Satellite Communication Systems
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Lecture - 36
Effect on Higher Layer – I

Welcome, we will today for couple of hours we will talk about another issue, in satellite communication. You know the satellite medium is the physical layer. Now the effect of the physical layer on the higher layers that is that is the main issue of the discussion today. Now we will take the higher layer as our regular user friendly system, what we all of us use that is internet and internet mainly is based on the transport layer output call TCP and the protocol IP. So, on TCP IP which are higher layer than the physical layer what is the effect of the physical layer on that is what will be discussed today.

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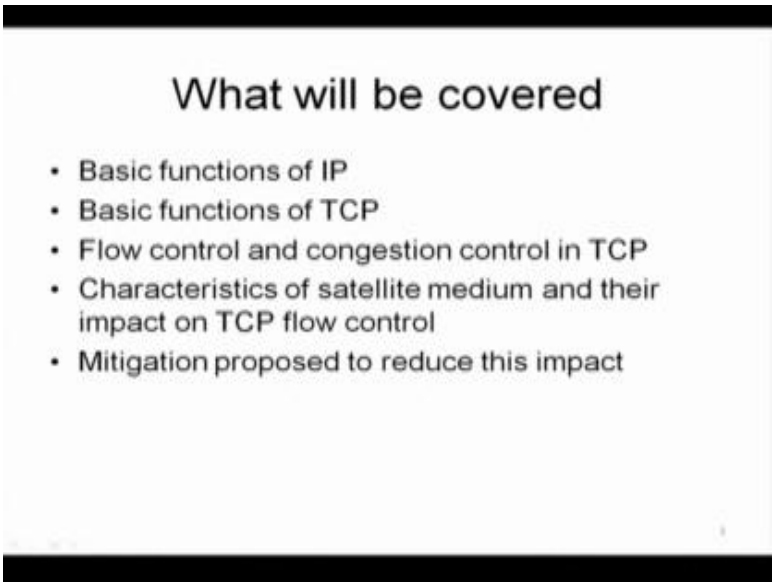

So, let us see what will be covered is the first those who are already familiar with TCP IP for them it is just repetition, but many of you know may not know and will not going through the details of TCP IP, we will see the effect in terms of delivery of the data integrity and in terms of a through put that can be maximum achieved.

So, from that angle we will see the basic function of IP and basic functions of TCP and mainly the through put is controlled using flow control in the TCP flow control and congestion control in TCP, some terms which are coming unfamiliar you have to get like

congestion control flow control congestion control in TCP. Of course, the characteristics of the satellite medium which you all know, but will see their impact on the TCP flow control protocol and of course, because there is some impact, they have some mitigation techniques. So, the mitigations which are proposed to reduce this impact that is what in the discussion today.

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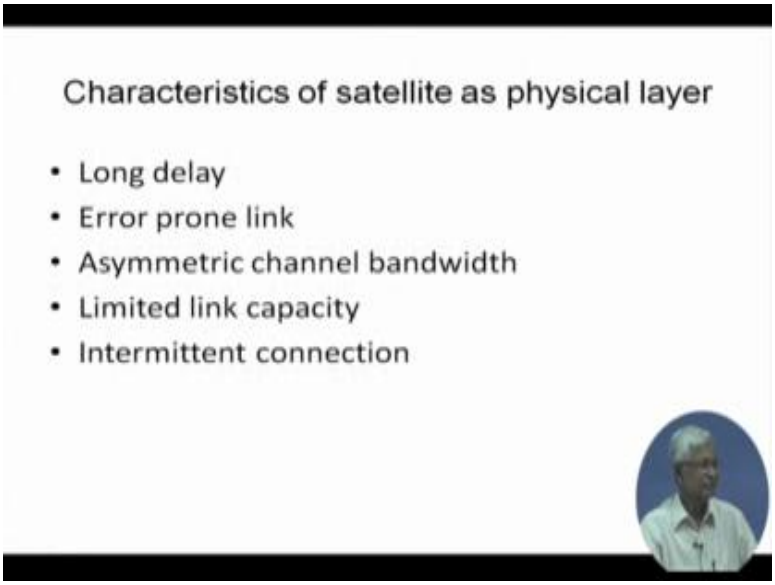

If we look at the characteristics of the satellites as a physical layer one thing we have now, by now we may familiar it a long delay because satellite is a repeat which is high about the earth. If communication through the earth and if it is between the planets are other satellites it have a long delay that is actually distance is big advantage of the satellite communication, but it provides a long delay.

