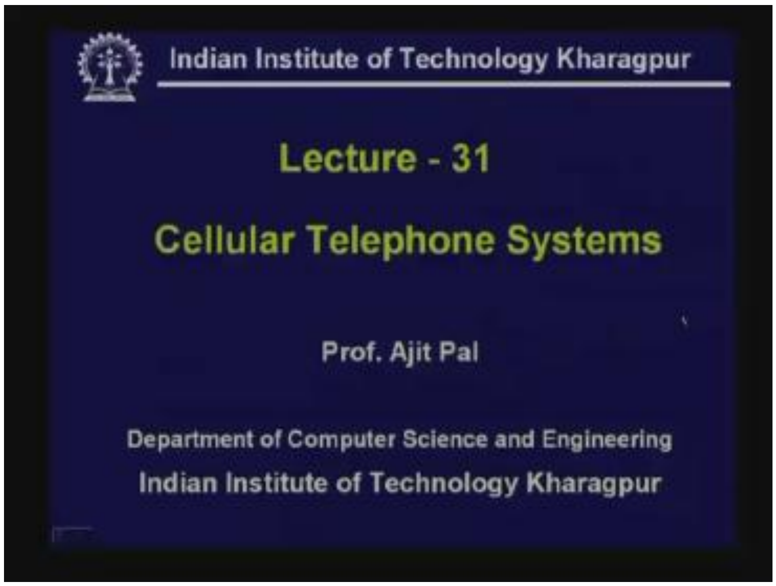
Data Communications
Prof. A. Pal
Department of Computer Science & Engineering
Indian Institute of Technology, Kharagpur
Lecture minus 31
Cellular Telephone Systems

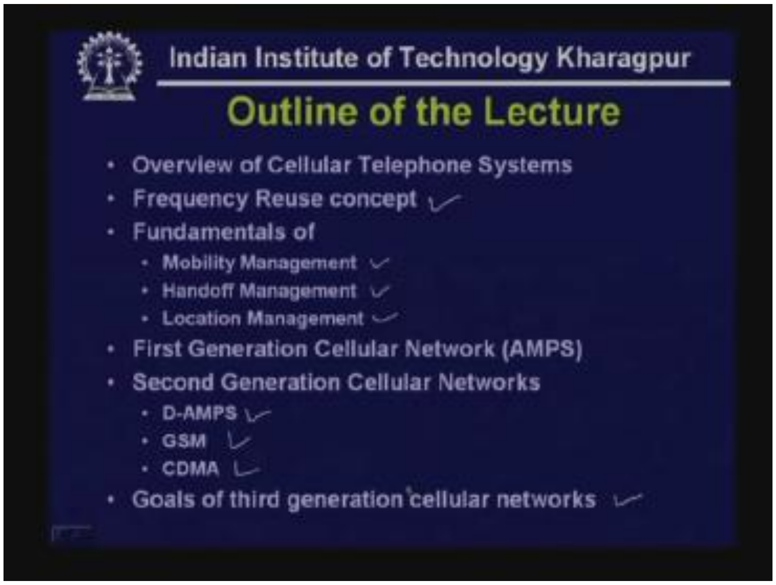
Hello viewers, welcome to today's lecture on cellular telephone systems.

(Refer Slide Time: 01:01)



In the last lecture we have discussed how wireless LAN can be used to communicate over a small geographic area. In today's lecture we shall see how wireless communication can be used to cover a large geographic area. Here is the outline of today's lecture.

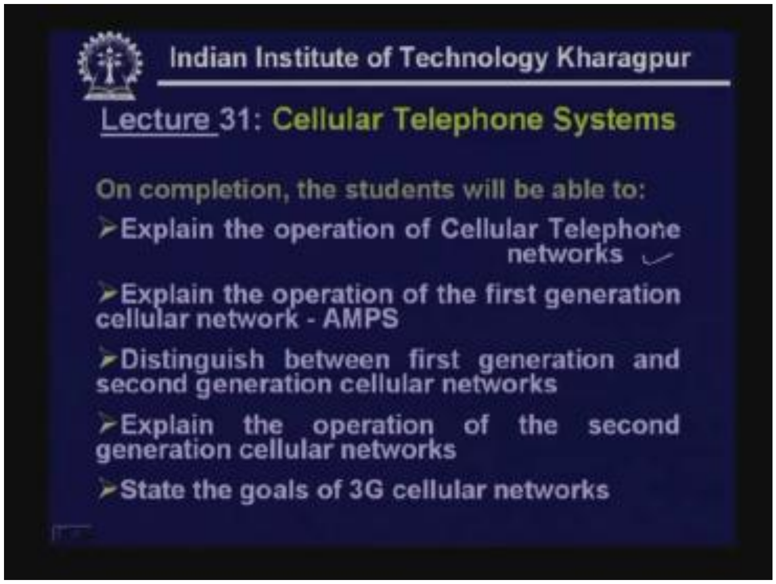
(Refer Slide Time: 02:40)



First I shall give an overview of cellular telephone systems. Then there are several important concepts that are being used in cellular telephone systems. First one is the frequency reuse concept. I shall discuss about it which is very important for efficient utilization of channels in cellular telephone systems. Then there several other concepts like mobility management, handoff management and location management because the users are now moving from one place to another so as a consequence you require these features. Then I shall discuss about several practical systems.

First one is the first generation cellular network AMPS which was developed in North America based on analog technique, then there are several second generation cellular network like D-AMPS, GSM and CDMA. We shall discuss about them in detail then finally discuss about the goals of third generation cellular networks. This third generation cellular networks are still under development and also being deployed in some places.

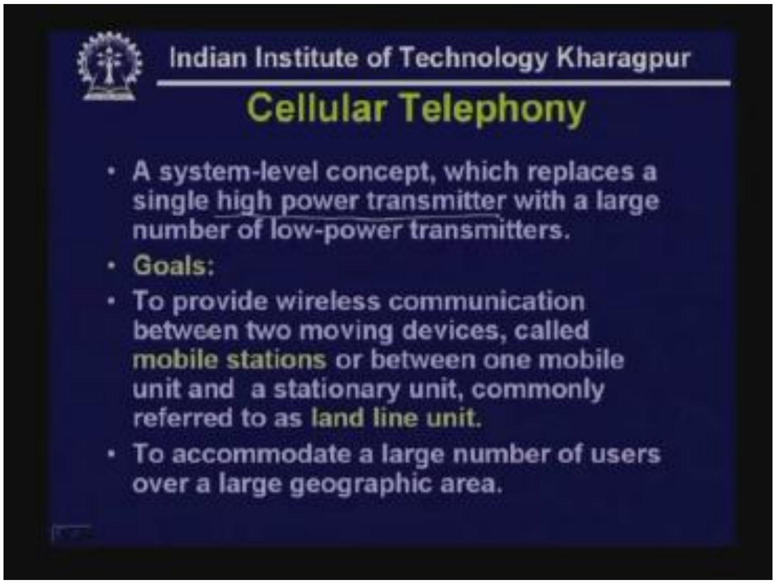
(Refer Slide Time: 03:26)



On completion of this lecture the students will be able to explain the operation of cellular telephone networks as how a cellular telephone network works and also explain various other features of it, they will able to explain the operation of first generation cellular telephone network based on analog technique that is your AMPS Advanced Mobile Phone System, then they will be able to distinguish between first generation and second generation cellular networks.

Second generation cellular networks are essentially developed for digital technique compared to in contrast to the analog technique used in the first generation AMPS network. Then they will be able to explain the operation of the second generation cellular networks, the three types that I have mentioned, they will be able to explain the goals of third generation cellular networks. First let us try to give the motivation behind cellular telephony.

(Refer Slide Time: 04:52)



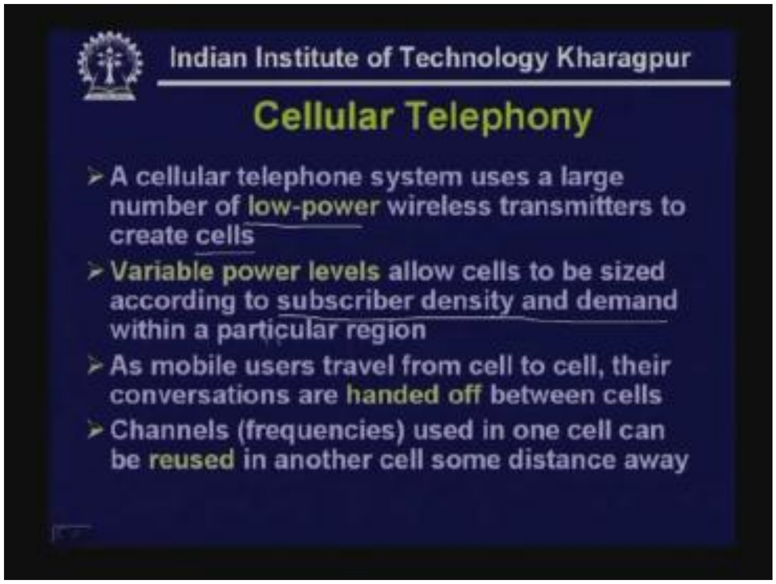
It is essentially a system level concept which replaces the single high power transmitter with a large number of low power transmitters. Conventionally a very high power transmitter is used when a large geographic area is used to be covered. But this concept is not used in cellular telephony or cellular telephone networks.

What is being done?
A large number of low power transmitters are being used to cover a large geographic area; that is one important difference between the conventional approach and the cellular telephone approach. And here the goal is to provide wireless communication between two moving devices. The moving devices are essentially the mobile stations or handsets or between one mobile unit and a stationary unit usually referred to as landline. So, communication between two mobile stations or between a mobile station and stationary stations are to be provided. And of course as I said another important goal is to accommodate large number of users over a large geographical area.

