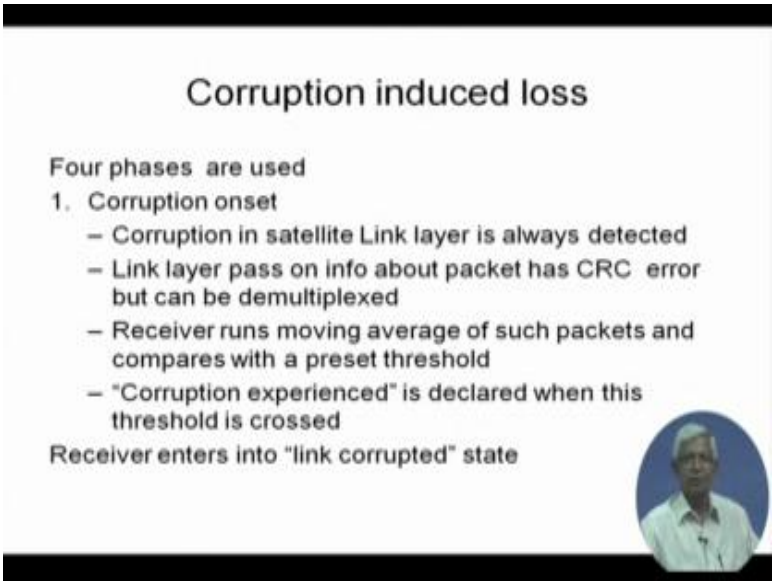
Satellite Communication Systems
Prof. Kalyan Kumar Bandyopadhyay
Department of Electronics and Electrical Communication Engineering
Indian Institute of Technology, Kharagpur

Lecture – 38
Effect on Higher Layer – III

Welcome back, we were discussing about the space data protocol and the modification of TCP for that. So, for that what we have found out that in the space system the loss of packet can be due to many reasons at least three reasons identified which is a corruption that is noise and condition.

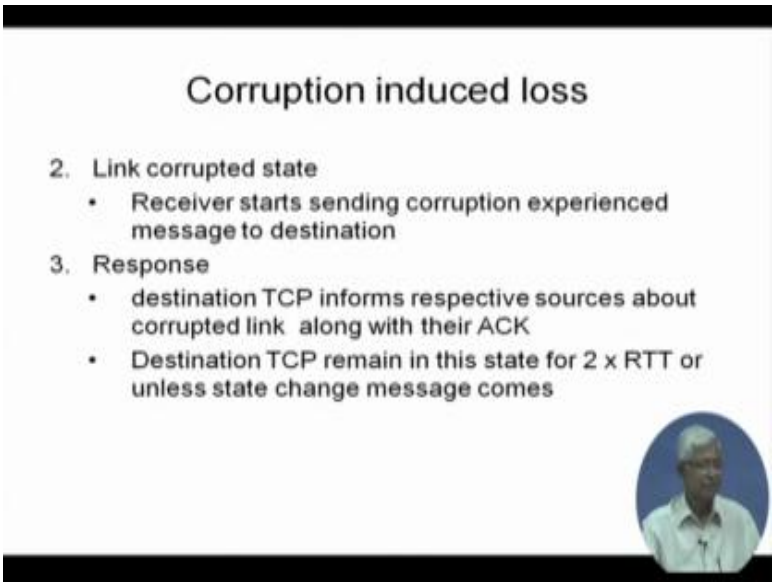
So, we were talking about the corruption induced loss and in that said how it is handled first the onset of the corruption is to be identified.

(Refer Slide Time: 00:39)



Which is identified by the link layer and the link layer is passed on the information to the higher layer that it says that it has a CRC error, but it can be demultiplexed, it can be still used. So, receiver runs a moving average and sets a threshold from that threshold, once it exceeds the threshold it says that corruption is experienced. So, it declares that then the threshold is crossed and the receiver goes into the link corrupted state. So, it changes the state.

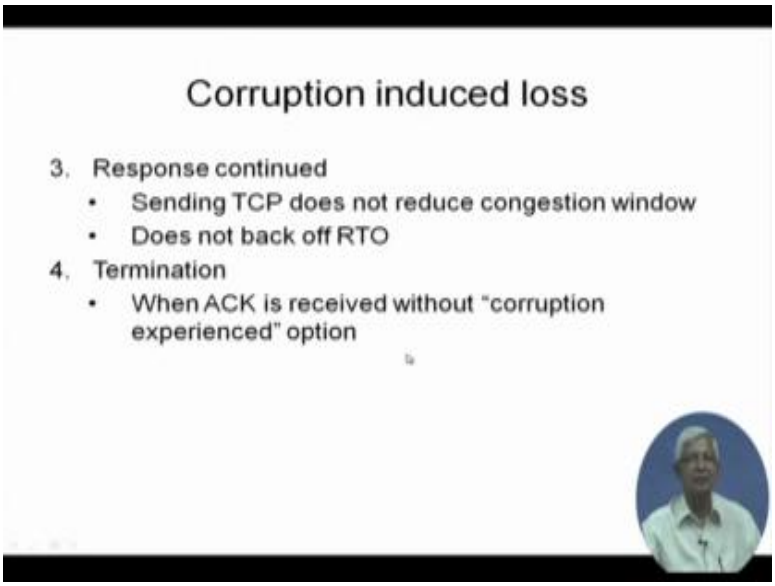
(Refer Slide Time: 01:22)