Now the other thing is error prone because of this long delay we know that the power which is receives a which is received is very low, very weak and you cannot transmit very large power from the satellite type of, where the source of power is a is limited. So, therefore, work out loose by n. So, therefore, error is obvious, in addition on the ground system there will lot of multipath wireless link. So, other interferes that may come in. So, it is error prone link asymmetric channel band width; obviously, this is very common use that is we like say in internet browsing we ask for a lot of information that we asking for a short query. So, the uplink and down link band widths always asymmetric that happens in the most of the cases in satellite communications.

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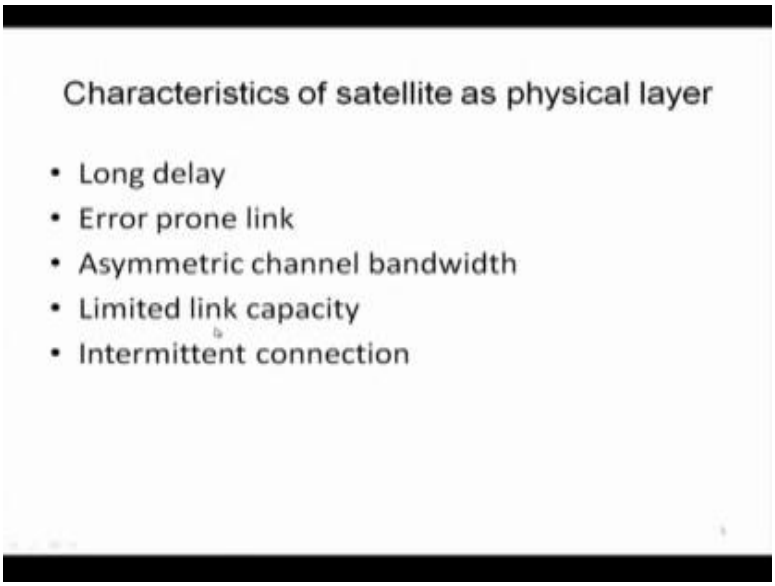

So, it is asymmetric channel band width and of course, it is limited link capacity as we have seen in terms of error prone link I mentioned that the power and the band width compared to the channel that is limited. So, it is a capacity and the satellite channel is a limited link capacity in terms of power and band width intermittent connections this is also another thing which does not happen always.

In other communication system is let us say a satellite probe is orbiting the moon and from the earth, another station is trying to communicate. So, when it goes behind the moon it is communication is broken it can happen in atmosphere also at higher frequency range we have seen in k e bands and higher up bands when we communicate in tropospheric rain absorbs the energy and; obviously, link goes down. So, connection is intermittent that is another problem in another characteristics of satellite physical layer with this characteristics in mind let us look at what is the IP protocol TCP protocol they do and how they work.

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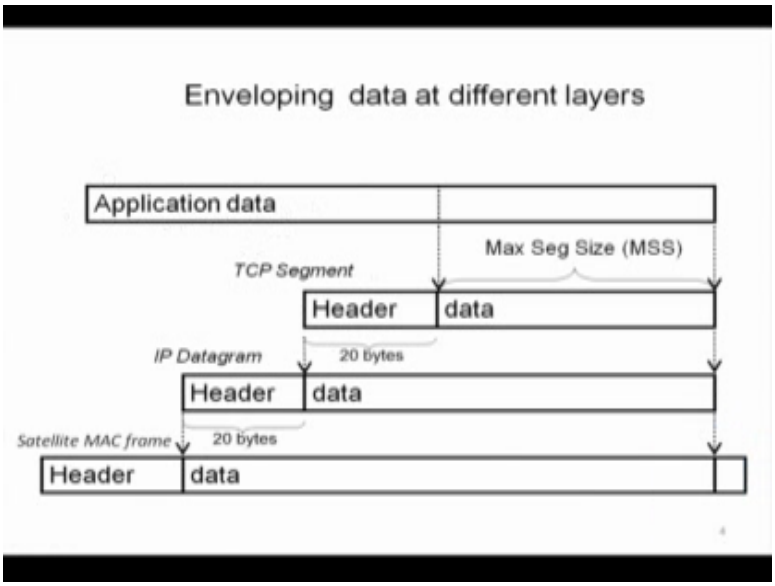

Communicating with certain application, this application data is formatted in a higher layer that is TCP layer in the data is segmented and the maximum segmentation in possible TCP layer finds maximum segmentation you call it maximum segment size m s s this term m s s may come during our discussion. So, this is a either segment size or maximum size, TCP segment you see the words which are used in the data gram package frames. So, here they call TCP segment. Now it segmented the segment is to be sent is to be sent whom and who is sending and any other information that goes as a header. So, TCP as a header and it is standardized TCP header is roughly about 20 bytes of information. Now with this TCP information or TCP segment is passed out into lower layer which is IP internet protocol this IP they call it data gram like telegram.