You will look at the two points. First one is the large number of users which will be possible because of frequency reuse which we shall discuss and over a large geographical area. So, these two are the important objectives to be satisfied.

And as I mentioned it uses a large number of low power wireless transmitters to create cells. Cells are of a small area varying from 10 to 20 km across. Then the power level of both the transmitters and the handsets are variable to allow cells to be sized according to the subscriber density and demand. That means the geographic area to be covered under a transmitter is no longer fixed, it is variable. We shall discuss how it can be done.

(Refer Slide Time: 06:06)



As mobile users travel from cell to cell their conversations are handed off. That means when a user or a mobile station moves from one place to another it is very common that they will move away from a particular cell and go to a new cell so it has to be done in a seamless manner and the approach to be used to satisfy seamless transfer is known as handoff. So, the conversation is to be handed off between cells.

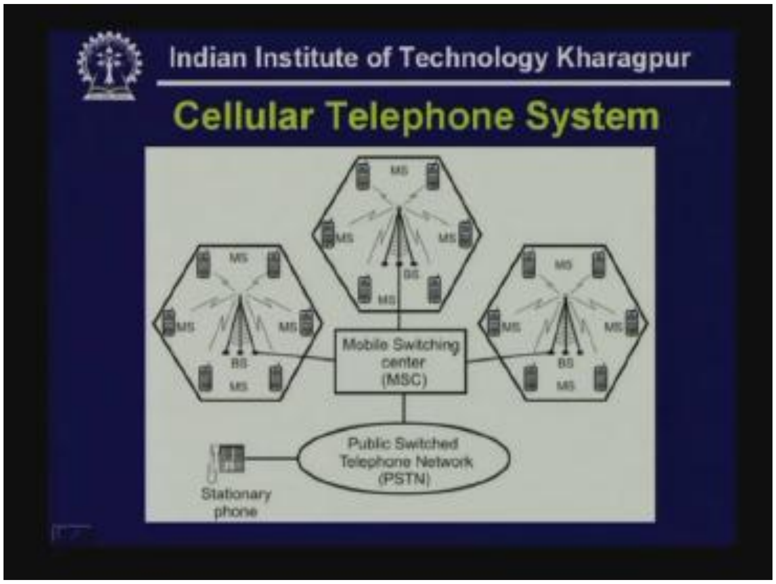
Then, the channels used in one cell will be reused in another cell some distance away. As I mentioned this concept of reuse of cell frequency channels leads to higher capacity of cellular telephone network. So let us have a look at the simplified structure of a cellular system. It comprises the following components:

Mobile Stations (MS): Large number of mobile stations which are essentially mobile handsets which are used by the user to communicate with each other. Cell is a service area where each cellular service area is divided into small regions called cell. So it can be 5 to 10 km across.

(Refer Slide Time: 07:40)

And there are base stations; each base station contains an antenna which is controlled by a small office. In addition to that there is mobile switching center where each base station is controlled by a switching office called mobile switching center, it will be clear from the next diagram.

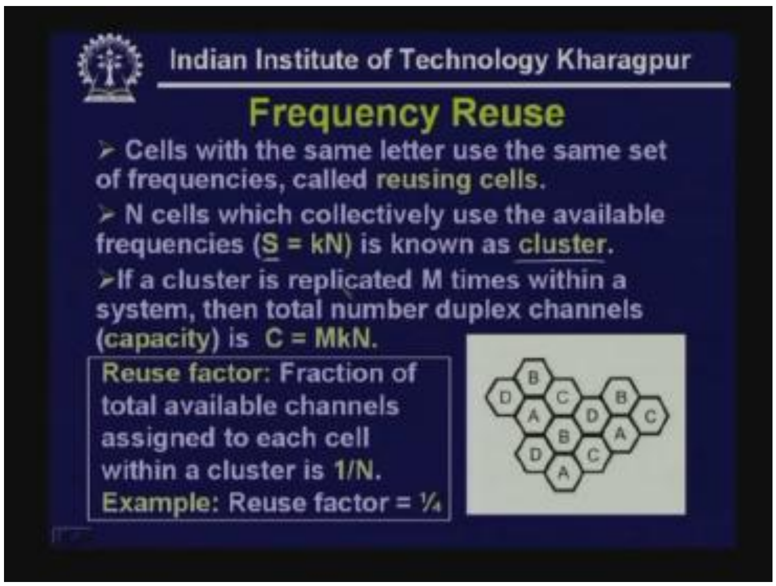
(Refer Slide Time: 08:18)



Here we have got a number of cells. This honeycomb like cells are shown here. In reality it will circular but for the purpose of modeling this honeycomb like cells are convenient that you model. You have got the transmitter, apart from this transmitter there is a computer which controls this transmitter. so in each cell you have got a transmitter and a computer which controls the transmitter and you have got a number of mobile stations as you can see and a number of such cells are controlled by a single mobile switching center which can be considered as an end office in a Public Switched Telephone Network and this in turn is connected to the Public Switched Telephone Network so that the mobile stations can communicate through the base station and the mobile switching center and the Public Switched Telephone Network to a stationary phone or a landline phone.

These are the landline phones and these are the mobile phones (Refer Slide Time: 9:15). This is the overall structure of the system. Now let us look at the concept of frequency reuse which is very important from the view point of channel capacity.

(Refer Slide Time: 10:23)

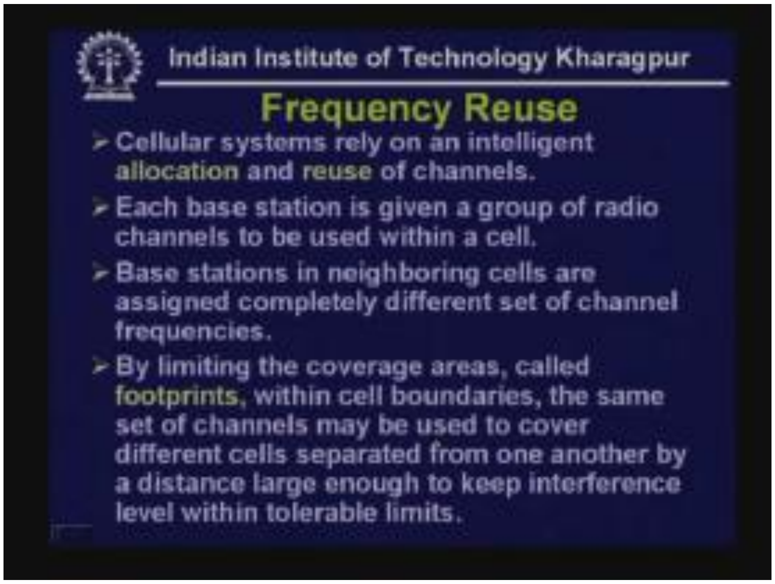


The cellular systems rely on an intelligent allocation and reuse of channels. So each base station is given a group of radio channels to be used within a cell and base stations in neighboring cells are assigned completely different set of frequencies. This frequency reuse concept is explained here.

For example, this is a cluster (Refer Slide Time: 10:09) this cluster is the area over which all the frequency channels are being available. That means ‘n cells’ which are collectively used in the available frequencies is called a cluster. So let’s assume S is the total number of channels available which is been divided among ‘n cells’ and in this particular case N is equal to 4 so it is A B C D that means each of these cells will get one fourth of the channels available. That means S by K is the number of channels that can be used in each of these cells.

As you can see here this A has appeared here, so A has appeared here, A has appeared here that means A has appeared twice that means same set of frequencies are to be used in these three cells. Similarly, same set of frequencies is to be used in cell B, cell B and cell B so in all these three cells same set of frequencies will be used. Hence, this is the frequency reuse concept.

(Refer Slide Time: 12:26)



At one point you must notice that two ‘As’ are separated in this particular case at least by one cell. So, if you have larger number of cells two reusing cells will be separated by several such cells. That means the transmitter as well as the transmitter power will be restricted such that the signal does not reach another cell reusing the same set of frequencies. So the reuse factor is used which essentially is the fraction of total available channels assigned to each cell within a cluster which is equal to 1 by N.

As I said if S is the total number of channels then the number of channels to be available in a particular cell will be equal to S by N is equal to K so K is equal to S by N so reuse factor will be 1 by N so in this particular case the reuse factor is 1 by 4.

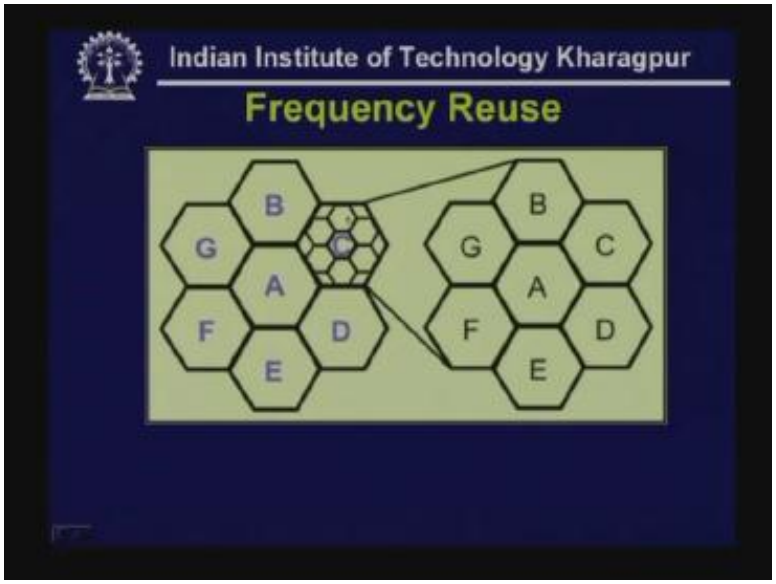
As I mentioned by limiting the coverage area called footprints within a cell boundary the same set of channels may be used to cover different cells separated from one another by a distance large enough to keep interference level within tolerable limits as explained in this diagram (Refer Slide Time: 12:41).

