Computer Networks
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Lecture - 6
Telecom Networks

Good day! Today we will talk about telecom networks. That means the kind of network that is used by telephones and, of course nowadays, by a host of other things as we will discuss. This telecom network is very important in the sense that first of all it is one of the earliest networks that we had; which means it is quite old.

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Secondly, the telecom network even today is mostly used for wide area communication. We have much fewer entirely or exclusive data networks. So we will look at the evolution of telecom networks.

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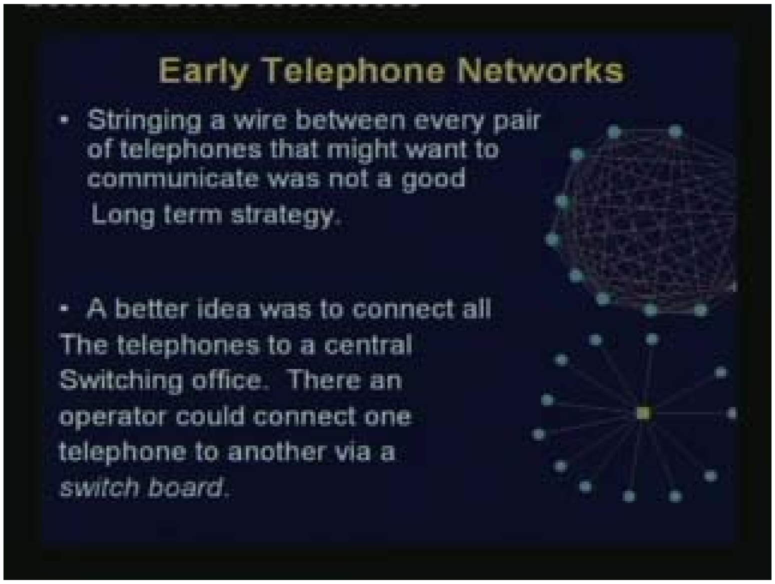

When Alexander Graham Bell developed the first telephone; it was a couple of telephone instruments connected by a wire. Now if you are trying to connect more than one people, that mean more than one subscribers, taking this principle forward, you will have to connect everybody to everybody else through wire, which of course becomes very unwieldy very soon. It's because connecting the wires between every pair of telephones that might want to communicate was not a good long-term strategy at all. Very soon we could have a veritable jungle of wires and, of course, it means it is costly and very difficult to manage.

Even at the subscriber end, you cannot handle so many wires coming into your premise. So a better idea was to connect all the telephones to a central switching office; there an operator could connect one telephone to another via a switch board. That is the next figure that you see; that the number of wires have come down. As a matter of fact, in the figure at the top, if you have n subscribers, naturally you have n (n) −1 by 2 links, which is approximately n^2 kind of links; whereas in the latter case, you have only n links. So the number of links increases as n becomes large. And you know today there are so many telephone subscribers; so there is no question of connecting them individually. You have to connect them to a central switching office and when some subscriber A wants to connect to subscriber B, it goes via the switching office and finally a connection is made.

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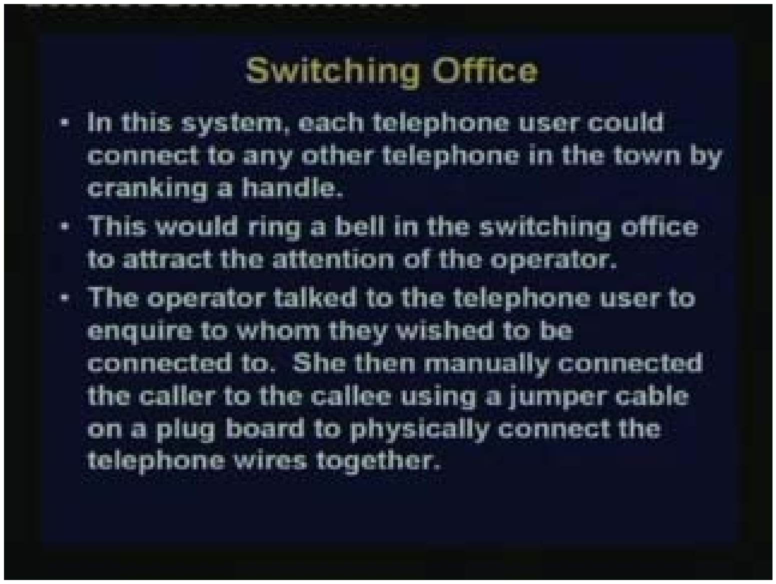

Now in the switching office in this system, a telephone user could connect to any other telephone in the town by cranking a handle; this was the old system. You know in the old system – if you have seen some of older movies or movies depicting an older time – somebody would go to the telephone, lift it up, and go with the handle like this – crank – and what this would do is that basically this would ring some kind of a bell or give some indication in the central switching office. The switch operator was of course a person, may be lady, who would know that this is the person who wants to talk to somebody.

Then he would talk to that person and find out who it is or who the subscriber is to whom he wants to be connected. When the subscriber tells connect me to such and such, through a wire, jumper wire, the telephone operator would connect this subscriber to the indented subscriber. That is how it would operate in the beginning, which of course is a rather a difficult thing to do and it is unbelievable that with today's teledensity we can handle in that way. So after this, this role of the person was replaced by some electromechanical gadget and those exchanges were called Stowager exchanges. There is an interesting story about the Stowager exchange – it seems that there was a person called Mr. Stowager; he was an undertaker. You know who an undertaker is; he sort of prepares coffins for a person who has passed away. It just so happened that there was another undertaker in the same town, whose wife was actually the telephone operator.

So whenever somebody wanted to connect to an undertaker necessarily her husband would get the job. So Mr. Stowager thought that was not a good idea at all; so he went ahead and designed some kind of electromechanical system so that there would be relays and mechanical switches would sort of rotate, depending on what you have dialed on the other side and connect.

This electromechanical exchange served us quite well. And even may be 15 or 20 years back in this country you could see StOwager exchanges were operating. But of course nowadays, these electromechanical things have been replaced by electronic switches and the architecture also has become more complicated. So this is how the switching office used to operate previously. There would be an operator physically who would make a connection, who would make a physical copper connection through a wire from the caller to the callee, using jumper cable on a plug board and there would be a connection between the two telephones. So that is how it used to operate.

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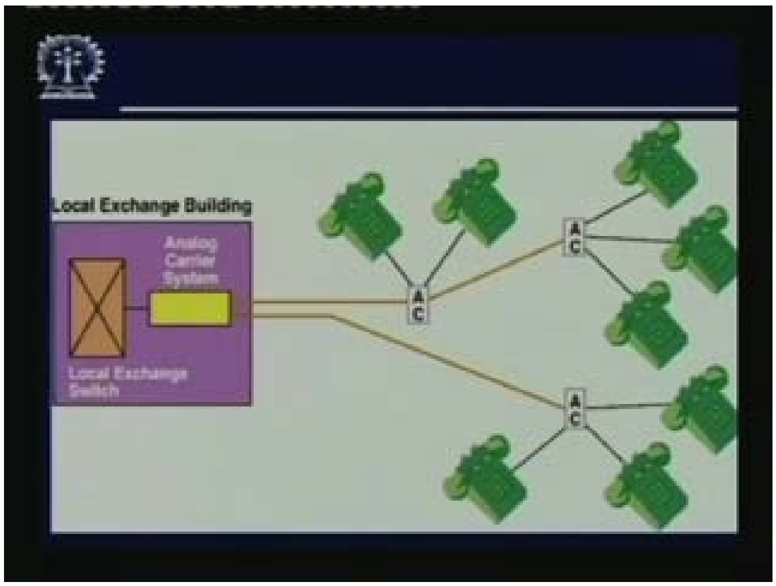

Nowadays we have a picture which is something like this; you can see that there is a local exchange building, where there is a local exchange switch, the kind of signal that is used for connecting this part – the local exchange – to the individual subscribers. By the way this part is also called the local loop in telephone parlance. So the telephones still use analog carrier systems mostly. And you see there are two types of wires used over here: one is sort of connecting the premise of each individual subscriber to some kind of a housing, may be some kind of a hut over here, through a category 3 cable, which is a thick kind of black cable, which actually comes into your home. So these cables (yellow colored) are much thicker, may be 50 pair or 100 pair kind of cables. These category 3 cables in this hut are connected to this through this; it goes to the local exchange where switching is done.

What is switching? Suppose this user wants to talk to this subscriber so there would be a switch over here because there are individual pairs of wires going from each subscriber to the local exchange and the switch would connect these two pairs of wires and they would have get connected. This is the scheme.

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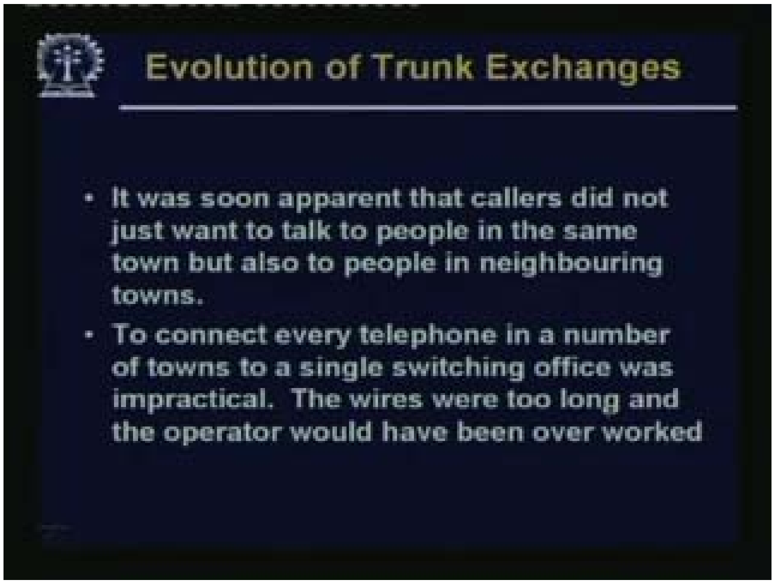

Now when telephones developed more and more, naturally people found it very useful. So it was soon apparent that callers did not just want to talk to people in the same town, but also to people in neighboring towns. Now this was the next hurdle to be solved. The first one was that the all pairs of telephones cannot be connected together so every subscriber was only connected to the local exchange or the local switching office, where individual subscribers would be connected. Now if you have two different towns in two different locations, what would happen is that you cannot connect all of them to the same local exchange.

