Communication Networks
Prof. Goutam Das
G. S. Sanyal School of Telecommunication
Indian Institute of Technology, Kharagpur

Lecture - 03
Introduction to Communication Networks cont'd

So, in the last class what we have seen? We have talked about this TDM multiplexing and we have talked about the advantage of TDM multiplexing and the disadvantage of TDM multiplexing and what is TDM multiplexing of course, that we have discussed.

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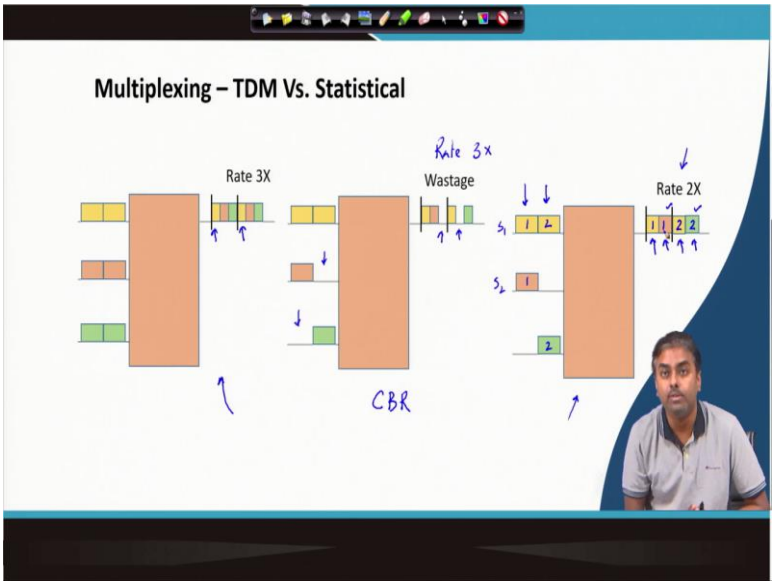

So, if we just see over here, so, we have already discussed how we do this TDM multiplexing this part we have already discussed. And then we have discussed that each of the location, so that location becomes the address of a particular stream. So, basically from the location timing location within a frame as long as we are assuming that you can identify the frame, frame boundaries and you can synchronize that, ok.

So, once that is being done you already know that which particular 8 bit is for stream 1, which particular 8 bit is for stream 2. So, the locations are becoming addresses, that was one very good thing. So basically, I do not have to really specify the addresses any longer. But the problem is as we have also started discussing that suppose each of this stream which are let us say 64 kbps stream they might not have data all the time.

So, this is that example we were trying to show that it might not have data over here, it might not have data over here. And due to that because this means every stream has a particular location in the timing space, so, I might have some of the timing space which will be wasted over here that is the disadvantage of TDM multiplexing.

So, if the incoming data is continuous stream ok or it is a continuous bit rate kind of thing. So, they call it CBR; Continuous Bit Rate kind of stream then it is very good, no problem with that. But if these incoming streams are more bursty in nature; that means, it does not have a continuous bit stream, sometimes it is there sometimes it might be that there are huge amount of data in a burst data comes sometimes there is nothing.

So, generally means data services are like that ok. Voice probably its more of a continuous bit stream, but if you talk about data services then its like that. Even voice also if we encode it like whenever there is nothing people are not talking. So, then if I just do not transmit anything, so, then voice also becomes bursty kind of thing. Whenever people are talking we have some burst of data and then there is no data followed by no data something like that.

So, if the traffic becomes bursty in nature, so, those traffic if we try to do statistical multiplexing sorry time division multiplexing then we will have will always have this wastage and more such kind of thing will be happening more and more wastage will be happening. So, unnecessarily we are probably putting a rate of 3 times, but we are most of the time not utilizing it.

So, what we can do? Either we can think about utilizing it more; so, in those gaps to put somebody or reduce the rate so that it matches with the overall incoming rate. So, that example will give in the next one. So, over here if you concentrate, so, this is other than TDM multiplexing. This is called the statistical multiplexing ok. So, we will talk about that why it is called statistical multiplexing.