Corrupted state the receiver starts sending corruption is experienced a separate type of message, which is a internet controlled message it sends to the destination that I have experienced it sends the data and also it sends the corruption experienced and the destination in response, informs the source of the TCP that the link is corrupted the acknowledgment is going along with that, it says that I am told that link is corrupted link is corrupted that is a important information for the sender. It does not it does not go into the slow start mode as normal TCP assumes that this is a congestion, it knows that is corrupted. So, destination TCP remain in the state for 2 times RTT unless the state changes the change state change messages come that in which is not corrupted etcetera.

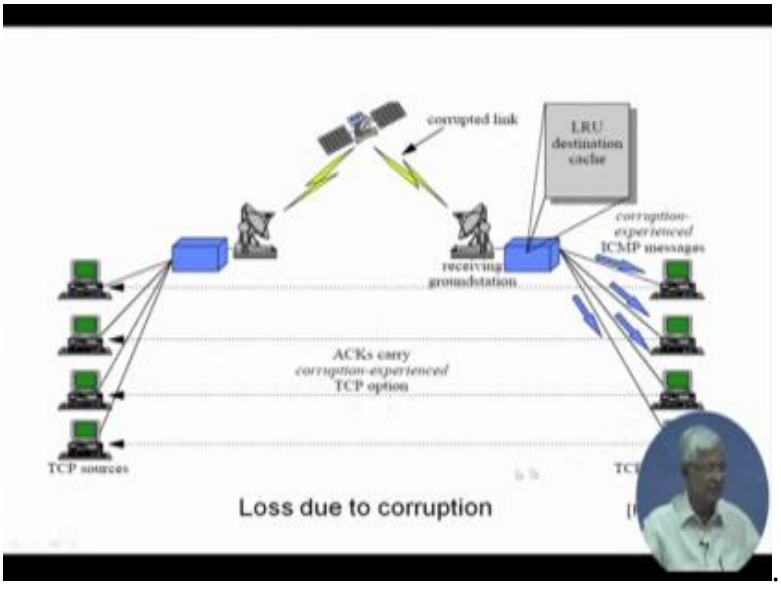
So, that is the response destination TCP waits simply that there is a there is a corruption a little bit of corruption it simply waits and the response sending TCP does not reduce the congestion window.

(Refer Slide Time: 02:32)



It does not reduce the congestion window and does not back off its RTO. RTO time out back of which normal TCPs algorithm it does not do that, it does not do the congestion control that is why TCP simply waits and then when the acknowledgment is received without corruption experienced. It is a very small corruption was there after that corruption experienced is that information is not there in the acknowledgment then it is says that a corruption state is come out. So, TCP starts working normally in that normally in that.

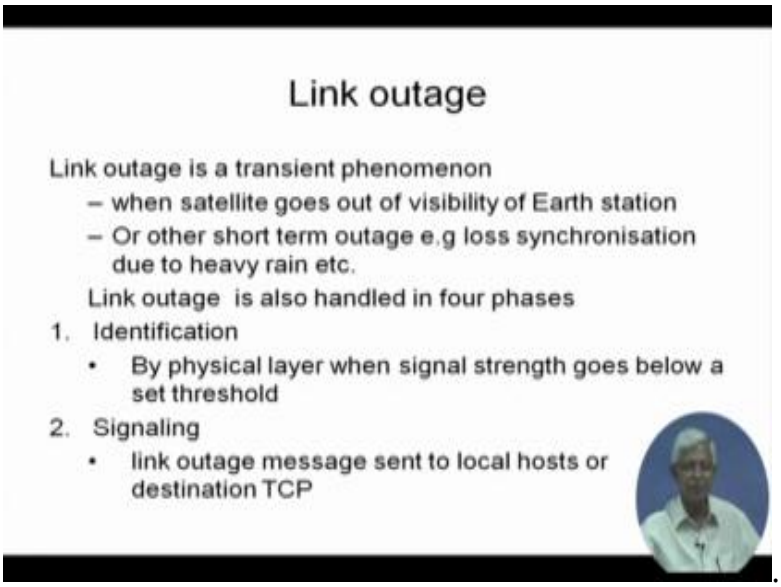
(Refer Slide Time: 03:12)



.