This is the frequency reuse concept which is used in cellular telephony so that the channel capacity total capacity is increased.

For example, here the capacity is M into K into N (Refer Slide Time: 12:55) that means if in a area if it is replicated M times total capacity is multiplied by M. So a particular set of frequencies may be replicated hundred or thousand times depending on the density and the number of uses. Hence, the capacity is multiplied by M because of this reuse factor.

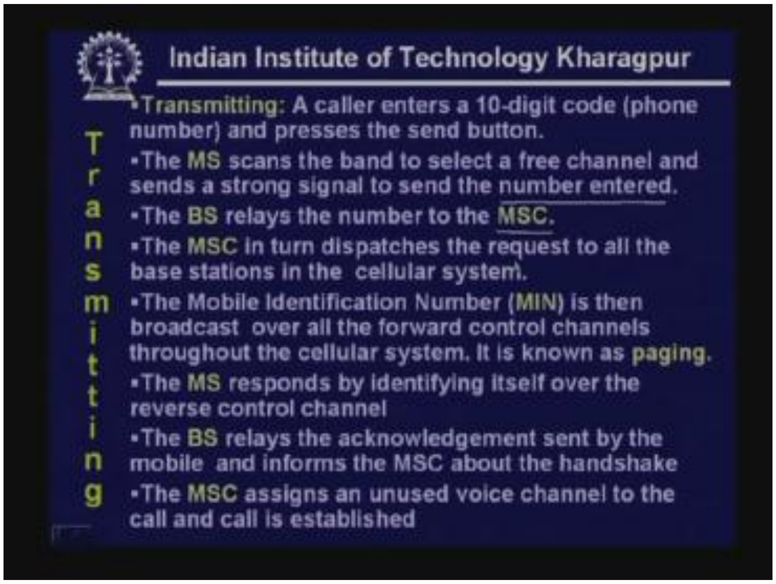
Now let us see how the frequency reuse is dynamically changed. For example, it is found that a particular area may be urban area where the population density is very high, densely populated, in that case the number of users is large and a particular cell is divided again into a number of smaller cells so micro cells as you may call and again you can reuse a number of the several frequencies.

(Refer Slide Time: 14:05)



In a rural area where the number of users is sparse then you can cover by using a single cell. Obviously both the transmitters of the base station as well as the mobile station will require larger power. On the other hand here the communication is restricted over a small area which is shown in the magnified form here. This is for the densely populated area. So in case of densely populated area you will be using smaller cells so you will require lesser transmission power to cover. On the other hand, sparsely populated areas you will be using larger size cells that means it will cover larger area so foot print will be bigger compared to (). So, in this way in a dynamic manner the cells can be of various sizes depending on the number of users or the population density. Now let us see how exactly the transmission and reception takes place.

(Refer Slide Time: 16:00)



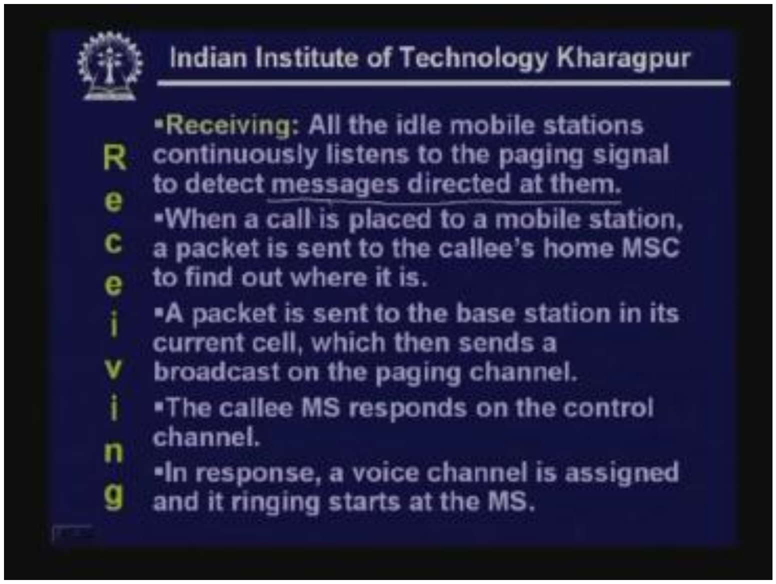
We are all familiar with cellular telephones nowadays, the caller enters a ten digit code which is essentially the phone number then presses the send button. The mobile station scans the band to select a free channel and sends a strong signal to send the number entered. So mobile stations now does the transmission, the base station relays the number to mobile switching center so after receiving from the mobile station the base station now relays it to the mobile switching centre and the mobile switching in turn dispatches the request to all the base stations in the cellular system.

So as I said a mobile switching center may control a large number of base stations so it is broadcast over all the base stations then the mobile identification number is then broadcast over all the forward control channels throughout the cellular system. This particular technique is known as paging.

The mobile station responds identifying itself. That means the destinations responds by identifying itself over the reverse control channel. There are two different channels; forward channel and reverse channel as we shall see. The base station relays the acknowledgement sent by the mobile station and informs the mobile switching center about the handshake and the mobile switching center assigns an unused voice channel to the call and call is established.

This is the sequence of events that takes place whenever a mobile station wants to transmit to another mobile station. Now let us see what is the function of the mobile station which is receiving the signal.

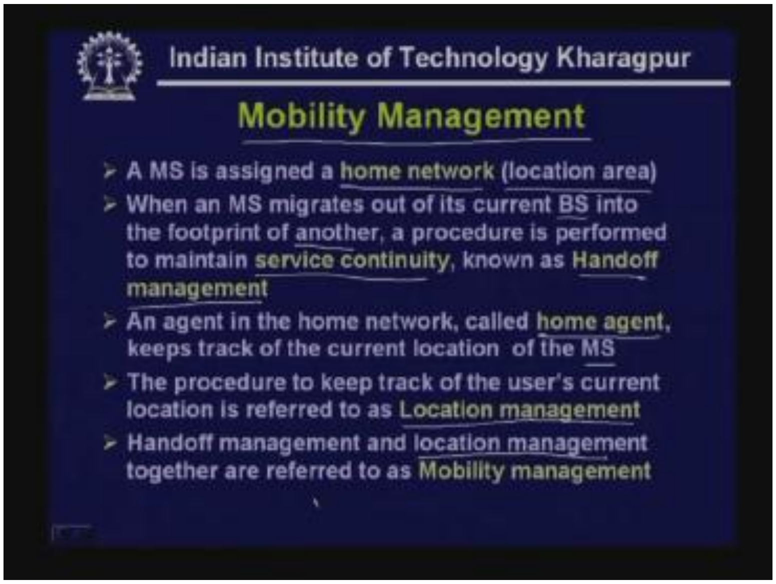
(Refer Slide Time: 18:12)



So, in the receive mode all the ideal mobile stations continuously listens to the paging signal to get messages directed at them. When a call is placed to a mobile station a packet is sent to the callee's home mobile switching center to find out where it is. A packet is sent to the base station in its current cell which then sends a broadcast on the paging channel. The callee mobile stations respond on the control channel. As we shall see the channel is divided into a number of data channels and controls channels so this communication takes place over the control channel and in response a voice channel is assigned and its ringing starts in the mobile station.
That means whenever a mobile station is in the receive mode this sequence of event occurs and finally ringing takes place in the mobile station and a particular mobile station can now receive a call. This is how receiving takes place.

Now let us consider how the mobility of different stations is managed. That technique is known as mobility management.

(Refer Slide Time: 18:42)

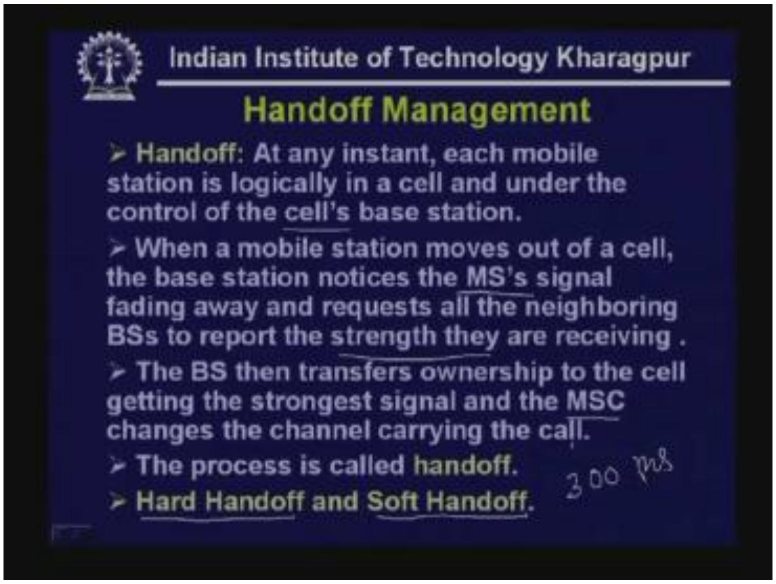


As you have already seen a mobile station is assigned a home network over which it can roam around and which is under the control of a mobile switching center called as the location area. When a mobile station migrates out of the current base station into the footprint of another a procedure is performed to maintain service continuity. This is known as handoff management. How it is been done?

An agent in the home network called home agent which is some kind of software learning keeps track of the current location of the mobile station. The procedure to keep track of the user's current location is referred to as location management. Now, handoff management and location management these two together are referred are to as mobility management.