So, this is also multiplexing. This is actually taking multiple input stream and at the output it is trying to multiplex them ok. So, it is trying to combine them. So, this is still multiplexing, but, let us now see similar kind of data. So, its again bursty sources. So, source 1 probably is CBR, but source 2 is bursty. So, it has some data, but then followed by no data.

Source 3 also is bursty; it sometimes have data sometimes does not have data. Now, what I do? Over here instead of giving 3 times rate I give 2 times rate. So, that will be cost effective because my transducer transmitter, receiver everything will be at lower rate. So, it will be more cost effective.

So, if I just do that now try to see. In the 1st slot over here, we have data from stream 1 and data from stream 2. We just put them one after another. So, data 1 from stream 1, data 1 from stream 2.

In the 2nd slot we have data from stream 1 and data from stream 3. So, we put that data from stream 1 and data from stream 3 we put that ok. So, the 2nd slot 2nd data from stream 1 and 2nd data from stream 3 we put them and we keep multiplexing them. So, within a slot if there are only two then I can do this ok. So, this should not be a problem. But now what is happened, what actually has happened? So, there is a problem that has been created now.

Now, look at the 1st slot ok and look at the 2nd slot. So, earlier what was happening? Whenever I pick a data from 1st slot in every frame I will be getting always data from stream 1, now that is no longer true. If I take the data from let us say the 2nd slot, one data is from stream 2, the next data is from stream 3. So, the datas are getting jumbled up. No longer the time location is the address of the stream or the incoming stream.

So, this is getting jumbled up. So, that is why it is called statistical multiplexing. So, basically the multiplexing is no longer with respect to output timing sequence. It is more jumbled up or more random according to the availability. Whoever is available you give him that slot.

So, because its random so that is why this multiplexing is called statistical multiplexing. You are still multiplexing them. You are still putting them one after another you are giving distinct location, means some location some means non overlapping location in time domain to all datas, but their locations are no longer fixed with respect to a frame, its more random. So, whenever whoever has data accordingly you are accommodating them. So, this part is called statistical multiplexing.

So, first thing that has happened is due to getting that advantage of better way means, usage of the output link we have reduced that facility of TDM multiplexing that is the

address is now gone, ok. I have to from the timing locations I cannot really say which from which particular source that data has come. So, that is one problem.

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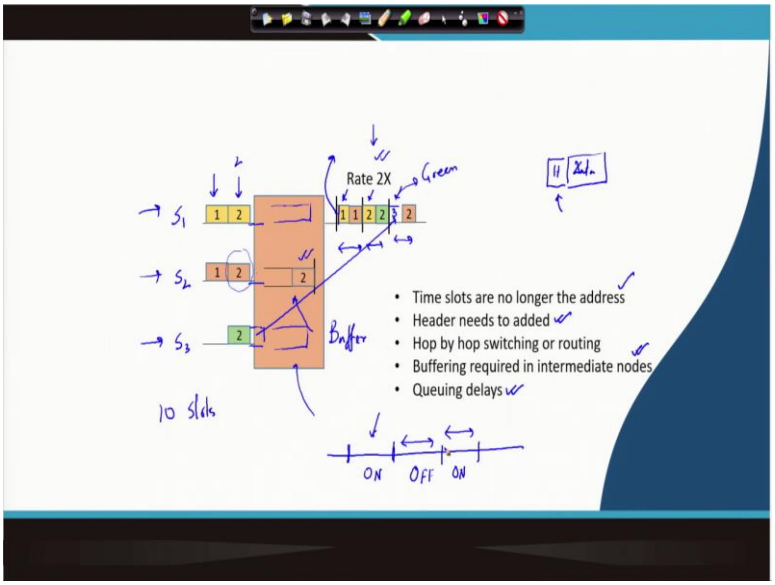

The next problem that I will be discussing, ok. So, now, let us try to see what has happened. So, due to this statistical multiplexing, so, again I am trying to put the statistical multiplexing part. So, what is happening? Suppose now instead of this I have more data ok. Suppose I am still doing statistical multiplexing with rate 2, but now what has happened?

