Data Communication
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Lecture – 32
Satellite Communications

Hello and welcome to today's lecture on satellite communications. In the last two lectures we have discussed about wireless communication. First of all it was wireless LAN which can give you coverage over a small geographic area, then we have discussed the cellular telephone network which can give coverage over a larger area may be a country. Today we shall discuss about another communication system which can give you global coverage. And in all the cases as you have seen there is always broadcast communication where it is necessary where a medium is shared by a number of stations so you have to use suitable medium access control techniques.

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Here is the outline of today's lecture. first I shall discuss about some of the important concepts related to satellite communication such as the concept of orbits, then the concept of footprints, then we shall discuss about three different types of satellite LEO, MEO and GEO lower earth orbit, medium earth orbit and geostationary earth orbit and I shall mention about the frequency bands which are used in the context of satellite communication then we shall consider one after the other different categories of satellites like LEO satellites and its applications, MEO satellites and its applications GEO satellites and its applications and finally I shall discuss about medium access control techniques used in satellite communication.

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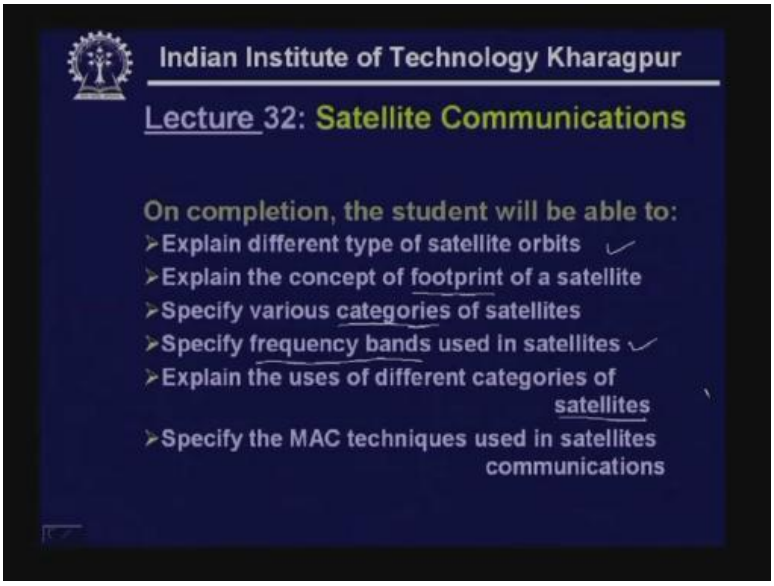

And on completion the students will be able to explain different types of satellite orbits, they will be able to explain the concept of footprint of a satellite, they will be able to specify the categories of satellites and they will be to specify the frequency bands used in satellite communication and they will be able to explain the uses of different categories of satellites and finally they will be able to specify the MAC techniques used in satellite communications.

So first we start with orbits. Although the number of orbits is very, very large in satellite communications but they can broadly categorized into three types. The three types are equatorial, as you can see here, this the equatorial plane (Refer Slide Time: 3:44), these are the poles, this is your earth and here is your the orbit so it is on the equatorial plane, then it can be inclined with respect to the earth polar line vertical axis or it can be polar so orbit can be vertical in this direction that means polar orbits.

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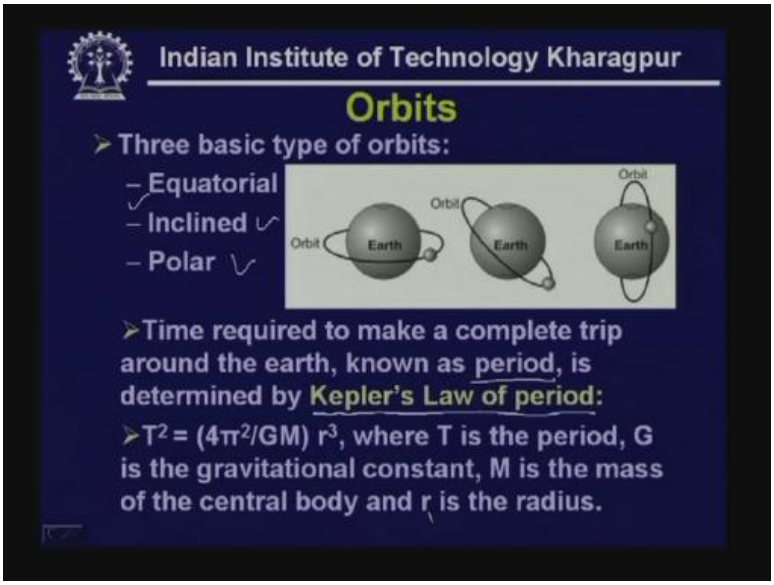

So you can have three different types of orbits and as you know the time required to make a complete trip around the earth is known as period. That means the time required to make a complete trip is known as a period. We are all familiar about the natural satellite that is moon and the period is known to you but here we are talking about the artificial satellites. And as you know the time required making a complete trip around the earth which is known as period is determined by Kepler's law of period. There are several laws but the Kepler's law of period specifies that period T square is equal to 4 pi square by GM into r cube where t is the period, g is the gravitational constant, m is the mass of the central body that is the earth and r is the radius.

This radius is different from the altitude from the surface of earth. Sometimes the radius of the orbit is given sometimes the altitude is given so we have to you have to understand the difference between altitude and the radius. Obviously the altitude will be lesser than the radius. So far as the footprints is concerned the signals from different satellites is normally aimed at the specific area called footprint. So here as you can see a satellite is covering a very large area in this particular case. So it can cover a large area and power is maximum at the centre of the footprint.

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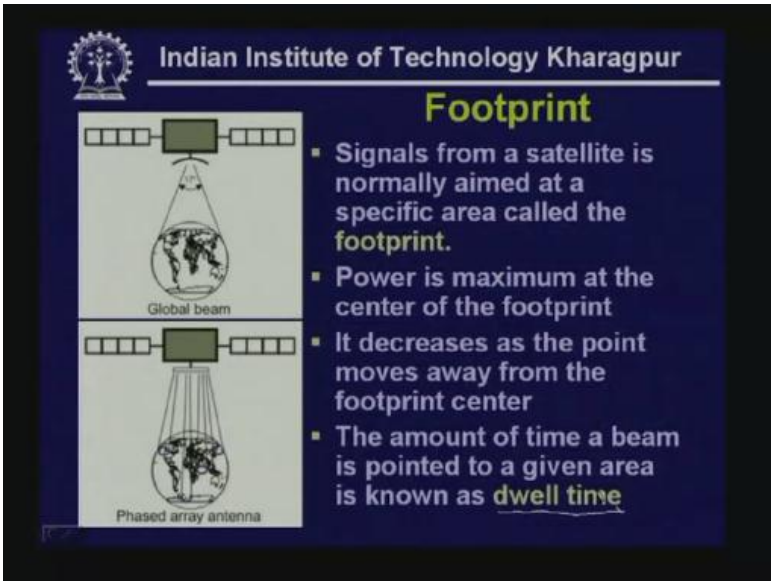

Obviously the power will be maximum here at the central part (Refer Slide Time: 6:00) and as you go towards both sides it will decrease. That means it decreases as the point moves away from the footprint.

Nowadays different types of antennas are used in satellites and these are all electronically controlled. For example, if a phase direct antenna is used then the footprint can be dynamically changed, it can be small, it can be large, it can be controlled, so the footprint can be changed. For example, here the footprints are small it is visible here, this part, this part and (Refer Slide Time: 6:40) this part, are all small and another possibility is that on a particular spot the beam can be focused for some duration which is known as the dwell time.

So the amount of time a beam is pointed to a given area is known as the dwell time. And of course whenever it changes from one position to another it takes some time and that time is of the order of microsecond so the dwell time should not be very short or it should not be very large so dwell time is controlled electronically and it can be focused on some parts for certain period of time and that time is usually of the order of few milliseconds. Therefore, we find that there are two important concepts; one is footprint and another is dwell time in the context of satellite communication.

Now let us look at the different types of satellites that are used for communication. This is the surface of the earth and the first satellite that was launched by the Russians was the sputnik and after sputnik was launched there was the discovery of Van Allen belts. Van Allen belts are essentially where there is high energy charged particles high energy protons are available and there are two such Van Allen belts as you can see, one is one is here above 3000 to 5000 and another is above 15000.

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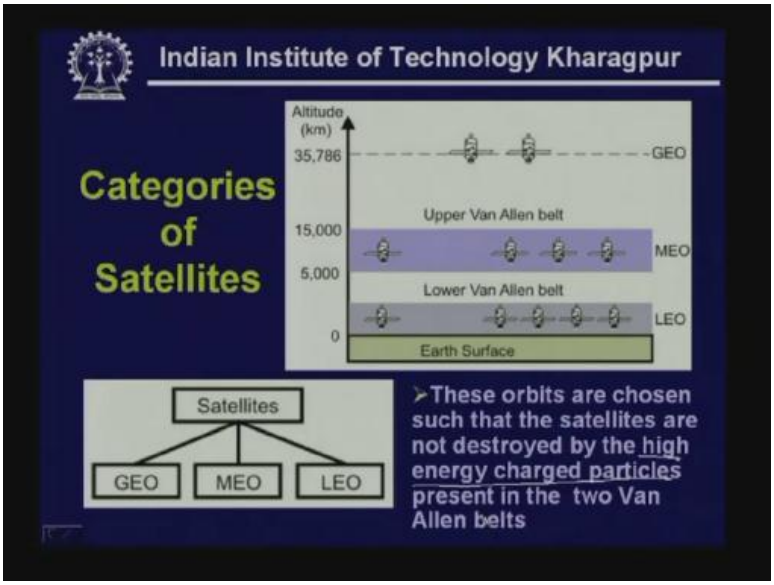

So there are two Van Allen belts and obviously when satellites are placed in these regions then they will be destroyed by the high energy particles. So satellites are placed avoiding these two Van Allen belts.