Let us last see how the handoff management is performed then we can see how location management is performed.

(Refer Slide Time: 20:20)



As we have seen at any instant each mobile station is logically in a cell and under the control of cell's base station. Now, when a mobile station moves out of a cell the base station notices mobile station's signal fading away and it requests the neighboring base stations to report the strength they are receiving. The base station then transfers ownership to the cell getting the strongest signal and the mobile switching center changes the channel carrying the call.

As we have seen, two adjacent cells do not use the same frequencies so as a consequence when a particular mobile station moves from one base station to another base station a different frequency channel is to be assigned. That is the function of the handoff. There are two handoff techniques commonly used. One is known as hard handoff and another is soft handoff.

In case of hard handoff a mobile station always communicates only with one base station and whenever it moves out from one base station to another base station first it terminates communication with the present base station and then it starts communication with the next base station to which it is moving in. So in this way there is a sharp transition which takes about 300 milliseconds. So as a consequence in case of hard handoff the communication is with one base station and as a mobile station moves it changes from one base station to another base station and the channel frequency also changes.

On the other hand, in case of soft handoff a mobile station communicates with two neighboring base stations. And as a consequence the base station can tell about the signal strengths, the base station and mobile station will know about the signal strengths both the stations are receiving and as a consequence a mobile station keeps on talking with two neighboring stations as it moves from one base station to another base station which is performed in a soft manner. That means while communicating with two at a particular instant it switches from one base station to another base station that's why it is called soft handoff. That means at a particular instant the communication is performed with two base stations.

Now let us focus on the location management. It requires two fundamental operations; one is known is location update and another is paging.

(Refer Slide Time: 23:04)

When a mobile station enters a new location area it performs location updating procedure by making association between a foreign agent and the home agent. That means the software keeps track of that. So foreign agent is essentially the software running in that host location area where it has moved and home agent to which the mobile station belongs to. So one of the base stations in the newly located area is informed and the home directory of the mobile is updated with its current location. So the home agent keeps track of it and it modifies the directory.

And when a home agent receives a message destined for the mobile station it forwards the message to the mobile station via the foreign agents. This means both the software running in two different systems communicate with each other to keep track of the mobile station. Of course whenever it is being done an authentication process is performed before forwarding a message for a mobile station. In a nutshell this is how location management is performed.

We have discussed about the basic operations and the functions to be performed in the mobile telephone systems. Now let us look at the different implementations. First we shall consider the first generation technique.

(Refer Slide Time: 24:51)

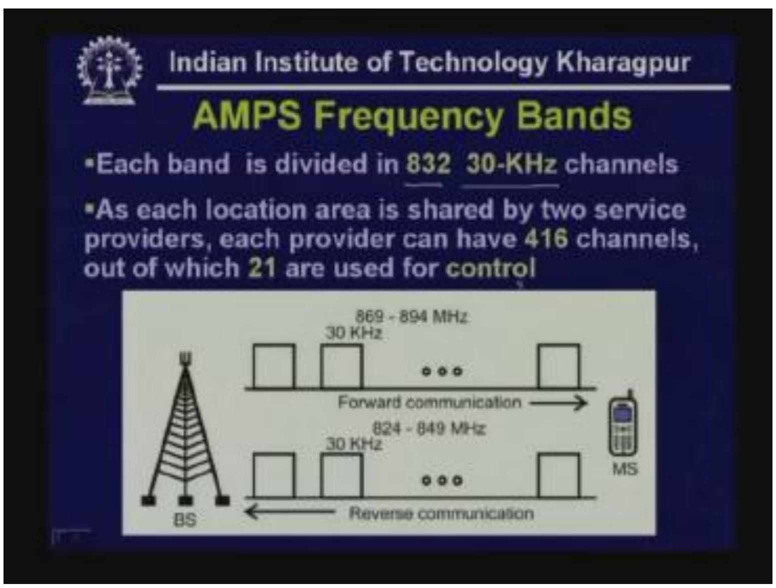
The first generation was mainly designed for voice communication. Although several systems were developed the most popular is the Advanced Mobile Phone System AMPS used in North America developed by the Bell Labs which was in operation in North America. And AMPS is an analog telephone systems and it uses 800 MHz ISM band which does not require any licensing. ISM stands for Industry Scientific and Medical band which does not require licensing and two separate analog channels are used, one is known as forward and another is known as reverse analog channel.

Thus, for duplex communication two separate channels are necessary. The band between 824 to 849 MHz is used for reverse communication that is from mobile station to the base stations.

(Refer Slide Time: 26:00)

On the other hand the band between 869 to 894 MHz is used for forward communication from base station to mobile station. Let's see pictorially how it operates.

(Refer Slide Time: 27:00)

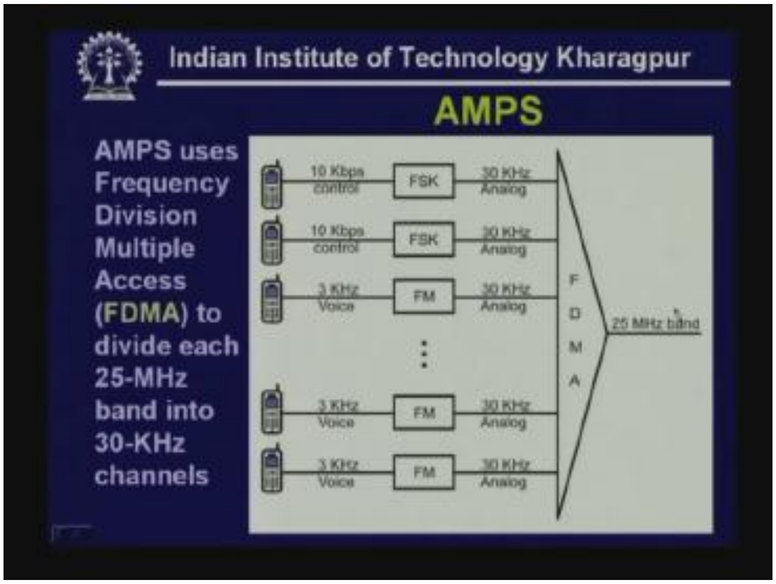


These are two different bands, this (Refer Slide Time: 26:20) is for forward communication 869 to 894 mega band divided into 832 30 KHz channel so you have got 832 30 KHz channel distinct channels with different carrier frequencies and similarly for reverse communication from the mobile station to the base stations you have got again 832 frequency bands each of 30 KHz.

And of course all of them are not used for data base communication. As I mentioned out of this 832 42 are used for control. Another approach is used.

Usually each area is shared by two service providers. That means since two service providers are operating in the same area that means the channels are also equally divided between them. That means 832 is divided into 2 so each of them have 416 channels available out of which 21 are used for the control and remaining are used for voice communication and it uses the FDMA technique. Let's see how it is being done.

(Refer Slide Time: 28:04)



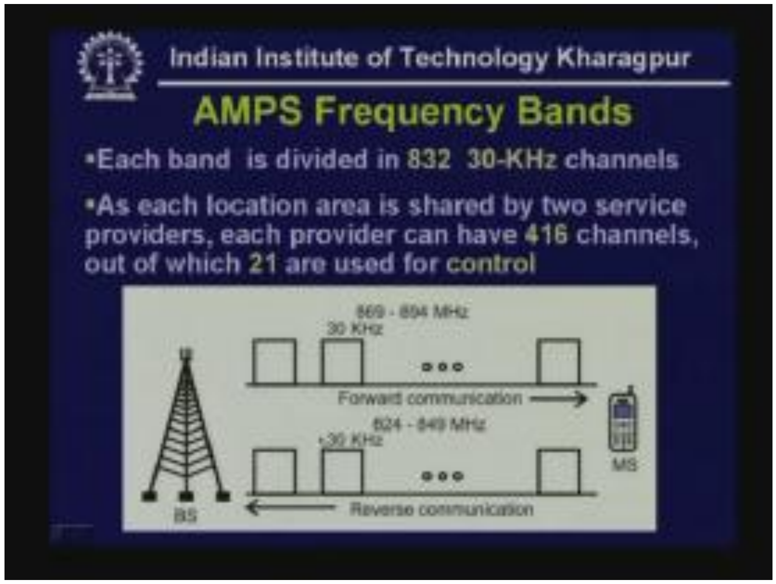
So it uses the frequency division multiple access to divide each 25 MHz band into 30 KHz channel. Hence so many analog channels are broadcasted simultaneously and here each of the 3 KHz voice channel is frequency modulated to generate 30 KHz analog channel which is used for communication.

Therefore, out of 832 voice channels you have to subtract 42 that means 790 voice channels are there each of 30 KHz so after frequency modulation you get 30 KHz. so 30 KHz channels which are analog channels are communicated between base stations and the handsets using the frequency division multiple access.

Hence, these are essentially transmitted in parallel through air and from the mobile station it goes to the mobile transmitter or receiver in the base station.