The stream 1 is having data in both slots. Stream 2 is also having data in both slots and stream 3 is having data in one slot. What I am trying to do? I am trying to do statistical multiplexing. My rate is twice. So, I can only within 125 microsecond or within a frame I can only put two data or two 8 bit data or 8 bit sample, ok.

So, basically in the 1st slot I have no issues ok. I can put data from stream 1 and data from stream 2 over here 1 1. In the 2nd slot I have a problem because in the 2nd slot now because its bursty in nature, so, anytime there might be data. So, every stream might throw data, but what has happened? I have under provisioned the output link. Whenever you are doing TDM multiplexing you have actually exactly provisioned the output link.

So, that is why even if in the worst case scenario everybody is throwing data you have space in the multiplex screen. But that is not happening over here, I have under

provisioned it. Even though three streams I am multiplexing I have actually kept place for two streams and I was hoping that sometimes they will be having data sometimes they will not be having data somehow I will be managing them.

So, I was expecting that in the worst case situation only two stream will be throwing data. It might be any combination of them, but it will be only two stream who will be throwing data. But that has been violated because traffic can be input traffic can be anything any random things. So, they might have data. So, at a particular slot they all might have data.

Once that happens, suppose in 2nd slot you can see all of them have data. Now what? I have only two locations. So, I can choose randomly two of them. So, suppose I have chosen stream 1 and stream 3. So, I have put them stream 1 and stream 3, but now what is happening? This stream 2 data is not being transferred. What can I do? There are two options. One is I can throw away that data because I am not capable of transferring it. So, I just delete that data.

That is one option, but that is a very bad option because while transferring some of the information you are throwing out that is not a good network service actually. That means, some of the data will be deleted in the network. Its not going to the destination and then getting deleted. Its in the network you are deleting data; that means you are not transferring what is what you are supposed to transfer. So, that is a dangerous thing.

Instead of that what you can do is now you can introduce another thing in the network that is called this particular entity which is called buffer or a storage place. So, because you see that there will be occasional these kind of things which will be happening that all bursts are getting synchronized everybody is throwing data. So, at that time my output is not capable of handling all the data.

So, what I do? I introduce a buffer. So, occasionally these things will be happening. So, buffer will be taking care of this aberration. So, whenever there is extra data what will be happening? The buffer will be storing that extra part. Like over here in 2nd slot what has happened? All three has thrown data. So, I do not have place for it. So, I keep it in the buffer.

Remember for every stream now there will be buffer. So, stream 1 also will be having buffer according to requirement, stream 3 also will be having buffer according to requirement and they will be storing data whenever the overall data that you are throwing at the multiplexer is higher than it can handle at the output, ok. So, that is exactly what has happened in the 2nd slot. So, it was having three data. So, you could actually pass two of them. One, you have extra. So, you have stored it in the buffer.

And then what will be happening? Next time the third this one instances whenever that is coming at that point you try to see whether you can accommodate it from the buffer. So, basically what you will be trying to. Now, what you will be hoping that in the third slot; suppose if there is a third slot for these streams, so, let us say hopefully if this happens, so, suppose only stream 2 has stream 3 has data and nobody else.

Then what you can do? You can put the stream 3 data over here ok, of course, it should be green in color. So, that should be green. So that means, that is coming from stream 3 and the stream 2 data of the previous slot which you could not transfer you can put it over there. So, basically what will be happening? What you are trying to do?

You are putting an average rate over here, ok. So, there might be peak rate over here that can arrive all of them at the peak rate. So, at that point because you have a average rate you will not be able to accommodate. So, some of them you are not able to accommodate you keep them in buffer ok.

So, you are hoping that because there is a peak, so, there will be a place where it will be lower than average rate. It will be throwing data at lower than average. At that point you actually clear your buffer. Whatever is stored in the buffer you clear them.

So, what is now happening over here? First of all my address is gone due to statistical multiplexing. Now, I have to introduce buffer. And because of the introduction of buffer now I do not know how much time it will be data will be waiting in buffer because suppose in the 2nd slot also there are three data ok, it might happen. So, out of those three you will be able to accommodate two of them.

Now, the problem is now you have additional delay which is happening at the nodes because you are not getting chance to clear. Because you do not know when this chance

to clearance that particular instance when it will be coming that is now random also that depends on how the sources are throwing data.

