Communication Networks
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Module - 01
Communication Networks Basics
Lecture - 01
Introduction to Communication Networks

Alright, so myself, professor Goutam Das, I will be discussing today or kick-starting the course, a new course called Communication Network, and I am actually an associate professor from G S Sanyal School of Telecommunication, IIT Kharagpur.

So, what we'll do is will initially give a basic introduction to this particular course; what are the things we should expect from this course and why this communication network is important, what are the problems it is solving, and why it is in which direction it is going. So, that is something we'll give and briefly will actually go through the course.

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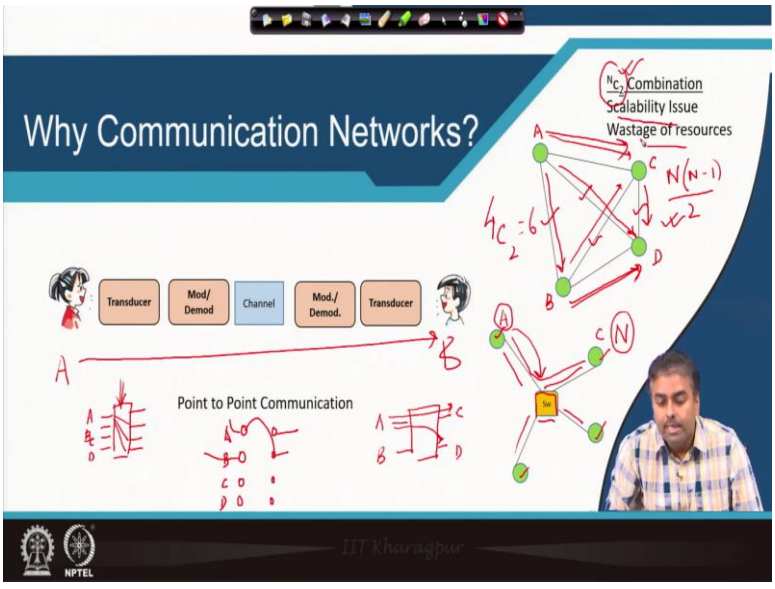

So, let us see what we mean by first; we have two terms actually, communication and network. Let us first talk about the communication. So, if you see this diagram over here. So, initially communication started with mostly voice communication. So, in voice communication, what happens, you say something, and that has to be communicated to somebody who is a distant means far away from you.

And it needs to be, I mean, some methodology has to be implanted so that this information that you are trying to transfer to the other party can be transferred faithfully and reliably. So, what do we do? Generally, whatever you wish to transmit, let us say, voice.

So, whatever you talk, initially, the first thing is a transducer. So, what will that do? That will convert your that sound energy into an electrical signal. So, that transducer is the first part, which actually converts any of the things information that you have to transfer to a corresponding equivalent electrical signal.

So, that is the first part. Now, it can be an image; also, it can be a video; also, it can be any other digital form that is coming out of your computer. So, all those are information actually; that information will be accordingly converted to, which means you enter something from the keyboard, so that is also some information. So, finally, what will happen, it will be converted to a corresponding electrical signal. So, that is what happens after the transducer.

So, the output of the transducer will be some electrical signal; that electrical signal can be of any form, that might be if you are entering from a computer keyboard, that will probably be a digital signal; if it is just pure voice and you are converting to an electrical signal, then it will be an analog signal. So, that means it is the values or the voltage correspondingly that will be generated that can take any value, whereas, if it is digital, then it can only take discrete values, discrete levels.

So, this kind of signal can be generated. So, whatever signal will be generated, can have different forms; but whatever it is, that information has to be transferred. So, for communication, what you do, that we all have done in basic communication courses. So, you actually will be doing modulation; demodulation means modulation actually when you are transmitting, so that should be the modulation block. Why I have shown modulation and demodulation; because it is a two-way communication.

So, if you are trying to connect to somebody, they might also send something. So, basically, the first block should be the modulator. So, it will be modulated first. Why do we do modulation? So, those are part of the communication course that you have already done probably. So, that is what I am assuming. So, you do modulation, the purpose of

modulation is all well known, and then after modulation, the signal is transferred to the channel through which the signal will be going.