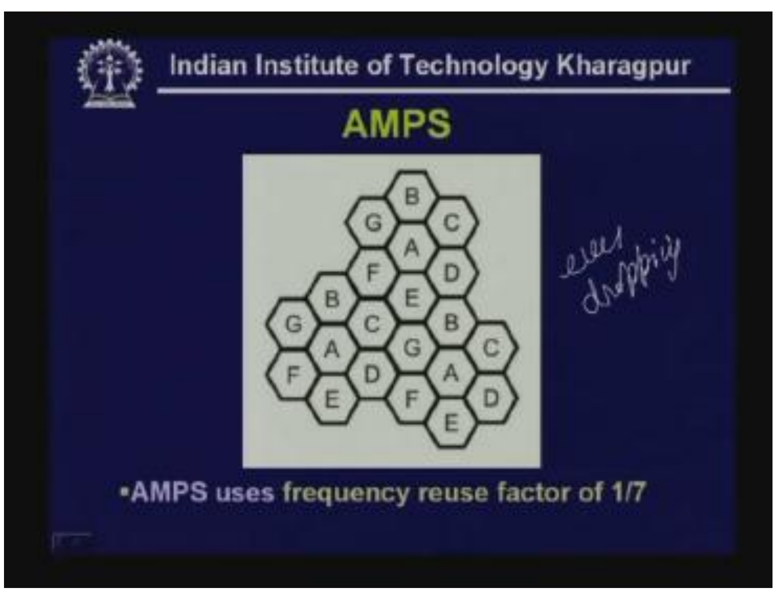
Similarly, for the forward channel from the transmitter instead of so many base stations you will have the transmission of the base stations from which the signals are transmitted by using different frequencies and again 25 MHz band is created. However, in that case the frequency band is different. So two different bands are used for communication in two directions so full-duplex communication is performed between the mobile station using the base stations and two way communication is performed.

(Refer Slide Time: 29:56)



So, two mobile stations communicate with each other through the base stations. and as you can see in AMPS it uses frequency reuse factor of 1 by 7 so this is one cluster and the 832 frequency bands are divided by 7 and each can be used in each of these cells so frequency reuse factor is 1 by 7 so 832 by 7 that is the number of channels available in each of these cells so you have got seven cells in a cluster so these are repeated in a honeycomb like fashion that's why it is called cellular communication because of these cellular network as the same thing is repeated over and over in an honeycomb like structure. This is AMPS based on analog communication.

(Refer Slide Time: 31:00)

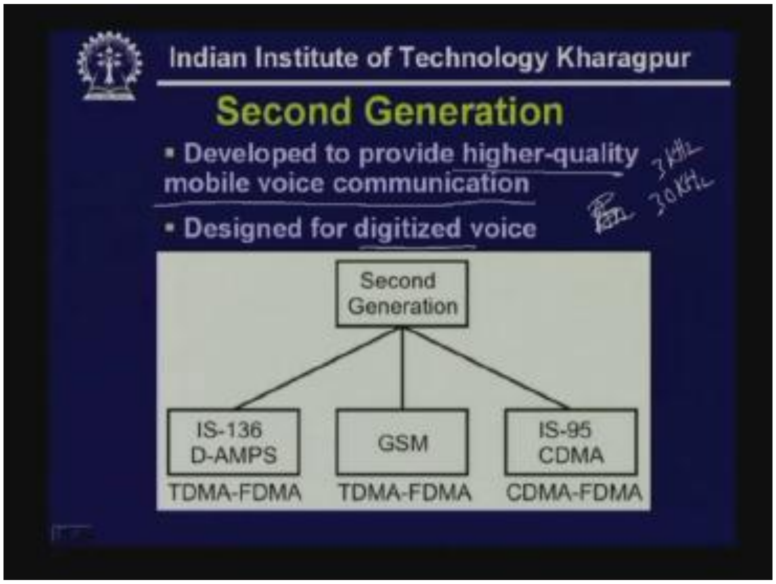


Now in case of second generation communication it was based on digital technique. We have seen AMPS uses analog communication and it is very easy to perform eavesdropping. That means any receiver receiving a particular carrier frequency or when the channel is tuned to that particular frequency then it will be able to receive the voice.

Here is an interesting story about how the communication of Princess Diana was recorded as she was communicating using the cellular phone, that led to some problem. Privacy is less; there is no privacy you can say because there is no encryption or any other technique being used so very easily one can hear the conversation between persons. Also, it is not very reliable and is not of very high quality. So the second generation technique was developed to provide higher quality mobile voice communication and it is mainly based on digital technique. Instead of using analog approach we have seen here that the bandwidth of the voice is only about 3 KHz and that is the frequency modulated to generate 30 KHz. instead of the analog technique here it is done in a digital manner.

Therefore there are three different approaches developed for that. First one is interim standard 136 which is also known as digital AMPS. AMPS as you know is Advanced Mobile Phone Systems used in North America in the analog form and the digital version is known as interim standard 136 and it is based on TDMA and FDMA.

(Refer Slide Time: 33:34)

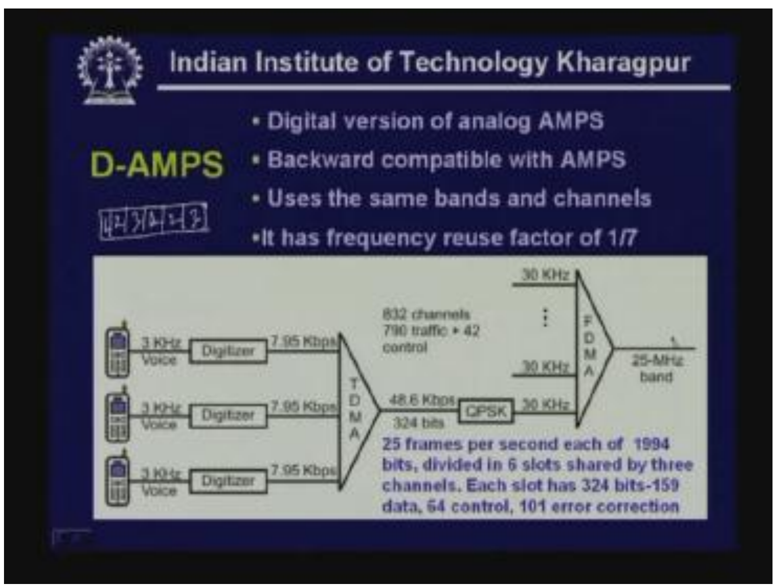


The second technique is known as GSM which was developed in Europe. before the digital system came in different parts of Europe like France, UK and in other countries different analog techniques were used so they wanted to use a common digital technique and that common digital technique that emerged was given the name as GSM, again which is based on TDMA and FDMA. Another technique that was developed based on CDMA FDMA is known as interim standard 95. So we shall discuss these three digital techniques one after the other.

First let us consider the D-AMPS which is essentially the digital version of analog AMPS and it is backward comfortable with AMPS. By that I mean that, if somebody is having an analog telephone and analog handset and if somebody is having the digital handset they can communicate with each other that's the basic objective of backward compatibility. And as a consequence they had to use the same bands and same channels as it is used in AMPS. So the bands and channels used are same and are not different and it also uses the same frequency reuse factor 1 by 7. So, except it is digital but the rest of the thing is same as we see in terms of frequency reuse factor, in terms of frequency bands and channels it is identical to AMPS to maintain backward compatibility.

Here we shall see how it is being made digital. We notice that here the 3 KHz voice is digitized using a very complex PCM and [compression… 36:00] technique to generate 7.95 Kbps. If you perform simple digitization obviously it will at least say 3 into 3 KHz so you have to sample at 6 KHz then you have to multiply with 6-bit or 8-bit that means 6 into 8 is equal to 48 Kbps. But by use of suitable compression technique the digital signal is having 7.95 Kbps.

(Refer Slide Time: 36:38)



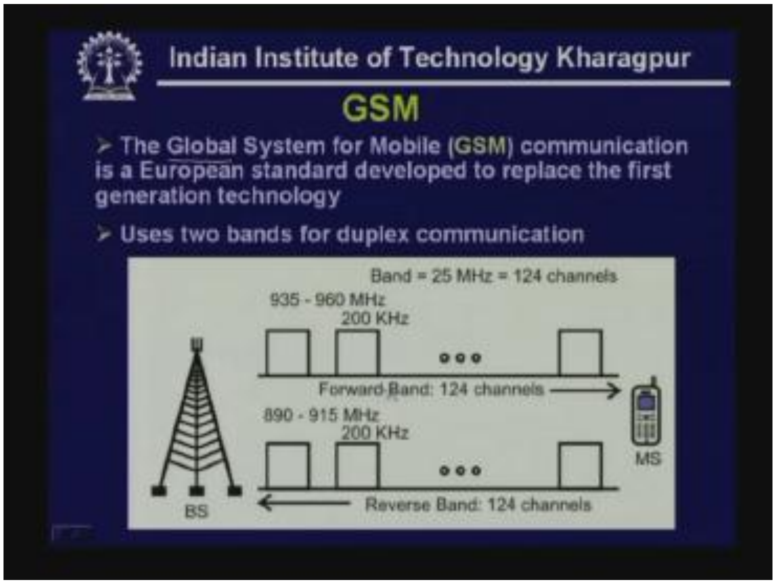
So three such digital channels are Time Division Multiple Access so multiplexing is performed in time division. Let me show you the next diagram to explain this (Refer Slide Time: 37:10). Actually what is being done here is 25 frames are been sent each of 1994 bits divided into 6 slots and these 6 slots are shared by three channels that means here you have got 6 slots say 1 2 3 and 1 2 3 so this is one frame and you have got twenty five such frames per second each of 1994 bits and each slot is having 320 bits out of which only data is only 159 bits, 64 control and 101 is used for error correction.

Thus, in this way you have got this 48.6 kilo bits and that 48.6 kilo bits is converted into analog form analog signal by using QPSK to generate 30 KHz analog signal and that is being sent from the mobile station to the transmitter receiver of the base station or from the base station transmission receiver to the mobile station. So this part is same as the analog AMPS and this part is different so that the digital technique is used.

The second technique that is being used is known as GSM. As I mentioned this GSM is meant for global system for mobile communication that's a European standard to replace the first generation technology. The first generation technology that was used in various parts of Europe was different but here it is combined to have global system for mobile communication throughout Europe. It is based on duplex communication so it has the same type of concept as D-AMPS but the frequency bands are different.