For example, this is the earth (Refer Slide Time: 8:56) and the low earth orbit LEO satellites are positioned between 500 to 2000 km as you can see this is the orbit. So the altitude is 500 to 2000 km. On the other hand, the medium earth orbit which is between two Van Allen belts is from 5000 to 15000 km and these are known as medium earth orbits or MEO satellites medium earth orbit satellites.

There is the third geostationary earth orbit known as geo. That is at the precise distance of 35786 km. So these are the three popular orbits which are used for placing satellites. however there is another one in between MEO and the GEO stationary orbit that is your GPS global positioning system which is another constellation of satellites which is placed at a distance of 20000 km. Obviously it is above the second Van Allen belt but definitely much below the geostationary earth orbit which is at a distance of about 35800 km.

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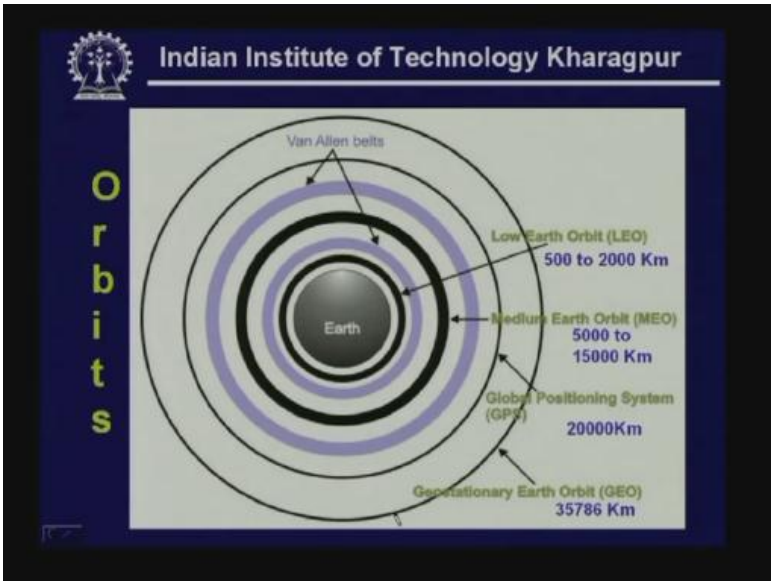

As I mentioned, these orbits are chosen such that the satellites are not destroyed by high energy charged particles present in the two Van Allen belts. So we find that we have broadly three types of orbits.

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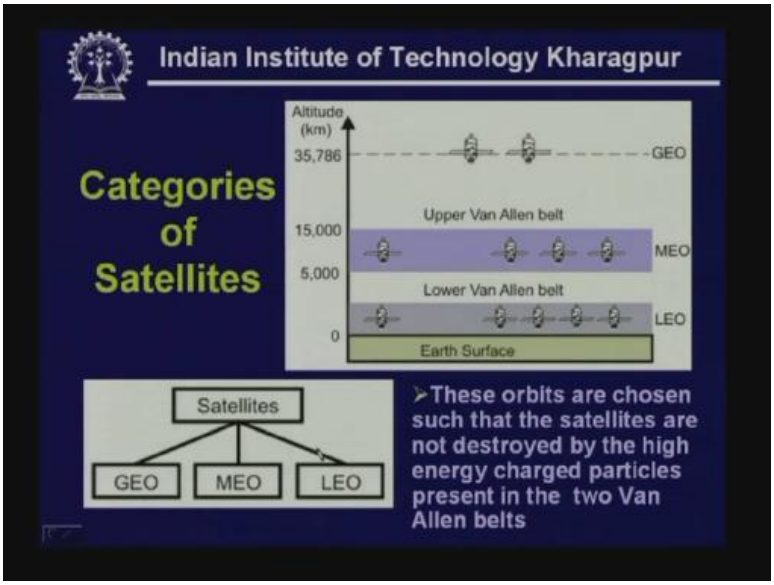

Now let us look at the frequency bands used in the satellite communication, this is in the microwave range where line of sight communication is performed. There are several frequency bands L band which uses two frequency bands; one is for downlink and another is for uplink so frequency is in the gigahertz range so downlink range is around 1.5 GHz and uplink frequency is around 1.6 GHz.

For the S band the downlink frequency is around 1.9 GHz and uplink frequency is around 2.2 GHz and this is the bandwidth available for data communication. C band is very popular and widely used in geostationary satellites is 4 GHz and 6 GHz where 4 GHz is downlink and 6 GHz is uplink frequencies. These bands are gradually becoming congested and presently ku band is widely used and Ku band has got downlink frequency of 11 GHz and uplink frequency of 14 GHz.

Once the Ku band gets exhausted or fully utilized then we have to go for Ka band which is in the range of 20 GHz for downlink and 30 GHz for uplink and which can give you very high bandwidth of 3500 MHz. hence, these are the frequency bands and in all cases it is line of sight communication and it is in the microwave frequency range.

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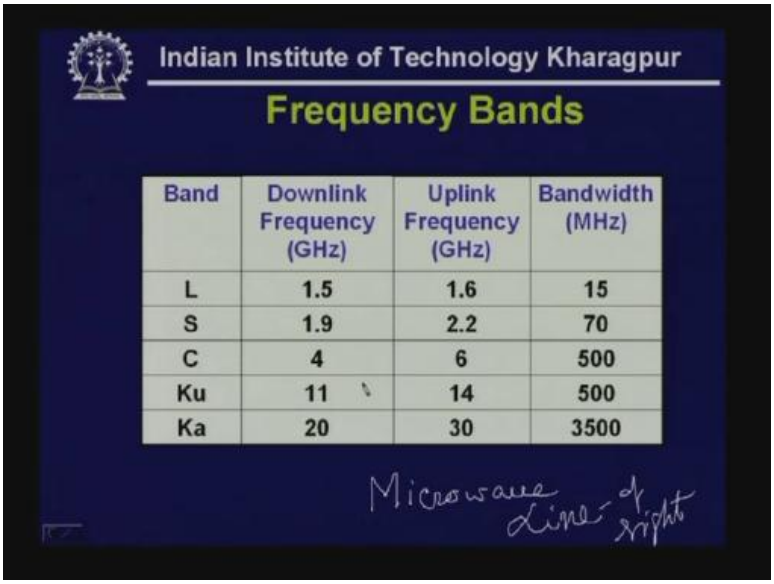

Now let us consider the low earth orbit satellites. There are several examples for the low earth orbit satellites. Essentially a single satellite is not used, a constellation of satellites very similar to cellular telephone network are used that work together as a network. So, it is not a single satellite but a number of satellites are used in the low earth orbit to form a network.

Usually in LEO satellites polar satellites are used in the altitude of 500 to 2000 km but not the radius and typical value is 850 km and the period based on this altitude we can find out the time period which varies from 90 to 120 minute and for example for 850 km altitude the period is hundred minute and the satellite rotates at the speed of 20000 to 25000 kilometer per hour. And whenever a satellite is placed at this altitude the footprint can be eight thousand kilometer diameter and of course you can focus over a narrow earth area but this will be the maximum radius. Because of line of sight communication the earth's curvature the footprint cannot be varying at large. Higher the altitude the diameter of the footprint the covered area can be large.

And the LEO satellites can be broadly divided into two types. First one is known as little LEO. The little LEO communicates at less than 1 GHz range. For example, we have seen that less than one Gigahertz range is they don't use L band lesser than that then big LEO uses 1 to 3 GHz, one notable example is Iridium.

The third category of LEO satellite is used for broadband internet access and one notable example is Teledesic. I shall discuss more about these two systems iridium systems and Teledesic systems.

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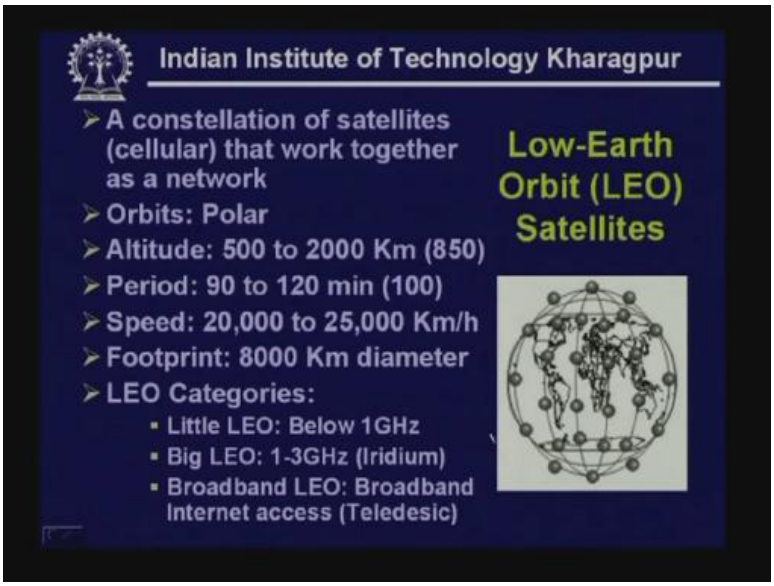

Let us consider how they communicate. In case of low earth orbit there are three possible types of transmission. First one is communication of transmission between two satellites which is known as inter satellite link as you see two satellites can communicate to each other so data transfer can be done communication can be done from one satellite to another satellite.

