a finite buffer. Now, what might happen? If everybody is pumping too much of data what will happen this buffer has a finite capacity. So, it will overflow because he will not be able to handle all of them, so there will be some data loss.

So, this is called this particular things that sometimes buffers are getting full in some portion of the network this is called congestion ok. So, this congestion I must avoid because otherwise I cannot really deliver data reliably there will be huge difficulty. Even if I deliver it will take huge amount of delay every time there would be packet loss if packet loss happens what do I do.

So, suppose in our communication what do we do, suppose I say something and the other guy was not concentrating enough or there was too much noise around that vicinity. So, he could not hear me properly, then what do we do generally he will request ok I could not hear you or I could not understand you can you repeat that and then I repeat.

So, this is a protocol as you can see those also should be part of the reliability ok that is one thing and then if I do this if there is a congestion deliberate congestion happening, then there will be a lot of data loss. And then again this hand shaking has to be going on between the source and destination that destination should tell ok I have not received them faithfully can you deliver them retransmit them.

So, this retransmission has to happen, but more retransmission happens then there will be more delay because same data has to be multiple times delivered and then only faithfully it will be delivered on the other side. So, then there will be increase of delay.

So, congestion is not good for delay or even for because it will be losing packets so basically for reliability. So, you have to somehow control the congestion. So, this congestion control is another task, and how I can do congestion control is another thing

that the user's flow must be controlled properly, they should not deliver a flow that makes the network congested.

So, there again there should be flow control. So, as you can see I can keep listing there are so many task. So, if you start thinking about all these tasks and this will be now also the problem that happens is this task will be done in a distributed fashion, because multiple people will be doing the routing will be done by the router; whereas, this flow control has to be done by the source ok.

So, different tasks will be executed at different locations how do I coordinate, these things this is becoming already a daunting exercise. So, that is when people started thinking can we have some method in this madness, you have too many things that needs to be done. So, definitely the way to approach is can I organize this in a better fashion, can I classify the task, can I segregate who will be doing what task, where it will be executed.

So, all these things if we do then it will be easier to handle all these task, because there are so many tasks that I have already listed I have not listed many small small tasks are there as we progress the course you will see that there are many other tasks which are there.

So, how do we actually handle this; this is where the layered architecture started coming in or creeping in into the mind of network designer. So, what they started doing can I segregate this task first of all. So, they could see that this media access control or the physical layer task that is something that is very local and that is probably a function of only one link ok.

So, it is just happening over this link the physical link from this to this that might have a particular characteristics accordingly we will have to put. So, this point to point one particular point in network it might be source to the next switch or it might be switch to the next switch. So, this point to point link I have to means properly give the physical layer specification and those task has to be done whatever physical layer task because the physical layer also will be changing from one particular section to other section.

So therefore, the task also gets varied. So therefore, I need to specify this task locally. So, this is the physical layer task and also media access control that is also being done

very locally ok. At the access probably there will be a media most of the time this is where the shared media will come. So, media access must be done at the layer that is very close to the user ok.

You can still do media access over here sometimes it is being done, but that is generally that media access becomes very simplified also it might be sometimes point to point there is nothing to access over there it is a dedicated link and you just put that ok.

So, that is all over there ok. So, this might be the case, so these tasks are generally location specific and location wise getting segregated. So therefore, we can segregate those tasks. Whereas, this routing that something must be done by the intermediate nodes they are the one who are responsible for these things ok.

So, the routing will be done by the intermediate nodes. So, let us try to see that particular part can we segregate that thing and give it to those particular entities only? So, we can segregate that like that people started thinking that maybe these tasks can be segregated properly.

So, that is where people started coming up with layered architecture and each of the layer does its specific task ok. Those layered are ordered actually you will see why this ordering is required that also you will see. So, I will just first talk about the layers and then in the next class we will start talking about how they function actually.

So, the layers mean I will talk about this 5-layer TCP IP layer because that is sufficient for us there is also a 7-layered version of OSI, we will see the difference between them, but we will not talk about that. So, this TCP IP layer will also come back to this name also, but this is let us take this as some x-layered structure which has 5 layers the first layer is called the application ok.

The topmost layer followed by transport or that is where TCP comes into picture, followed by network. So, this is network or network layer where IP comes into picture followed by data link layer DLL data link layer, this is where the MAC also comes into picture we will talk about that later on and followed by physical layer.

So, these are the 5 layers which are there only if you talk about the 7 layer or OSI layer that also puts this application layer further it segregates them into 3 category or 3 layer.

So, one is application is still there then session presentation two more layers they talk about, but for our networking purpose we are good up to this only.

So, up to TCP layer if we talk about that as ok application layer we would not be touching ok. So, that is why application layer getting further segregated we should not be bothered about that ok. So, what we will be trying to do we will be every week is that we will be trying to figure out what is the functionality of these layers' physical layers we would not do this because you have already studied communication techniques.

So, basic communication technique you know I will just mention physical layer, but that is not in networking probably we do not have to discuss this; this is a point to point physical layer where all the physical layer task that you do you actually do all of them starting from modulation to coding to everything ok.

So, that is something we will not be touching, we will be mostly concerned about these three layers and a detailed discussion of these three layers how they function before even going to detailed discussion of these things we will try to see at least in these integrated structure how they do the whole task of networking that is something first we will try to appreciate in the next class.

After that we will concentrate on each of these layers their functionality, what they do, how they resolve those things, and in different parts of networking how they do or cooperate with each other. So, this is something we will be targeting in the next class.

Thank you.