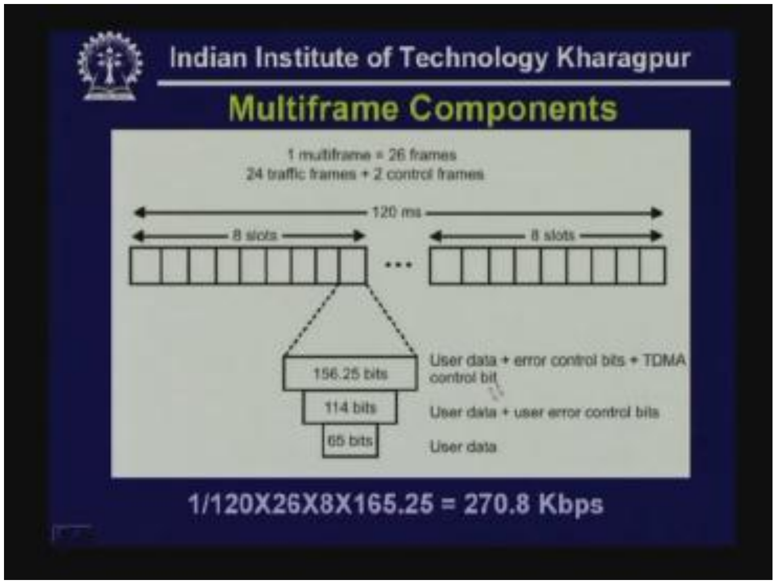
As you can see here it is more towards 900 KHz than the earlier one which was towards 800 MHz but here it is closer towards 900 MHz. So this is used for forward band from 935 to 960 each of 200 KHz, similarly from mobile station to base stations you have got 890 to 950 KHz and you have got 124 channels each of 200 KHz.

(Refer Slide Time: 40:00)



How different signals are generated is shown here. Each voice channel is digitized and is compressed to generate 13 Kbps and then eight users can communicate using Time Division Multiple Access and then they are converted combined to a multi-frame. As shown here in the diagram below (Refer Slide Time: 40:40), this is coming from the user this is your user data and the user data plus user error control bits is 114 bits and then you have got some control bits these are added together to form a slot.

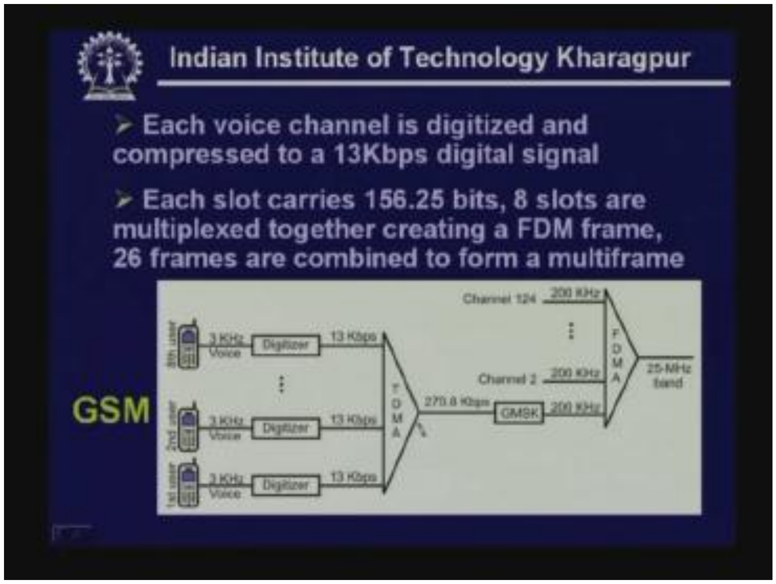
(Refer Slide Time: 40:52)



You have got eight such slot that is first user, second user….. and the eighth user so from eight subslots data is coming and these eight slots form a frame and 20 such frames form a multiframe and out of this 26 frames 24 are used for traffic that means for voice or data communication and two are used for control and this is repeated in 128 milliseconds. So, if you combine all these together so to send one multi-frame each multi-frame requires 120 millisecond so it is 1 by 120 so you have got 20 such frames and there are five eight slots in each frame and each requires 126.25 microseconds as we have seen and that gives you 270.8 Kbps.

In this way you get 270.8 Kbps digital data. Hence, this digital data is converted into analog signal (Refer Slide Time: 42:10) by using this GMSK technique which is essentially a modified version of FSK.

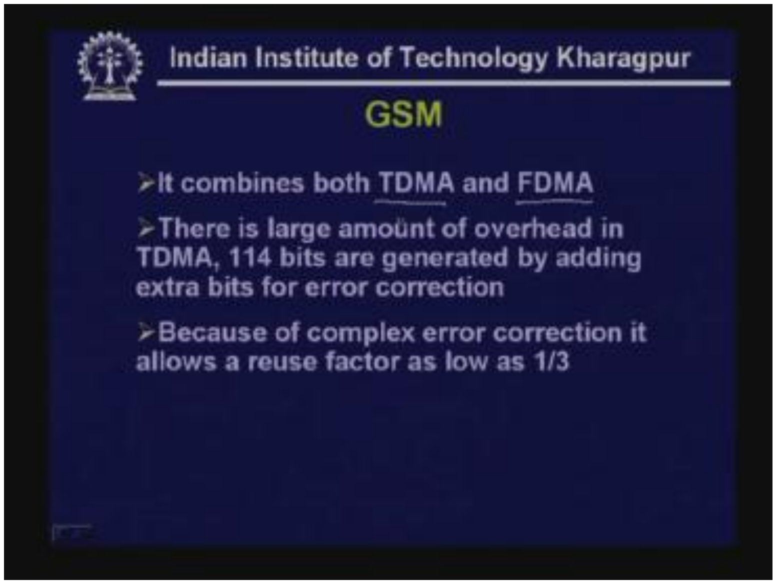
(Refer Slide Time: 42:33)



This (Refer Slide Time: 42:43) generates 200 KHz analog signal which is sent to the transmitter from the mobile station to the base station. Similarly, from the base station to different mobile stations it is sent except the carrier frequencies will be different. So you have got 124 channels so each of these channels can support eight different users sending digital voice or digital data which is also possible. This is how communication is performed in GSM.

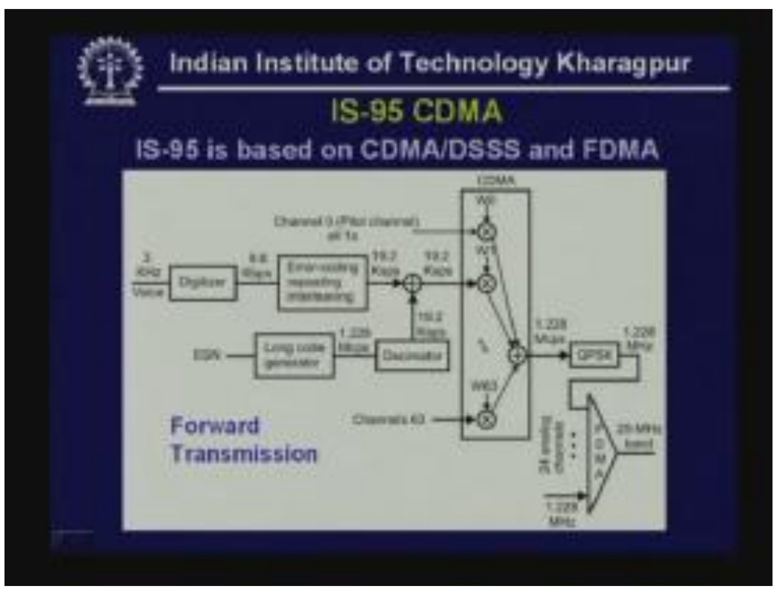
Now we have seen that it combines both TDMA and FDMA. So by combining both TDMA and FDMA it is able to send 8 into 124 so many voice communication is possible simultaneously, of course some of them will be used for control purposes. There is a large amount of overhead in TDMA. We have seen that 114 bits are generated by adding extra bits for error correction so a very insignificant portion is data so overhead is very large in GSM and because of complex error correction it allows reuse factor as low as 1 by 3. That means here the reuse factor will be 1 by 3 and each cluster will be having only three cells, this is the case of GSM.

(Refer Slide Time: 43:57)



Now let us consider the interim standard 95 that is your CDMA.

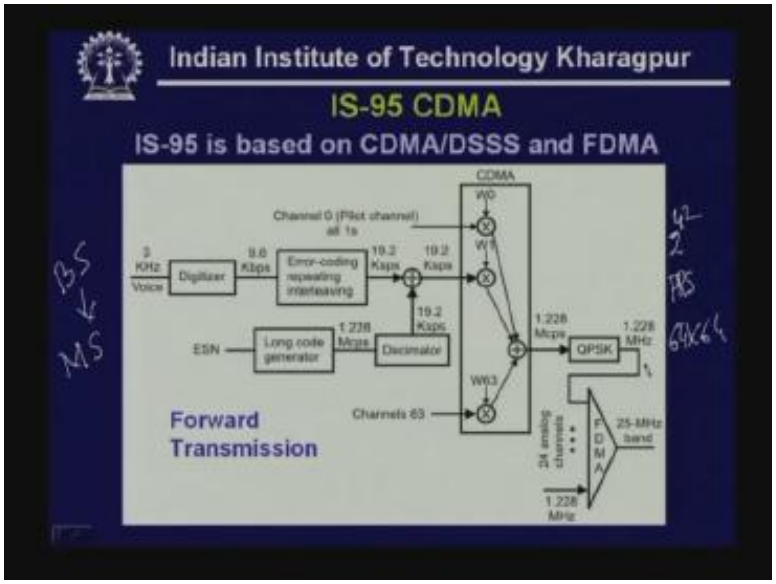
(Refer Slide Time: 44:35)



CDMA is quite complex in the sense the forward transmission and reverse transmission is different. Forward transmission is from the base station to the mobile stations, this transmission uses one type of technique on the other hand mobile stations to the base stations uses a different type of signaling techniques. Here it uses CDMA on the other hand from mobile stations to base stations it uses Direct Sequence Spread Spectrum and FDMA.

