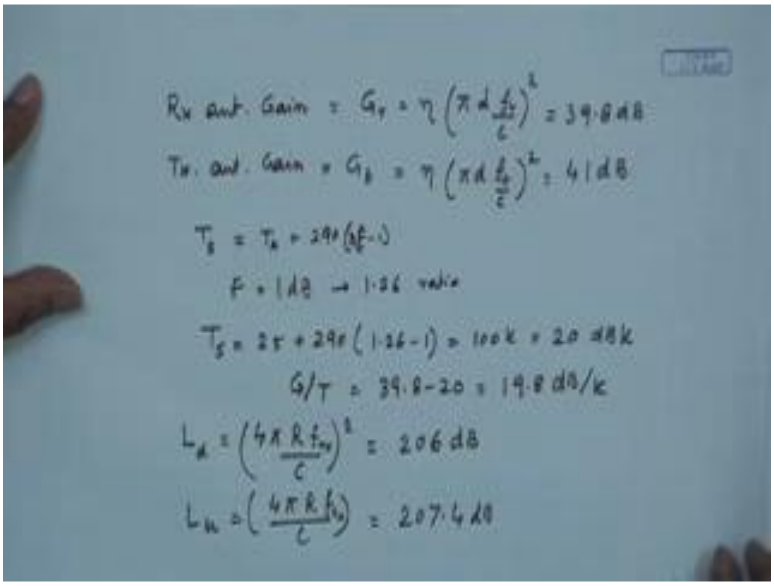
**Satellite Communication Systems**
**Prof. Kalyan Kumar Bandyopadhyay**
**Department of Electronics and Electrical Communication Engineering**
**Indian Institute of Technology, Kharagpur**

**Lecture - 24**
**Ground Segment-3**

Welcome back. We were doing a certain quick calculation to see if a VSAT directly communicates with another VSAT via satellite in one single Hub, what should be the power requirement at the VSAT. We have taken both these are size same efficiency same uplink and downlink frequency we have taken some numbers and we had started the calculation and we were in between the calculation.

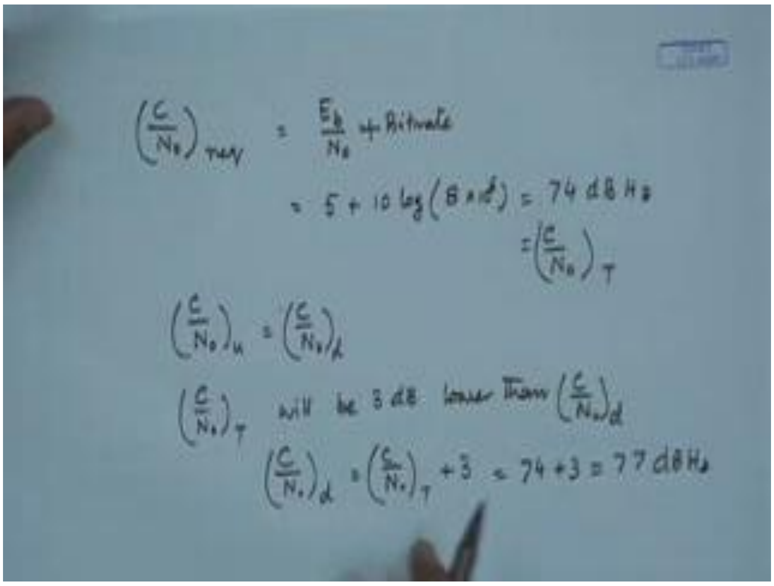
(Refer Slide Time: 00:46)




If you recollect, let us go back we were calculating the received antenna gain got 30.8 dB transmit antenna gain is 41 dB both for VSAT for different frequency it is different. And we tried to calculate the G by T, for that we have seen the received noise temperature based on the figures which are given we got T as 20 dBk and G by T as 19.8 dBk. Now, let us calculate the losses.

The downlink loss is 4 pi this R that is the range f by C and then this is whole square, this is in kilo meter it was given 40000 kilo meter, you have to convert into meter because c you will take in meter and this f is in hertz. So, with all these things you will get a number as 206 dB approximately. And similarly the uplink you will find the range of the using the same expression only the f here it is received and f here it is transmit, so the numbers will be varying transmit frequency is higher you will find 207.4 dB, we will keep these numbers it will be useful.