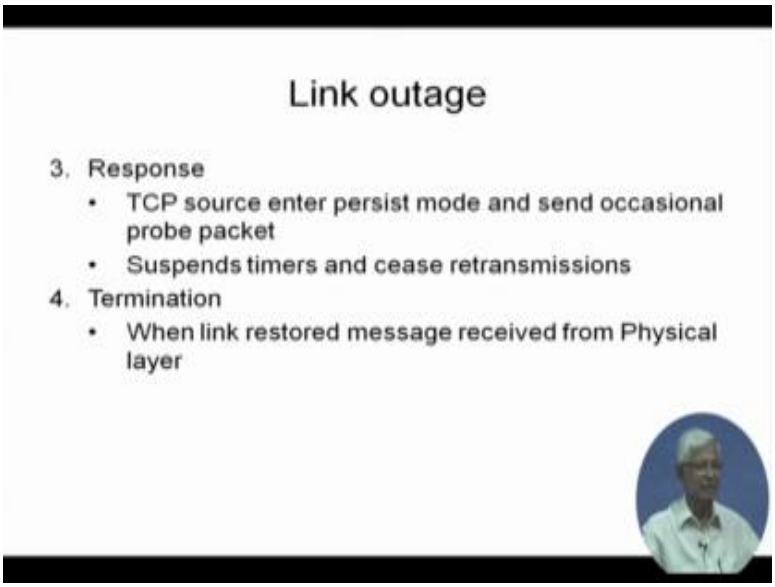
So, its pictorial instrument taken from a reference that is as the link is corrupted in the down link in this case the receiving ground station the local cash they detect it and it along with the data it says that there is a internet controlled message packet that is corruption experienced a special message is sent and that is sent back along with the ack. The receiver that is the destination sending to the source that corruption is experienced, experienced is this additional information which is going in the loss due to corruption.

(Refer Slide Time: 03:57)



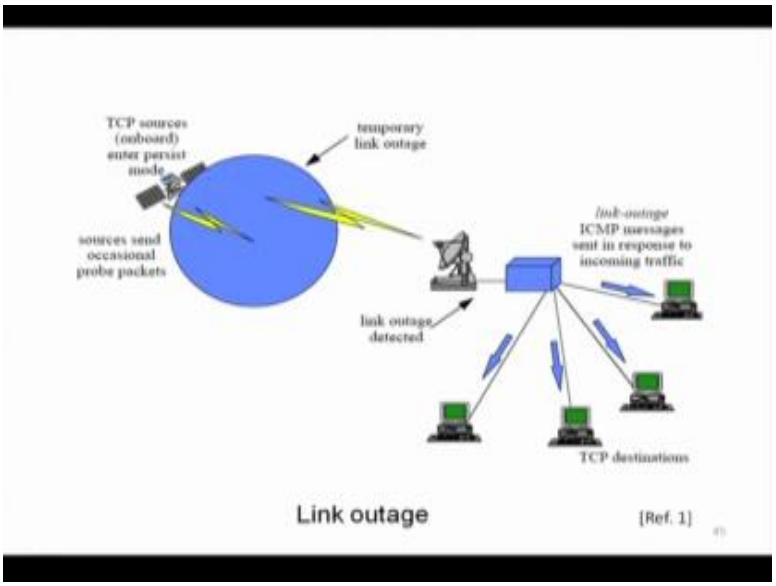
Let us see other possible with the link outage link outage is a transient phenomenon link outage is a transient phenomenon for a short duration it may come, when the satellite goes out of visibility of the earth station due to any object it comes under the shadow of object or because of any other reason or some short term outage due to loss of synchronization due to heavy rain etcetera. I was just mentioning the earlier then have many reason. So, link outage is handled also in similar four phases as we discussed in corruption case - first are identification and the physical layer again can identify this link outage means no signal is coming. So, signal strength has gone below a threshold the synchronization is lost. So, a once that is done it sends a signal that is link outage message sent to the local host it is not corruption experienced it is called link outage message it lightly different message is sent to the local host or that is destination because link is out.

(Refer Slide Time: 05:04)



In the forward set to towards the destination it can send that message. And the response of that is a TCP source enters in the persist mode and send occasional probe packet it just it just stop the transmission it just sends sometimes after sometime a probing packet that link has come back one or two and it suspends all timers and sees a normal retransmissions etcetera if it is supposed to happen it does not send anything. It does not transmit and it does not retransmit, but only occasional packet probe packet it transmits and when termites terminates that when, link is restored message is received from the physical layer that this phase is terminated that is the link outage phase the link restored information is available from the physical layer that is modulated demodulated when get into sink and that message can be sent to the higher layer since it can be pictorially.

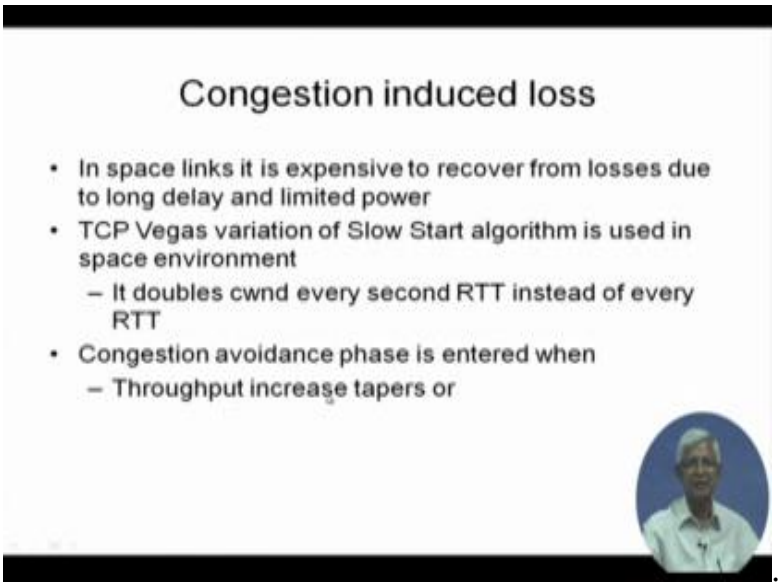
(Refer Slide Time: 06:05)



Shown that is there is a satellite is gone into the shadow of the received station and there is a there is a temporary link outage which is detected here because this signal is not coming and so there are that is special controlled message packet that sent to the destination that link is called there. So, it cannot do anything and the TCP source goes into persist mode it does not get ack. So, it goes into persist mode and it occasionally send probe packet.