This is a problem; first of all from one town to another the distance would be quite large. So irrespective of where you put your exchange, whether in this town or that town or somewhere in-between, there will be lot of wires involved and naturally this is not feasible. So what is required is that there will be a local exchange for this town and there will be another local exchange for that town and these two exchanges have to be connected. So this was the next step in telecom evolution; so to connect every telephone in a number of towns to a single switching office was obviously impractical as the wires were too long.

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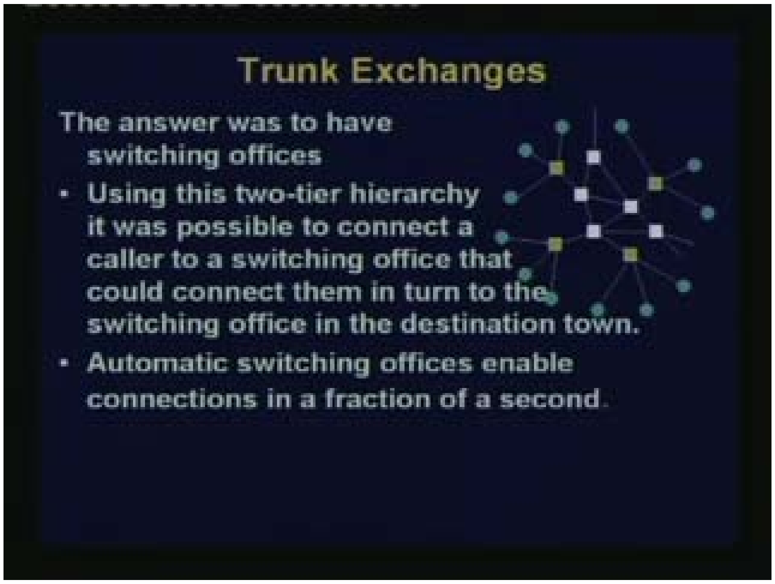

So we came to the so-called trunk exchanges; now what are trunk exchanges? Well, there are local exchanges and if one local exchange wants to go through to another local exchange, it usually goes through a trunk exchange; this is a two-tier hierarchy. There will be some trunk exchanges and then each of the trunk exchanges would be connected to a number of local exchanges and the trunk exchanges would be connected between themselves in some fashion. Automatic switching office enables connections in a fraction of a second. That means your connection request – if it is local, then the connection request is just served by the local exchange.

That means if you just want to make a local call between two subscribers who are under the same exchange, it need not go anywhere else; it can just simply be locally connected. If the caller and callee are under two different local exchanges, it is possible that their local exchanges are connected. But the general scenario is that they would go to the trunk exchange and the trunk exchange would connect to other local exchange and then that local exchange would make the connection available to the callee. So this is how connections are set up. As telecom grew bigger and bigger, you not only want to talk to the person in the next town, you want to talk to the person in next state and may be in the next county or a country around the world. So in that case also more levels of hierarchy came into the picture as we will see here.

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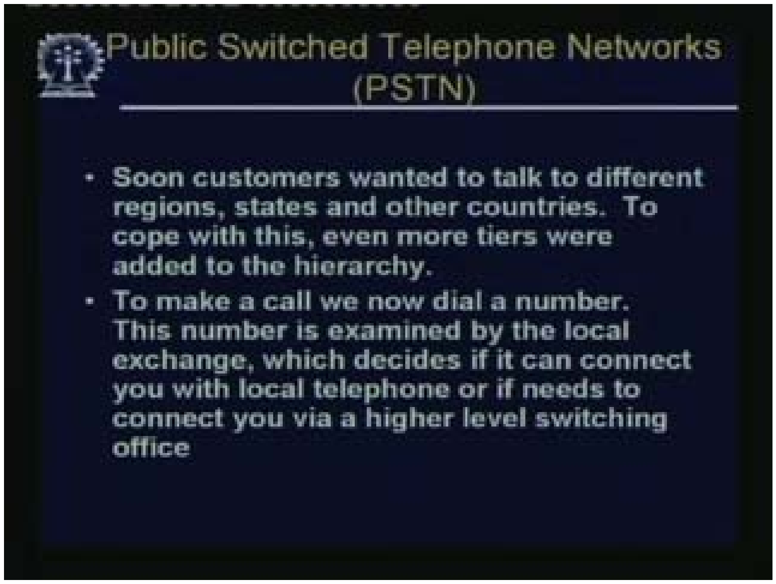

And soon customers wanted to talk to people in different regions, states and other countries. To cope with this, even more tiers were added to the hierarchy. To make a call, we now dial a number. This number is examined by the local exchange, which decides if it can connect you with local telephone or if it needs to connect you via a higher level switching office so this is the public switched telephone network that we have today or namely PSTN.

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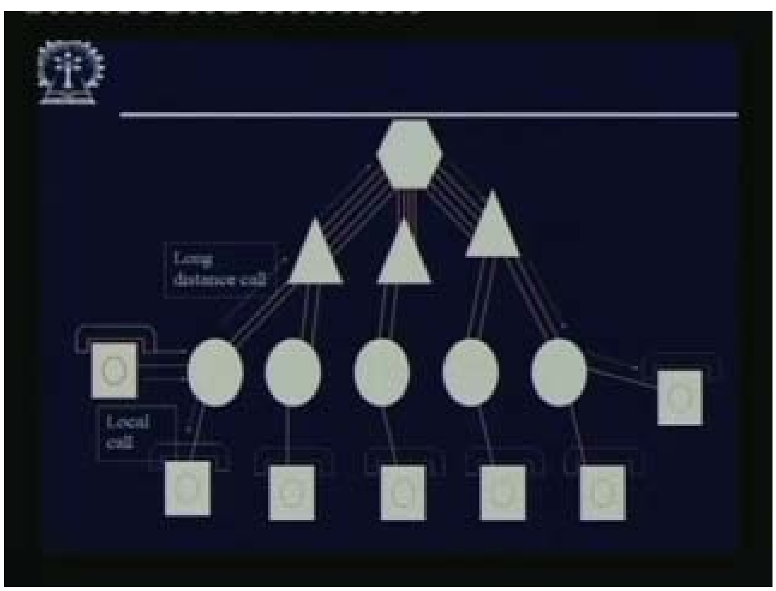

At the bottom of this figure we have these individual telephones, which are connected to the local exchanges and the local exchanges may be connected to some trunk exchanges.

These trunk exchanges may be connected to still other trunk exchanges and so on. Not only that, the picture is even messier than it is shown here. For example, some of the local exchanges would connect between themselves straight away. If there are lots of calls between two local exchanges, then the telephone company might like to connect fiber between these two exchanges. For example, let us say in India, if you are making a local call that is fine. If you are making a call which is to an exchange that is just adjacent, then you would go through some connection between the exchanges. If you want to make an STD inside the same state then this trunk exchange would somehow go to the trunk exchange on the remote side. If you are going out of a circle – for example, West Bengal may be a telecom circle and then Bihar would be another telecom circle. So the main trunk exchange of West Bengal would be in Kolkata and the main trunk exchange of Bihar would be in Patna;

so these two from Kolkata to Patna main trunk exchanges would be connected through very high speed lines and what would happen is that, it will go from the subscriber to the local exchange to the local trunk exchange to the main trunk exchange at Kolkata and then to main trunk exchange in Bihar, let us say in Patna, and then to further trunk exchanges then further to local exchanges and then to the final callee. Of course, if you have international calls, if you are making ISD calls, then you have to go through still other hierarchy; that means, there are some particular gateways through which you will have to come before you can go out of the country.

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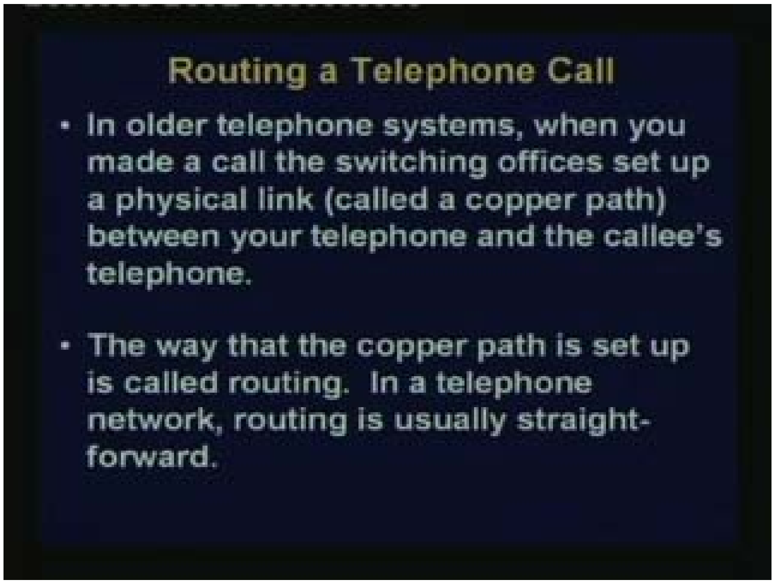

There is a question of routing a telephone call. Routing a telephone call means, how do you find this way? That from one exchange to another exchange to trunk exchanges to other trunk exchanges and finally to the destination, you have to make a connection; that means on each of the switch on the way, you will have to make some provision or some connection for this particular telephone connection. So how do you find out?

For example a particular trunk exchange may be connected to a number of local exchanges and then number of other trunk exchanges also. So how do you know which trunk exchange to go to next? This is the problem of routing. So you have to route a telephone call. In older telephone systems, when you made a call the switching office set up a physical link called a copper path between your telephone and the callee's telephone. The way that the copper path is set up is called routing. In a telephone network, routing is usually straightforward and I will come to the reason.

