Real Time Systems
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Lecture 47
Introduction to Real – Time Communication

Good afternoon to all of you. So, now today we will discuss a new chapter on real time systems. So, the topic that discuss we will start from today is on real time communication, how communication will be made in real time systems.

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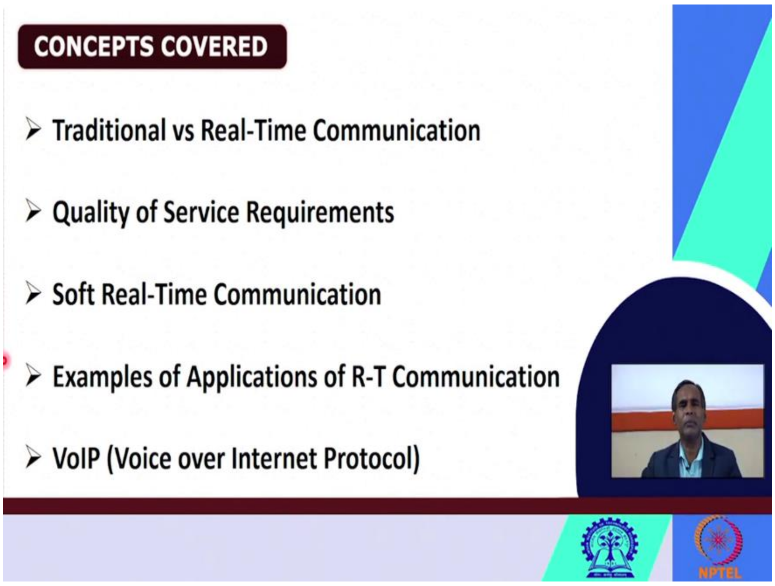

We will first see about this, how does this real time communication differ from traditional communication, what are the quality of service requirements or QoS requirements, the different types of communication in the real time systems mainly there are two types, soft real time communication and we can say that simply non-real time communication. Then examples of applications of real time communication where real time communication is applied and finally we will discuss about VoIP, voice over internet protocol.

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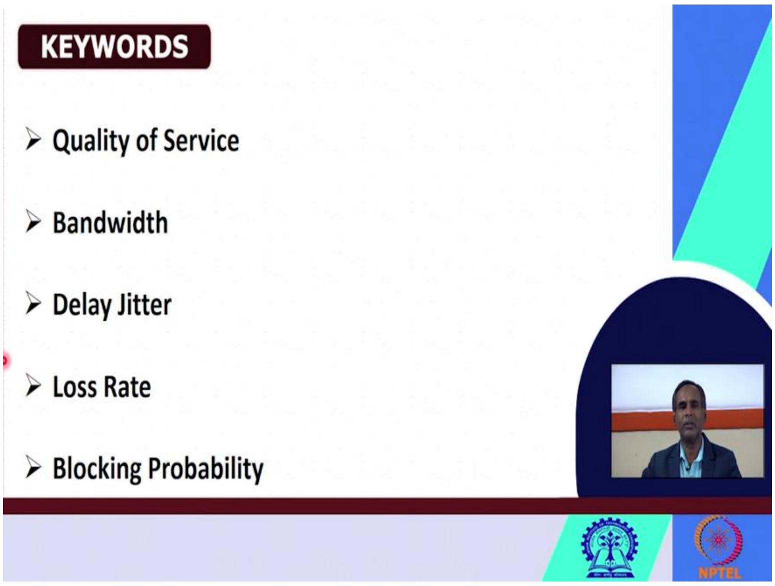

We will use these key words, quality of service, bandwidth, delay jitter, loss rate, blocking probability and so on.

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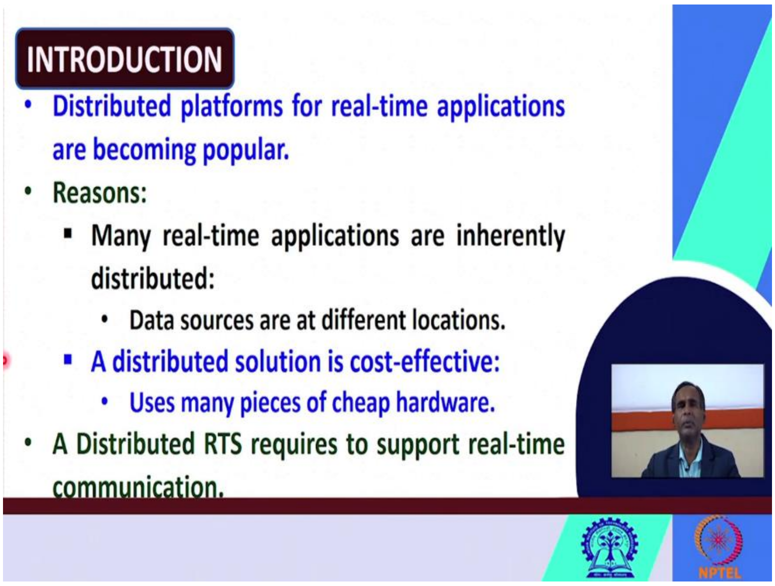