So, when the probe packet is through then signal is again detected and then this will come out of the destination and normal thing is restored. So, it does not go into slow start mode that is very that is very important this is a transient phenomenon it says satellite is moving and it will go out of the shadow of this object and the link will be restored. So, therefore, it does not go into the congestion about congestion experienced and a slow start mode that is the link outage.

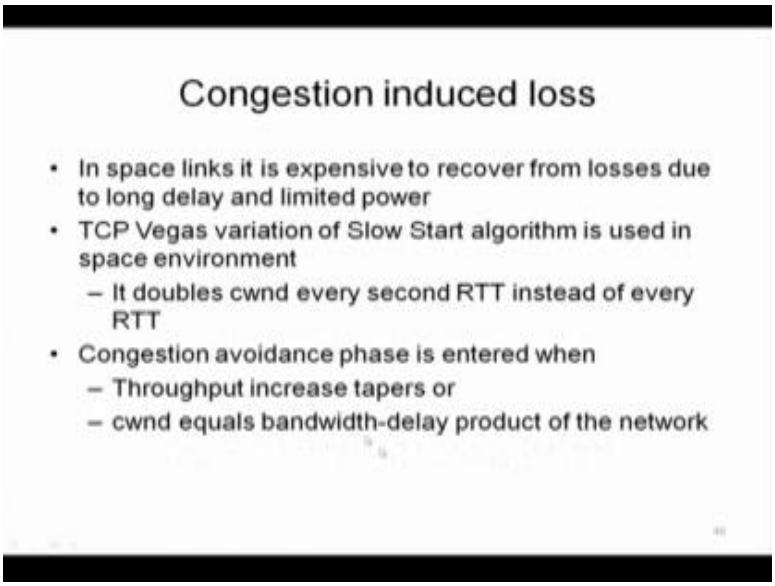
(Refer Slide Time: 07:17)



But then in satellite network there also can be congestion like a normal network. If it is there when it exceeds the network capacity its congestion, in that case also there are there are slight modification of the protocol I mean we are not going into very detail, but just briefly here, I will try to mention in a space link it is expensive to recover from the losses due to long delay and limited power that is important right as limited power and it is a long delay.

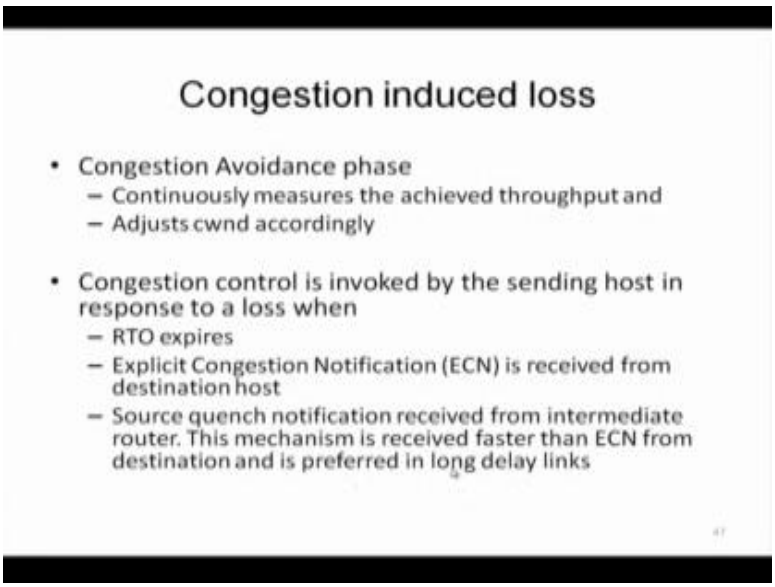
Therefore, it is its great expensive to recover. So, there is a variation of the normal standard TCP which is called TCP Vegas and we are not going to very much detail of that and briefly I will mention some of the important of that the TCP Vegas. Variation of the slow start algorithm is used in this space environment now what it does that it doubles the CWND second RTT every alternate RTT instead of every RTT goes up sorry slowly there that is part of the TCP Vegas, its a standard thing and congestion of avoidance phase is entered by measuring the throughput reduction of the throughput through put increase and normally throughput go on increasing. So, when it tapers then it understands instead of earlier standard TCP that is it exceeds CWND exceeds the s s threshold that is what is the congestion of avoidance phase in this case the through put is tapered.

(Refer Slide Time: 08:47)



So, CWND equals the bandwidth delay product of the network and it tries to maintain always.