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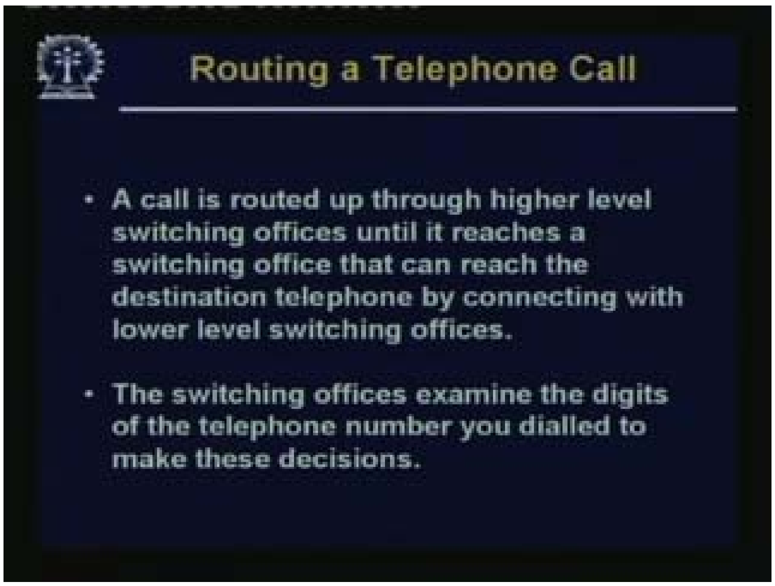

A call is routed up through higher level switching offices until it reaches a switching office that can reach the destination telephone by connecting with lower level switching offices. The switching offices examine the digits of the telephone number you dialed to make these connections. So this is really in some sense fairly simple, in the sense that the way the telephone numbers are distributed in any country is in quite a systematic manner. For example, let us say if you are making an STD call in India, usually we start with the digit 0. Now the digit 0 is not really a part of the number of the callee; digit 0 is just indicating to the local exchange that we will have to be connected to some other exchange.

This is not the same local exchange. So that is some kind of an escape from its local exchange to somewhere else. But as I said, the telephone numbers are distributed in a fairly methodical manner. For example, after 0 if it is 3, you immediately know that this will be somewhere let say near Kolkata; at least it will go through the Kolkata trunk exchange. Similarly if it is 011, you immediately know; you do not even have to look at the other digits and as a matter of fact for a remote caller or to the exchange to which the remote caller is connected, the other digits do not make any sense because they are really a number under an exchange which is far away, but it knows just by looking at the first few digits that that is the trunk exchange which I have to reach. For example, somebody is making a connection from let us say Kolkata to Delhi.

Now immediately you would know: suppose from Kolkata so you start typing say 011 and then something, the local exchange would know that this is not only a trunk call, it is the so-called subscriber trunk dialing, STD, call. So this will have to go through the main tax exchange in Kolkata in order to connect to that main tax exchange in Delhi. So it just makes the connection just by looking at those say first two digits and after that whatever digits follow, they will be looked at by the exchange at let us say Delhi and then the next few digits may indicate a particular exchange in Delhi.

So it will look at the next few numbers, maybe two or three digits and decide that that is the exchange to which it is connected. So it is immediately routed to that exchange and that exchange will look at the last few digits may be and know that this is the subscriber, so the connection would be made. So you do not have to really have to search around in the entire country to find out where this number belongs to; just by looking at the numbers, looking at the digits one or two at a time, you can find out what the next step is that the connection has to take. This makes the routing problem easy, unlike some other cases which we will get to later on. But for telephone, the routing is fairly straightforward so it will look at the digits and make up the connection.

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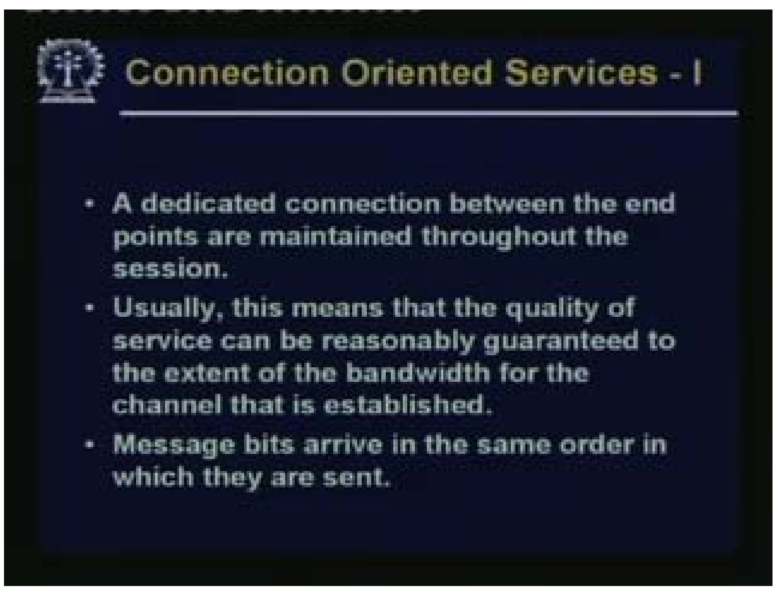

And one point is that we are always talking about connections because essentially telephone service is a connection-oriented service. What do we mean when we say that telephone service is a connection-oriented service? It means that – usually this is sort of changing somewhat a little bit – the overwhelming majority of telephone connections are still connection-oriented. In a connection-oriented service, what happens is that a dedicated connection between the end points is maintained throughout the session. When you are actually calling, during the time by looking at the call number the path will be set up and at each point, at each switch, let us assume there is a physical connection, which may not be physical connection, but the connection may be some kind of virtual connection.

But for our purpose at the moment, let us assume that they are physical connections, so there is a physical connection at each switch so there is a continuous path from the source to the destination from the caller to the callee and this path is maintained, is held reserved, for this particular session during the entire session. This is not shared with anybody else and this has number of advantages. Usually it means the quality of service can be reasonably guaranteed to the extent that the bandwidth for the channel that is established – whatever bandwidth this channel might be having – is exclusively for this particular call, for this particular session. So there is no contention for bandwidth by multiple users. Usually we are talking about just landline phones for the time-being. So first of all, the bandwidth is held constant; hence the quality of service is good. Second thing is that since the path, the actual path is held constant; the message bits arrive in the same order in which they are sent.

By the way, please note that this always need not be so. For example if this path was not reserved and held constant for a particular session, that means if some part of your call is going through one path and some other part of your call is going through another path, then later bits may arrive earlier, depending on what these two paths are. So such a thing would not happen in a telephone connection usually, so message bits arrive in the same order. These are the advantages of having a connection-oriented service.

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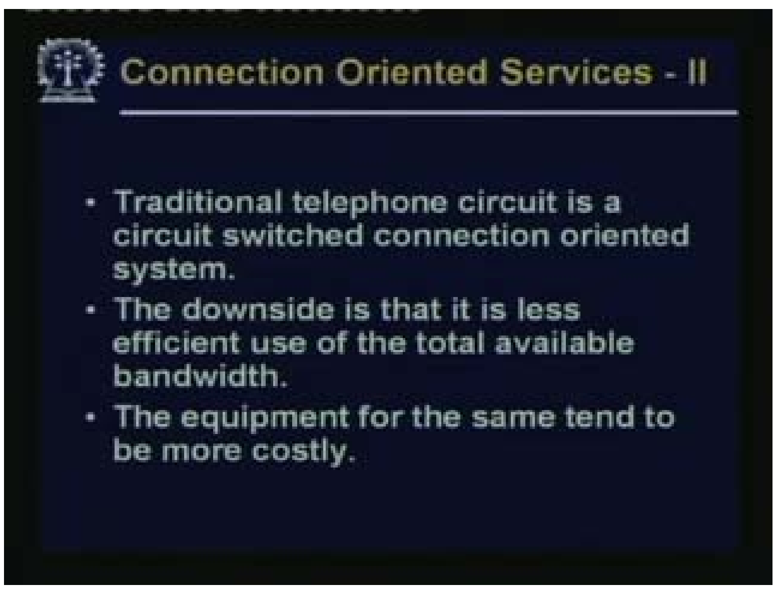

So traditional telephone circuit is a circuit switched, that means actual physical connections are made with a connection-oriented system. The downside of this is that it is less efficient use of the total available bandwidth. The reason that this is less efficient use of the total available bandwidth is that whenever we speak there are – for example, this is just one of the factors, there are many other factors – considerable periods of time or epochs of time during which nobody is speaking. At that time the channel is lying idle. Remember this particular channel that has been set up for one particular call is held constant during the duration, during the entire duration of the call.

So at that time nobody else can use it. So this is one source why this is sort of inefficient use of bandwidth. Another problem, actually a very serious problem – this happened due to historical reasons – is that this traditional telephone equipment tends to be more costly. Now why is that so? Well, the reason is that this telephone system and the way the switches, etc., were designed at least the earlier ones had a long history, and naturally in this particular field, the rate of development of technology is very high and the next generation of technology would always have a tremendous cost benefit advantage compared to the previous generation of technology. So it so happened that the computer technology started leading the technology base; of course it does not mean that the traditional telecom technology was steady only at one point.

This was also evolving and the computer communication field was also evolving; but it so happened that some competing technology, which is the so-called connectionless service, came about. We have been talking about connection-oriented service in telephone, so in the connectionless service it always or it quite often has the advantage of using the next generation of technology, making it much cheaper. And this proved to be a great hindrance to the traditional technology in telephones and that is why most of the traditional service providers are slowly now depending on how they are moving to this new technology, which essentially sort of sprang from another field. And that is the so-called connectionless service.

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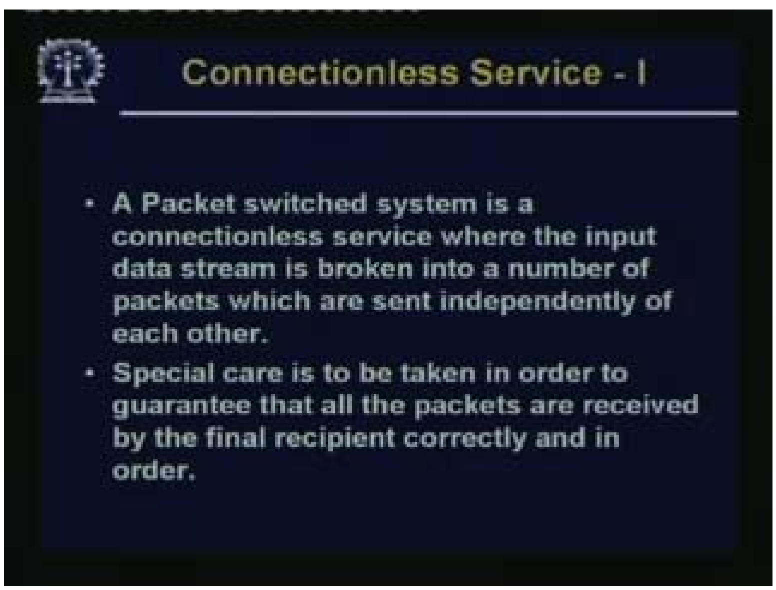

Now, what is a connectionless service? Connectionless service is packet-by-packet; this is not over the entire session; one packet of data or that particular data may be containing first data. So one particular packet is sort of thrown into the system and routed independently of all other packets. So as we had seen earlier that this means that you have to have the destination address at each packet.