Let us very quickly have a look at how it is being done in case of your IS minus 95. In IS - 95 as you see you are using 3 KHz voice channel and by using digitization you are generating 9.6 Kbps then by using error coding, repeating and interlinking you are generating 19.2 Kbps you can say 19.2 kilo symbol per second and this kilo symbols per second is being multiplied using some Pseudo Random Sequence generator. Here you have got an electronic sequence number which generates a long code generator each of 2 to the power 42 long Pseudo Random Sequence generator PRDS.

(Refer Slide Time: 46:22)



So this is pseudo random sequence generator which generates 1.228 mega chips per second. So 1 out of 64 is selected by this decimator, the decimator chooses one out of sixty four and that's how it gets 19.2 kilo symbol per second which is being multiplied with the incoming data and to generate 19.2 kilo symbols per second. Then you are using a CDMA technique which uses a 64 by 64 walls table you already know walls chip and for CDMA it requires some kind of synchronization.

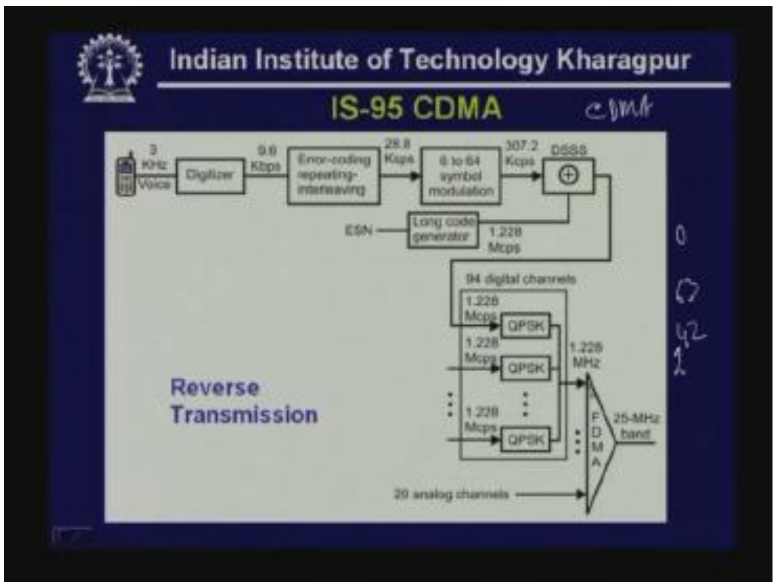
Here the synchronization is provided by the global positioning system to satellite. The satellite provides the synchronization base station and that's how the CDMA technique is possible. And as you can see all will be transmitting simultaneously.

Here there is no serial communication, then these are performed using QPSK you are generating 1.228 MHz and by using FDMA you get t25 MHz band which is being sent to the mobile stations so it goes to mobile stations and you have got twenty five or twenty four such channels.

On the other hand, the reverse communication is completely different. as you can see (Refer Slide Time: 48:12) it uses a digitizer to generate 9.6 Kbps from the 3 KHz voice and after error coding, repeating and interleaving you get 28.8 kilo symbols per second and from this it selects two 64 symbol modulation. Actually it selects six symbols and each of them is coded from 1 to 63 different numbers so 0 to 63 numbers and by using electronic sequence number again you generate long code sequence generator that is again 2 to the power 42 Pseudo Random Binary Sequence which generates 1.228 Mbps and this is multiplied with this signal coming here (Refer Slide Time: 49:13) to generate Direct Sequence Spread Spectrum.

So here you see CDMA is not being used so this Direct Sequence Spread Spectrum goes to QPSK to generate analog signal and these twenty analog channels goes from the mobile station to the base station. This is how the CDMA technique is used and reverse transmission is performed in IS - 95 CDMA technique.

(Refer Slide Time: 49:30)



We have discussed the three different approaches used in second year generation. Now let us have a look at the third generation technique.

(Refer Slide Time: 50:12)

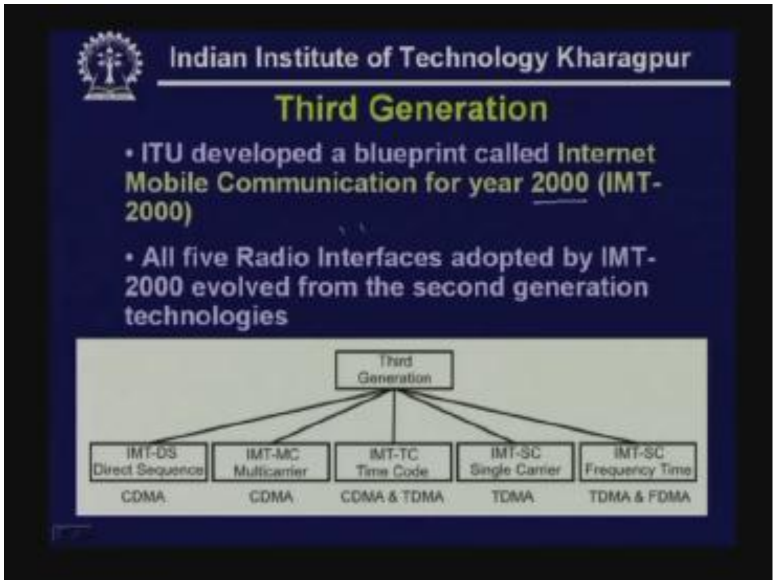
The third generation technique uses both digital data and voice communication. So, in case of your second generation either voice or data of very low capacity can be sent. But here the objective is to send data of little higher rate and good quality voice. And one objective is to provide universal personal communication that means one can listen to music, one can watch a movie, one can access the internet so all these things are possible by using third generation technique.

There is a report that in Japan where the third generation technique has been deployed people are not using the laptops but instead of that they are using 3G cell phones which perform most of the things which are being done using laptops. So these are the criteria of the 3G technology. So the voice quality should be good as good as the Public Switched Telephone Network.

There are three different types of data rates to be supported. For moving at higher speed for example, you are traveling by car or train then the data rate can be 144 Kbps, on the other hand, if you are moving slowly, for pedestrians, the data rate is 384 Kbps, and on the other hand, for stationary objects, for example, sitting in a room you can communicate at the rate of 2 Mbps. Thus you can see high data rate is supported in 3G technology and it is to support for data communication through both packet switch and circuits switch services and to provide 2 MHz bandwidth as I mentioned and interface to the internet so that access to internet is possible. with this objective ITU developed a blue print called Internet Mobile Communication for the year 2000 IMT minus 2000 and it uses five different radio interfaces so you can say it has got five different standards using five different radio interfaces and all these five have evolved from second generation technologies.

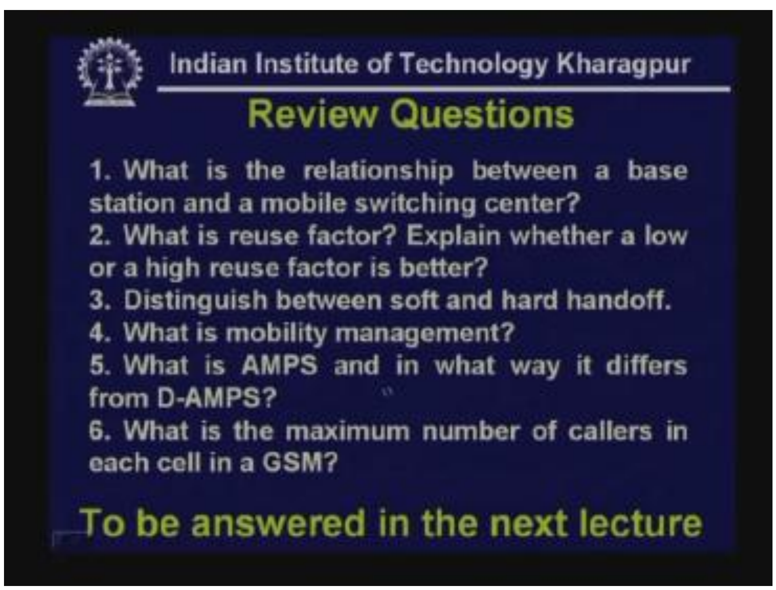
The first two are based on CDMA. First one IMT - DS using Direct Sequence Spread Spectrum, second one is multi-carrier IMT minus MC using multi-carrier, the third technique is using CDMA and TDMA the IMT- TC then the fourth technique is based on again TDMA IMT - SC using signal carrier and the last one is based on TDMA and FDMA IMT - SC which uses frequency time. So these are the five different techniques.

(Refer Slide Time: 53:00)



I have just given you the goal and the overview of third generation technique. Now it is time to give you the review questions.