(Refer Slide Time: 08:54)

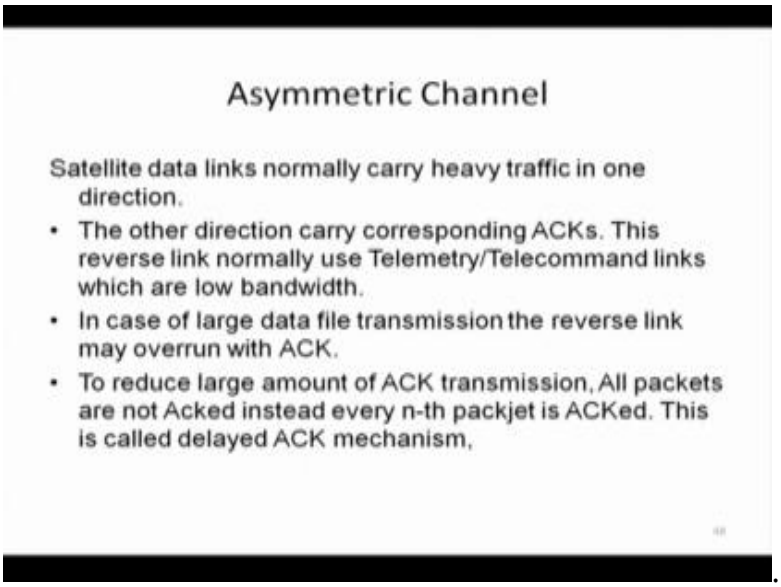


And then in congestion of avoidance phase a continuously it measures the achieved throughput and it adjusts the CWND accordingly. When you are going into detail, how it is adjusted those who are interested they can read that rf is corresponding and standards which are available from the internet transports congestion control is invoked by sending a host in response to a loss. When RTO expires and when the explicit congestion

notification is received from the destination host this is also existing in the standard TCP. So, there is a special notification when the layer the in between router routers they understand that there is a congestion is happening they try to send this notification to the destination saying that congestion this congestion is expected. So, this ensures accordingly.

So, the congestion control is invoked based on these two issues and then there is a source quench notification received from the intermediate router this mechanism is received faster than ECN from the destination and is preferred in a long delay link and the difference I will just try to mention that in between router. When it understands that there is congestion is going to happen, ECN it sends to the destination and then destination will send in its acknowledgment that congestion ECN has come. So, sender will take certain action that is a longer process and if this router sends source quench notification sends back to the sender then this mechanism is received faster than ECN than in a long delay link it is advantageous.

(Refer Slide Time: 10:45)



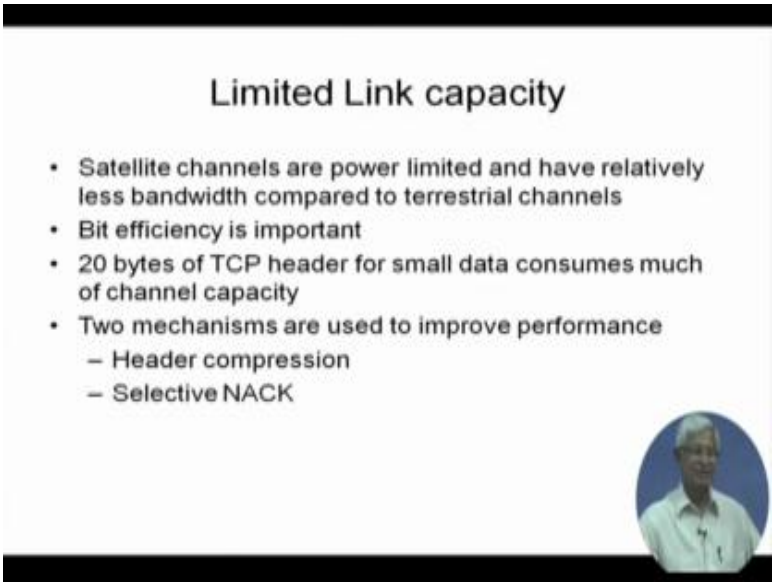
So, satellite data links normally carry heavy traffic in one direction. So, that is about congestion thing and different types of error sources detection and corresponding mitigation technique what we thought.

Now, we are getting into the another issue in the satellite channel which is asymmetric channel and satellite data links are normally carry heavy traffic in one direction and other

direction carry normally acts like say is a say a large volume of data is monitored and say a radar data are moon surface data is collected, which is a high volume data is sent in one direction the other direction will be only ack. So, other direction carries only ack. Now ACK is very small amount if it is only header. So, this reverse link is normally put along with the telemetry and telecommand which is a very low bandwidth link. So, in one side a heavy volume of data is coming the other side the ACK is going which goes along with telemetry telecommand link which is a we have seen earlier is already ten kilobits per second that type of a link low bandwidth.