That is one thing; so if you have the destination address in each packet, may be you can route it fast enough to reach the destination and the next packet from between the same caller and callee will come as another packet. It will also have the same destination written on it and it may so happen that some router in-between is going to route it in a different path. This connection is not held constant like the connection-oriented service. This is a connectionless service; it is packet-by-packet service. This has some disadvantages also. For example, one reason is that some of the lines may be good, some other lines may be bad and some of the packets may get dropped in-between. Secondly, what might happen is that a packet, which had been sent later, may, through a different path, arrive earlier at the destination. So all these problems are there in a connectionless service;

But the major advantage of connectionless service, one major advantage is that it is cheaper. It is cheaper firstly because it is somewhat more efficient than the traditional circuit switch systems, and secondly it is usually more efficient because it usually tends to use more recent technology in terms of silicon, in terms of IC, etc. It has higher volume; its pricing is lower. That is attracting all these other telephone service people also into this technology and there is a definite shift towards this kind of technology. By the way, you can take special care to guarantee that the packets are correctly received by the final recipient and in proper order but you have to put in some extra effort for that. So we will look into this later.

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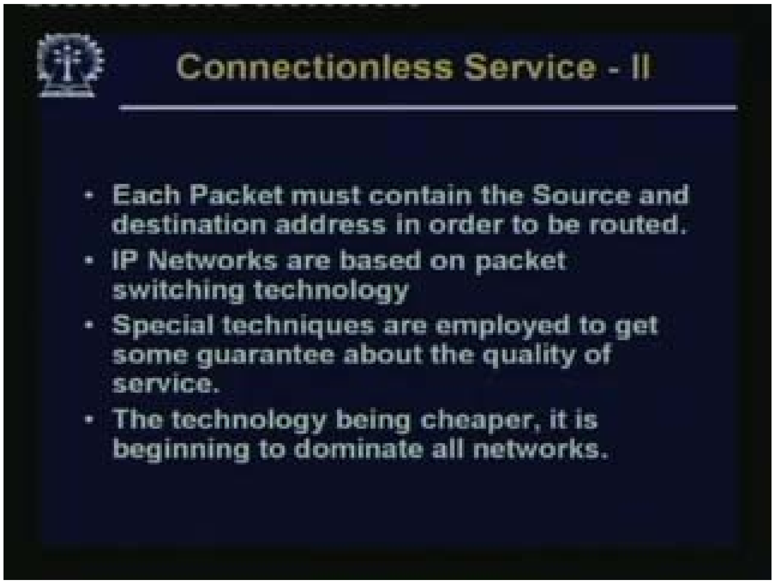

As mentioned earlier, each packet must contain the source and the destination address in order to be routed. IP networks are based on packet switching technologies. So this is what most computer systems use; special techniques are employed to get some guarantee about the quality of service. The technology being cheaper, it is beginning to dominate all networks: traditional networks as well as the current networks.

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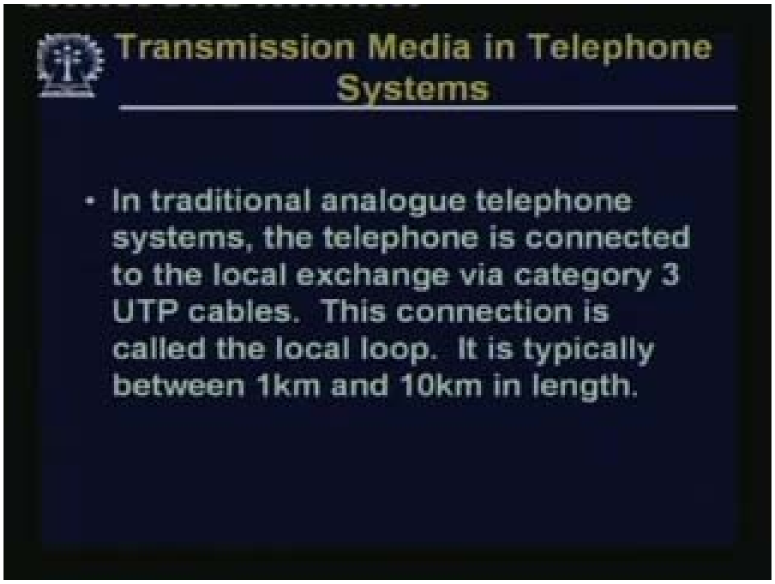

By the way, I mentioned this earlier in the lecture that you must remember that it is not that we have a whole parallel network for data from computers, etc., all over the globe. It is not there because the telecom network has been around for a long time; it had a long and very excellent history. So that is why even today most of the wide area networks traffic still rides on this telecom network. Originally it might have been a packet; then it might be sort of made into some kind of a session for which some part of the connection is dedicated. So all kinds of technology have come in, but even today most of the wide area networks are based on the telecom networks and telecom.

So that is one side of the story. The other side of the story is that telecom networks, the telecom people, are actually in the process of routing some of the voice calls and may be some of the other kinds of calls into this packet kind of technology. Now about the transmission media in telephone systems, we have already talked little bit about it earlier, so I am not going into the details. In traditional analog telephone systems the telephone is connected to the local exchange via category 3 UTP cables, and the connection is called the local loop. It is typically between 1 km and 10 km in length.

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Higher up in the hierarchy, higher bandwidth cables are used to carry multiple telephone calls. This is far cheaper than using separate cables for separate calls. Specifically digital lines on fiber are used. Analog systems use a technique called frequency division multiplexing to do this. Nowadays of course time division multiplexing is the most dominant standard. So if you remember the earlier figure we had, we had this local exchange; so your particular subscriber would be connected to the local connection hut maybe through a category 3 cable, from that hut a fat cable would usually run to the local exchange and this fat cable – in most cases today are still basically a collection of pairs of cables – is just in one sheath so that is why it is a fat cable, physically it is fat.

Maybe there are 50 pairs of cables or 100 pairs of cables; so if there are 50 subscribers coming into a hut, they can be connected through individual pairs in this bunch of pairs of cables that run from the hut to the local exchange. So you may say that up to the local exchange we have these pairs of copper cables running. But once you go to the exchange level and beyond, that means, higher up in the hierarchy, like, to the trunk exchanges and so on, there of course you need to carry lot of calls and usually this connection is through fiber.

So there are all kinds of multiplexing techniques but specifically time division multiplexing, which is the dominant one. Some specific version of time division multiplexing, which we will see later on, is used. Today a fiber may easily carry say 1000 voice calls or even 3000 voice calls just on a fiber; so that is no problem at all. For example, think of a connection between let us say two big cities. A lot of subscriber pairs from both sides will want to talk to each other at the same time. That is the great thing about these fibers, because they can accommodate a large number of channels.

So it has got a huge bandwidth so they are connected through fiber and all these calls are sort of multiplexed may be in time division multiple fashion, which goes to the other end, gets the multiplex, and finally feeds to the local loops, which again are individual copper pairs.

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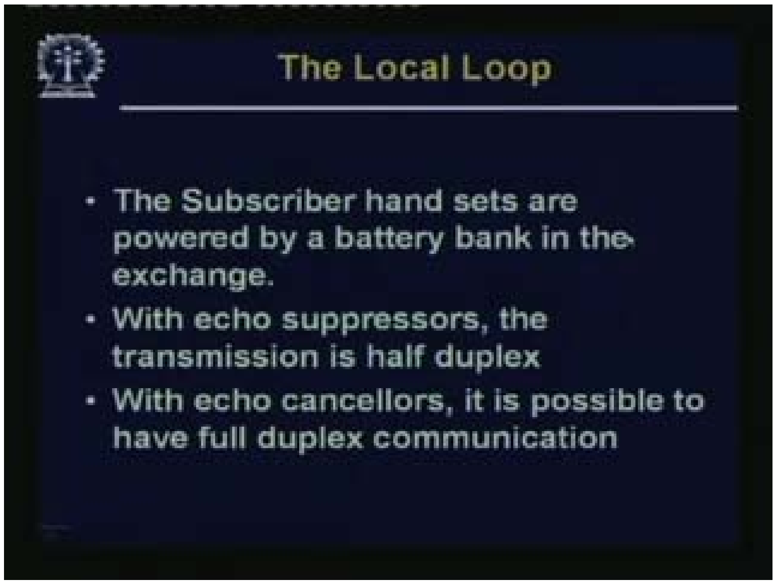

Local loop: The subscriber handsets are powered by a battery bank in the exchange. For example, I mean with at least the ordinary handsets, you do not need to connect it to any power; it actually derives its power from the same cable which is coming and connecting your telephone set. And with echo suppressors, the transmission is half duplex and with echo cancellors, it is possible to have full duplex communication.

So if you remember we talked about half duplex and full duplex communication. Half duplex communication means that the communication can go in either direction from this side to this side or from this side to this side: A to B or B to A – but then, only in one direction at any one particular point of time. So at some point of time A may be connecting to B or A may be transmitting to B and then A will become quiescent and B will be communicating to A through the same the line. This is half duplex communication. We require some kind of echo suppressors for this because otherwise we will be hearing our own voice, which is really irritating. There is a way of echo cancellation and it is possible to have full duplex communication on the same line.

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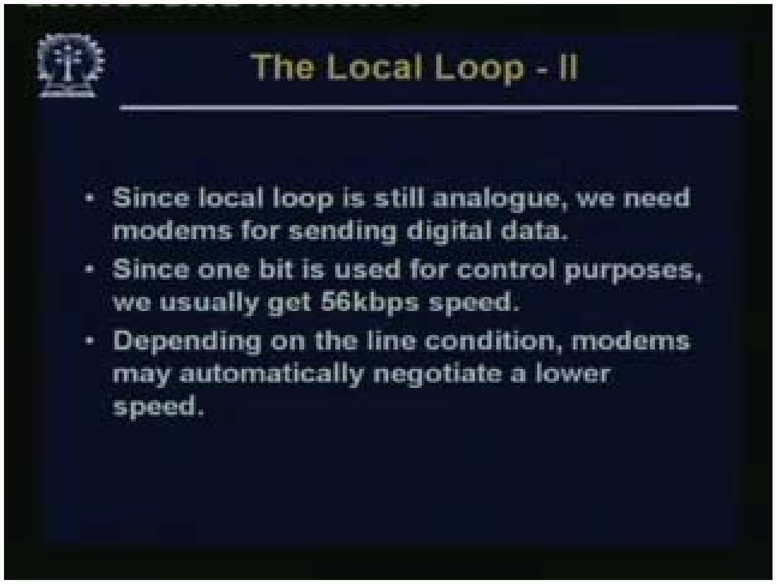

Since local loop is still analog we need modems for sending digital data. That is, this local loop being analog has quite a bit of implications; one of the implications is that when you try to communicate digital data over it – and we are talking about this telecom network in the context of computer networks, but if you want to connect a computer network to a local loop – your computer produces digital data. So they have to be modulated and demodulated. So modems always come in pairs for sending the digital data;.