Now, so, you connect datagram or sometimes IP packet they also had certain header they have certain some functions to perform for that a different type of header which is added which is also of the order 20 bytes. So, now, IP datagram looks as after header it looks as a rest of thing is data at data contains the header of the TCP segment and the segment and that data contents the actual data. It is like that the then this IP going through the physical layer. So, it will pass on to the medium access control that is satellite medium access control which is we have seen that medium access control f m d a a t d m a c d m we that other things are there. So, that medium access control mac frame also acts an header we have discussed this one earlier that like a c r b t r by Unicode and many things they are. So, that is also having a header and sometimes have trailer also, it is enveloped.

So, how they are enveloped actual data is segmented and it is enveloped by TCP header then it is enveloped by IP datagram then it is enveloped by mac frame.

So, this is how the data is getting enveloped at different layer and each layer performs based on that header and trailer information it is one portion.

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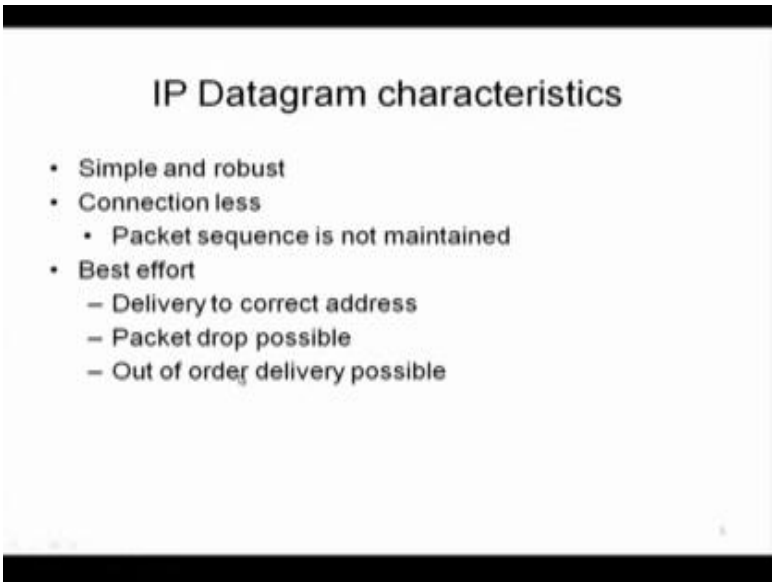

Now, what is IP datagram characteristics very briefly will touch that what is the characteristics it is simple and robust it is very simple and because of simplicity it is connection less that is was very surprising it is a datagram telegram like telegram it is datagram. So, it does not maintain the connection in future what is maintained it just one simple packet which is called datagram and it simply it does not know whether previous to that another packet which is linked to this information was linked to this was sent to this destination or this particular sources sent or in future it is be sent it does not maintain that.

So, it is connection less it is no connection it is just a one simple packet or data gram as to be delivered. So, there is no packet sequencing each packets are not sequenced at the IP level is not packet sequence is not maintained at IP level remember and it says that is a best effort, what is best effort best effort is delivery to the correct address. So, the address to maintain properly source and distortion address are properly maintained there is should have been in does not tolerate error in that, but packet drops are possible it may get missed.

So, it does not care IP whatever it does not care if it is dropped. It does not care if the delivery is not in order we will say first packet there may be a ten package going from one source to another. Since it does not maintain any sequence number. So, if the forth package as gone to some other router and it get deal it and third packet fifth packet is going too delivered and then the forth packet arrives. So, 3, 5, 4 and then 6, 7, 8, it is coming like that it does not care because it does not maintain sequence. So, it is possible that that delivery is not in order. So, that is what is called best effort and then, it is unreliable we surprised it is unreliable because the data part is not protected data part error protection is not there it just says. So, many bikes are there error is protected.

So, let us look at the there is the format of the datagram in the IP datagram in the format it is a 32 bit's each of the line each of the row here it is shown like this.

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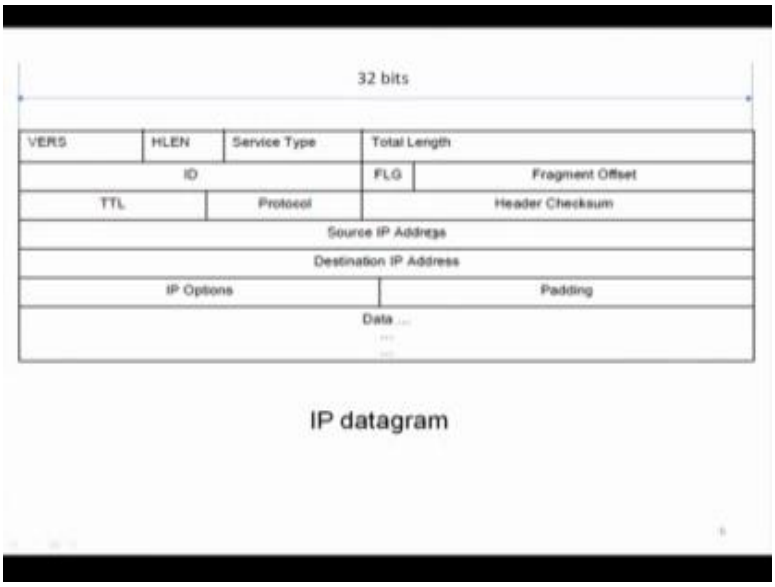