So, if it is a wireless channel, then it will be through an antenna; if it is some other thing, accordingly, you will be putting your means, you will be launching them. So, if it is optical fiber, then it has to be laser modulated and then launched into the fiber. So, if it is a coaxial cable, accordingly, you will be doing it.

So, whatever be that, so there should be a channel, then on the other end of the channel. So, now, the channel will be carrying the signal. So, in through some electromagnetic wave; so if it is wireless, it will be electromagnetic wave through means unguided media, so it will be propagated.

If it is some coaxial cable or optical fiber, it will be a guided electromagnetic wave, which will be going to the other end, ok. So, on the other end, you take that signal again; if it is wireless through the antenna, if other things are wired media, so accordingly, you will be taking that. Then what do you do? You do demodulation, the reverse operation. So, you have modulated the signal, and you demodulate it.

Once you have demodulated, you get the original form of the signal; of course, in between, you will be doing all those things because you want to faithfully do the communication. So therefore, to keep the information intact, you have to do some more things. So, as we all know, we do different kinds of encoding, source coding, and channel coding, so all kinds of things are there.

But once you do this demodulation, you do all those aspects of demodulation, and then after that, you actually go give it to the transducer one more time. So, the transducer will be actually reverting back to what you have done on the transmitter side. So, it will be reverting back; it will be again converting it into, let us say, if it is voice, then sound energy, so basically sound these things it will generate.

And then you get to listen to what has been told on the other side. So, this particular communication is up; we call it point-to-point communication, as I am mentioning here. So this is called a point to point communication; so from one particular originator or source to another destination. So, this part has been covered in your communication courses. Now, what we want to see is this communication - how it goes into networking.

So, this is the part we will be mostly discussing in this particular course, that should be our major prime concern, actually. So, now, we know through communication that, from one particular point to another particular point, I can always transmit. So, this is something we already know. Now, what we have to see is, from there, this particular networking thing where from it comes. So, let us try to see.

So, whenever you are doing this kind of communication, is it that in this world, only two fellows will be talking to each other at a particular time? Probably not; that will not be the case; multiple people are there, and multiple machines might be there which wish to communicate with other people and other machines. And the requirement will keep on changing with time. So, let us take this example of these four nodes.

So, let us say these are four entities that wish to communicate with each other. Now, the problem is if we just say this is probably, let us say this is node A, this is node B, so C and D. So, now, at a particular time, what might happen- A wishes to communicate to C. So, that is like this link, ok. So, at this point, A, this is A, and this is B, so that kind of communication. So, this is a point-to-point link that is required at that particular instance.

But what might happen? At the same time, B might wish to generate another link to D; this is possible because A is already talking to C, so A and C are occupied already; they are talking to each other. Now B and D are free, and they might also wish to communicate among themselves. So, this is a possibility, and this is something that you have to facilitate; because you cannot say that just because in this world, A is talking to C; therefore, nobody else can communicate.

So, that is a restrictive service, and we do not want to give that kind of service. So, if this is our requirement, then I have to make arrangements to do this. What can we do? So, basically, what we can do; is right now, what we can see that may be if this is the requirement, A to C, I can construct this kind of communication link. So, the transducer is followed by modulation, and then the channel will be there whatever channel will take.

If it is a fiber, then it will lay fiber from A to C; probably then the modulator and then another transducer ok A and C can talk. Now, from B to D, you have to give, so another such kind of link you put, but what might happen is - it is not restricted that A will be only talking to C. So, A might wish to talk to B at some other time, some other point, and A might wish to talk to D. So, similarly, B can also try to do and so C and so D.

So, if everybody wishes to communicate with each one of them; so what I need to do is, now we can understand. So, this kind of point-to-point communication link we have to construct among them. So, everybody should have these kind of links.

So, all these links have to be constructed. Immediately, we can see that point I want to emphasize; that there might be this kind of N C 2 kind of; if N is the number of nodes which are there, so N C 2 combination will be coming into the picture.

So, many communication channels have to be given point-to-point links. So, if for our case it is 4. So, 4 C 2 immediately, we get six links. So, as you can see, I have constructed six links over here, and those six links have to be exclusively given; but now let us try to see what is happening; I can probably provide these links.