Second type of transmission is gateway link. That means there is an earth station which is used as gateway and here for example (Refer Slide Time: 15:58) for this satellite this is the footprint and this is the footprint of another satellite. And as you can see this satellite can communicate with this satellite another satellite and also the down stations or gateway links so this is known as GWL, GWL that is your gateway link and third is your user mobile link so directly the mobile phones can communicate with the satellite in this case. So there are three different types of links which are used for communication ISL, GWL and UML User Mobile Link, Gateway Link and Inter Satellite Link.

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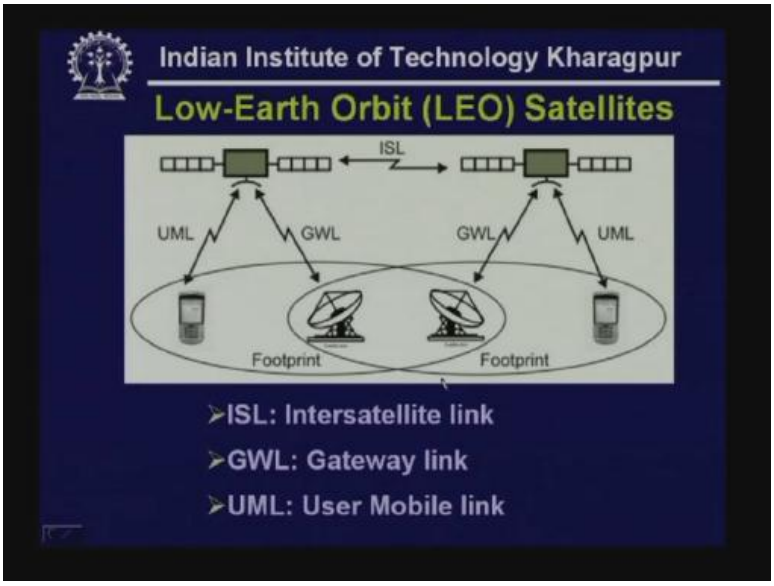

And let's consider in little more detail the iridium system.

This project was started by Motorola in the year 1990 with the objective of providing worldwide voice and data communication service using handheld devices. So the basic objective was that with the help of the satellite people should be able to talk to each other and that will cover a large geographical area.

And of course it took quite some time to materialize the project and after about eight years it materialized with 66 satellites. And although the project started with 77 satellites initially it started with 77 and because of this initial number of about 77 the iridium has been taken because iridium is the 77th element in our periodic table so the name has been taken from this but unfortunately the number of satellites got changed but the name has been retained. So, using 66 satellites these are divided into six polar orbits so you have got 11 satellites in each orbit.

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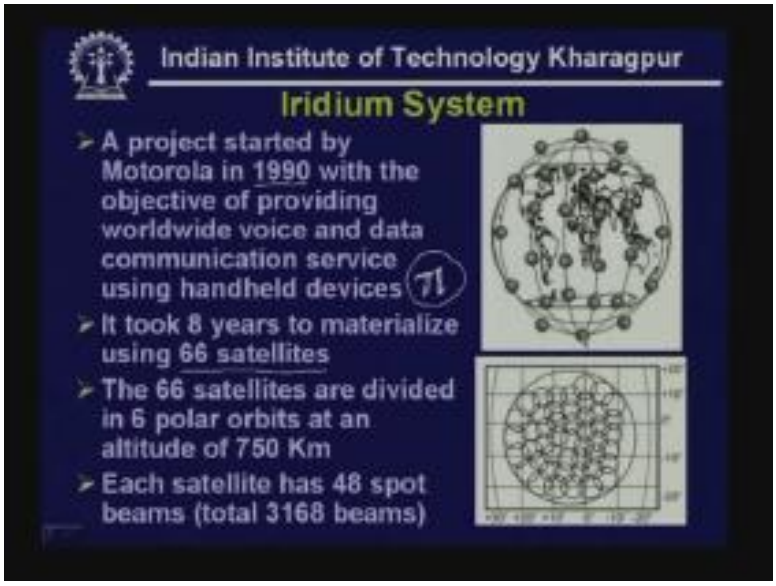

As you can see each orbit has got 11 satellites and you have got 6 orbits 1 2 3 4 5 and 6 (Refer Slide Time: 18:04) so you have got six polar orbits rotating around the earth at an altitude of 750 km which is not far away from earth's surface and in each orbit you have got 11 satellites and each satellite has 40 spot beams.

So the footprints of different satellites are possible here and the total of 3168 beams is possible. However, all are not used but around 2000 beams are actually used although possible spot beams are 3168 beams so it can cover small geographic area at a time and by controlling the dwell time different spots can be covered. In this way the whole earth can be covered by using this constellation of 66 satellites used in iridium system.

Another important notable system that is worth mentioning is the Teledesic system. It started with a very ambiguous project by Craig McCaw and Bill Gates in the year 1990 with the objective of providing fiber optic like communication facility. We have seen that the iridium project was developed with the objective of providing voice communication and at most low bit rate data communication. But this Teledesic project was developed with the objective of providing data transfer at a much higher rate very similar to fiber optic like communication in other words to provide broadband service. And this Teledesic system ultimately was designed with 288 satellites in 12 polar orbits.

There are 12 polar orbits very similar to the iridium and there are 288 satellites so you have got 24 satellites in each orbit and you have got 12 such polar orbits and these are stationed at an altitude of 1350 km compared to 750 km of iridium and the communication is being done using Ka band and at a particular instant 8 neighboring satellite communicate by using ISL Inter Satellite Link and GWL is used between the satellite and the gateway and also the user mobile name is been used for communication between the user and a satellite. And as we have already discussed satellite focuses its

beam to a cell during a dwell time and it allows data rates in the order of 150 Mbps for uplink and 1.2 Gbps downlink.

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Such a high data rate is quite sufficient for any type of communication both voice, video and data and that's why this Teledesic system is being developed to provide fiber optic like communication but it has the potential to cover the entire earth with the help of the 288 satellites.

Now let us consider the MEO satellites. These MEO satellites are positioned between two Van Allen belts as we have discussed. The typical altitude is 10000 km and the period is 6 hours and not minutes. As you can see as the altitude is increasing period is also increasing so six hours is the period for the typical MEO satellite.

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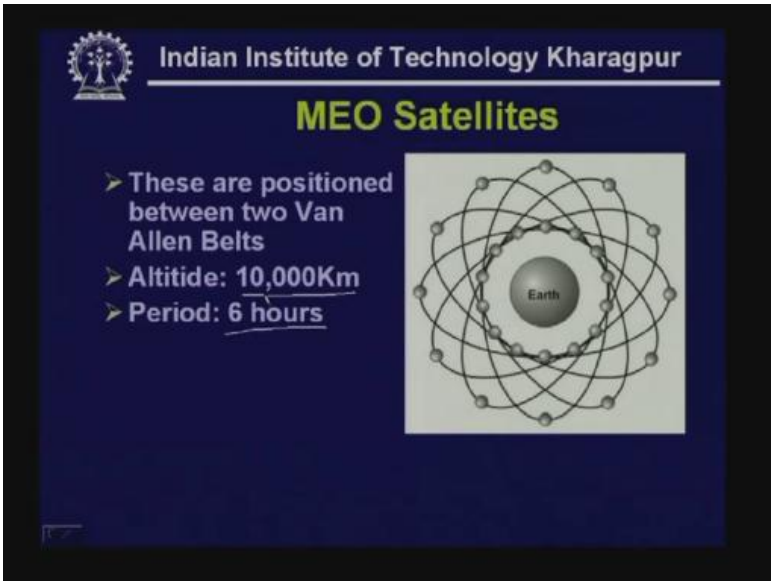

And as I mentioned Global Positioning System or GPS is a very popular satellite system used nowadays and this is used for satellite based navigation system. And this comprises a network of 24 satellites at an altitude of 20000 km with a period of about twelve hours. That means twice in a day it is visible from a particular location and it has the inclination of 55 degree. This was originally intended for military applications. That means this particular satellite system was developed by the department of defense of USA and original plan was to use it primarily for military applications. But in the year 1990 they changed their policy and it was made available for civilian use. With the help of the GPS system one can do global positioning from which it has derived its name.

Actually it allows land, sea, and airborne users to measure their position that means three dimensional positions can be measured, velocity can be measured and the exact time also can be measured with the help of a GPS receiver. So a GPS receiver has been found to be very invaluable tool for the captain of the airplane, for the captain of a ship and also very soon it will used by people traveling on road for vehicular traffic. So, every car owner, or the captain in the ship or every pilot will be having such a receiver thus not only the position but the time is very accurately measured and the accuracy can be within the range of 15 m and that is the reason why is one of the most widely used satellite for measuring the position, velocity and time.