So, now there is additional delay that will be incorporated in the network which is the queuing delay in every buffer of corresponding multiplexer or switches that you will be putting. So, this buffers has to be introduced for statistical multiplexing. Not only that because the means location related information of from which stream it is coming that means the address that is lost. So, you have to now additional put address into the means whatever data you are transferring.

So, because now I cannot say this is always from stream 1. So, what I have to do? While transferring the data I have to also include from which stream it is coming, otherwise means at the output I will not be able to identify them. So, basically what is happening? Every data chunk that you are transferring needs to have a header along with the data chunk, so, the data will now have earlier that was not required now will have a header associated with it.

So, this is the data, this is the redundancy you are adding just to identify from where it is coming ok. So, every data will have its own identifier that from where it is coming and where it wish to go. So, that will identify that from which stream it is actually coming. So, that identifier is now getting carried with the data. Earlier in circuit switch network that was not the case. Your location in time was already the address. So, you do not have to add any another means identifier over there.

So, once you fix the location it will be for the entire duration of the call because that is why it is it was called circuit switch network. So, it will be over there only. You can only put data in your specific place and nobody else can take that place. So, you have a placeholder in the entire network and over there whether you have data or not you can always reserve that. That is particularly for your specific data transfer. So, that is the address of you whenever you are transferring data.

So, addressing was not was inherent to the network, whereas, now that is no longer the case because you have done you have you are jumbling up. You are not doing that kind of switching. So, this new switching or new switching paradigm is called the packet switching network.

So, we can say time slots are no longer the address. We need to add header to it. This is one thing we have understood ok and the switching now will be done hop by hop. So, every hop because now the data streams are all getting jumbled up. So, there is no means as you progresses from one switch to another everything is getting jumbled up.

So, every hop you have to; you have to do switching by seeing the packet header. So, now, the addresses are being carried with the data and every switch or every multiplexer or demultiplexer has to read those header and accordingly decide where exactly he has to put that. So, the in circuit switch what used to happen? You construct a circuit at the beginning and then you have a placeholder in time in space everywhere.

You have a placeholder and you accordingly just the data does not have to do anything. That will have no address. You just keep on throwing them and the switch will be doing in a regular fashion whatever they are supposed to do. So, basically you have a placeholder in the entire network and that is exclusively for you.

In packet switch network that is not the case. You do not have a placeholder; you do not have any particular location in time of space ok in the switch. So, all you have to do is everywhere at the input of the switch you have to read that header, try to understand where it has to be forwarded and you accordingly forward it put a place in the output.

The next switch it goes, it again does the same thing. So, that is why it is now a hop by hop switching and the switching is done with the data itself. So, data has a header, you read that header and do the switching. So, entire paradigm has been shifted. Around 1980 actually this has happened. People have understood that maybe my traffic is not like voice.

So, why this change has happened? It was because of the traffic. Remember always network is driven by the traffic, how or by the application who are trying to use the network. So, people started seeing that I have to now share email ok. So, email whenever I am transferring it will go in a bulk ok. So, whenever I am transferring at that time huge amount of data will be coming, rest of the time no data will be there.

So, it automatically it has this kind of nature in the data. So, its bursty source. Sometimes there is data sometimes there is no data. If that is the case I have to do these kind of changes in the networking. No longer circuit switching is good. I do not reserve a circuit

for transferring my email I do not do that. I just throw it to the network with headers in each packet and then network actually does the switching for me.

He reads at every location there is a IP switch or whatever it is. So, there is a switch that switch reads the header and accordingly it decides where it has to be forwarded and how it put a timing, whether it has to be buffered sometimes it might be needed that it has to be buffered.

Accordingly, even the delay also will not be now deterministics that is another disadvantage of these things. Because you are putting this buffers in every intermediate node, so, you will be having queuing delay and this is going to be random according to all the sources.

Now, the sources also are becoming interdependent. So, if all the source are throwing data at their full capacity there will be huge amount of delay being generated over here that you can already see because I can only put two at a time.