Let us, start about little bit introduction to these real time communications, you know that distributed platforms are becoming very much popular for real time applications. Why? What is the reason? Why distributed platforms for real time applications are becoming popular? The reason is that one of the reasons is that many of the real time applications they are inherently distributed in nature, how? Or why? Because the data sources are at different locations, where the data where from the data are coming those locations are at different places.

So, the data sources are at different locations so many of the real time applications by nature they are inherently distributed. So, also you will see that a distributed solution it is cost effective, because it uses different pieces of or many several pieces of cheap hardware, those it uses several pieces of cheaper hardware which are less costly or which are cheaper.

So, that is why the distributed solution, it is becoming cost effective in several situations. A distributed real time system it required to support real time communication. So, that is the important thing you have to remember. A distributed real time system it has to support real time communication not the traditional communication.

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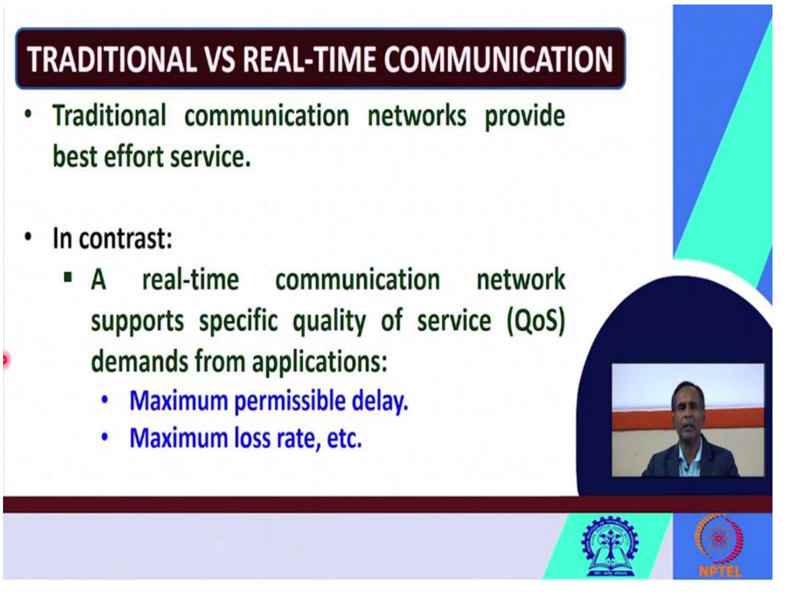

Now, let us see how does this real time communication it differ from this traditional communication, you know this traditional communication networks they provide best effort service, whatever what best effort service can be provided this traditional communication networks they try. So, traditional communication networks they provide the best effort service to the applications. But in contrast in real time communication, what is happening? A real time communication network it provides it supports some specific quality of service we call them as QoS.

So, a real time communication network it supports some specific quality of service demands from the application. So, any real time communication what does it demands? It demands some certain specific quality of service from the applications. So, real time communication network, it supports specific quality of service or specific QoS demands from different applications. The examples of sub, such specific quality of service demands maybe like what should be the maximum permissible delay, what could be the maximum loss rate etcetera, so these things have to be specified in real time communications.

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So, now let us see what actually is real time communication. So, in real time communication once the network accepts a connection request, what does it try? It guarantees the requested service quality. So, what service quality is requested from the application it tries to get into that, so in any real time communication once the network accepts the communication request, it guarantees that requested service quality, it guarantees the requested service quality.

So, what exactly then is the service quality? What do you mean by service quality? As I have already told you that in real time communication, when the network accepts a connection request, it guarantees the requested service quality. So, then what do you mean by this service quality? Or what do you mean by the quality of service? What exactly is service quality or quality of service let us discuss.