(Refer Slide Time: 02:14)

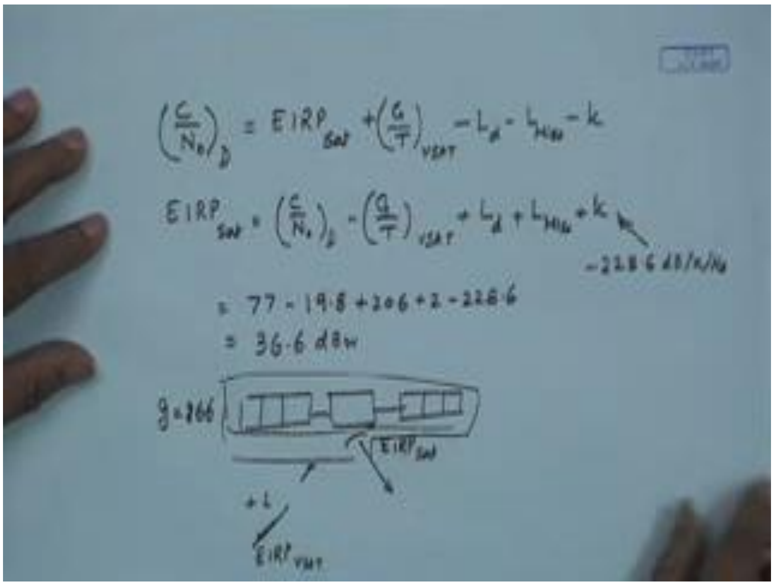



And let us try to find out now C by N naught required. This can be found out from what is Eb by N naught required and in dB and the bitrate which is Eb by N naught was given 5 and bit rate was given 8 mega bits per second so it is 8 into 10 to the power 6 which comes out to be these will be a 1 mega bit is 60 dB and 8 mega bit is 9 dB more, so 60 9 dB and 6 dB together it will give 74 dB hertz.

Now, remember C by N naught required in the totality the whole link, so therefore I can call it as same as C by N naught total. Now if you remember we said at the beginning C by N naught of the uplink and C by N naught of the downlink are same, because the same sizing is used and if they are same then C by N naught total will be 3 dB lower than any one of them C by N naught down or C by N naught up or I can say C by N naught down is C by N naught total plus 3 dB and C by N naught total we got, so therefore C by N naught down is 74 plus 3 is 77 dB hertz.

You have understood the way we calculate. So, we come to know now what the C by N naught is down, so one side link is known. And since the other parameters of that link are known we can find out what is the EIRP from the satellite.

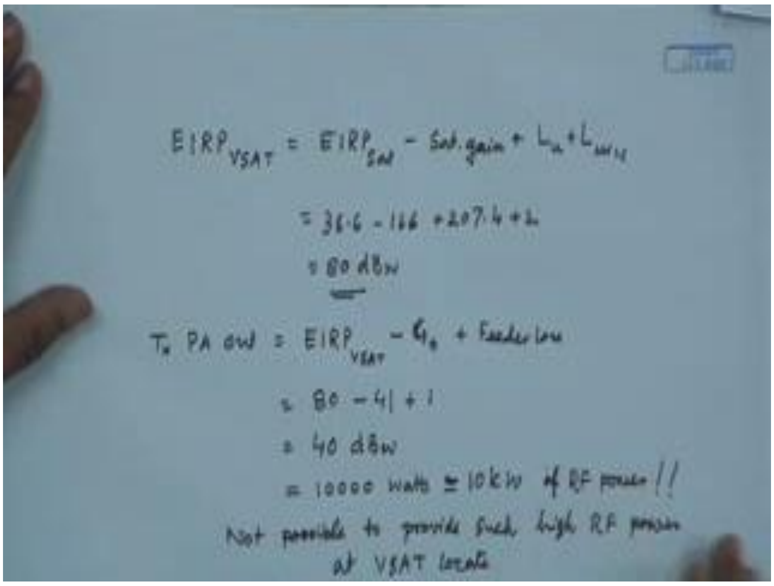
(Refer Slide Time: 04:25)




So, now in the downlink C by N naught down is EIRP from the satellite plus G by T of the VSAT minus loss path loss in the downlink minus miscellaneous loss y s k (Refer Time: 04:45). So therefore, EIRP of the satellite is C by N naught down minus G by T of VSAT plus in the path loss in the down plus loss the miscellaneous plus k. Now, this value k, if you remember it is minus 228.6 dB per k per hertz. If you put the numbers 77 minus that is 19.8 if I recollect correctly this was 206 this was 2 and then this is minus value, so minus 228.6 that gives a number as 36.6 dBw.