In case of large data file transmission the reverse link may over run with the ACK because, large files are coming with segment side. So, each segment will be sending ack. So, now, the ACK will be more than telemetry telecommand. So, this may overrun. So, that could be a problem. So, reduce large amount of ACK transmission. We have to we have to reduce that all packets that are not ACKed all packets are not ACKed instead only nth packet is ACKed. So, it is some sort of a delayed ACK mechanism. So, I reduce the volume of ACK to accommodate then in the reverse link which is telemetry telecommand link which is a low bandwidth link this is the managed this is how it is managed in there in the space link.

(Refer Slide Time: 12:44)

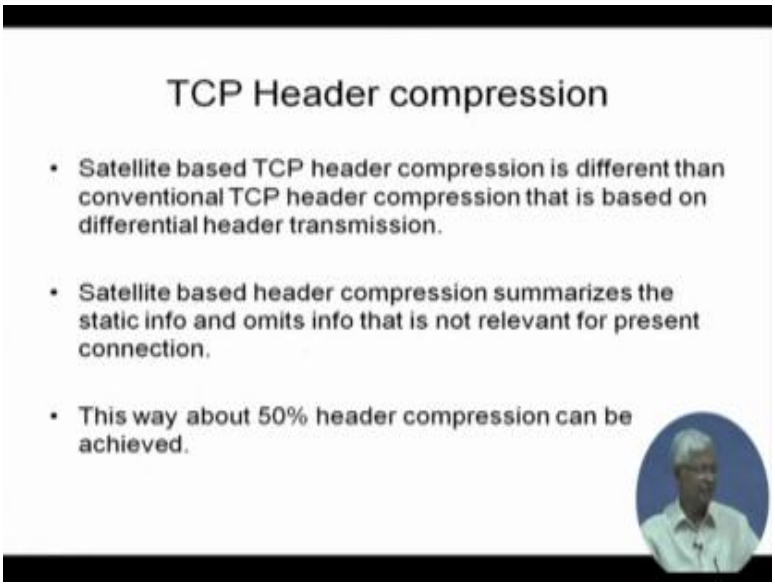


Let us see the other thing which is linking capacity it is a limited link capacity; we know the power available at the satellite probe is limited. So, accordingly to get the proper c by

n the link capacity the bandwidth has to be reduced satellite channels are power limited and have relatively less bandwidth compared to the terrestrial channel we know this.

So, here the since bandwidth is less bit efficiency is very important we should not send the bits which are not relevant or not important for that particular link. So, now, you see TCP had a header of twenty bites normal header it is not extended yet 20 bytes for small data when the data volume is small compared to the header. The header is much larger then channel capacity is unnecessarily absorbed or consumed by the header itself and all the twenty bytes may not be useful. So, 2 mechanisms are proposed in this to improve the performance this is specifically for the space data link one is called header compression and another is called selective negative acknowledgment let us let us look at these two techniques briefly.

(Refer Slide Time: 14:09)



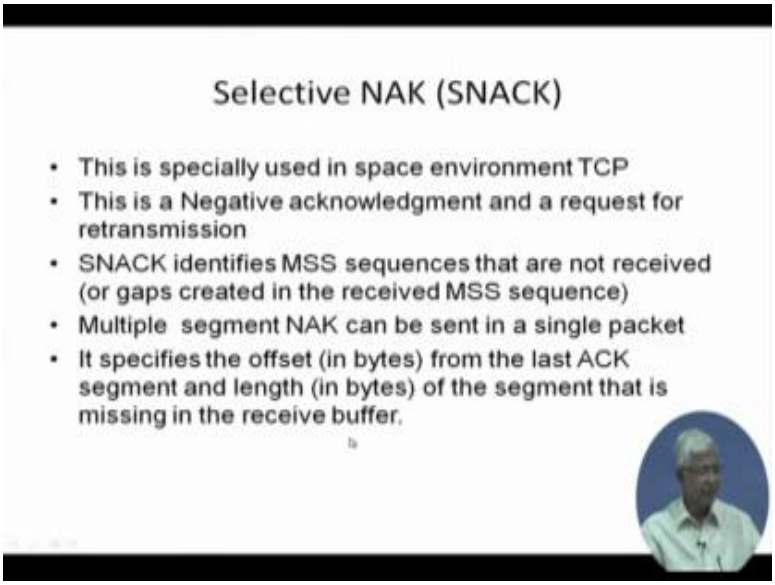
Header compression then there is a standard header compression which is available in the TCP which is actually a some sort of a delta function that is whatever earlier header was there and the new header the difference of these two and is a very simple, but that is a standard, but in this case they are not between that the satellite based TCP header compression is different than the conventional TCP header compression which is also available in standard that is based on differential header transmission it is not that there are problems.

So, when we are not discussing through. So, so many details what is proposed that is

what we will discuss satellite based header compression summarizes the static information and omits the information that is not relevant for the present connection, I had briefly just mentioned that is instead of source address and destination address which are quite long in terms of they give sudden identifier port identifier source port and destination port address are very long. So, many bits are there.

So, instead they use unique and port identifier for each fragmented each segments as long as the connection is there that port identifier identifies clearly. So, that could be much smaller in length unique identifier or in the like TCP flags and all flags may not be used. So, those things can be that static information which is not dynamically changing during the connection that can be reduced. So, this way about 50 percent of the header compression can be achieved. So, this this is the technique which is slightly away from the standard header compression proposed by I t f that is internet enhancing transports is slightly different than that, but it is much more reliable it has been found experimented and proposed and accepted by the CCSDS and roughly about 50 percent header compression there.