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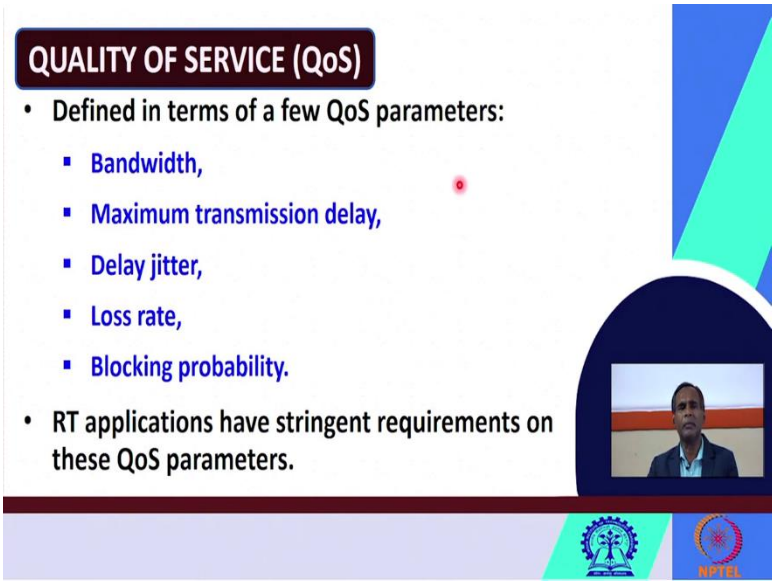

So, quality of service how it is defined? It defined in terms of few parameters. Service quality or quality of service which we do know as QoS very much important in networking or in real time communication. So, this quality of service is defined in terms of a few parameters we call them as QoS parameters or quality of service parameters. Let us, see in what parameters are there.

So, quality of service is defined in terms of a few parameters named as QoS parameters. For example, some of the QoS parameters I have listed below such as what should be the bandwidth, what should be the maximum permission over transmission delay, what should be the delay jitter, what should be the loss rate, what should be the blocking probability? So, this quality of service is defined in terms of the following quality of service parameters.

These real time applications they should have stringent requirements on these quality of service parameters. Whenever you are talking about any real time applications, the real time applications they should have stringent requirements, on what? On these quality of service parameters.

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Now, let us see what do you mean by this quality of service requirements. We have classified the applications normally, please recall in the initially you have known the real time systems they can be classified into three categories, hard real time systems, soft real time systems and firm real time systems, is not it? So, we have already earlier classified applications into what three types, we have classified the real time applications into three categories such as hard real time system, soft real time system and firm real time system, based on what? Based on their task characteristics.

But while we will discuss the real time communication such types of classification cannot be met, it is very difficult. So, such types of classifications as we have seen soft real time system, hard real time system, firm real time system, such classification of communications based on the quality of service requirements is very much difficult.

So, what we will do? So, we shall try only to classify these real time communications into two major categories number one, the real time communications, number two the non-real time or the soft real time communication. So, through our, these lectures we will discuss about only two types of communications maybe real time communication and non-real time or soft real time communication.

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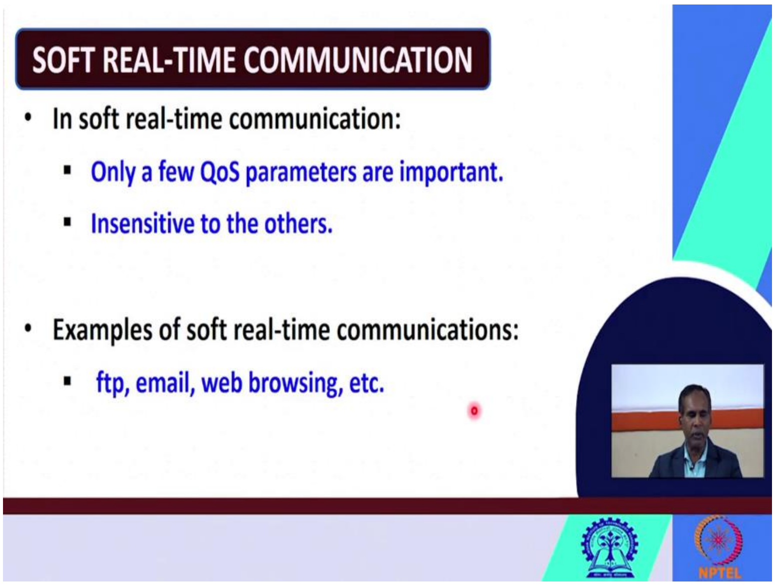