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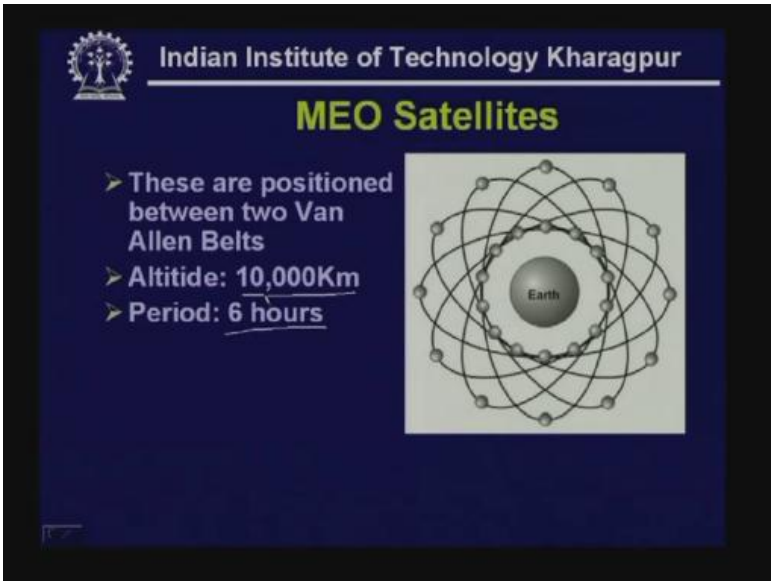

In this global positioning system actually measurement is done for land and sea navigation using the principle of triangulation. So here you have got three known positions A, B and C. These are the three positions of the satellites known as 'unknown position'. It can be proved that if these three positions are known the point of unknown position can be identified with the help of suitable device. So that is been done with the help of a GPS receiver. So, by time stamping the signal is sent to A, B and C and the delay is measured by the distance of A, B and C then the point at which these three diameters coincide is the exact position. And another satellite is used to provide the time. These GPS satellites each having four very accurate clocks based on that nuclear material those clocks give very accurate times so the fourth satellite provides the very accurate time and the other three satellites gives you the exact measurement of distance and with the help of that one can very accurately position the distance, time and the speed of a particular vehicle or a air plane or a ship.

So, requirement is that at any point of time at least four satellites is visible to the user from any point on the earth. It is not necessary that it has to be on any point on the earth it can be in space also. For example, from the aircraft also it can be used. So a GPS receiver can find out the location of a map so nowadays there is no need to use the compass but you can use GPS receiver for the purpose of positioning. In fact it was widely used in Persian Gulf War for identifying the position of different vehicles used in war. So this is your GPS.

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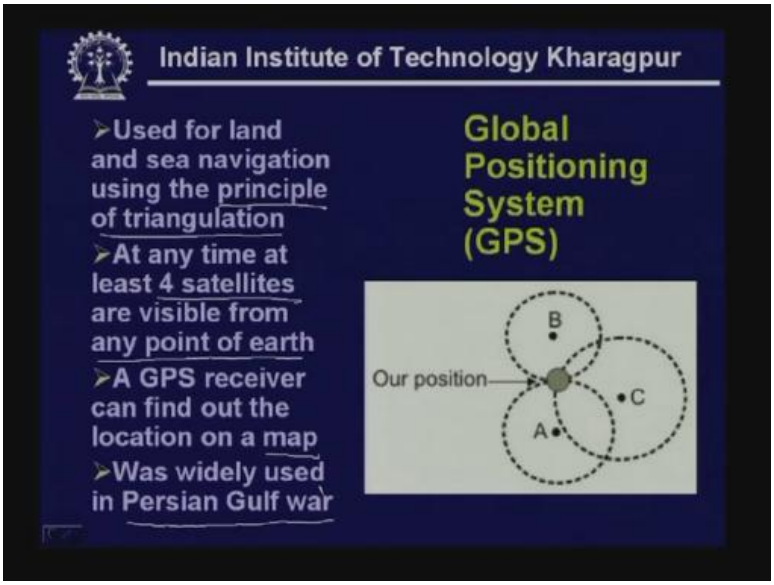

Now let us focus on the GEO satellites. So, to facilitate constant communication the satellite must move at a constant speed as the earth which is known as geosynchronous satellite. We have seen, in case of MEO and LEO or even in GPS satellite the satellite is moving around the earth and from a particular position if you look at it you find that its position keeps on changing so you have to keep track of it, you have to compensate for Doppler Effect and so on.

But if it is so positioned that its movement is stationary with respect to a point on the earth then it is called geosynchronous satellite. There is a special situation where when the geosynchronous satellites are on the equatorial plane. So if it is on the equatorial plane then it is called geostationary satellites. That means geostationary satellites are special case of geosynchronous satellites when the plane is on the equatorial region. So it uses the equatorial plane to place the satellites.

Obviously you have got 360 degrees and with the present technology you can use up to 180 satellites in the equatorial plane and with the help of that you can do communication. And as I mentioned the altitude is 35786 km and the radius is above 42000 km that means from the center of the earth the radius is 42000 km but the altitude from the surface of the earth that is from sea level it is 35786 km. and period is exactly same as the rotation of earth that is roughly 24 hours.

And as I mentioned the orbit is on the equatorial plane and you can have at most 180 GEO satellites based on the present technology by using Ku band. Whenever Ku band is used you can have up to 180 satellites but as you go for Ka band the number of satellites can be increased. Although you can have 180 geostationary satellites the whole globe can be covered only by using three satellites.

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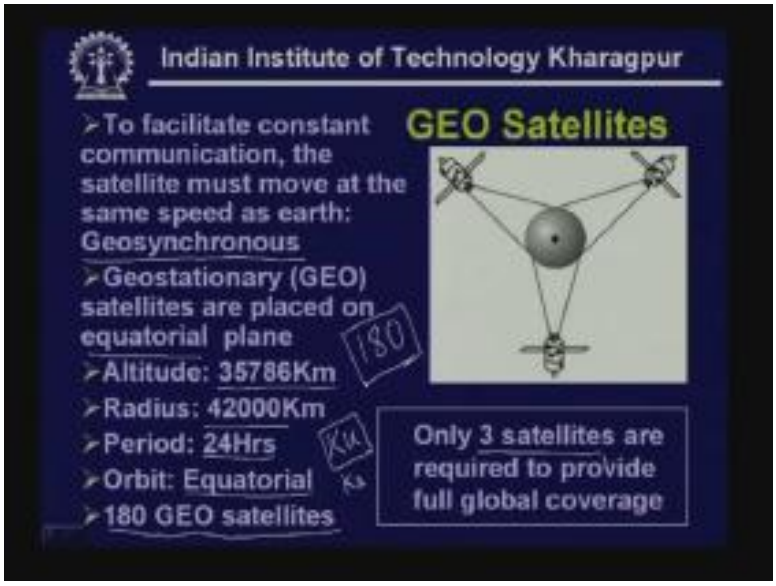

As you can see here (Refer Slide Time: 30:05) a particular satellite roughly covers one third of the earth. So if one satellite covers one third of the surface of the earth then by using three satellites the entire earth can be covered. In other words with the help of three geostationary satellites it is possible to have global communication. From any place on the earth to any other place on the earth communication can be done with the help of three geostationary satellites.

Now let us look at the key features of the geostationary satellites. One important feature is long round trip propagation delay. As you know the distance is about 36,000 km and even with the speed of light the electromagnetic radiation goes from the surface of the earth to the satellite and comes back and the speed is 3 into 10 to the power 8 meter per second. Even with that speed it takes about 270 milliseconds between two ground stations. That means the round trip delay is 270 milliseconds. Then, while designing systems you have to take into account this parameter particularly when we consider the medium access control technique.

Secondly, it is an inherently broadcast media so it does not cost much to send to a large number of stations. Now we are familiar with our conventional telephone systems, we use local calls then as the distance increases the cost of communication increases. That means whenever you use STD calls or whenever you call to the USA you have to pay more that means the cost of communication increase with distance. But that is not true in the case of satellite communication.

The cost of communication is same irrespective of the distance between two points. However, it suffers from low privacy and security and for that reason suitable encryption technique is essential to ensure privacy and security. This is a very important aspect of communication. Then finally as I mentioned the cost of communication is independent of distance.

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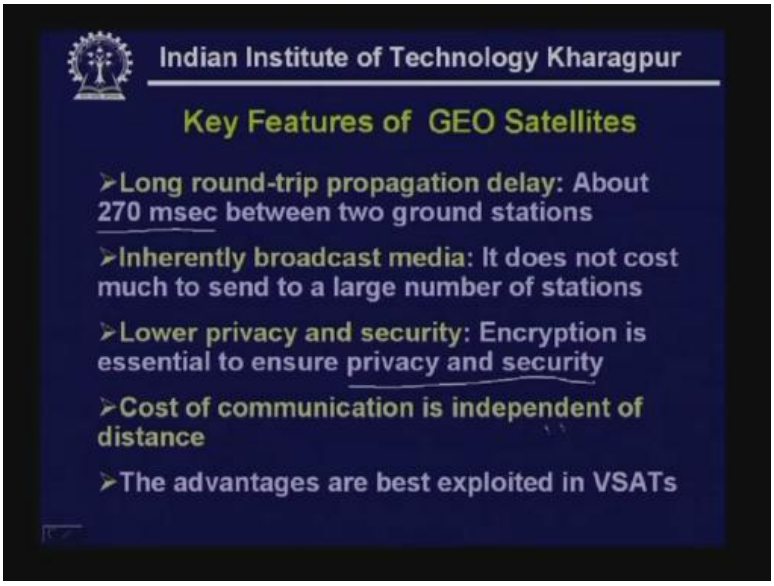

You have to take into account these features or you have to exploit them and one of the systems where these features are widely used is in the VSAT which stands for Very Small Aperture Terminal. Normally the antenna of a ground station has to be several meters in diameter and as a result the cost of the antenna and the communication system is quite high. But to make it affordable to common people that is this VSAT terminal was developed to make access to the satellite more affordable and without any intermediate distribution hierarchy. That means communication can be done directly with the satellite and at the same time it has to be made affordable to the common people and with that objective the Very Small Aperture Terminals were developed and for example most VSAT systems operate in Ku band with an antenna diameter of only 1 to 2 m which is relatively small compared to the bigger antennas that is being traditionally used. and it requires transmitting power of only 1 to 2 watts for communication so neither the power is very high nor the diameter is high it can be very easily used in houses.