(Refer Slide Time: 53:45)

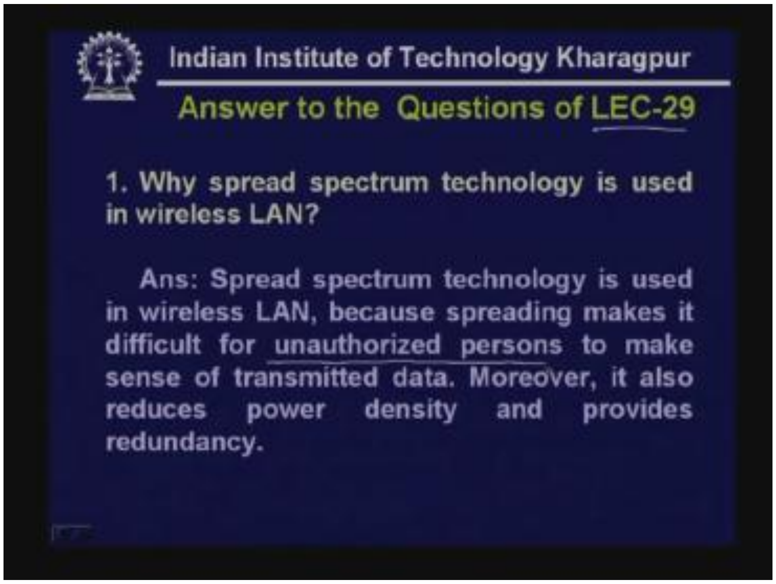


1) What is the relationship between a base station and a mobile switching center?
2) What is reuse factor? Explain whether the low or high reuse factor is better

3) Distinguish between soft and hard handoff.
4) What is mobility management?
5) What is AMPS and in what way it differs from D-AMPS?
6) What is the maximum number of callers in each cell in a GSM?

Here are the answers to the questions of lecture minus 29.

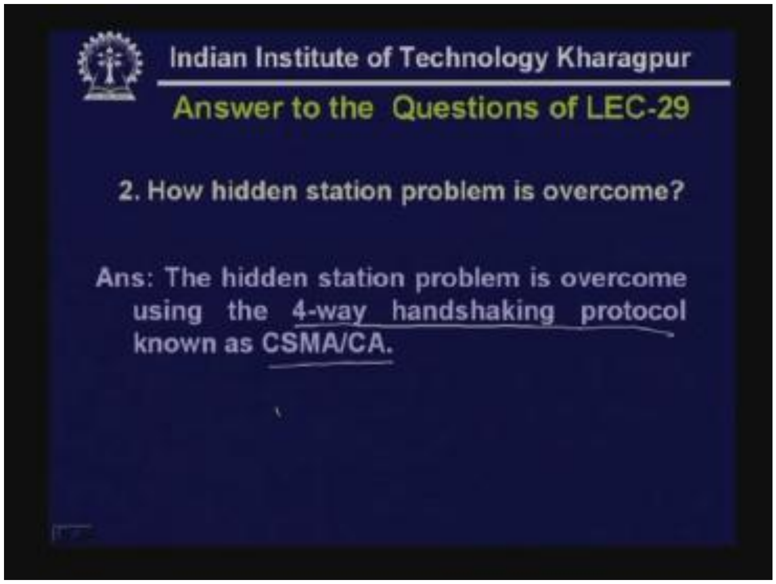
(Refer Slide Time: 54:30)



1) Why spread spectrum technology is used in wireless LAN?
As mentioned, spread spectrum technology is used in wire less LAN because spreading makes it difficult for unauthorized persons to make sense of the transmitted data. That means it provides you some kind of privacy and security.

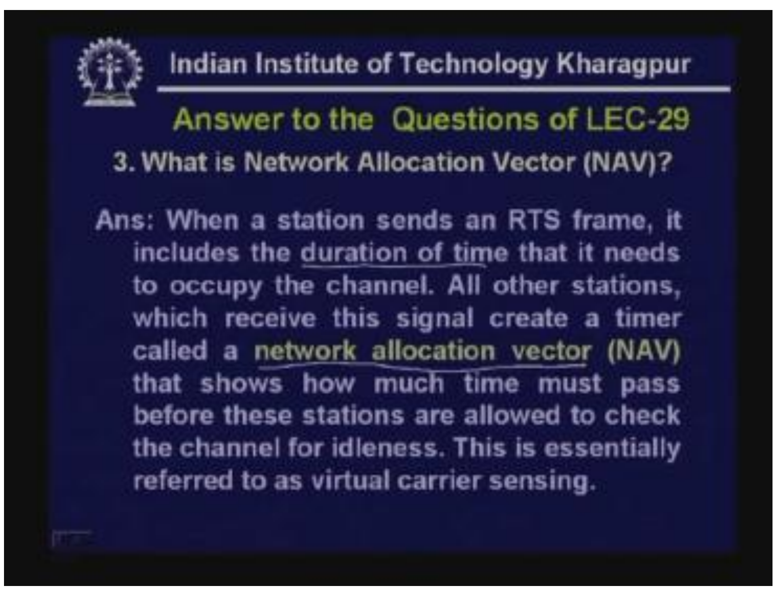
Moreover, it also reduces the power density and provides redundancy. So, power density and redundancy is provided by using this spread spectrum technique.

(Refer Slide Time: 55:00)



2) How hidden station problem is overcome?
The hidden station problem is overcome by using a 4-way handshaking protocol known as CSMA by CA. Therefore, by using this 4-way handshaking protocol collision is avoided and also the hidden station problem and exposed station problem is overcome. This has been discussed in the previous lecture.

(Refer Slide Time: 55:45)

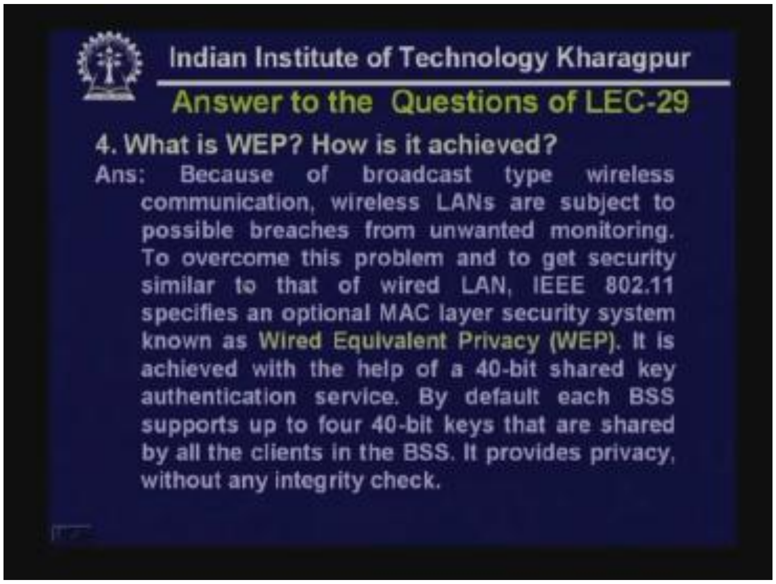


3) What is Network Allocation Vector or NAV?

When a station sends a request-to-send frame which is one of the signals used in 4-way handshaking it includes the duration of time that it needs to occupy a channel. All other stations which receive the signal create a timer called a network allocation vector.

So, based on this information a timer is set and which is called network allocation vector that shows how much time it passes before these stations are allowed to check the channel for idleness. So this is essentially is referred to virtual carrier sensing which we have mentioned in the last lecture. So this network allocation vector allows implementation of virtual carrier sensing.

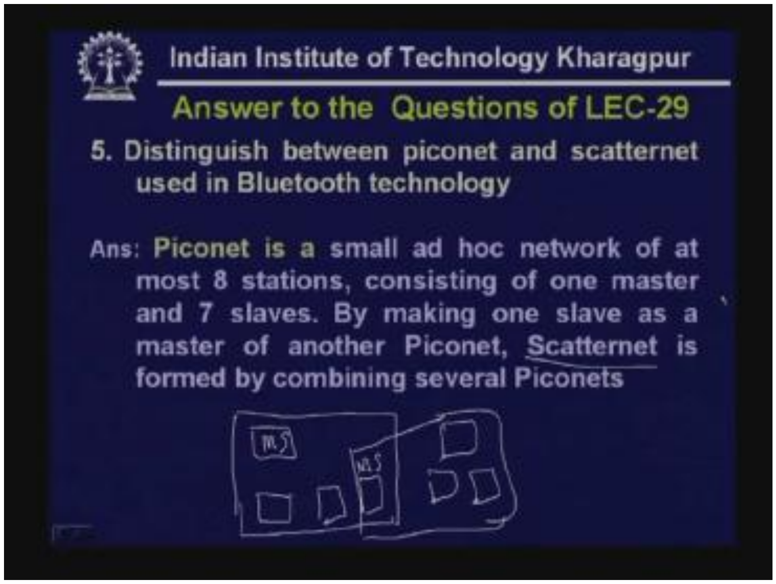
(Refer Slide Time: 56:30)



5) What is WEP and how is it achieved?

We have seen that because of the broadcast type wireless communication, wireless LANs are subject to certain breaches from unwanted monitoring. To overcome this problem and to get security similar to that of wired LAN IEEE 802.11 specifies an optional MAC layer security system known as Wired Equivalent Privacy. It is achieved with the help of a 40-bit shared key authentication service. By default each BSS supports Basic Service Set that supports four 40-bit keys that are shared by all the clients in the Basic Service Set so it provides privacy without any integrity check.

(Refer Slide Time: 57:57)



5) Distinguish between piconet and scatternet used in Bluetooth technology.
piconet is a small ad hoc network of at most eight stations. You can form a piconet having a master station and a number of slaves up to seven slaves. Now a scaternet can be created by using this as a master station which is a slave of this piconet of another piconet. So here you can have a number of slave stations. So this slave of this piconet becomes the master of this piconet (Refer Slide Time: 57:52) that's how the scatternet is formed by combining several piconets.

So with these we come to the end of the today's lecture and in next lecture we shall discuss about another wireless communication technique over much larger area by using satellite in other words. In the next class we shall discuss about satellite communication systems, thank you.