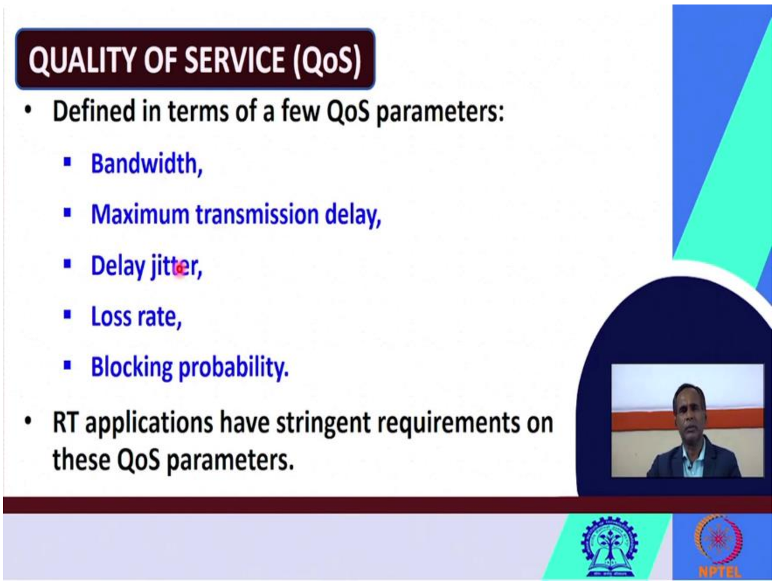

Let us, see first what do you mean by this is soft real time communication. In soft real time communication what is happening? Only a few quality of service parameters are important, we have listed so many quality of service parameters you see, we will see the definitions I will tell I have given these examples of some quality of service parameters, but while we will discuss this soft real time system, so the soft real time in the soft real time communication, what happens only a few QoS parameters are important not all, only a very few quality of service parameters are important.

So, what is about the others? The real time communication is insensitive to the others, it does not bother about the other parameters. So, only it considers a few quality of service parameters as important, other parameters it does not consider it is insensitive to the other parameters, for example, if we will see the soft real time communications, what could be the examples of soft real time communications?

So, few examples of soft real time communications are FTP, I hope you know FTP, it stands for file transfer protocol, every day you are sending emails you are browsing the web etcetera, these are all examples of soft real time communications, or in these systems you are using soft real time communication.

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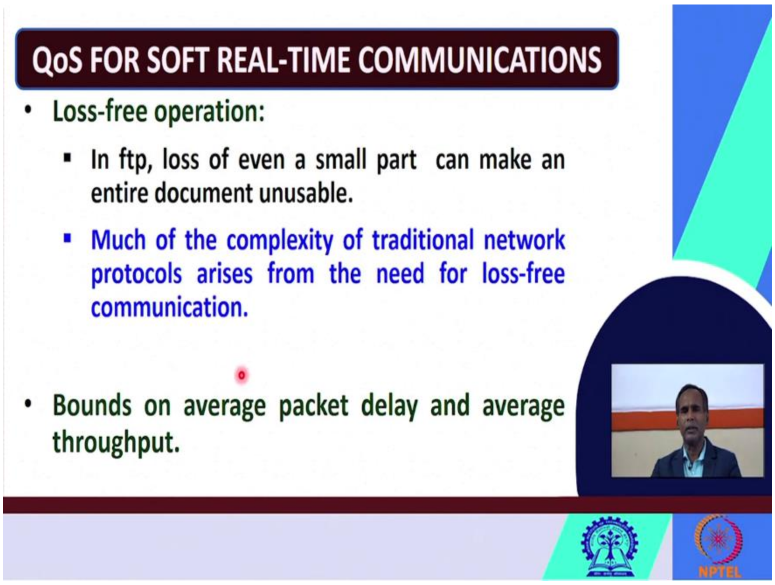

Then let us see something about the quality of service for the soft real time communications, le us see. So, normally it uses loss free communication, let us check about this FTP. So, let us see what do you mean by this loss free operation in case of FTP. In this file transfer protocol loss of even a small part can make an entire document unusable, please try to understand in FTP what we are doing? File transport protocol, we are trying to send a we are trying to transfer a file from say one end to another end.