Since one bit is used for control purpose we usually get 56 kbps speed on this local line. You remember that the computer lines are designed to handle 64 kbps; 64 kbps is the basic rate for communication purpose. If you remember, we have this 4 k bandwidth, which has sampled at doubled the rate, which is the Nyquist rate. This 8 kilo samples, 8 bits per sample is for indicating the level or the intensity of the signal; so we have 64 kbps. So this line is really designed for 64 kbps. When you are sending a computer data over it, you are using a modem and these modem pairs, etc.

They need to communicate with each other and there is one bit used for control purpose. So finally we get a 56 kbps speed; so that is why now almost everywhere you will see that the modem has 56 kbps speed. People talk about 56 kbps modem; that is where this particular figure comes from. But of course although you may be having a 56 kbps modem you may not always get a 56 kbps speed because depending on the line condition, maybe some of the connections are weak, etc. So however, it is noisy so it is picking up a lot of noise. So depending on that, the two modems will automatically negotiate a lower speed and in actual practice you might find the lower speed for your computer communication.

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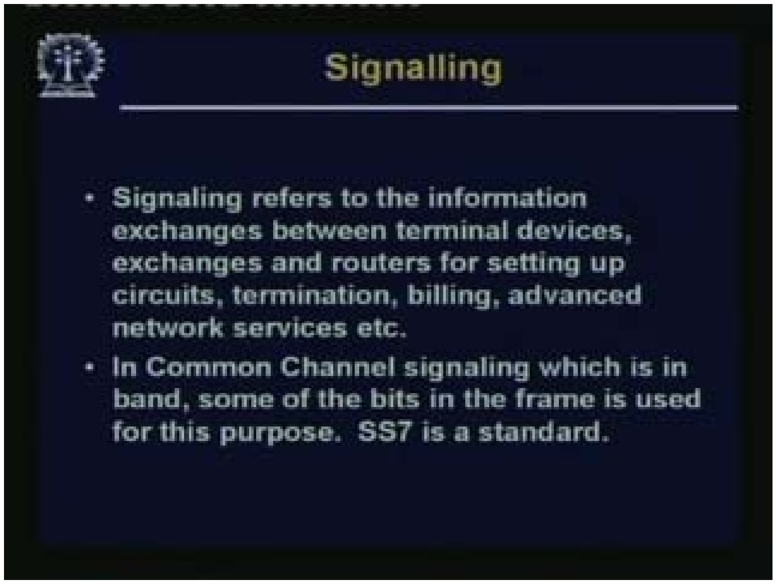

And just one another point before I go to signaling – I want to mention that another implication of having fully analog technology in the local loop is that on an analog signal before you can use TDM or other kinds of multiplexing techniques higher up than all those in-between for connecting between exchanges, etc., you need to convert it to the digital signal over there. So an exchange usually will have a bunch of codecs for coders and decoders and there are various coding and decoding standards. But any way it will have a bunch of codecs, which will convert the analog signal which is coming through this local loop into a digital signal and now this digital signal is ready to be multiplexed with other digital signals to reach its final destination.

Now let me tell you a little bit about signaling: this is a rather vast area; we will just be touching upon it. We will just mention some names and basically what signaling is. Signaling refers to the information exchange between terminal devices, exchanges, and routers for setting up circuits, termination, billing, advanced network services, etc. So what it means is that when you are making a telephone call – of course, suppose you are making a simple voice call, what you are finally interested in is that your voice should be audible to the callee at the other side and his voice should be audible to you. So this voice should communicate; that is the main communication which is going on through this channel, but in order to achieve this, all the intermediate nodes – that could be a local exchange, that could be a trunk exchange, that could be sort of switches in-between, there could be routers and multiplexers – have to get some information and then need to exchange some information for basic setting up of the line. Now apart from basic setting up of the line, you need other kinds of services. Of course from the service provider side, you need to bill a person. If he is making a call, you want to bill him, and depending on whether he is making a local call or whether he is making an STD call or an ISD call, you may bill him at different rates.

Similarly, for making the connections, we have to capture those digits and those digits have to be fed into the particular exchange; it may be computers, routers, switches, etc. So they have to be fed over there in order to make the connection. All this is a part of signaling. Apart from the actual transfer of, let us say, voice or it could even be data but whenever you want to set up some call and take some service, some signaling will always be required. So there are various types of signaling systems but it is sort of converging to some standards. In common channel signaling there is in band; by in band we mean the same bandwidth, which is used by the voice, is used by the signaling also.

Why does it not interfere with voice? Well, what is done is that first of all usually this signaling would be suppressed even if they go on during the call but usually most of the signaling is done before the call is set up, so common channel signaling works very fine. Some of the bits in the frames are used for this purpose. That means that finally, even your analog signal is converted to digital signals and you make a frame out of it, you could stuff this frame with some extra bits for this control purpose. SS7, signaling system 7, is a widely accepted standard and this is slowly spreading; this is a complex standard but this is slowly spreading now.

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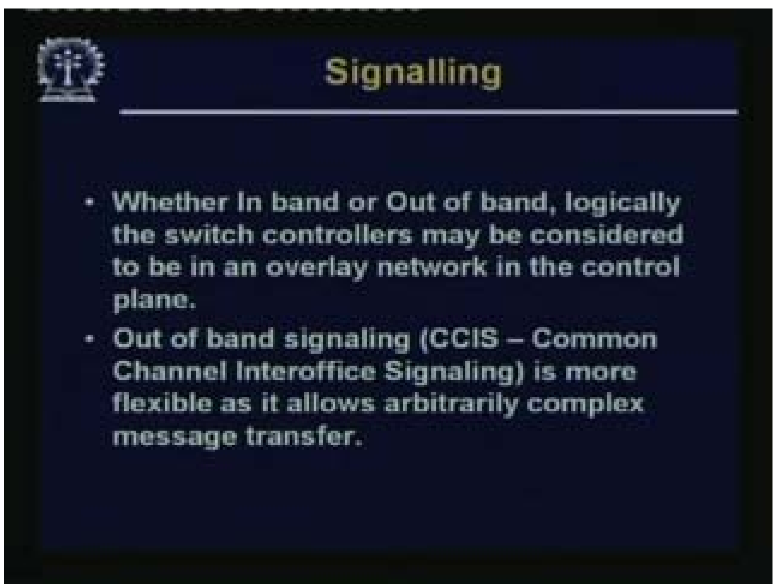

Whether in band or out of band, logically, the switch controllers may be considered to be in an overlay network in the control plane. That means, you have all the switches through which the actual connection is taking place but then you have some switch controllers, which will actually give instructions to this switch, to switch in a particular fashion, or maybe do some billing, etc. There is a network of switch controllers; first of all, there is this network of subscribers that are connected through their voice set or may be through modem, etc., all over. So that is the primary service-giving network but overlaid on this same network, you have these switch controllers at various points who are talking to each other for giving all these services and they are using the same network. So this is some kind of an overlay network over the basic network that we have.

There are all kinds of extra services being given these days. For example, you know that nowadays where ever SS7 or any other advanced signaling system is there, you can get the caller id. That means if your local exchange supports it, whoever is the caller, his id, that means his telephone number, will appear in your hand set so that even before you answer, you know who it is that is calling and then you may choose not to answer his call. Anyway, you can make a note of it. Now how is that done? The numbers that he dialed at his end – circuit has been set up there and not only that, because the local exchange has to know the source number, the source number is also transmitted and finally fed to the receiver's end so that he gets the caller id number. So all kinds of intelligent services are being given these days. This is the signaling system 7 and there is an out of band signaling, which is different from in band signaling. That means in out of band, for signaling purpose, a separate channel is always earmarked so they do not interfere with this regular channel at all. So this is more flexible as it allows arbitrarily complex message transfer.

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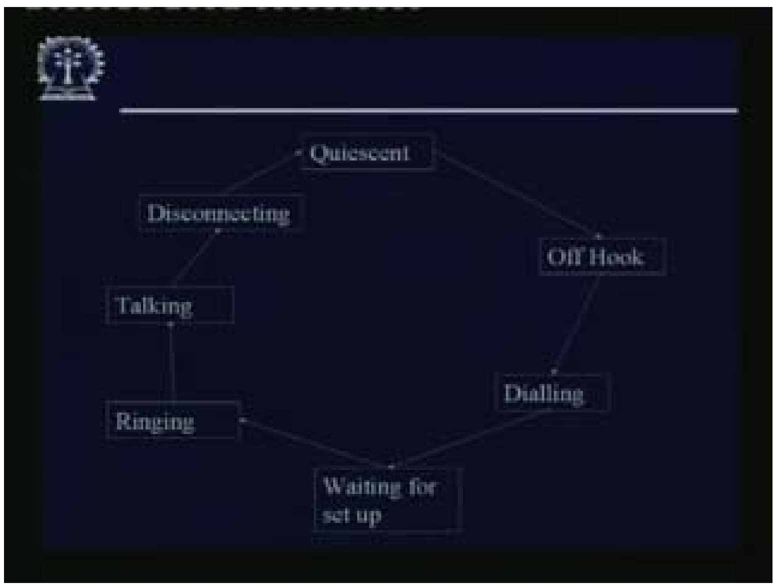

So this is a state diagram – a very rough diagram – of the kind of states that the system goes through when a call is being made. First of all, it is quiescent. That means it is not doing anything. Then you take the receiver off the hook. Nowadays of course telephone services have improved tremendously; otherwise, you would have noticed that the moment you take it off the hook and the moment you get the dialing tone there may be a gap. Actually these two are not the same thing: you pull it off the hook, which gives a signal to the local exchange that you want to make a call and the local exchange then finds some resource to serve you and when it finds the resource to serve you, it gives you a dial tone. So when you get the dial tone, you know that the local exchange is ready to receive the numbers that you dial. Then you will dial some numbers and you have to wait for some time for the call to be set up. If it is simply a local call, it may be a small fraction of a time; if it is a long-distance call, you may have to wait for some time, for some appreciable time, when the call is being set up.