But remember, these links are really costly because you have to; suppose if it is laying fiber, you have to lay fiber over there, ok. If you are laying a coaxial cable, so you have to lay coaxial cable; they are costly; remember this A, C, B, and D are physically means distant. So, basically, they are located in different places. So, for each and everybody and every machine, if I have to construct this kind of point-to-point link, that will be very costly.

Remember, the cost is ok; we can still go towards the means costlier solution if we get a return to that. So, let us try to see the scenario that; I have constructed these six links, but what will be happening? Suppose the time A is communicating with C; at that time, let us say B is also communicating with D. So, that is the maximum thing that can happen; all four parties are already engaged. So, what is happening?

At that instance, how many links are actually getting activated and being utilized? Only two links A to C links, and B to D links, all other four links, this, this, this, and this are not utilized. And this is the best-case scenario; that means all four are involved. If all four are not involved, suppose in a particular scenario only A is talking to D; that is the only link that will be activated, and all other five links will not be activated.

So, this is a scenario which will be happening. So, most of the time all the infrastructure that you are building with some huge amount of cost, that is getting wasted, that is not getting properly utilized. So, as a engineer, you have to think about utilizing them

properly or reducing the infrastructure; whereas we should not compromise on the kind of service that we want to provide.

That means, if A wish to talk to C, I have to immediately provide a communication channel between them. So, this particular or A wish to talk to D, immediately I have to construct a communication channel between them. So, this particular requirement I should not compromise, because otherwise the service will be compromised. So, I do not want to compromise the service; but what I want is, I want this resources that we are putting upfront that must be more utilized.

So, that is the design where communication network comes into picture. So, in the entire course we will be trying to show how efficiently we can design these particular aspect of communication network. So, this is actually called network; network means multiple entities among them you want to give a communication channel, so that anybody at any time wish to communicate to any other party they are capable of doing that.

It is a flexible communication network that you are providing, so that anybody can freely talk to any other and the service is being provided by this network infrastructure that you are building. And now as an engineer, our task should be how efficient or how, means how cost effective we can make it. So, that should be our target. So, let us see one way to make it cost effective.

So, let us try to target that, can we make it a cost effective network? So, what is the one way of doing that; one way of doing it is instead of putting this six links, let us put some central node which we are calling right now as switch; let us let us call a switch or hub or anything you can call ok, whatever it is it is a new entity. So, there were four nodes; node A, B, C means A, B, C, D. So, those four nodes were there.

So, right now what we are doing? We want to give connectivity among themselves. So, in between I put another node, ok. This is not an active node; he does not have a communication need generally, he is the facilitator. So, he is part of the infrastructure. So, I put that infrastructure and then I actually connect all the nodes to him. So, basically I connect all these four communication link, ok. So, what is now happening?

Immediately you can see. So, if N C 2 connectivity were required earlier, with this configuration I only need N connectivity; that scales very nicely, it scales linearly,

whereas this scales exponentially, right. So, basically as the number of node increases, huge number of connectivity will be; means I should not say exponentially, it is actually quadratic, N C 2 will be N into N minus 1 right divided by 2.

So, it has a N square term. So, it is in a quadratic fashion it increases, whereas this is increasing with respect to N in a linear fashion. So, I actually give this connectivity. But now let us see whether all those facilitate facility that we wanted to give or we wanted to provide that kind of flexibility of anybody can talk to anybody at any time, can we provide that. So, for that this switch has to be designed properly, ok.

So, what we are trying to facilitate over here is something like this. So, at any time this switch should be a reconfigurable one. So, that if A wish to communicate to C, then the switch must give this connectivity. So, switch must be something like this ok, where this is A and let us say this is B; of course it should be little bit different, we will talk about that later, right now this should be sufficient.

So, if A wish to communicate to C, it should be this; if A wish to communicate to D, it should be like this, ok. So, if we want to make this four cross fours, everybody can communicate to any everybody. So, what I should do is something like this; all A, B, C, D, so basically A, B and C and D I put and then they will be also connected to all A, B, C, D. So, all four basically and then I, this switch I can configure.

So, this is a configurable switch, where with an instruction A can be connected to B, A can be connected to C, A can be connected to D; you will later on will be discussing about the how these switches are designed, so all those things will be discussing later on. But right now this should be sufficient to understand that, I will be providing this connectivity in a flexible manner.