So, there are many fields which are there look at this there are source IP address and destination IP address which is the part of the header is the, header. First few 32 bytes 30 bits this header is a checksum. So, only header as a checksum subsequently there are data, data it is not protected. So, header is well protected. So, little bit the correct address and then of course, there are other information like what is the total length that is after the header how much is the data. So, the total length could be variable that is why they put a field.

So, there is a total length of field there are other field such that version number or header length header may be some options may be there, that header length can be increased the type of service and then identification. Whether there is a priority packet or ordinary packet there are different flags there are time to leave t t l is time to leave it like that is there options and paddings and data is there at this very important that there is a source IP address destination, IP address and there is a header checksum for that and let us see what is a TCP which is next higher layer what is there format the TCP segment.

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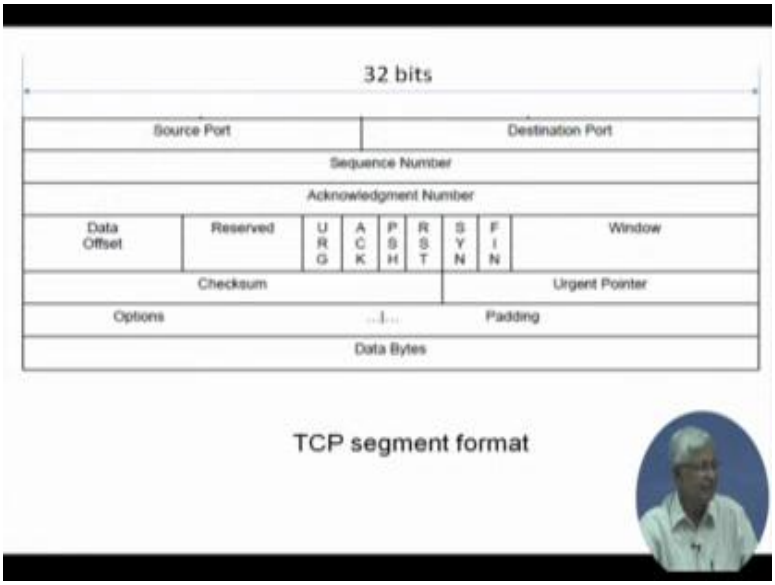

Now, it is called segment TCP segment format is also extend 32 bits and it is shows are shown here is a source port and destination port address are given and it contains a sequence number.

So, it will provide the connections it will provide the orderly delivery. If there is a acknowledgment number based on that sequence number from the receiver to the address which are. So, there is a field of acknowledgment and there is a checksum this checksum is protecting the header as well as the data. So, it is a reliable in this case and other options let they are urg pointer, in urg flags, ACK flag are many other different flags available, but we may not be interested on that, but there is something called window we will come to this window thing will try to understand what is that there will be a discussion on that. So, this is the TCP segment.

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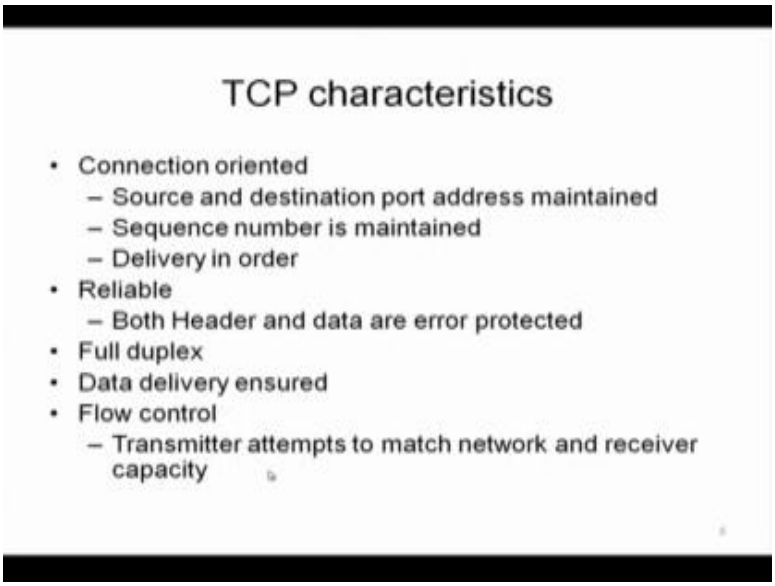

So, what is the characteristic of TCP that is it connection oriented because it is maintains the address of who is sending to whom and the port address mentioned and then the sequence number is also maintained. So, therefore, it will deliver in order in proper sequence that the receiver and the transmitter, we know in which sequence which segment place where in the memory and then it is reliable because it is protective header and data both are error protected and it is a full duplex. Therefore, the data delivery is ensured in full duplex acknowledge will come when, the where is the data reaches and checksum is checked properly it is correct then acknowledgement will comes. So, data delivery is ensured.