Now we know the satellite here, this satellite EIRP this side is known that is the downlink EIRP satellite is known. Now as we have said thus this whole satellite including the antenna has a gain G is how much was given 166 if I recollect 166 dB. Transponder gain is 166 dB; satellite gain is 166 dB, so this particular block is 166. So, EIRP minus the gain is the input power which is the satellite plus the uplink losses, if I add the uplink losses then we get the EIRP here that that is the EIRP of VSAT.

(Refer Slide Time: 06:57)

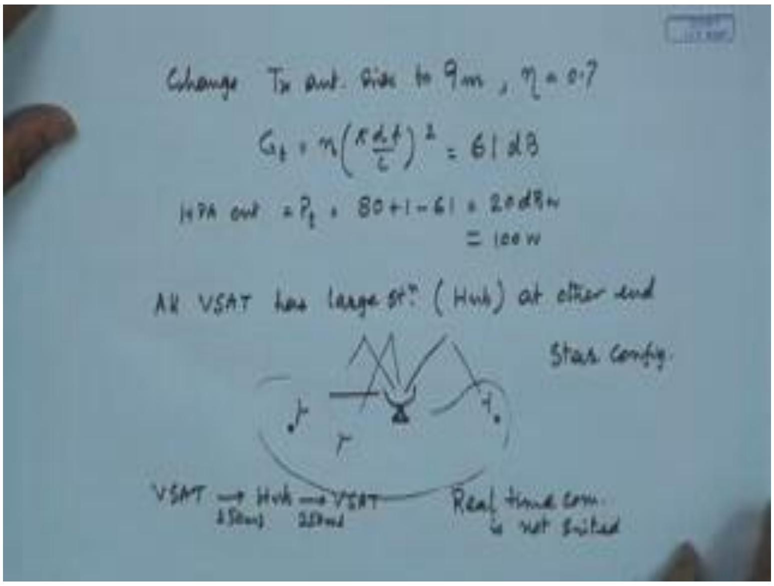


So therefore, we can write in this way EIRP of VSAT is equal to EIRP of satellite and then I reduce the gain that is the satellite gain and then I add the losses uplink and miscellaneous losses so that comes out to be 36.6 minus 166 plus 207.4 uplink was larger 207.4 plus 2 that comes out to be 80 dBw we got EIRP of the VSAT.

Now, if we try to calculate the VSAT transmitted power amplifier out which will be the whatever is the EIRP of VSAT minus the a gain of the VSAT transmit and then plus some losses that is feeder loss, this is 80 and if I recollect the antenna gain which was calculated as 41 dB transmit antenna gain it was calculated as 41 dB. So, we put 41 here and feeder loss was 1 dB. So, this comes out to be T plus 1 each 40, 40 dBw. Now what is the meaning of 40 dBw convert into what? So, this is approximately 10 to the power 4 watts, hence 10 kilo watt; 10 kilo watt of RF power of RF power output. So, the d c power requirement is depending on the RF power amplifier efficiency is much larger than 10 kilo watt

It is not possible to provide such high RF power at VSAT location. Remember we were talking about the VSAT locations which are at bank, ATMs, etcetera. So, normally very high wattage is not used is smaller capacity this may be possible in a large station. So, if you want to communicate of 1 meter to 1 meter VSAT with 8 mega bits per second with certain gain of the satellite system you get absurd type of dc I mean RF power requirement corresponding dc power requirement.