There are several implementation approaches particularly they can be categorized into three types such as one-way, split two-way and two-way. We shall discuss in more detail about one-way and two-way. The split two-way is a little special situation where VSAT does not require uplink transmit capability which significantly reduces the cost.

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In split two-way what is been done is the satellite sends data in the downward direction using broadcasting or some other technique. Then there is no uplink transmission from the ground station to the satellite and that communication is done with the help of some other system it can be PSTN Public Switched Telephone Network or cellular telephone network or whatever it may be. So that's how it is a split two-way system which does not require uplink transmit capability that makes it simpler, this is used in many situations. Let us consider the other two the one-way and two-way communication systems.

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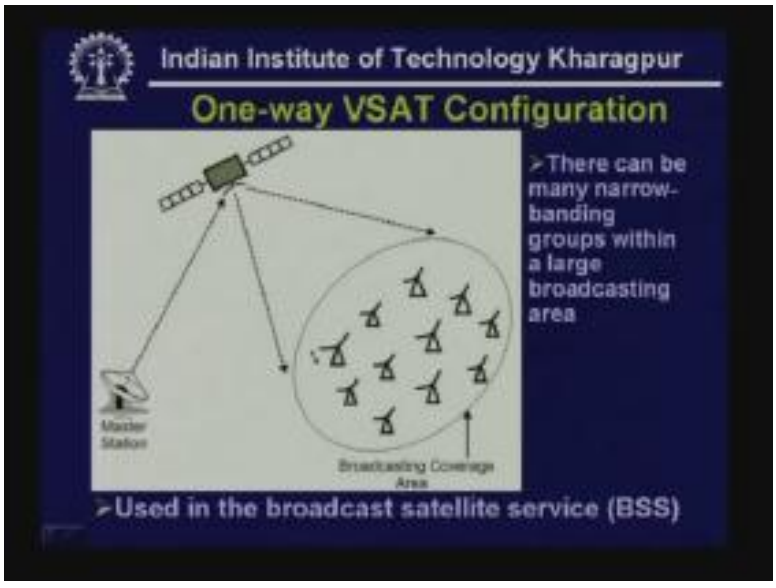

In one-way VSAT configuration it is essentially simplex communication. We know that in simplex communication the communication is only in one direction and that is what is being done in this particular case. Here for example, there is a master station it sends data to the satellite and the satellite relays it over a large geographic area so it is essentially the broadcast coverage area and all the ground stations in this area can listen to what is being transmitted by the master station through the satellite. So the satellite here just acts as a relay in the sky and it is used for broadcast satellite service that means whenever something has to be broadcasted then this type of simplex communication can be used. For example, the satellite television distribution system has this type of one-way communication.

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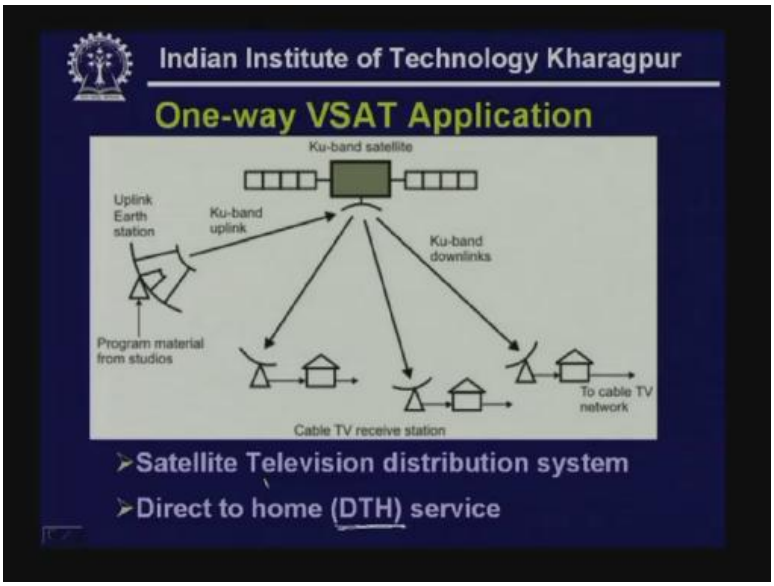

For example, here is the studio of the (TV, Doordarshan) and here is the uplink earth station and in the uplink earth station by using Ku band it uplinks the signal then the satellite sends it to a number of cable TV service providers. So the cable TV service providers have antennas located in their place and then the cable TV operators distribute the television signals to a number of houses. This is the ku band uplink (Refer Slide Time: 37:24) and this is the Ku downlink signals which are being received by the cable TV operators and then they distribute it to the households. So this is a Satellite Television distribution system.

Nowadays another important service is becoming popular that is your Direct-To-Home DTH service which is been publicized by our Doordarshan. In the Direct-To-Home service in the house one can put an antenna which has the diameter of less than 1 m and then by using one set top box directly from the satellite the digitized television channels can be captured and then one can put it on the TV. So, bypassing the cable operators nowadays by using the Direct-To-Home service this type of one-way communication is used for television signal distribution.

Although I have shown one large geographic area you can have one small group also which requires some specialized service so that is also possible in one-way VSAT configuration.

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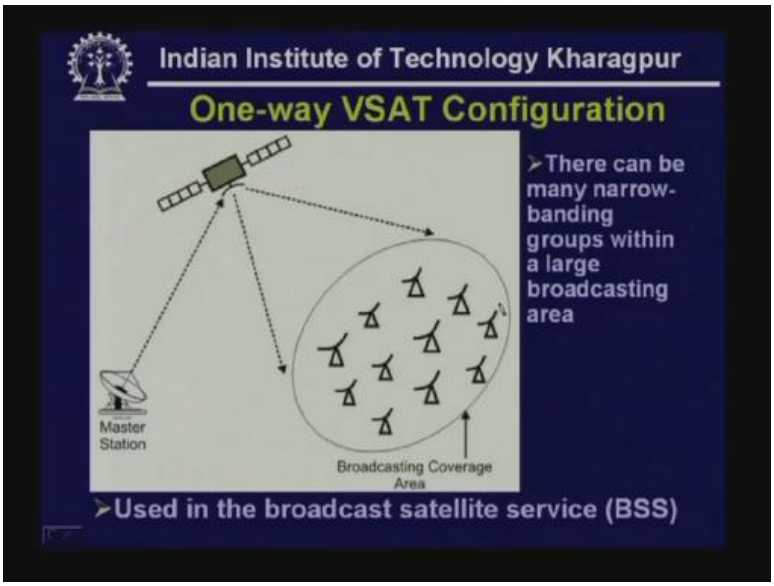

Now let us look at the two-way VSAT configuration. In this two-way configuration all the traffic is routed to the master control station hub. Actually VSAT antennas are small in size and also the power of transmission is small. So because of low gain antennas and small power that is being used in VSATs direct communication between two VSATs is not possible so a master control station is named which is also known as hub. So in this case the configuration is somewhat like this. This is your satellite (Refer Slide Time: 39:24), this is your satellite, this is your satellite then you have got the VSAT hub and you have got a number of VSAT antennas. It is like a star. So all the VSAT hubs are communicating through this master control station or hub. So this hub is at the center of the star topology and the communication is done in this way. So this is the star topology that is being used.

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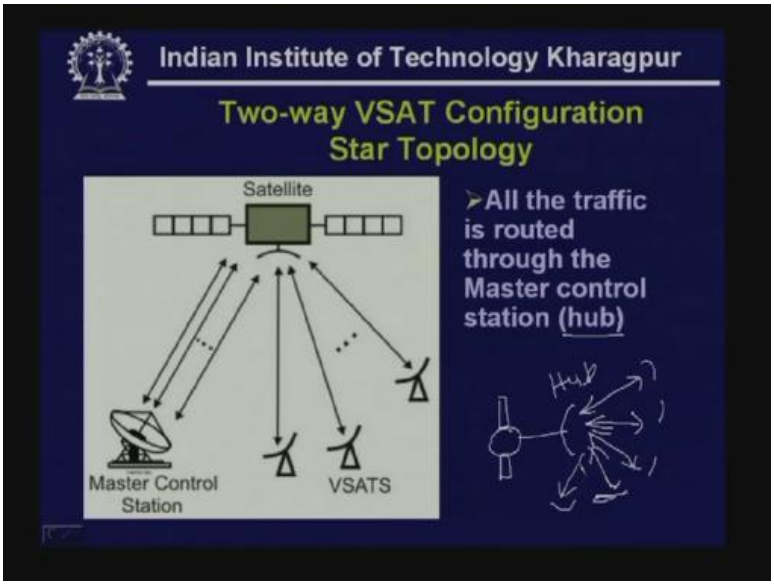

However, nowadays with the advancement of technology it is possible to have direct communication between two VSAT antennas. So in such case each VSAT has the capability to communicate directly with any other VSAT you don't require a hub so this one can be considered as the mesh topology. although the satellite is there it is being used as the via media, but here say suppose this is one VSAT and this is another VSAT, this is another VSAT, and this is another VSAT (Refer Slide Time: 40:42) all of them can communicate with each other so it forms some kind of mesh network since they can communicate with each other. Hence, it is a mesh type of network that can be formed although VSAT is there which is used as via media. So this is two-way VSAT configuration using mesh topology.