And there is a flow control this is important that the through put, they are trying to maintain to the maximum possible through put that can go through a particular link transmitter attempts to match the network and receiver capacity we will discuss this one because flow control is a major issue what will discuss today.

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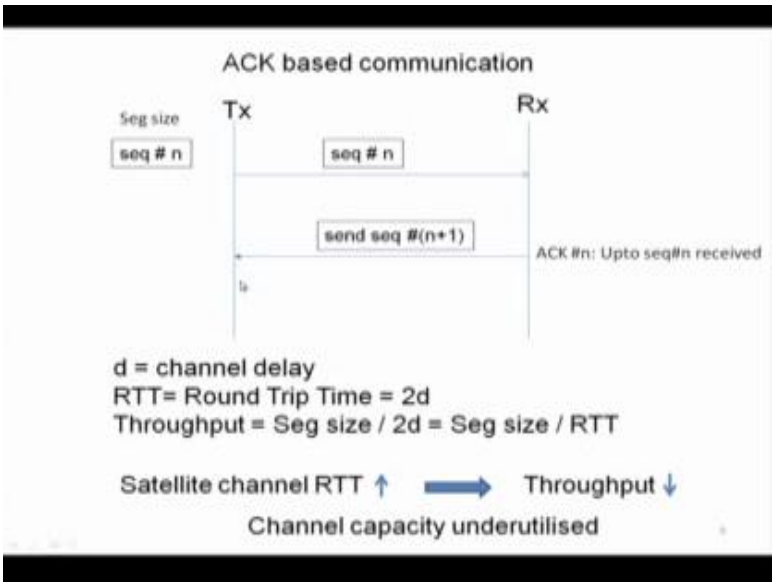

Let us see how the ACK base communication takes place it is very simple in a segment as per the segment size there is a sequence number. Let us say 6 naught sequencer number n for this segment is being sent by transmitter sequence number n is a going I am not showing the delay properly say this y axis is the delay. So, after sometime the sequence number n is acknowledged up to sequence number n is this meaning of that acknowledgment is very important for the for the TCP, those who want to understand actually what is what goes is send be the sequence number n plus one or actually instead of sequence they in true sense they are asking for the next byte it gives a byte count and the byte number.

So, up to this byte I have received properly give me the next byte. So, the next byte number, but for our understanding we will say this is the acknowledgment up to n. So, nth sequence is acknowledged acknowledge n, but actually send this sequence number n plus one that is that is the message which goes. So, this is how it goes, but let us see a very simple way of let us look at it d is the channel delay let us say this is the channel delay of including the processing and then, the RTT is a round trip delay including that is two times d which includes the processing of the receiver that is by the time it recognize and send back. So, the through put is the segment size divided by RTT. So, that is the through put now look at it in satellite the RTT will be high it is the order of quarter of a second may be half of a second they depends on where the satellite is that got high. So, the since the RTT denominator is high through put will go low.

So, as the satellite distance is more than more from between transmitter and receiver through put goes down it is a major problem for us. So, channel capacity remains underutilized say satellite channel is large band width, let us say a good amount of band width is given, but because of the RTT and the segment size limited segment size the whole thing remains underutilized because it as to send segment next segment after it gets replaced that send me the next segment. So, this much delay during that time and the buffer the sequence n number is waiting and subsequent sequence are not going up.

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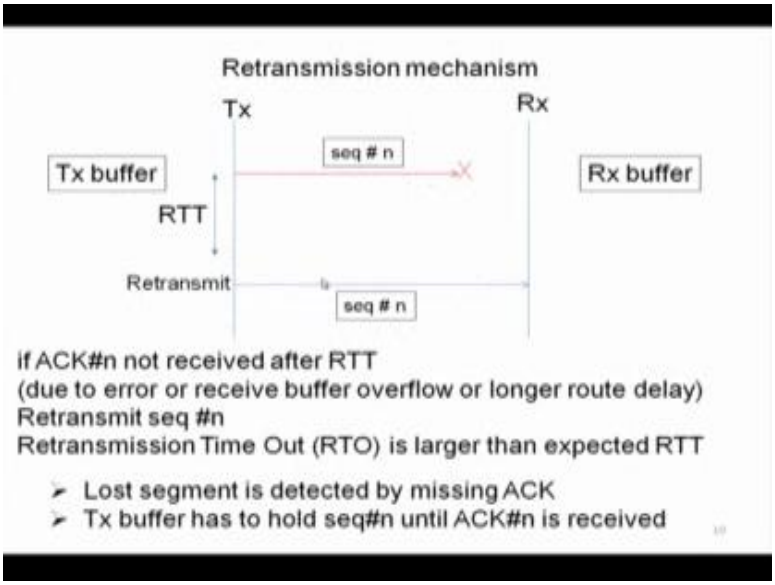