(Refer Slide Time: 10:35)

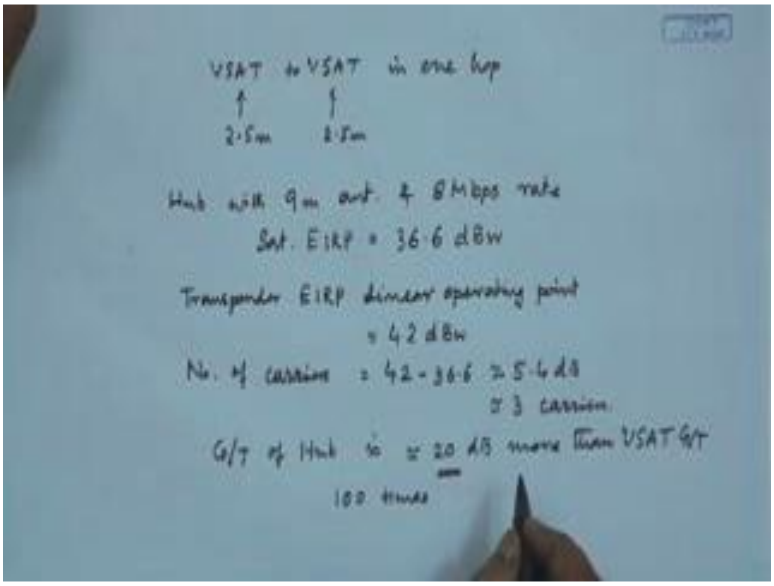



So what can be done, I can do one thing I can increase the receive antenna size. So, to change the transmit antenna size to 9 meter instead of 1 meter I change it to 9 meter with efficiency, obviously efficiency is better we have discussed earlier. So, Gt is efficiency into pi d f by c whole square which will come out to be roughly of the order of 61 dB. Now then the HPA out that is our Pt is 80 plus 1 minus 61 which comes out to be 20 dBw which is roughly about 100 watt, which is tolerable.

So, all VSAT has large station we call it Hub station at other end. Now you will realize what the word Hub is, there is a VSAT which is communicating with a station which is via satellite which is large station. There is another VSAT which is communicating with a large station. So, all VSATs are communicating with the large station. So, in total networks of VSATs we have one central station which is we can call Hub and it is a star type of configuration. One big advantage is start up configuration is the routing from VSAT to VSAT can be easily done at one place. One of the big basic disadvantages that is we are communicating from VSAT to Hub to another VSAT. So, if there is a real time communication from these VSAT to these VSAT you will need two Hubs and each Hub is 250 milliseconds, so therefore half a second will go reach there.

So, real time communication is not suited in this step, but non-real time that is why it is in the ATM that is the bank transaction, commercial transactions, where data communication is taking place. Then therefore, people try to do a real time communication with a larger type of antenna in the VSAT.

(Refer Slide Time: 13:34)

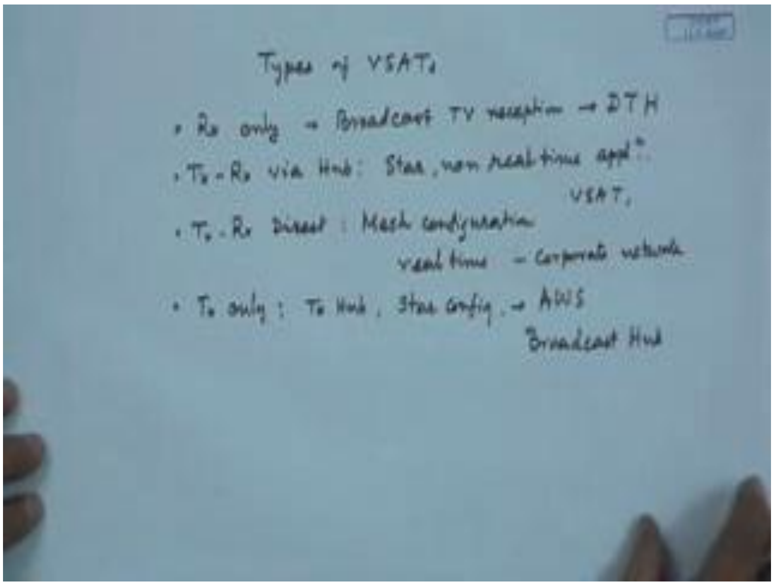



And it is possible that VSAT to VSAT in one Hub, you can use a VSAT antenna of the order of 2.5 meter or so. The corporate officers when they have this VSAT network by their own they use this type of thing where it is much more tolerable you have a single Hub communication. In this process I will try to show you how to calculate the number of carriers that can be supported by a satellite. Let us take those numbers that is Hub with 9 meter antenna and 8 Mbps rate the satellite EIRP we have already calculated as 36.6 dBw. Now transponder EIRP is of the order of in the linear region of linear operating point in the linear region of operation is of the order of 42 dBw.