(Refer Slide Time: 16:09)



The other technique is selective NAK SNACK.

Now, SNACK is not in the standard TCP protocol in the TCP protocol there is a NAK only NAK, but which is not used as a standard, which is already proposed and selective ACK which is already existing and proposed as well as taken as a standard TCP. Now

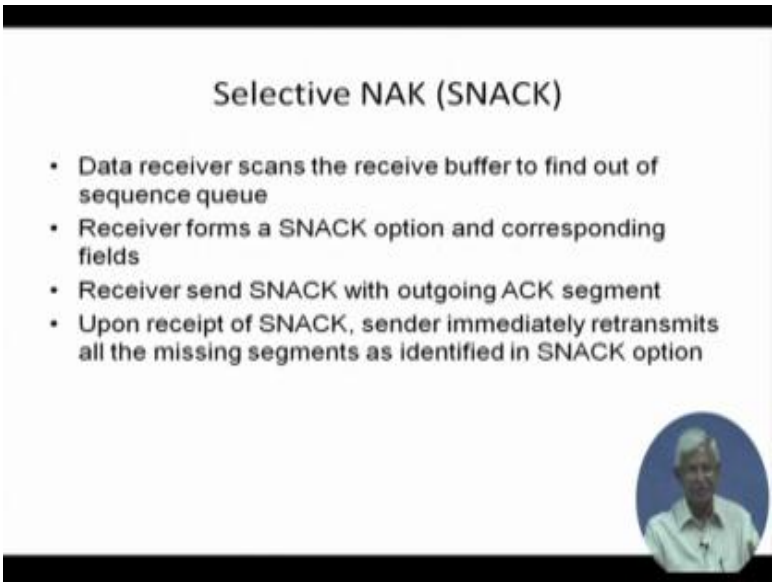
this is slightly different than these two this is specially used only for space environment TCP there is a negative acknowledgment and this is a negative acknowledgment and request for retransmission. Normally you if you remember the TCP say acknowledgment which is positive acknowledgment and if you do not get a positive acknowledgment within certain time then you retransmit.

So, not receive a positive acknowledgment is treated as a loss of data in this case receiver says that clearly says that this is not received. So, it is a negative acknowledgment. So, there is a hole in my or there is a gap in my receive buffer and that gap is identified with the start of the gap from the beginning there is offset of that and the length of the gap. So, like that there may be many gaps. So, only that gap information is passed on from its received buffer and though is updated as a selective because we are selecting the gaps and it is a negative acknowledgment that I do not have this it is a gap, this is how the technique works.

So, it requests for a transmission. So, SNACK identifies the MSS sequences that are not received or gaps created in the received MSS sequence.

So, multiple segment negative acknowledgment can be sent in a single packet, but it all depends that its SNACK packet is limited by its size with even with extension. So, if there is much more than what it can accommodate much more gaps are there. So, there will be subsequent NAK s represent its specified the offset from the last ACK off set in terms of number of bytes last ACK segment what was when positive ACK segment and the length of that gap in bytes of the segment that is missing and the receive buffer.

(Refer Slide Time: 18:40)

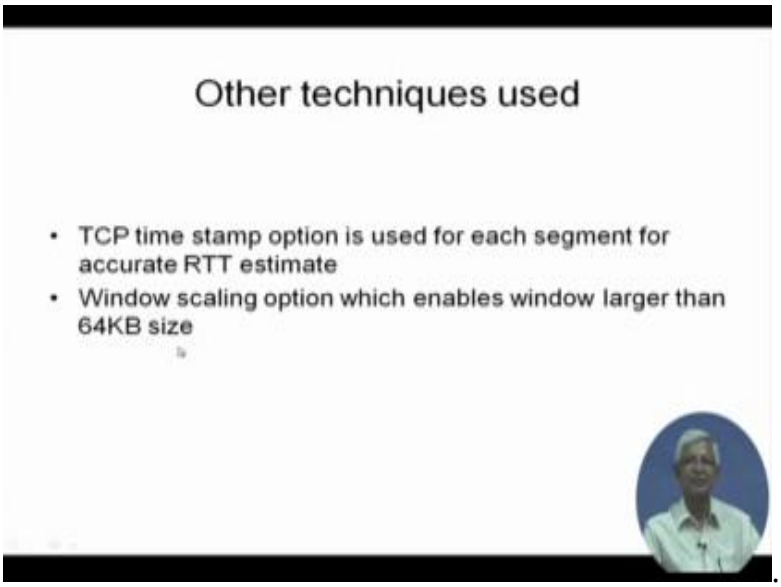


Now, the data receiver actually scans the receive buffer to find out the sequence in to find out the out of sequence queue and the receiver performs that SNACK option and there is a specific control filter which says that this is a SNACK and corresponding fields. It sent and along with the normal outgoing ACK segment sends that these are the these are the ideas which are which are not received you understand this that is that he has received something and he is sending ACK earlier TCP standard says that it can send ACK only up to what he has received in order properly in this case he sends he has received some segment and he sending ACK for that segment and even, if there are certain gaps he will send those gap information earlier you would not have send the ACK for this you would have send the ACK for the up to last one which is ordered and sequence received and if there are gaps you will second duplicate ACKs of, duplicate ACK of the previous one which sends the ACK of the correct one received and in between which are not received I say. So, that is SNACK.