When it says what happens if the sequence is lost say due to some error receiver did not get it. So, after expected RTT acknowledgment is not received after RTT due to the error or may be receiver buffer already over flowing or may be the route delay is much more than expected RTT acknowledgment has not been received.

So, what transmitter will do it will retransmit, retransmit the sequence number n and this retransmission there is a timer for once you send the segment you start a timer and when this retransmission time out timer fires and then it will be retransmit. So, it is stated here retransmission of RTO is larger than the expected RTT there is a method of calculating retransmission time out we do not go in detail of that. So, after certain time out it will retransmit fine. So, the lost segment is lost is detected by what method by detected by the acknowledgment is missing acknowledgment did not come within certain time. So, that is all the segment is lost transmitter will come to know in the segment is lost because,

there is a missing ACK and transmitter buffer as to hold the sequence number n until the acknowledgment for that is received.

So, transmitter buffer as to hold. So, these are the two learning of this retransmission method.

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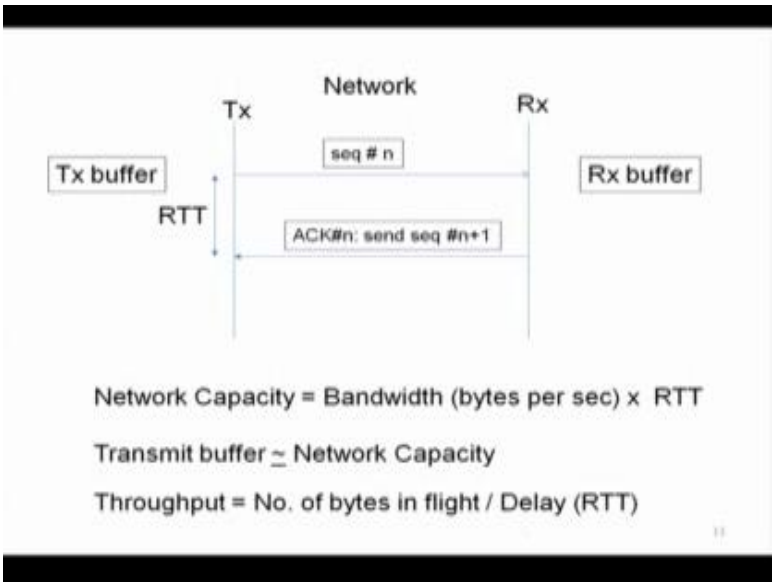

Let us say what happens subsequently sequence number n is sent and the receiver send the acknowledgment of n that is send sequence number n plus 1. So, the network capacity is the bytes per second no instead of bits per second in TCP at this layer people taking about bytes. So, it is bytes per second into RTT that is the network capacity. Now; that means, that many bytes are possible to keep in the flight. So, transmit buffer can be of that size which network capacity. So, transmit buffer approximately can be up to network capacity, so through put is number of bytes again put in flight divided by the delay. So, I can own pumping what happens instead of wait instead of waiting for the first acknowledgment to come or nth acknowledgment to come and then sending n plus one and do not sending n plus one let it be in flight. So, that way through put can be increased.

So, number of bytes in the flight which is the large based on the RTT and the segment size. So, number of bytes in flight divided by delay there is a RTT.

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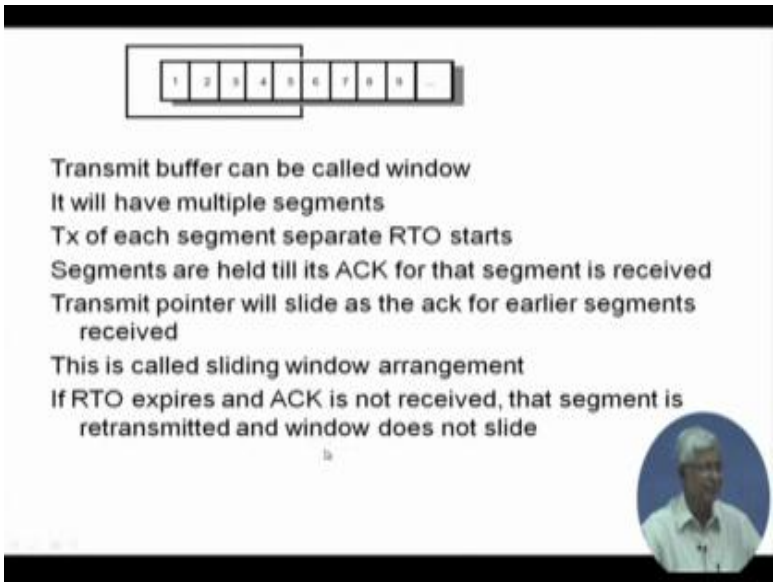