So, the number of carriers is 42 minus 36.6 is 5.4 dB which correspond to roughly about 3 carriers.But then if you VSAT is communicating to a Hub, the Hub antenna is 9 meter. So, its G by T of Hub is quite large it will be of the order of 20 dB more in this particular case than VSAT G by T what we earlier calculated is almost near to 20 dB per k or 19.0 some dB per k roughly this is approximately 20 dB. So, since this is 20 dB more, so therefore from the satellite the EIRP part carrier VSAT carrier will be could be 20 dB less to maintain that and what is the 20 dB, 20 dB is equal to 100, so there 100 times more carrier that can be used for VSAT to Hub.

Therefore, people normally use a separate transponder for a Hub carriers and separate transponder for VSAT carriers. These things you can go on calculating for using different numbers of Hub and different numbers of VSAT.

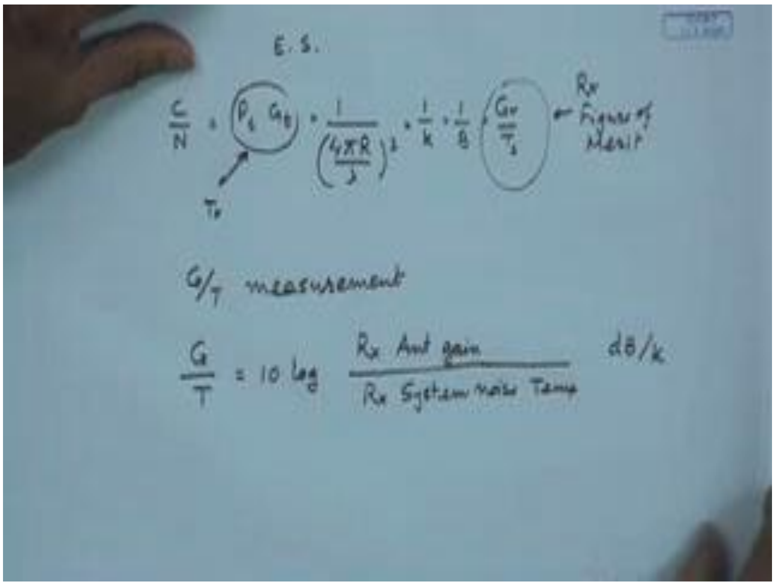
(Refer Slide Time: 17:19)




There are different types of VSATs; that is receive only, that is for broadcast TV reception called DTH its antenna is very small and the of the less than 1 meter and only receive chain is there. Then transmit receive via Hub, this is a star configuration, and non real time application like we have seen in VSAT for bank, ATM etcetera.

Then another thing is there that is transmit receive not via Hub but direct from VSAT to VSAT that is in Mesh configuration, and this is real time because one single Hub, it is going this is for corporate network where real time communication is required. And there could be transmitted only that is two Hub and it is a star configuration. Examples are automatic weather station we explained also it could be the broadcast Hub that TV transmission is done by the Hub station for broadcasting, so that is only one uplink. So, that is transmit only it could be very large or could be very small depending on the requirement of the type of VSATs these could be different categories of VSATs, after seeing this quick calculation on why in a network a small station needs always a large station at the other end.

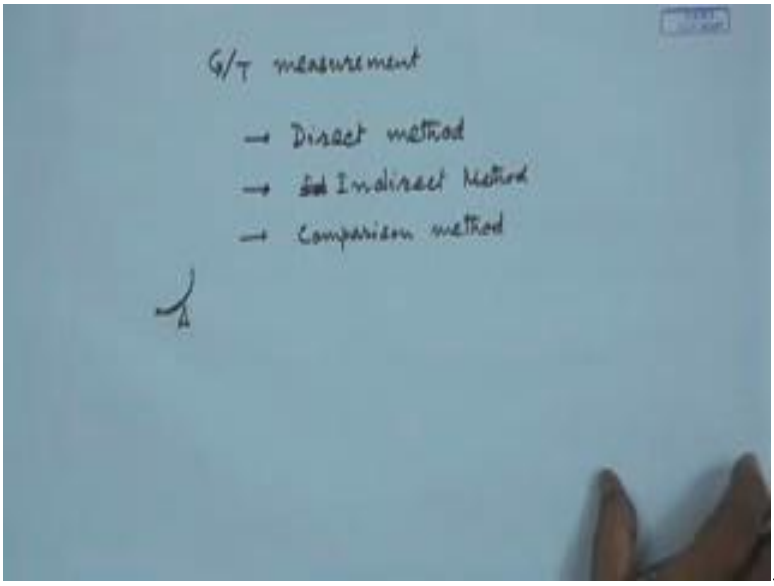
(Refer Slide Time: 20:09)