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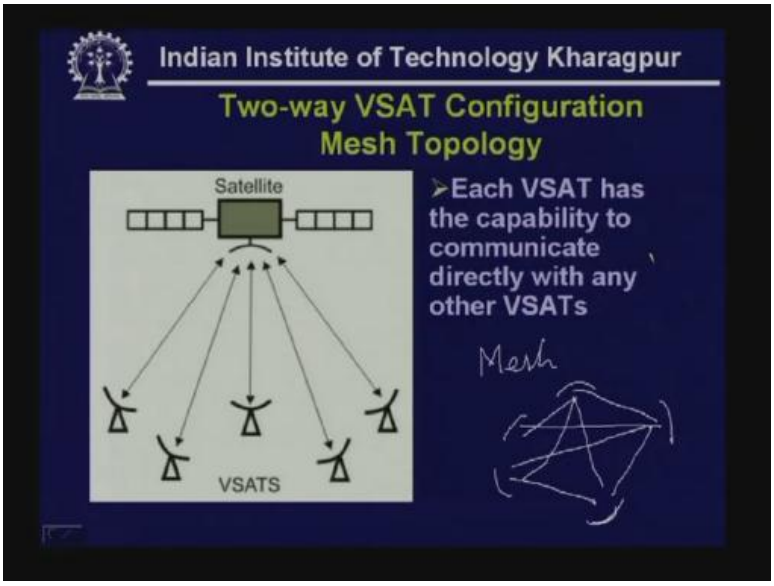

Now you require medium access control protocol for satellite communication. Why you require that, is explained here. It is a very important design issue in satellite communication particularly how to efficiently allocate transponder channels. As you know each satellite is having 12 to 20 transponders and using each transponder communication can be done with the earth stations. Now, in satellite communication from the satellite to the earth station it is essentially a broadcast type of communication so there is no need for medium access control.

However, as you can see (Refer Slide Time: 42:00) by using this same frequency band uplink frequency the ground stations are simultaneously communicating to the satellite and as a consequence this uplink channel is shared by all the earth stations that is communicating with the satellites and that requires medium access control.

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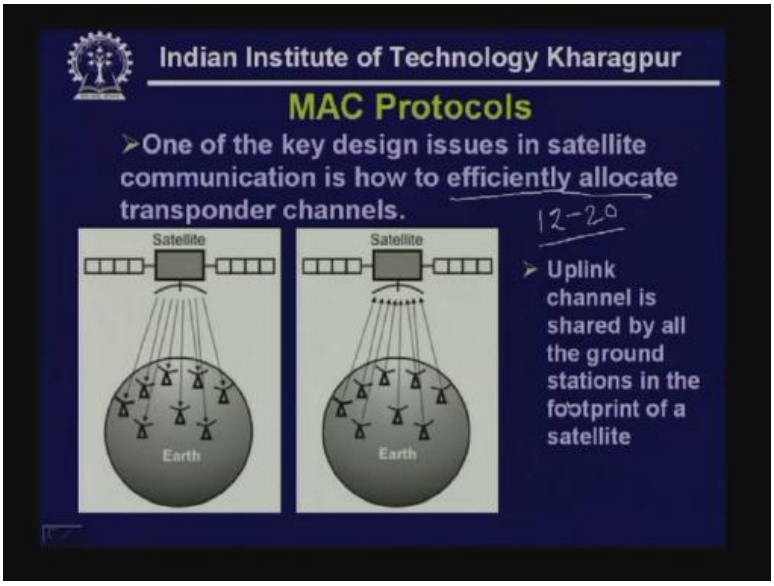

Many medium control techniques are used based on the environment and applications and they can be broadly categorized into the following types. First one is fixed assignment protocol. In this case the number of users is small so you can use fixed assignment and another approach is demand assignment protocol known as DAMA Demand Assignment Multiple Access and in some situations you can use random access protocols or it can be hybrid of random access and reservation protocols. Finally they can be either distributed or centralized control.

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Now we have already discussed about the medium access control techniques for satellite communication. As you know the collision based medium access control technique cannot be used because of long round-trip delay. Also, we cannot use token passing based techniques. So, only possibility is to use ALOHA or slotted ALOHA and the reservation based protocols. Let us see what are the different types used.

We can use FDMA, TDMA and CDMA depending upon various applications. FDMA provides the simplest communication because here there is no need for synchronization, there is no question of collision, however, when TDMA technique is used you have to do synchronization because at different time slots different channels can be used for communication and there can be collisions if two ground stations send signals simultaneously. So synchronization is necessary and there is a possibility of collision in TDMA but that can be resolved. Another approach that can be used in CDMA where it is possible to have parallel communication using the same channel in the same time and as you can see 'n' stations can communicate with each other. So TDMA, FDMA and CDMA are all used in satellite communication.

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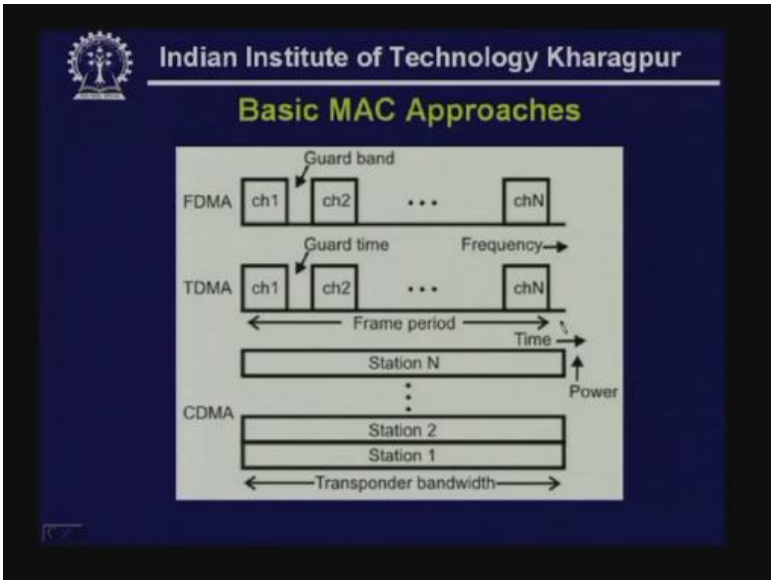

Let us look at contention-free medium access control protocol. First one is the fixed assignment protocols using FDMA. As I mentioned FDMA is the simplest one, they allocate different frequency bands to different ground stations and communication can be done in parallel using different frequency bands. Or you can use TDMA, this allocation is possible, allocation of channel is static so it is fixed it does not change with time and this is suitable when the number of stations is small. So, when the number of stations is small permanently some frequencies of time slots can be allocated to the ground stations and this provides you deterministic delay. In spite of the long propagation delay this delay will be deterministic because there is no collision here which is important in real-time applications.

On the other hand, this demand assignment based protocols DAMA is suitable when the traffic pattern is random. That means a particular ground station sends for some time then waits for some time when the traffic is bursty in nature. In such a case you have to use random assignment protocols particularly when the traffic pattern is random and unpredictable. Efficiency is improved by using reservation based on demand; the reservation process can be implicit or explicit.

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Here you can see how TDMA can be used, the time is divided into time slots and the frame is done. Here in this particular case a frame has got four time slots. so you can see different ground stations are sending at different time slots so this is being sent so this one is sent by one ground station, these packets are sent by another ground station and these packets are sent by another ground station and this is the TDMA stream (Refer Slide Time: 47:16) which is broadcasted by the satellite towards all the ground stations.

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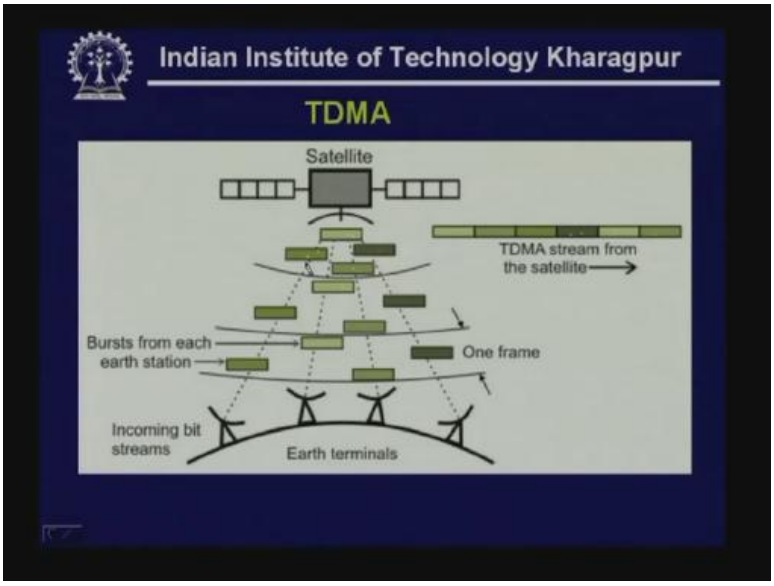

So you can see it is following the same order; first this one, then this one, then this one so the same order is being followed, this followed by this followed by this followed by this (Refer Slide Time: 47:32) so this is being repeated one after the other. This is how the TDMA works.

And in case of random access based MAC protocols as I have already mentioned collision detection multiple access protocols cannot be used so it has to be either pure ALOHA or selective reject ALOHA or slotted ALOHA and with this we can combine reservation so it can be reservation R ALOHA or reservation ALOHA and sometimes a combination of random access with reservation access protocols. This hybrid technique is used to have advantages of both random access and time division multiple access.