So, whoever wish to connect to whoever that, flexibility I will be providing; if I can do that with that switch, then my purpose is served, because now I can always connect to anybody to anybody according to the requirement. So, basically the user has to tell this. What I will talk about over here is a nice story, which has happened for the initial days of telephony networking.

So, in telephony networking, what used to happen; earlier so suppose in a locality there are like this. So, four users are there let us say. So, those four users wish to connect to

each other. So, the first option was something like this 4 C 2 all six connectivity you give; but that was costlier people understood that. So, at that time, what happens? So, they wanted to provide the switch. So, instead of a switch, what they did was an operator room.

So, where physically an operator was there; so whenever he wished to talk to somebody, he used to call the operator. So, the first option is the first talk to the operator; you might have seen those earlier movies from the 1940s or something. So, you might have seen that people used to call the operator and then they used to say ok, to the operator that in this locality, I want to talk to this.

So, suppose C or B or D, whichever he wants to talk to, then the operator manually used to connect them. So, basically, they were this connection facility for A, B, C, D, and there were connection facilities, and these links were going to A, these links were going to B, and so on. So, basically, the operator used to with a jack to connect them. So, whenever he listens to A, then he sees whom A wants, and then he used to connect them.

So, this used to happen. So, this was a kind of manual switching that used to happen at that time; that is still a switching, and you can see that number of links will be reduced. So means, every user has to connect to that operator room. So, as many users are there, that many links will be there, and then the operator has to do that. So, with that, there was a funny story.

So, this is what happens, there was a guy named Strowger, who was an undertaker at that time, ok. So, he used to get his business for doing this, all funeral services, ok. So, what used to happen; he used to get calls from all the other parties from the locality, and then he used to take that means to provide that service. So, what happened- suddenly, for some time, he started observing that his business was down.

So, he was not getting enough calls; he then started enquiring what had happened, whether my service was bad or people were not happy with my service. So, they started looking into that aspect. Then after enquiring, he could see that there was a lady who was the operator and that lady was actually she was the wife of another competitor of his.

So, another undertaker actually in that locality and what that lady used to do is; whenever she received a call for him, for Strowger actually that particular one wants the

service of this guy, then she used to divert that call to her husband. So, this was the thing that was happening. So, that is probably the first case of corruption that you could see, you could observe due to manual operation, and that is one of the solutions; we are talking about digitization to take out corruption in India and all those things.

So, it is just the story. Actually, it is a funny story; but it suffices, and this was the first engineering decision probably which has made, which means eradicating corruption from the system. So, what Strowger did, he thought, ok, and he was a knack of engineering, he had that knack. So, he started thinking ok, I will get rid of this manual operation, I want to make this particular thing means automated.

So, he started building that automated switch, which means a version of that is already there in these days telephony; basically, he was the father figure of developing that. So, he was in a separate business; he started developing because he wanted to save his business. So, he started making it automated. So, that is when the switches started becoming automated, and now the automated version you see that you dial a number.

So, basically, if older days phone, if you see, they used to dial a number some nine-digit ten digit number. So, with that number, it used to go to the switch; the switch was automatically seeing those numbers where it wished to reach. So, it is used to configure which port to which port it has to be connected, which means it has to make the connection, and automatically the connection is made.

So, that was the story of Strowger, who was the first to actually make it automated. But whatever that story is, this is just a nice story nice anecdote about how switch becoming or networks started becoming automated. So, these days we are talking about cognitive networking, networking with artificial intelligence, or network with intelligence or intelligent networking. So, this all started at that time in old age telephony switching itself.

But whatever that is. So, we have now understood how networking was coming into the picture at least in those days in telephony networking, and what the requirement means to make the network more efficient. So, as you can now see what is happening, this is taking out the scalability issue, this part, and this is also reducing the wastage of resources. So, these are the two things which are happening due to this invention, ok.