So, suppose let us say up to 10 slots everybody is throwing full data. Then what will be happening? 1 1 data will be always delayed and for 10 slot 1 1 data will be delayed. So that means, huge amount of delay everybody; even if you make it fairer that you are not means making one of the particular streams to be waiting. So, even if you make that everybody will be delayed by a significant amount and that delay randomness completely depends on all other traffic.

So, every stream are now getting actually every stream is affecting each other. So, they are getting correlated and this kind of delay that will be introduced over here that is becoming random now, ok. So, therefore, any kind of traffic where you cannot tolerate random delay that is not means this particular kind of switching might not be good or we might have to do something to mean something to be introduced so that we can handle those things.

This something will be seen in the means length of this course will be trying to see appreciate those things. But now probably you have understood how from circuit switch network to packet switch network this paradigm shift has happened. Why it has happened? It was remember, this is something which people often miss.

This was not a whimsical network designing. This came from the traffic need. The input that is coming to the network or which is wishing for some services to be given for that only you have shifted this whole paradigm. So, the traffic was something different from the actual circuit switch network traffic. It was voice earlier. So, that was having continuous bit rate traffic. So, that is why time division multiplexing was good.

But whenever the traffic has shifted to data ok like you are sharing something you do all those webpage browsing you are sharing let us say some voice means some portion of voice or some portion of video like video streaming, so, this kind of or images you are trying to share. So, all these kind of traffic are bursty in nature that depends on human activity.

So, when we say bursty in nature that depends on human activity. That means, if you see any human activity its like we do something. So, basically human activities in general are driven by on off period and they are always interleaved. So basically, we work for some amount of time. So, even if in browsing what you do? You actually start searching something. You keep on searching till you get something then you will be reading.

So, basically if you see the traffic pattern when you are searching you keep on fetching data keep on requesting and fetching data. When you have got something meaningful to read you will be reading for the rest of the time.

So, that time you will not be generating any traffic. So, if you see the traffic it will be governed by some on period followed by some off period where you will not be active, you will not be doing anything. Again, you will by induced by that reading you might start searching some more things.

So, like this there will be on and off period and that is the actually means that is the most important part of the nature of human behavior that introduces this bursty traffic even while we are talking about voice. So, even in voice also that is there. We say something and then wait for the other party to say something. So, there is a means even in that human activity also there is a on period followed by off period. So, you have to understand that this on-off nature.

If I modulate my voice accordingly with this on-off nature then its very clearly understandable that even voice also will be will become bursty in nature. Once this kind

of sources has to be handled by networking I have to think about some other things. Because I cannot always give provision the network estimating that everybody will be at the peak of their traffic and then I dimension my network in a TDM fashion that will be a worst design.

Because for everybody's peak behavior you dimension the network your network requirement will be huge and most of the time those resources will not be. So, as we have now seen that there is a paradigm shift which is required driven by the traffic or nature of the traffic.

So, we could see that why in 1980s or around that time probably people started thinking about ok we should have a voice network that is alright, but we should also have a separate IP or data network, ok. So, and both the networks has different philosophy as you can see.

So, the way packet being forwarded, way you handle them, so, those are completely different. So, the major differences over here is you have to add header to the packet ok. So, whatever that is some data chunk you add header to it one thing. Second thing is you have to put buffer and third thing is you have to really do statistical multiplexing.

That means, you do random switching according to your requirement. Some of the data you might take from stream some of the data you might take from the buffer which is means where the packets are or the datas are being stored when you do not get any chance. So, this is exactly what is happening over here ok.