So, through put can increase, so what we will input that transmit buffer can be put we can call it window now the term window comes transmit buffer can be called window. And which the window contains many segments here at the number 1, 2, 3, 4, 5, 6, 7 like that it have multiple segments and this window depending on the size of the electro capacity or the RTT at what rate we are sending the window can have. So, many segments and once the acknowledgment of the first one which is gone the first receive then window can shift a little bit because network in the network second, third, fourth or still on the fly only the first has been received. So, I can first as gone out of the network. So, network is empty by one segment I can push next segment that is 6.

So, transmit of each segment of course, there is one thing you have to remember each segment is lost what will happen. So, for each segment separate RTO as to be fired separate RTO as to starts and then, segments are held till the acknowledgment for that segment is received is not received then of course, that as to retransmit that is why the segments are already send many segments are already send for each of them that we held and each of them separate RTO as to be started the transmitter pointer will slide. When the acknowledgment for the earlier segment as received when the number one is received it will slide to 6, now you have 2 3 4 5 6 then two acknowledgment is received which has gone out of the network to the received buffer. So, then 3, 4, 5, 6, 7, it slides one more.

So, like that slide this is called sliding window arrangement this is what is done in TCP. So, that window size very important you remember the field window. So, window size is important. So, if RTO expires for any one of the segment; that means, the ACK as not received for that segment then, that segment as to retransmitted, but window will not slide this is another protection they, are provided that window should not slide and because we are not sure that network is over flowing or not.

So, if ACK is not received. So, that particular segment is retransmitted and it is assumed the network capacity is flow in that and window will not slide until the acknowledgment of another one as received acknowledgment received which is come out of the network and received buffer is accept. So, window will slide at that place.

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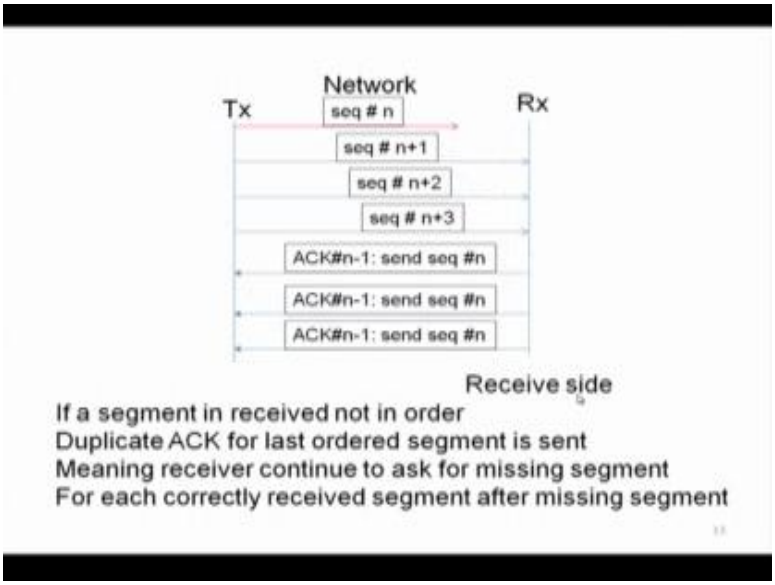

So, this sliding window let us see that something segments are already flying what happens to them. So, sequence n as lost. So, now, send the sequence number n minus 1 as per the standing window arrangement already capacity we went on sending n plus one as been send and acknowledgment for the since the n has been receive receiver did not receive the n, but it receives n plus 1, receiver sending that n plus 1 has been received and send n plus 2, he has not received n if you remember we say acknowledgment means up to that as received correctly. So, we cannot send the acknowledgment of for n plus one in that case he says that up to n plus 1 have received everything actually he has not received n. So, then he will continue to say that send me send me sequence number n

send me the sequence number n; that means, he is acknowledging the previous segment up to segment I have received which is n minus n and n have not received. So, send me n though he has received n plus 1.