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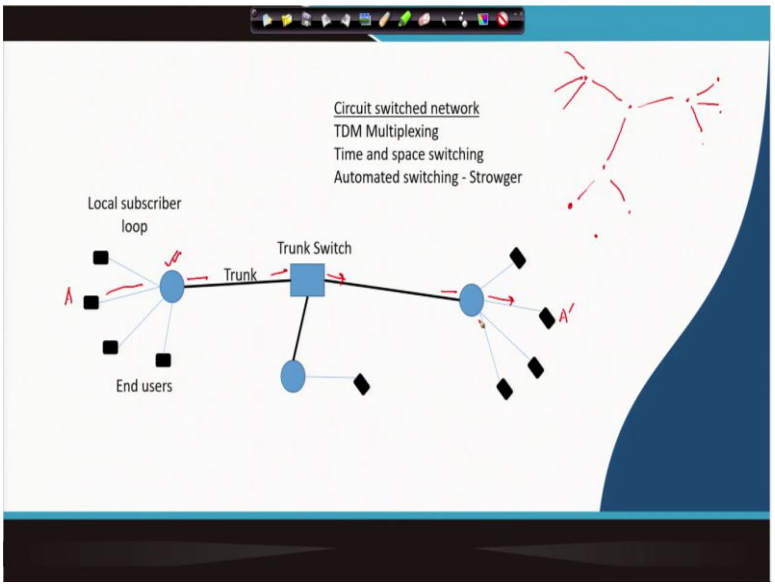

So, if we just, so alright. So, from there, let us continue on that journey of this telephony network actually. So, if we just see, this is a kind of overall network that used to happen in those days; these days also, it is still there, telephony old telephony network is still something like that. So, basically, there is a local subscriber loop so where all the users used to connect to a particular local subscriber loop.

So, from there used to go, the trunk switch will mean trunks. So, trunks are actually aggregating all this. So, if somebody from a particular area is communicating with somebody else, suppose this is my node one, sorry. So means, whatever we have discussed so far; so we can understand why communication network is so important. So, if we just give one example, of course, we will go into the details of this example.

So, how a telephony network; so in the chronology of all the networking, telephony came first, and that was the network which was extensively tried out and deployed. So, how that came into the picture, and what are the salient feature of that particular network; we will try to appreciate that first. So, there what used to happen? So, basically, initially telephony network was within a locality.

So, with the same locality as Strowger's case, I was talking about discussing. But basically, networking cannot be restricted to within a locality. So, it was a success because we could connect them globally. So, for that, I need to construct a global

network. So therefore, the local part of the network, which is this part, so is one of the parts ok; but I have to actually multiple such localities I have to connect.

So, that is where this particular thing comes into the picture. So, there is a switch which is the local subscriber loop probably; you can call it to switch; we can call it a multiplexer; we will talk about that later on. So, there is switching, plus there is also multiplexing. So, we will talk about that later; but whatever it is, let us, for the time being, let us take it as a switch. So, you have a local switch; but between local switches also, you have to give connectivity.

So, that is what the trunk switch does between different localities. So, we have constructed locality A, locality B, and locality C. So you can have all these trunk links between this locality to a trunk switch. So, it is a hierarchical thing. So, basically, what we are trying to do is, we are generally multiple users we are connecting to a switch; then everywhere multiple users are getting connected to a switch, ok.

And then, among the switch, again, we are constructing a network. So, basically, this switch has to communicate. So, if there are 3 or 4 switches, then again, we put another switch, and they connect to all these switches. So, this is how in a hierarchical manner, in a tree or mesh fashion, partial mesh fashion will be actually connecting everybody. So, then it might happen that you have to not only make the decision at one switch; but you have to make the decision in successive switches.

So, let us say a particular guy A, wishes to communicate with another guy A' over here. So, he has to configure this switch so that his connectivity goes into this; then, from this switch, that connectivity has to be configured, and this switch also that connectivity has to be configured.

So, it is a series of switches where you have to actually make the connectivity properly constructed, ok. We will see how the switch operates and how we make connectivity among switches. So, these are the things in detail we will be seeing later on. So, this is the particular part.

In the next class probably what we will try to do, we will try to discuss the features of these things; how philosophically this was constructed, what is the basic feature of this particular kind of switching, and how it is different from today's switching, and what

other shift, or paradigm shift that has happened in terms of this data transfer and switching and all those things. So, we will try to appreciate that in the next class.

Thank you.