So, of course, the hand set on the other side starts ringing but that is not the ring that you hear. When the local switch knows that the entire path has been set up, it sends the signal, which comes as the ringing noise to your phone. So you know that the other side the line must have been set up and then they start talking. The other side will also go off the hook and then they start talking and they will disconnect and at the time of disconnection, you want to know how much to bill this person, etc. So we will quickly go through this control plane protocol of SS 7. I will just mention some names, for example, names of some elements – you know that this is the very huge area, this software development for a telecom.

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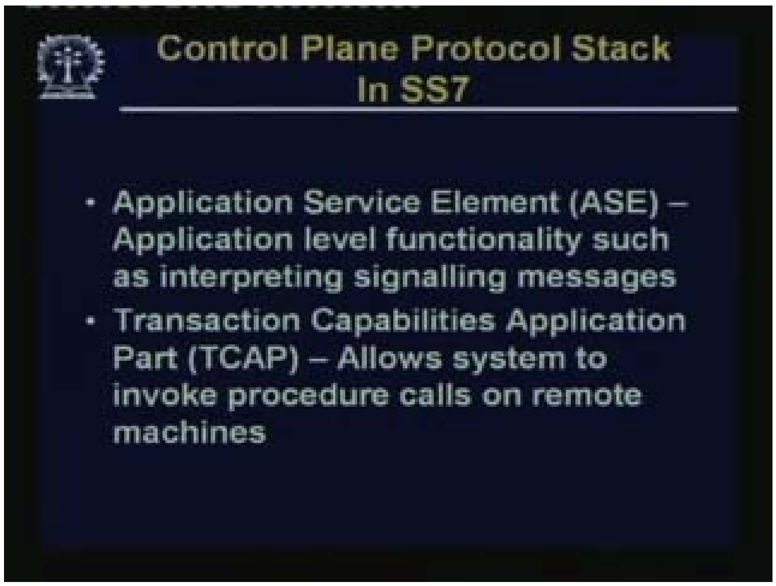

So these are some of the elements which are there in SS 7: application service element, that is application level functionality such as interpreting signaling messages, then the transaction capabilities, which allow systems to invoke procedure calls on remote machines, Signaling connection control part SCCP, connections, sequence numbering, segmentation, reassembly, flow control, etc. Some of these terms may not make any sense at the moment so we will discuss this later on in other context.

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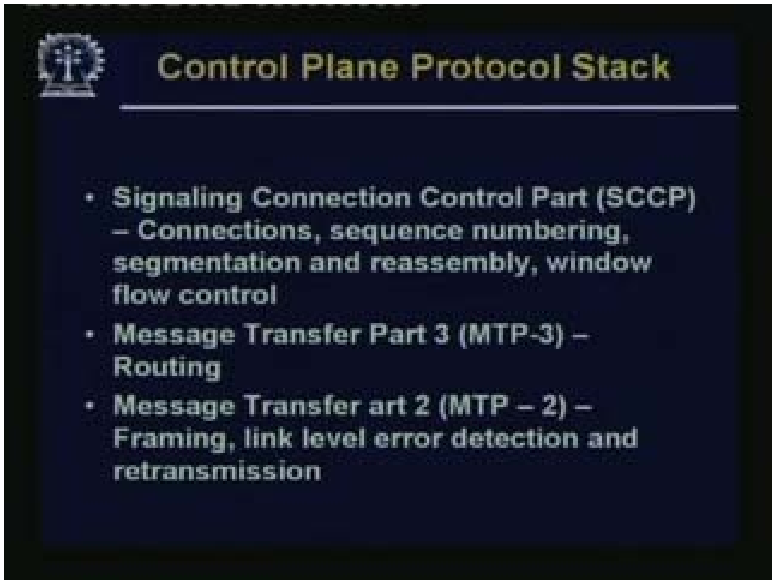

Then there is a message transfer part3, part2, and part 1. One of the main applications of SS 7 is the telephone user part, which is responsible for setting up voice calls. The TUP interprets dialed digits, routes, reserves resources, and maintains accounts etc.

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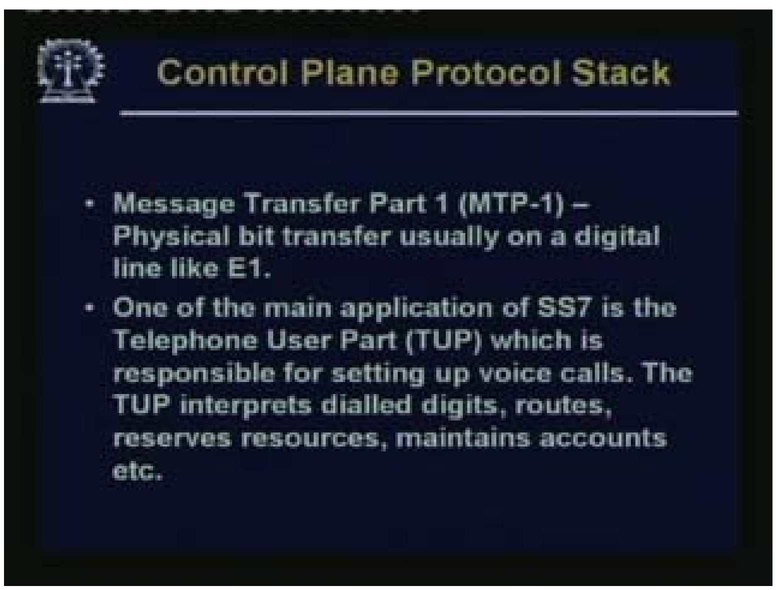

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Now we will take a quick look at the digital technology in the telephone network. As mentioned earlier, traditionally everything was analog. Then the exchanges started getting converted to digital technology, so a device called a codec is used to convert analog voice signals into digital information that can be handled by digital technology.

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The codec is also used to convert the digital signals back into analog on the other side, so that voice signals that can be handled by the older analog technology. Now most of the telephone network is digital; only the local loop is still mostly analog.

There have been attempts to make this digital also and one of the items was this integrated service digital network, the so-called ISDN. Let us take a quick look at ISDN.

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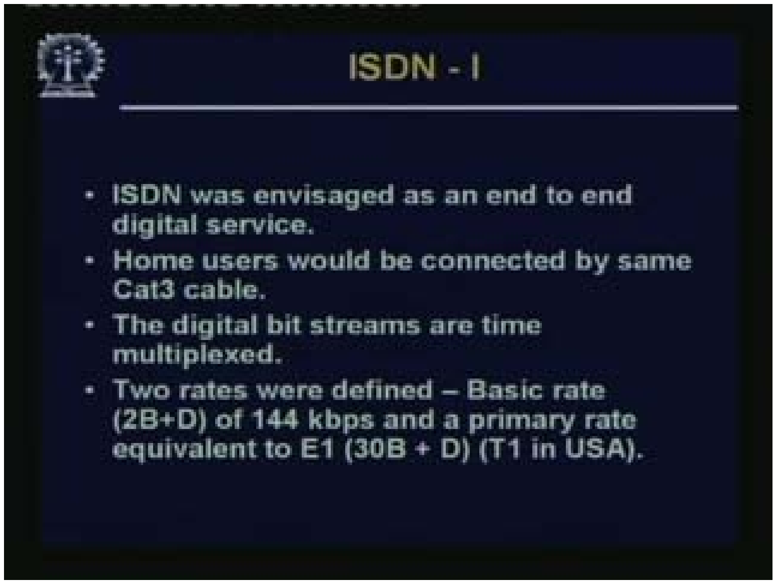

ISDN was envisaged as an end-to-end digital service; that means it starts as a digital service from the user's premise and goes straight that way as a digital service right to the other end. Now home users would be connected by the same category 3 cables; that was important because people are already connected by cat 3 cables and it is a very difficult and costly proposition to change all that cabling. So the idea was to use the same category 3 cables for this new digital service.

There would be some kind of network termination on the end so there were two rates; one was the basic rate, which was the 2B plus D or 144 kbps; 2 B means 2 voice channel of 64 kbps each, so that is 128 kbps; and 1 D channel that is for the control purpose. So you could do out-of-band signaling over here of 16 kbps, giving you a total of 144 kbps. That is the basic rate for ISDN. For higher users, you have a primary rate equivalent to E 1, so there are 30 channels for this, maybe voice channels, and 1D channel, etc., for an E 1 line, there is some thing else in USA; that we will see later.

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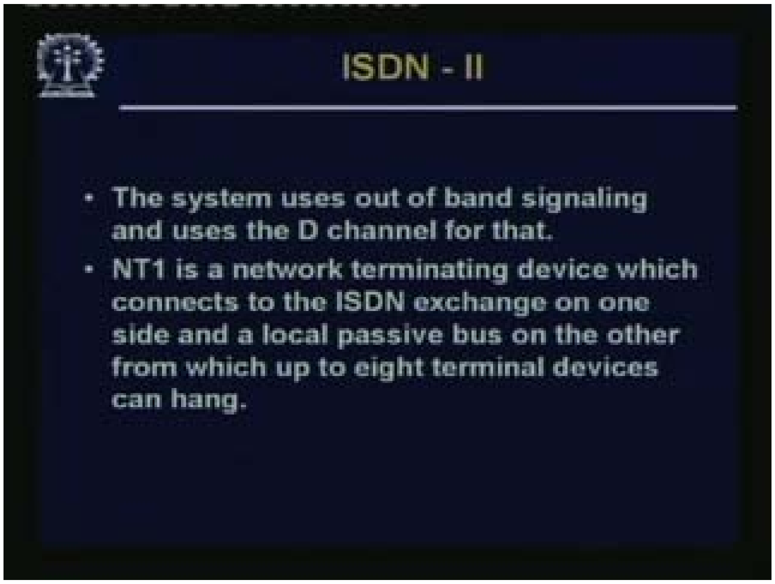

The system uses out-of-band signaling and uses the D channel for that. NT1 is the network terminating device, which connects to the ISDN exchange on one side and a local passive bus on the other.