Let us see some more important issues that is the earth's terminal earth station or having some important parameter that is let us go back to our transmission equation C by N is Pt Gt I continue to repeat this so that you get familiarized about with this one 4 pi R by lambda whole square into 1 by k. Now you just see I have put C by [noise], so N naught is not there so bandwidth will come in this side another way of presenting and Gr by T this T is system noise temperature. This is in ratio, is not in dB d b it will be just 10 log n plus of that. But in this one important thing is this particular thing which is G by T which is called receiver figure of merit. It talks about the receiver antenna gain and it says that receiver noise temperature, so the performance of the receiver is seen from here. And this two units that is Pt and Gt talk about the transmit system of the earth station.

Now, to know the performance of the station we must know how do we measure this thing let us go into a topic which is called G by T; that is what is G by T we repeat that G by T is 10 log of the received antenna gain by received. So, what is mean by 10 log, so it is dB per k. Now we will continue to discuss on this particular subject that is the measurement.

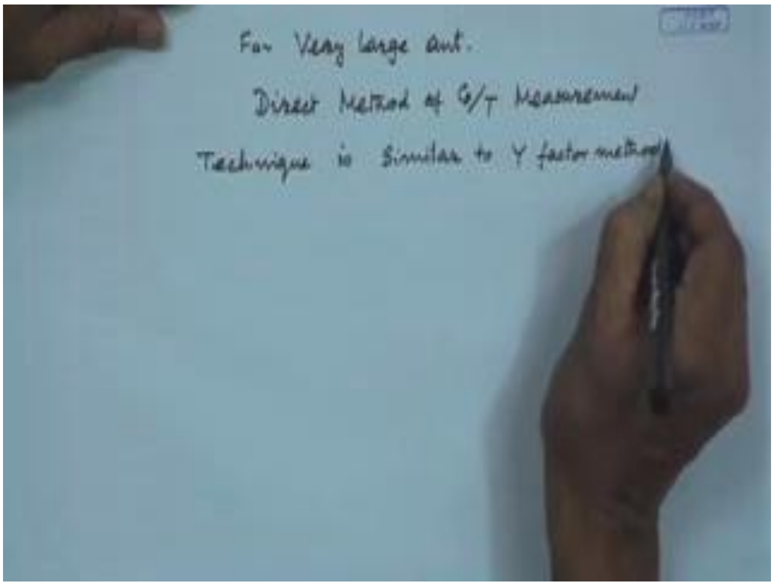
(Refer Slide Time: 22:43)



.

Now, G by T can be done in various ways; one is direct method, one is indirect method, and another is called comparison method. Normally the problem is this antenna is aperture which is communicating to the free space. Now you should try to do a measurement inside the laboratory just like as we measured the gain of an amplifier or noise figure or noise temperature of some sub systems, it can be measured with a giving certain input to the system and seeing its performance with that input through monitoring the output in terms of a power measurement or any other type of measurement. But giving an input to the antenna you can see in this free space and if the antenna is large enough which is 9 meter or 10 meter or 14 meter it is a real problem. So therefore, this measurements methods and techniques we have to understand carefully otherwise it has to only remain as a calculation.

(Refer Slide Time: 24:37)




Now, for very large station antenna there we use this direct method of G by T measurement. That technique is similar to, since the temperature is there if you remember the noise temperature measurement we have told you that there is a method which is called y factor method so it is similar to Y factor method. Y factor is measuring the noise temperature and the device temperature of two different loads connected at the input to the device under test.

So, two different noise sources and then ratio of these two measurements gives us a factor called Y and you can calculate based on the Y and the measured noise a power you can calculate and find out the noise temperature. Similar techniques are used here and since the aperture is very large they are putting a noise source in front of the aperture and calibrated noise source that too is a difficult scenario.

So, we will try to discuss and find out how it is done in the next class.

Thank you for the time being.