So, SNACK goes along with the outgoing ACK segment and upon received of the SNACK the sender immediately retransmits all the missing segments as identified by the SNACK option you know that is the sender size. Now he knows that these are the though it is in his transmit buffer sequentially they are put, but he knows now in which sequence are missing. So, he takes out and puts into his new queue and that it is not a standard sliding we will do arrangement what earlier TCP we have discussed it forms a new queue and sends this the missing segments and of course, it tries to fill up the network capacity

of that.

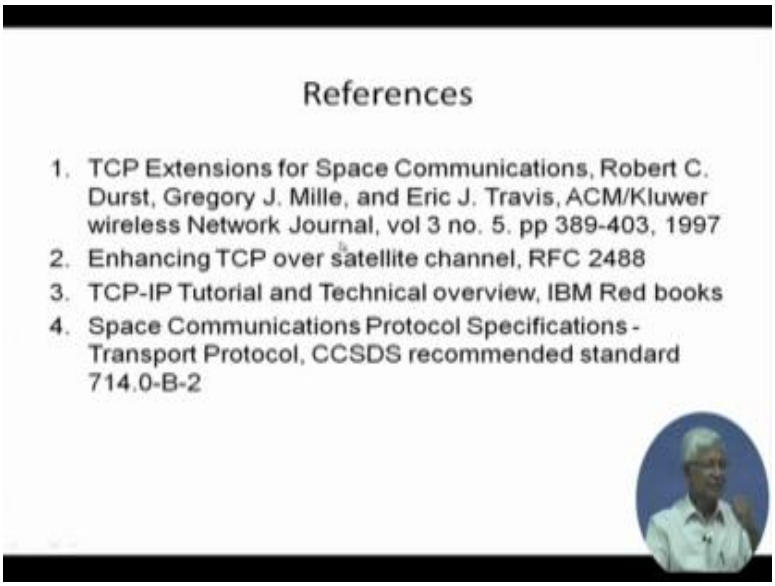
(Refer Slide Time: 20:39)



So, the other techniques which are used in this communication are of course, that the there is a time stamp option that is the RTT has to be estimated accurately. So, for that each along with each segment it gives a time stamp normal TCP it sends the time stamp at the beginning of the connection establishment, it sends a time stamp and that goes down through different router to the destination and receiver sends it back. So, the sender finds out the difference of the transmit time and received time of the connection initiation packet and he estimates that this is my total delay expected and then he does certain algorithm over that try to find out what should be the expected RTT and what should be its RTO for a normal packet, but in this case for every packet he is sending a time stamp for each segment and for every packet it knows what is happening to the delay because the satellite is moving the probes are moving or may be is on the ground there is a certain movement. So, because of that delays will be varying.

So, therefore, the accurate estimation of the RTT continuously is very important. So, that is and that is one of the thing which is done and also we have talked about the window scaling option which enables the window which is larger than 64 kilo bit size then in that case the we have given example, with the example we have seen that one is giving a option which is required that when RTT is much-much larger. So, these are the various techniques.

(Refer Slide Time: 22:31)



We have talked and the main thing it is not available always in the text book. So, therefore, those who are very much interested to know I would suggest this way of the looking at the references though I have listed 4 of them there may be. So, the basic starters I would suggest that take the reference number three which is the TCP IP tutorial and technical we are going to slightly, older issue, but you will know what is a generally what is a an particularly chapter chapters we do not have to read whole thing because, we are looking for the satellite communication part.

So, read that chapter which is there on internet protocol that IP and read the chapter which is on the TCP protocol transport into protocol and then you should also read, there is RFC request for these are available in the internet and that is internet engineering transports the issue request for common with sub numbers and various issues that is concerned that some of them are simply informational some of them are standards. So, this is a standard this is the information thing at the research is that going on slightly older this is a, but there you will know that what are the issues the TCP people they were enhancing transports were working. So, enhancing TCP over satellite channel this gives you certain overview of the problems what are faced initially and the solution they were suggesting those days, but that is not what fully implemented in what we discussed today that is available in the in the first reference this is a paper which is worked out in detail based on though it is 1997, but based on those days whatever TCP standard protocols are wherever available.

Now, more or less that is what is running. So, they what we discussed today is mostly from this paper and of course, they talked in much more detail I have given you only very brief the s part of dub thing and based on their recommendation, they have to reference first recommendation this the fourth one which is the standard s body CCSDS which has accepted. And now all the almost all the space agencies they are following this the transport protocol standard also they have IP protocol standard many other things are there in CCSDS. So, you can go through the CCSDS site also.

So, with this we stop at the this discussion on the higher layer impact on the higher layer because of the physical layer and certain missing mitigation techniques which are proposed and which are being used right now.

Thank you very much for your attention.