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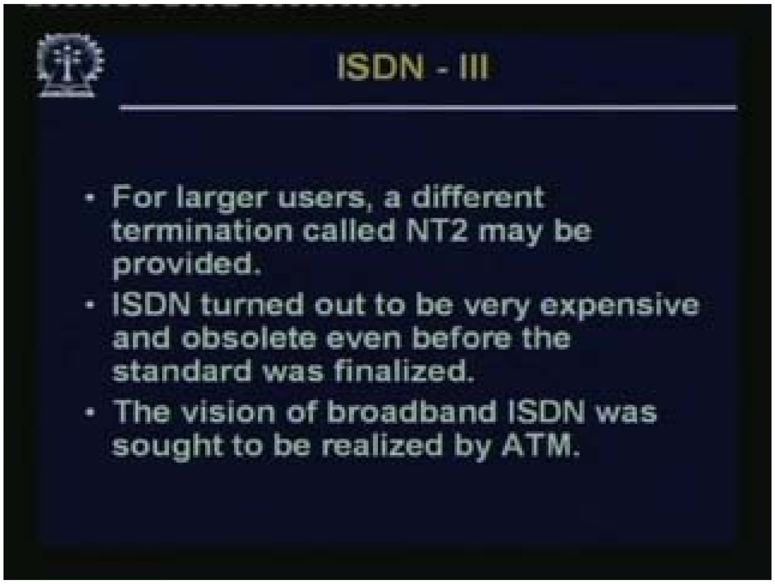

For larger users we have another kind of termination called NT 2. The ISDN turned out to be very expensive, which was a problem. ISDN was originally envisaged as a very broadband service with voice data, etc. on this same ISDN, but unfortunately, because of historical and technological reasons, the ISDN turned out to be quite expensive.

So, although it was deployed in some places – it is also deployed some places in India and a lot of places in Europe – since it was so expensive, it did not become popular. So that was the problem with ISDN; so people thought about an altogether new technology called ATM and we will discuss ATM later.

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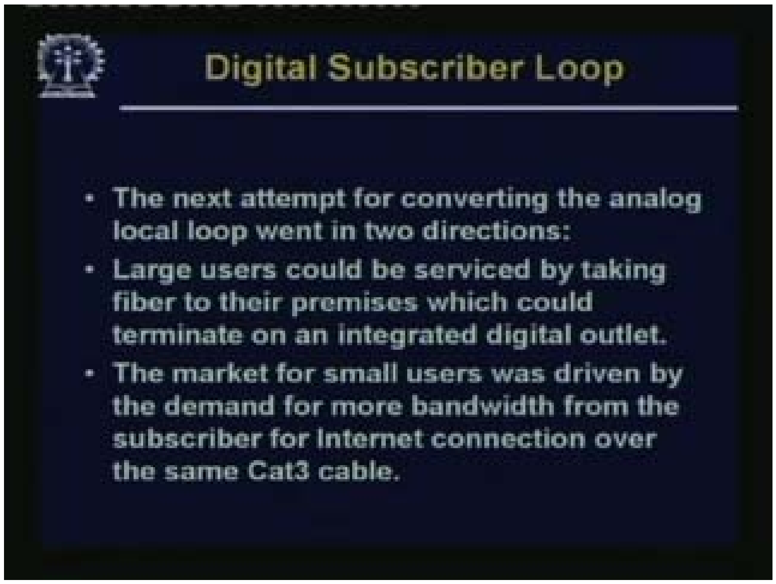

Another direction, in which this digitizing the local loop went, was the digital subscriber loop or DSL. So it had two basic approaches: one was that for the large user, let us say, a particular office or company. You can take a fiber to the premise of that company, which can be integrated like a sort of outlet and you can give all kinds of services – that is one thing. The other is to use the same category-3 cable – maybe different bands of it using some advanced technology of multiplexing signals and then give both data and voice at the same time on the same line.

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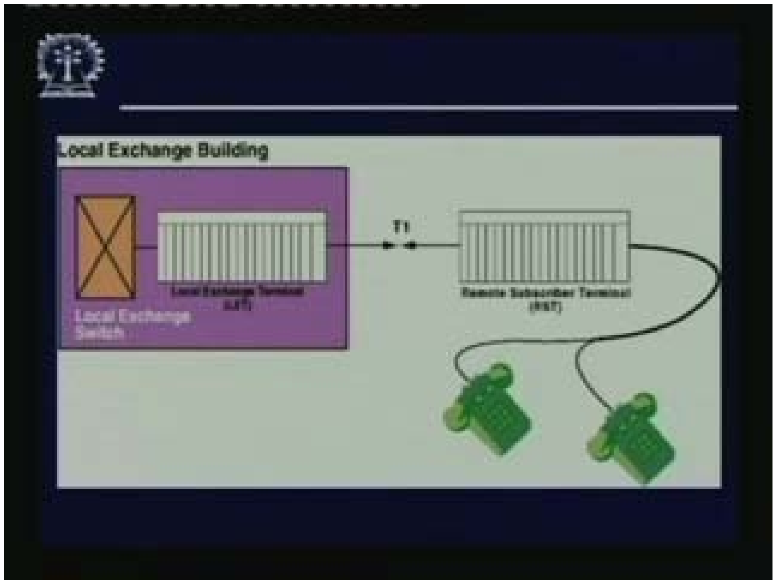

So you have this remote subscriber terminal, which is connected to the individual users.

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The copper twisted pair remains the same, but the new equipment is integrated, enabling a service provider to deliver voice and high-speed data service at the same time. So this is the picture that shows subscribers who are connected through the analog and DSL lines. Now in the centre of the side, you have some kind of a splitter and in this splitter, one side is the data:

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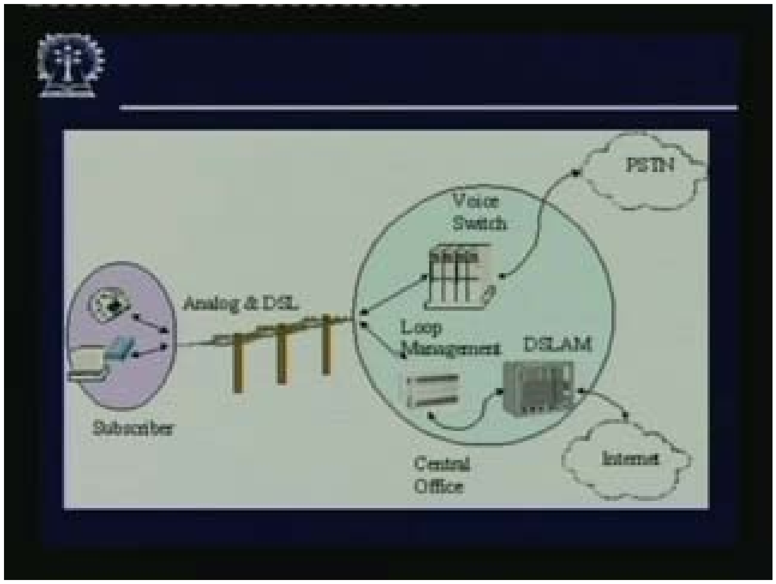

One side the data goes through this D SLAM, which is digital service digital service access multiplexer. So that goes maybe to the internet, the other part goes to the voice switch to the PSTN, which is the other, plain old previous voice services. So DSL at subscriber's end has voice traffic that is transmitted as standard analog telephony signals; data traffic is transmitted over the same line but via a DSL modem that transmits the data as high-frequency digital broadband signals on the same line. So if you have DSL modem, you can have both your voice as well as data at the same time, unlike ordinary analog lines.

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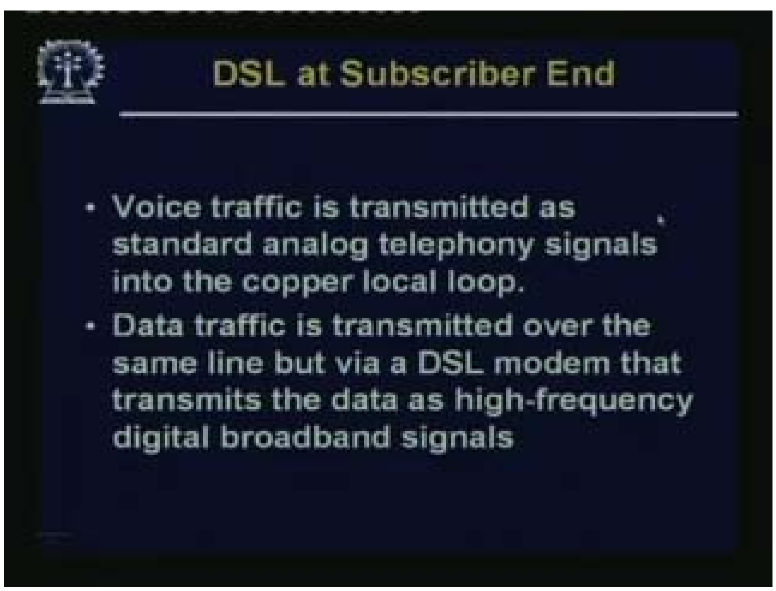

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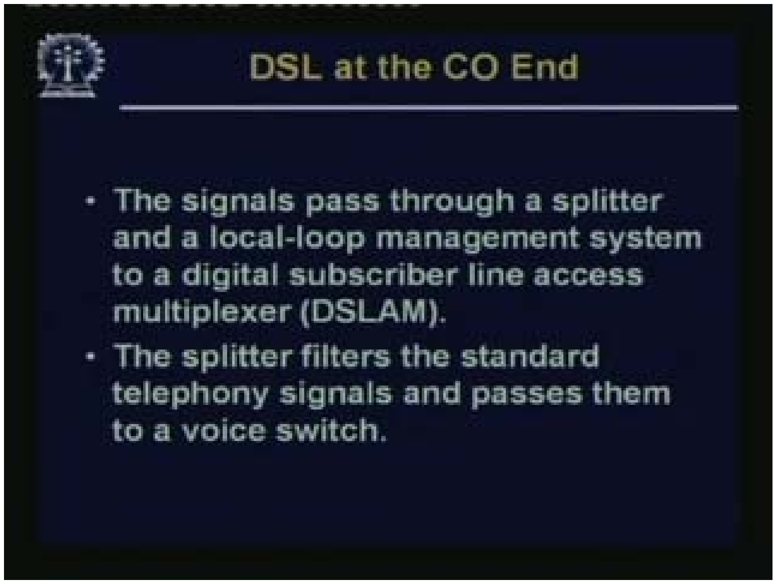

So with DSL at the central office end, CO end, the signals pass through a splitter as I have shown and a local loop management system, so the subscriber line access multiplexer is there.