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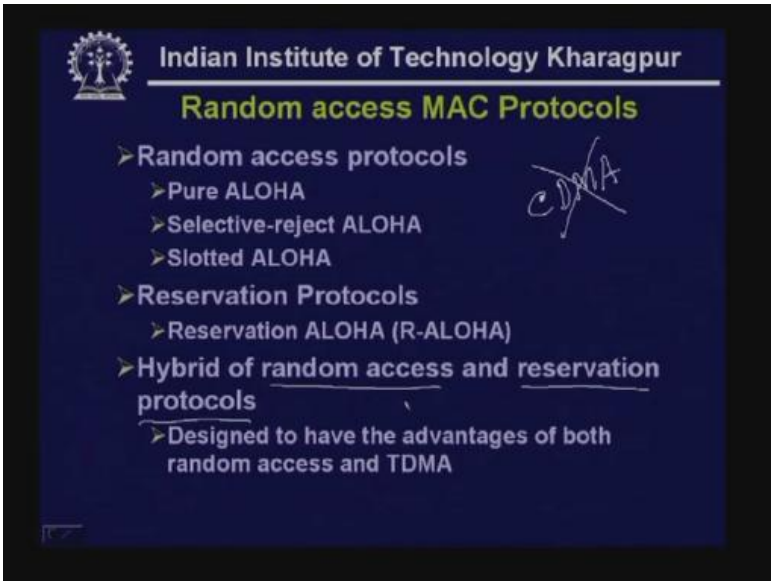

Let us quickly have a recapitulation of the techniques that we have used. We have already discussed in detail about reservation ALOHA that is being used when the number of ground stations is larger than the number of channels. So the reservation is done by directly trying to send in different slots. This is called reservation ALOHA. There is a possibility of collision in different slots. But once a station is able to transmit in a particular slot then same station will send data in the subsequent slots the.

However, if a slot is free is right now and in the next frame two stations can send so there will be collision which has to be overcome. Another technique is used, whenever the number of stations is smaller than the number of slots then you have got implicit allocations so it is one slot per station. When the number of station is small implicit allocation is there and then the excess slots can be accessed by using slotted ALOHA that means this part has to be acquired by contention based technique. This is Binder's scheme.

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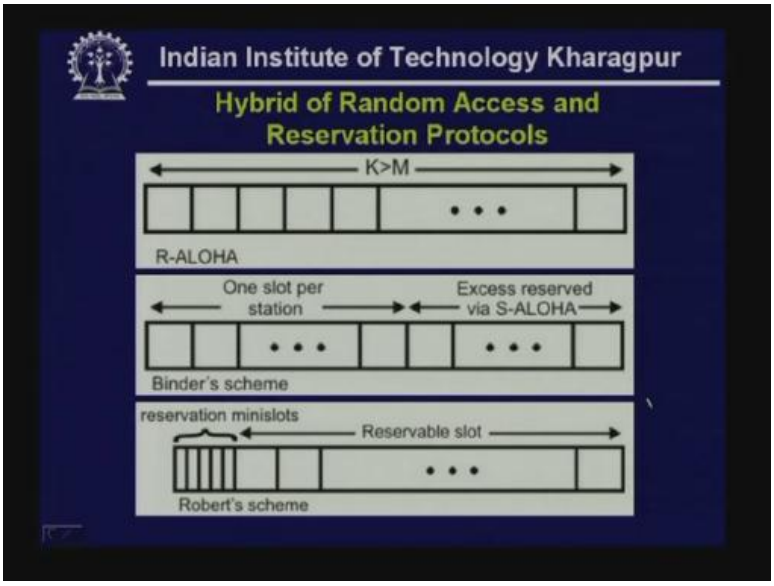

In Robert's scheme as we know a separate slot is being used which is known as reservation slot which is used for the purpose of performing reservation then data can be sent in different slots. There is centralized medium access control protocol the centralized FDMA is an extension of Robert's protocol. Here there are six reservation mini slots of variable length (Refer Slide Time: 50:23) but here one of the ground stations access some kind of master which does the reservation and variable length data can be transferred in this fixed priority oriented demand assignment.

Finally you have got Packet Demand Access Multiple Access Protocol PDAMA where there is a leader control slot and guard slot. In leader control slot acknowledgement is given to other stations about the reservation of slots and this guard slot is being used as a gap so that the ground stations get some time before reservation can be performed from the next time frame. These are the information subframe where the transmission is performed based on the reservation. This gives you a quick summary of the medium access control techniques that is being used for satellite communication.

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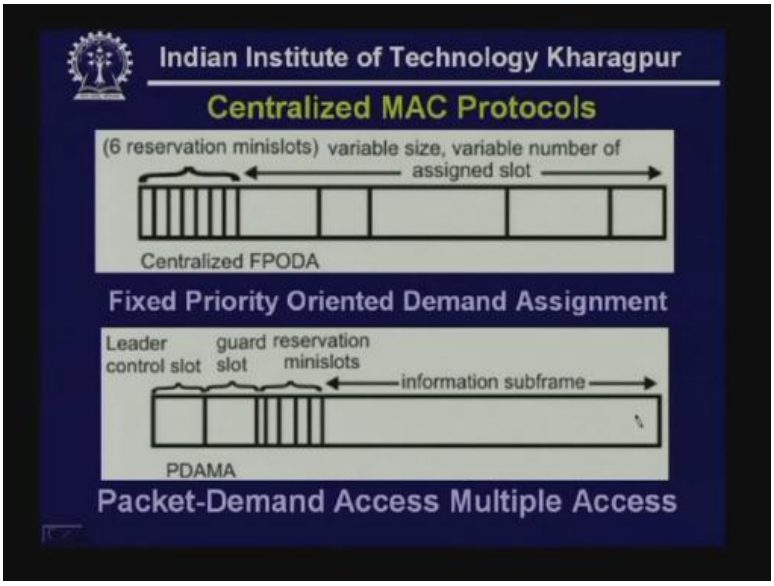

Before we discuss about the questions of this lecture let me summarize about the different systems where medium access control techniques are used. First we have discussed about the local area networks where we can use the contention based protocols like CDMA, CSMA/CD, Carrier Sense Multiple Access with collision detection and also we can use token ring and we have seen their applications in Ethernet, Fast Ethernet and Gigabyte Ethernet technique.

Then we have discussed wireless LAN where collision is divided by using a protocol known as CSMA/CA and then we have discussed the cellular telephone networks where FDMA, TDMA and CDMA are used and in today's lecture we have discussed about the satellite communication system where we have seen how various medium access control techniques are used for sharing the communication channel. I will give you the questions for this lecture

Review Questions:

1) Distinguish between footprint and dwell time
2) Explain the relationship between the Van Allen belts and the three categories of satellites.
3) Explain the difference between the iridium and Teledesic systems in terms of usage.
4) What are the key features that affect the medium access control in satellite communication?
5) What are the possible VSAT Configurations?

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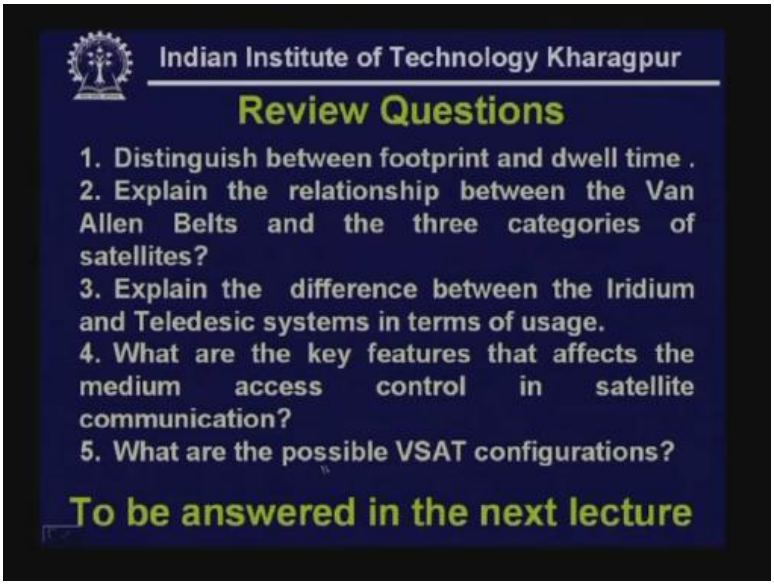

Now it is time to give you the answer to these questions of lecture - 31.

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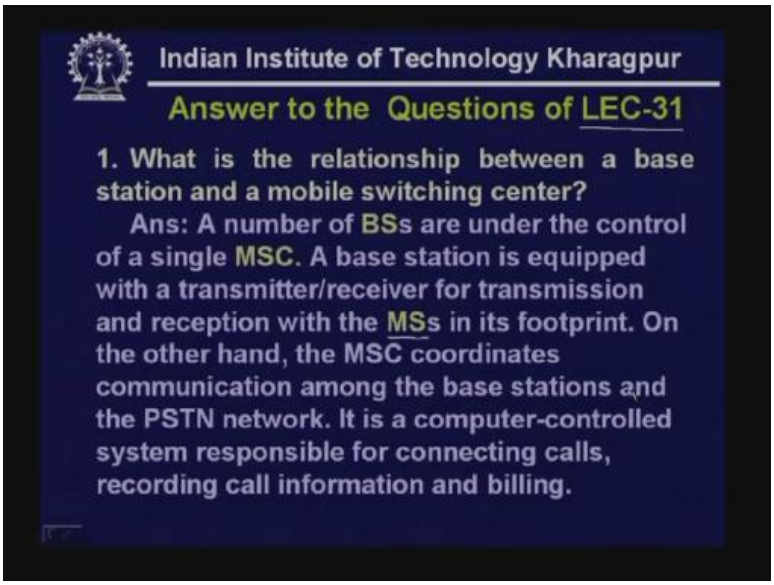

1) What is the relationship between a base station and a mobile switching center?
A number of base stations are under the control of a single mobile switching center. A base station is equipped with a transmitter receiver for transmission and reception and for transmission and reception with the master station in its footprint. On the other hand the MSC coordinates communication among base station and PSTN network it is a computer controlled system responsible for connecting calls recording call information and also do the billing.