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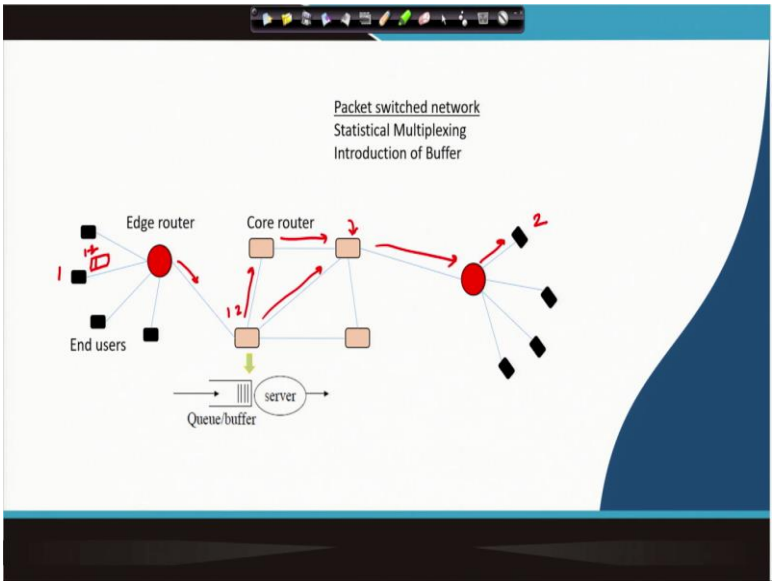

So, if you just see it probably ok; so, from there what we can summarize that we have come to a kind of packet switched network. So, in the packet switched network we are doing statistical multiplexing. Each packets will be having header and we are introducing buffer.

So, as you can see now we again similar network. So basically, we have all these end users. They are now connected we call these things now instead of switch or multiplexer we call them as router ok. What router must have? Router must have this queues. For each input stream there must be a queue and then it must have a server which decides where that packet has to be forwarded.

So, basically the server reads the packet and then accordingly forward which particular path it has to take. So, that is the switching it does. So, every router will be doing that. He will be having some input path sorry input links and some output links. So, he will be reading, he will be storing everything in the queue or buffer in a storage place, memory place then the server will try to read those packet make sense out of it and then try to see where it has to forward.

Those packets will be trying to understand all these things in due course ok, when we will be discussing about packet switching network, but this is the overall brief overview of how packet switching is being done. So, every router will have these kind of structure and they will keep doing one after another hop by hop there will be this routing or switching that will be happening.

And remember earlier you construct in circuit switch and packet switch that is the main difference. In the initial part of circuit switch network you actually construct the circuit. Once the circuit is constructed, that circuit is exclusively for you. So, suppose a 64 kbps link you have created from end user to end user; that means, actually you have reserved slots in a TDM this one and not only that for switch there is a fixed configuration. We will see that later on so when we will be discussing about switch.

So, there is a space configuration which has been already constructed through all the switches and there is a particular slot that has been reserved in the frame. So, once that is being done always that will be for you. Whenever you throw data it will be going through that path only and with that time slot. That is circuit switch network.

For packet switch network nothing like that. You do statistical multiplexing. So, what you do? At every router you try to because now the data that will be there that will be appended with a header. The header takes all the information about where from it is generated and where it wish to go.

So, every packet is switched according to his presence. So, every router is represented means given by this packet he reads that packet, packet by packet he does switching. So, every router will be switching it. He might switch it over here. This guy will try to see. Suppose somebody I want to connect from 1 to this 2.

So, I generate a packet along with header. Header says it has to go from 1 to 3 sorry 1 to 2. It comes over here, he sees that he tries to see where is this 2. So, that is somewhere here, so, I have to root it over here. Then he again sees that it is coming from 1 and it has to go to 2.

So, he sees that accordingly he decide ok maybe I will put it through this path that is given to this router. Again, router sees that header and accordingly he is does the switching and this guy also do and then the packet goes over there. So, every router at every stage does that switching.

Sometimes the path also might be changed. So, suppose at this location it sees 1 to 3, he might forward it over here then this guy might forward it over here and it again reaches. So, every packet has its own switching at every intermediate node that is packet switching for you.

So, you do not have a fixed path, you do not actually do the end to end switching at the beginning of your switching and you do not reserve anything over here. You do statistical multiplexing. If that statistical multiplexing is incapable of handling them you have buffer. So, occasionally you will be buffering them. Whenever there is a free slot available at the output you actually switch them ok.

So, this is the basic difference between these two paradigm. So, we have discussed about one paradigm shift due to the nature of traffic ok. The nature of traffic has been shifted. So, due to that we will see another shift which is happening now in our days. We will talk about that in the next class, ok.

Thank you.