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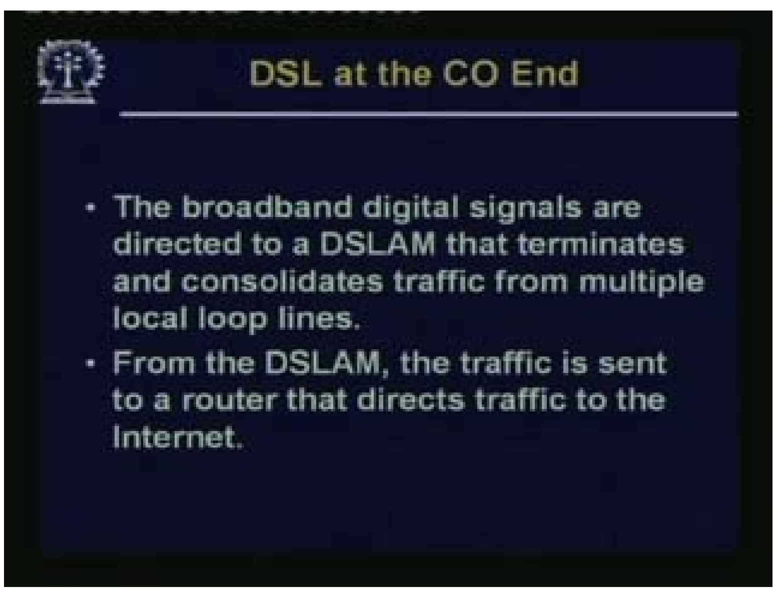

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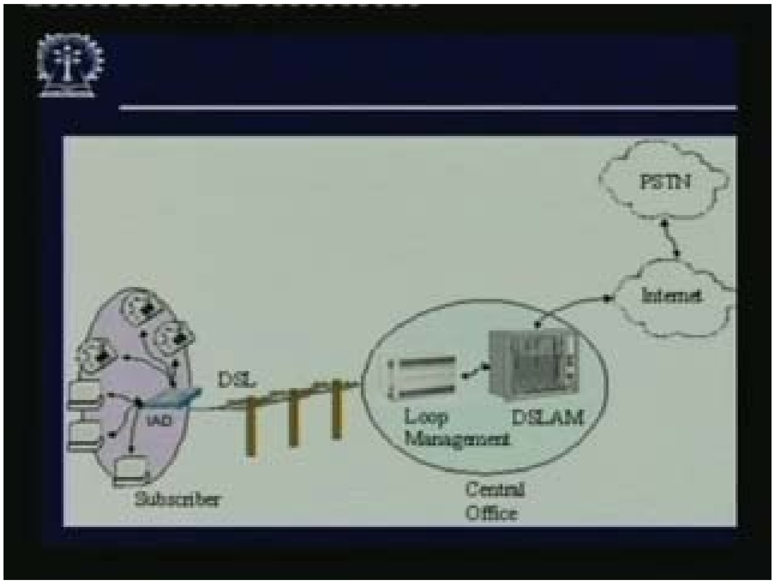

You can just have this figure where we have DSLAM and the loop management over there.

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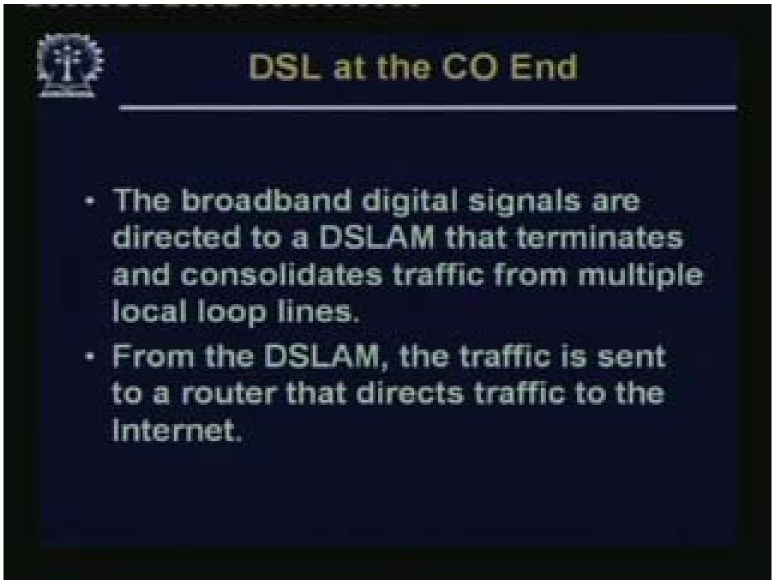

The broadband digital signals are directed to a DSLAM that terminates and coordinates traffic from multiple local loop lines, from the DSLAM the traffic is sent to a router and then to the internet. And finally we have the loop management system; this may be in front of the splitter or behind the splitter.

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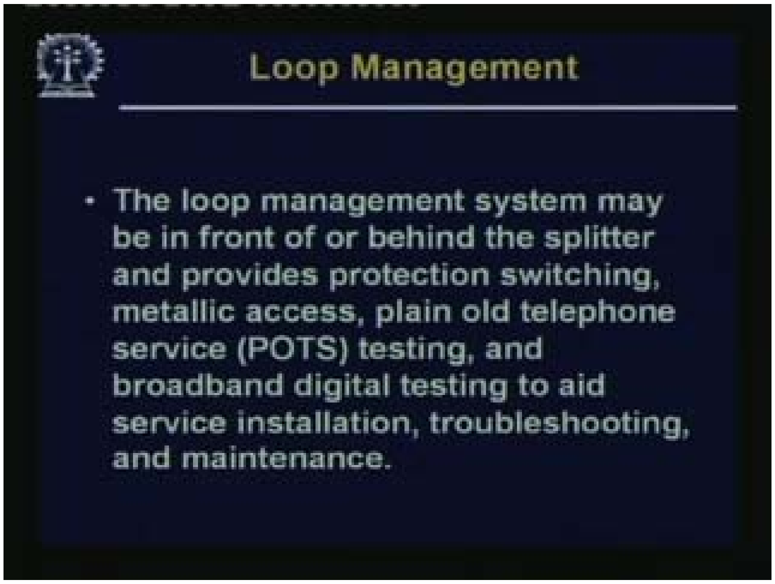

So this performs various functions as they are like giving the connections; testing; and all these services are done through the local loop management. Thank you.

Preview of next Lecture
Computer Networks
Prof. Sujoy Ghosh
Department of Computer Science and Engineering
Indian Institute of Technology, Kharagpur
Lecture Name - 07
Switches – I

Good day! so today and in the next lecture we will be talking about switches, switches are the most important part of computer networks and we will just look into some aspects of the different types of switches; so first in this lecture we will start with the some kind of switches which are used in the telecom networks. Then there is special version of these which we will cover in a later lecture. And then in the next lecture we will be talking about packet switches which are closer to the heart of data networks. So we talk about switches first thing is why do we need switches well………….. the problem is that each user can potentially call any other user as we have seen in telephone networks.

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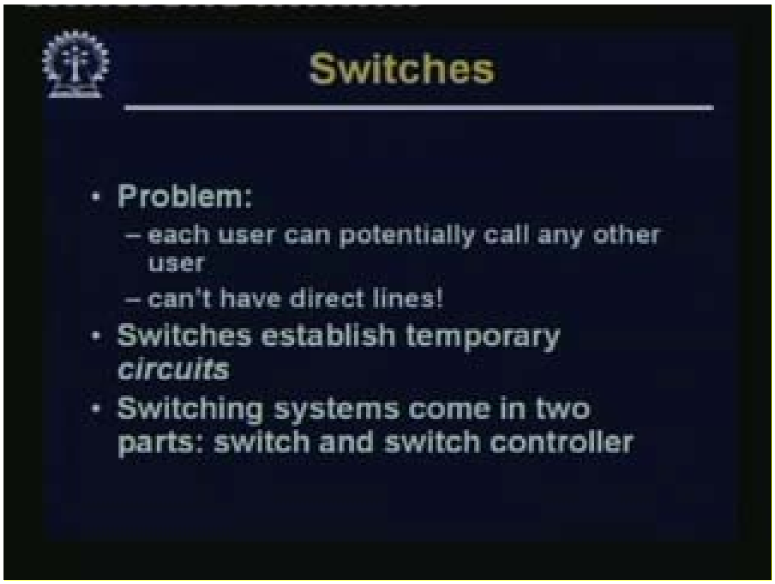

So and we cannot have direct lines we can not have order in square kind of lines. So every user is connected to an essentially a switch in the switching office and switches establish temporary circuits. That is they establish a temporary connection between the caller and the collie at the switching station and switching system comes in two parts one is the switch and the other is the switch controller.

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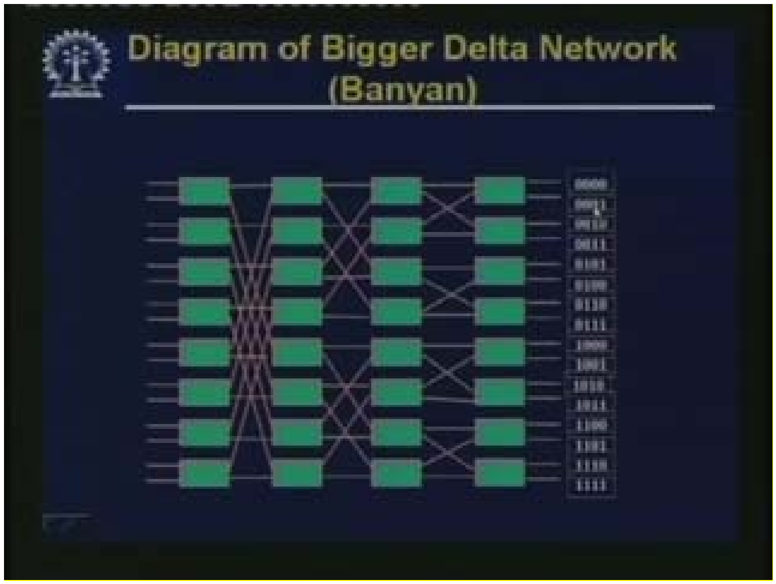

You see this fellow say zero wants to talk to zero one. So he will simply go like this and similarly another line over here may want to go straight down to somewhere over here. So many calls can go through together but this is not always the case. Now always the case as there may be contention for the same switching element. As we will see in this diagram you know because if you produce something in very large number you can ammonites the cost of its development etc.over a large number of switches so this cost of this switch comes down. So Ethernet switches have become very cheap. These days switches which use to cost may be lack or so may be 10, 15 years back cost only few 1000 rupees today. So this is the most common type of switch which we see every where.