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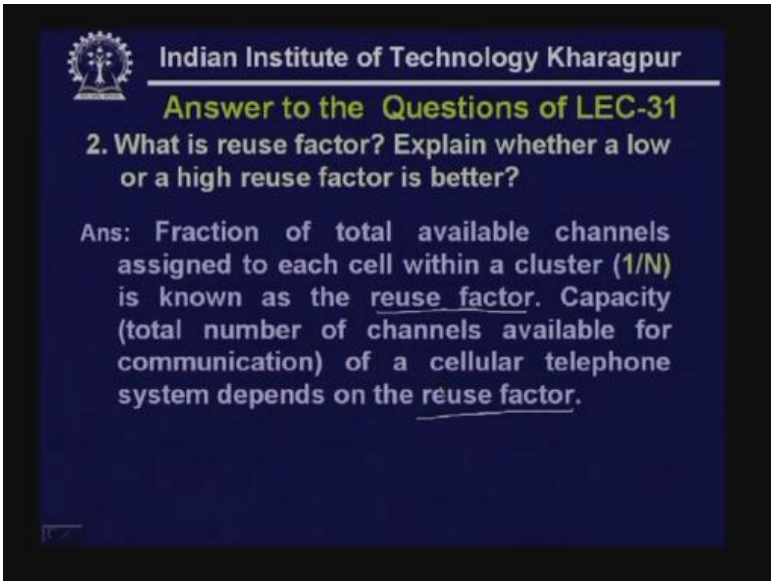

2) What is reuse factor? Explain whether a low or high reuse factor is better?
Actually the fraction of total available channels assigned to each cell within a cluster is known as the reuse factor. So if you have got n cells in al cluster then the reuse factor is 1/n. Capacity of a cellular telephone system depends on this reuse factor. So as the reuse factor increases then you have got larger number of cells so the covered area decreases. On the other hand, if the n is small then the area is larger.

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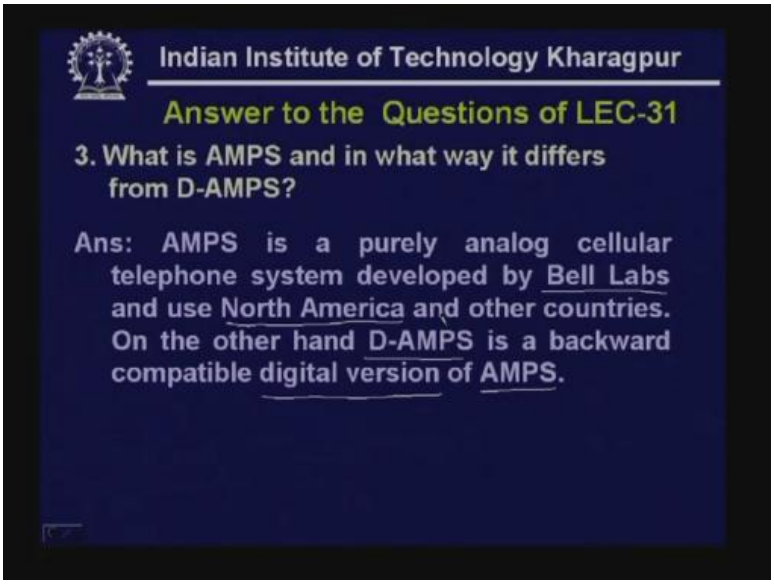

3) What is AMPS and in what way it differs from D-AMPS?

AMPS is your Advance Mobile Phone System is a purely analog cellular telephone system developed by bell laps and primarily it was used in North America and some other countries. On the other hand, D-AMPS is a backward compatible digital version of A-AMPS. We have discussed about the D-AMPS in the last lecture in detail.

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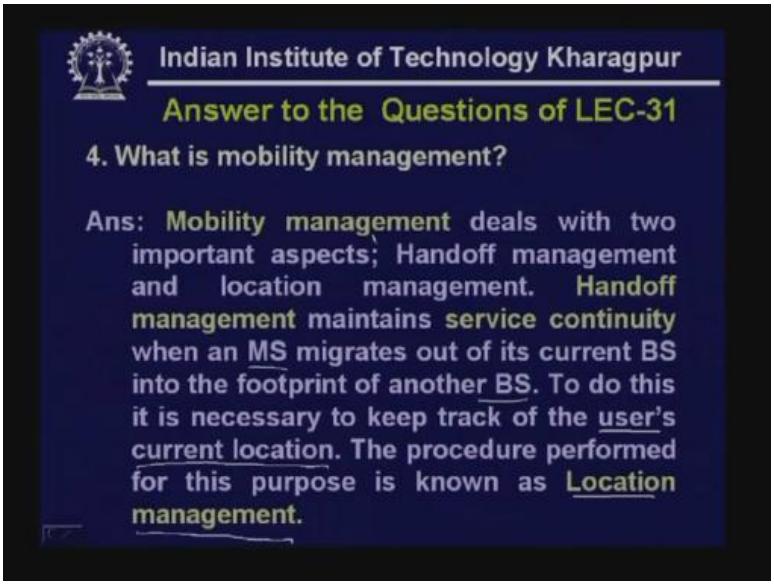

4) What is mobility management?
Mobility management deals with two important aspects; handoff management and location management. Handoff management maintains service continuity as we have seen when a mobile station migrates out of its current base station into the footprint of another base station. To do this it is necessary to keep track of the user's current location that is being performed with the help of location management. So location management and handoff management together performs the mobility management.

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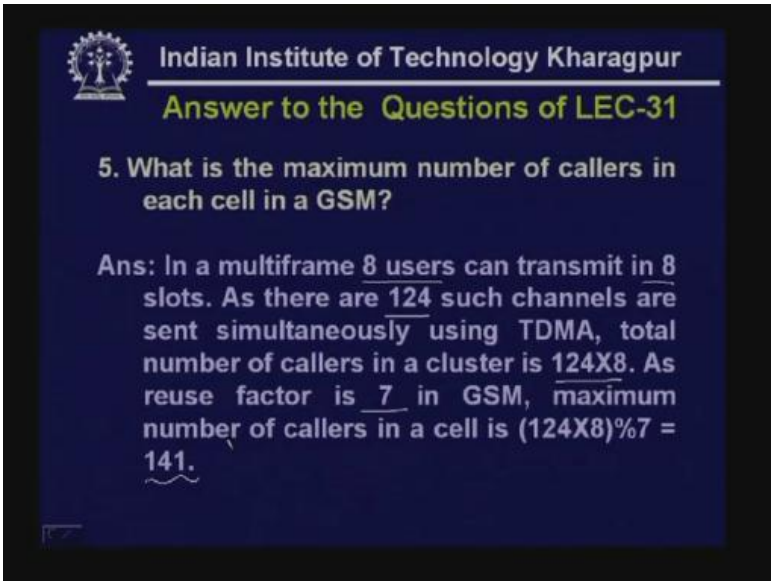

5) What is the maximum number of callers in each cell in a GSM?
As you know in a multiframe 8 users can transmit in 8 slots and there are 124 such channels which are sent simultaneously using TDMA. So the total number of callers in a cluster is 124 into 8 and as the reuse factor is 7 in GSM the maximum number of callers in a cell is 124 into 8/7 that is roughly equal to 141.

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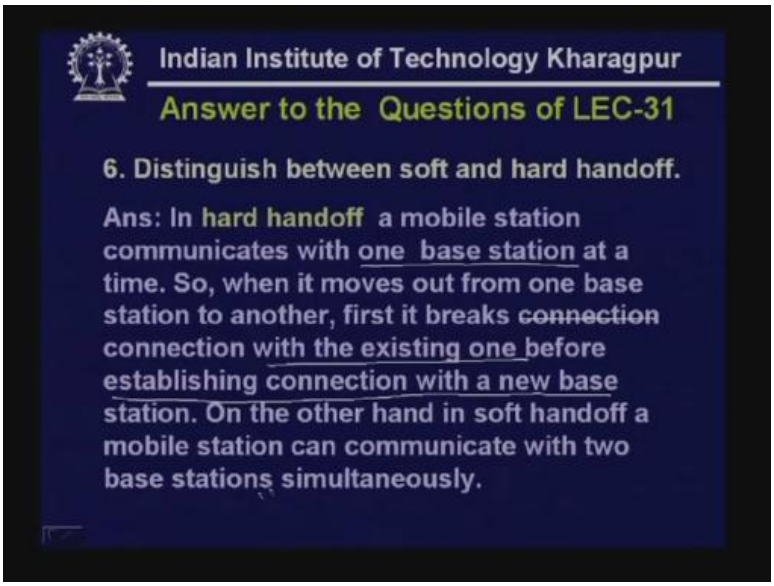

6) Distinguish between soft and hard handoff.
As you know, in case of hard handoff a mobile station communicates with only one base station at a time. So when it moves out of one base station to another first it breaks

connection with the existing one before establishing connection with the new base station. On the other hand, in soft handoff a mobile station can communicate with two base stations simultaneously and gradually the control is transferred from one base station to another station.

With this we come to the end of today's lecture, thank you.