So, this is a duplicate ACK earlier he has sent already that ACK n minus 1 already send that is sequence n as gone, but which is lost. So, this is a duplicate ACK another segment has been received by a receiver which is n plus 2 still he will send me sequence number n ACK for n minus 1 is gone another one still it like that he gone receiving go on sending duplicate ACKs and continuously trying to reminder send the reminder to transmitter that I have not received sequence number n which is a gap in my in my receive buffer there is a whole buffer, but this duplicate act are telling some more things, that I have received subsequent three segments they may not be subsequent I have received three more segments. So, three more segments have gone out of the network out of the out of the network received buffer. So, there are two meanings which are coming out of that.

So, meaning of receiver continue meaning that receiver is continued to ask for the missing segment that I still do not have that particular segment and for each correctly received segment after the missing segment it is sending the request. So, that after that I have received. So, many as many duplicates ACKs come segment number has been received I have received. So, many segments, two information are going out this.

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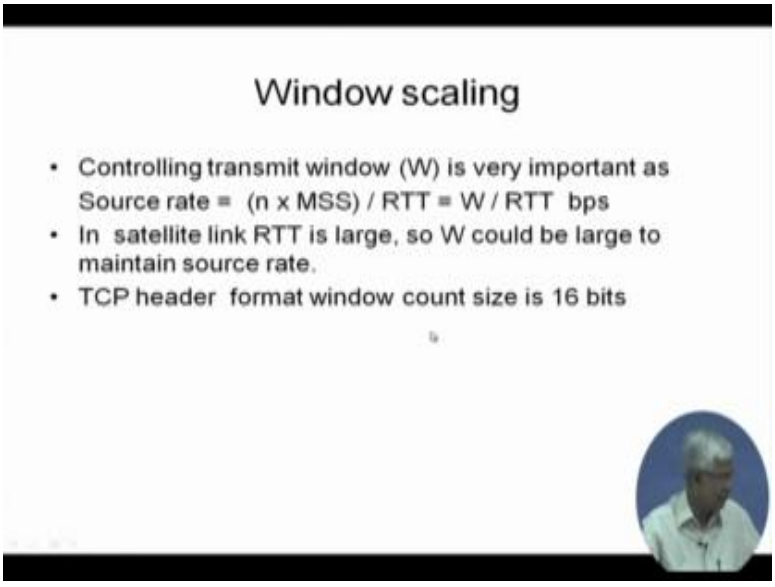

Now let us see the control of this transmit window is very important that is because, the source rate is n times MSS that is the maximum segment size divided by RTT that is actually nothing, but the w by RTT in actually it is in bytes per second though I have written small b. So, it should mean as bytes per second in satellite link RTT is large. So, w is also could be large to maintain the same source rate or through put I can I can maintain RTT is large w large, but then the problem is TCP header window count size is 16 bits; that means, 2 to the power 16 bytes is the maximum window size TCP header says if you remember the TCP header format that it say.

So, let us go back here this is 16 bits, 16 bits means 2 to the power 16, that is the window size 2 to the power 16 bits bytes 2 to the power 16 bytes is the maximum window size that is possible. So, therefore, in RTT we have to maintain the source rate RTT loss, w could be large, but it linked to 16 bits. So, therefore, maximum window size is two to the power 16 bytes and in case of satellite this may not be enough. So, you have to scale up, window size could be scaled up there is option.

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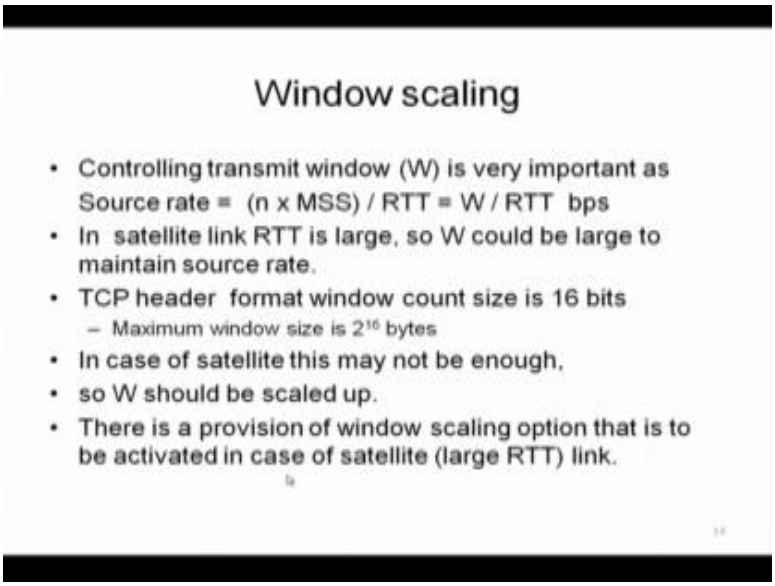

So, there is a provision of window size scaling option that is to be activated, in case of satellite link which is large at link since time is up will continue the discussion in the next period.

Thank you.