So, now suffer during this file transfer, so only a few part of the file it is what corrupted or it is being lost, then what will happen can you open the rest part of this file? No, you cannot open, even a there is loss of even a very small part in the file, it will just make the whole document unusable, you cannot open you cannot read the whole file.

So, it is what does it mean? That when you are making FTP, you should use the loss free operation, the file has been transferred means, whole the file has been successfully transferred not even a small portion of the file is lost. So, this is called as a loss free operation. So, we have explained how in FTP, even there is a loss of small part of the file it can make the whole entire document unusable. Much of the complexity of the traditional network protocols arises, why? Due to only this need for loss free communication.

So, these we have seen that these normal network protocols should support the loss free communication, but the traditional networks we have seen if we will apply this loss free protocol, this loss free communication to the traditional network protocols then it will become much more complex.

So, much of the complexity of the traditional network protocols it occurs it arises due to this need for loss free communication. So, it bounds on average packet delay and average throughput. So, this it bounds on the two things, the average packet delay and the average throughput. I hope what is the average packet delay or what is the throughput you have already known.

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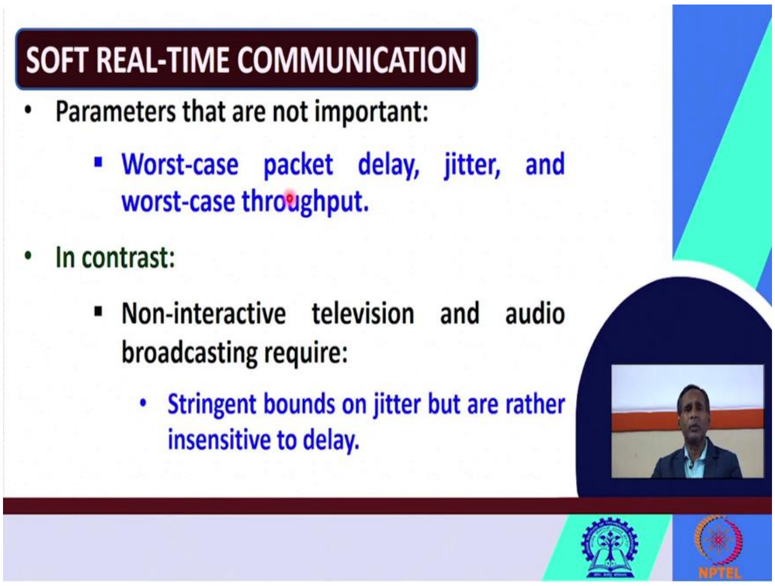

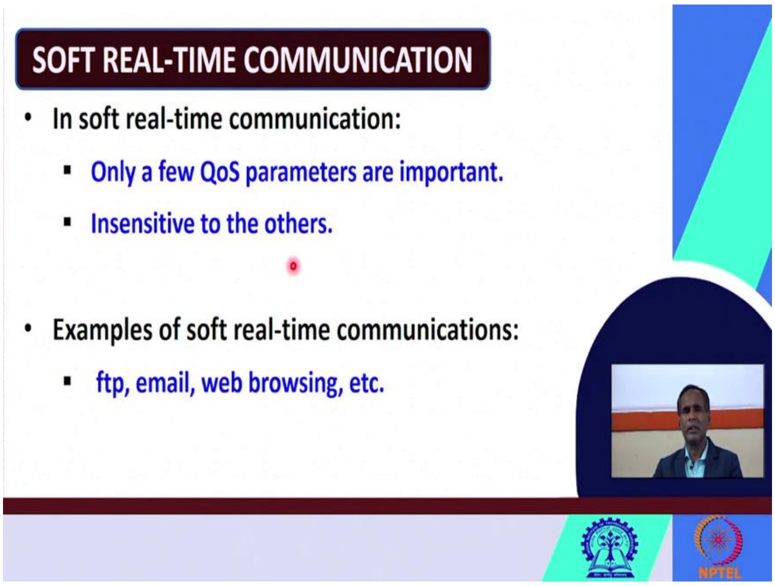

So, now let us see in soft real time communication what parameters are not important, I have already told you in soft real time communications only few parameters are important rest parameters are insensitive and let us see what are not important for soft real time communications. So, let us see. So, parameters that are not important though they are insensitive in soft real time communications are as follows like, what is the worst case packet delay, the jitter and the worst case throughput etcetera. These are not so important in case of sub real time communications.

In contrast, if we will see the non-interactive systems like in case of television, it is not interactive, you cannot say only the what this, what from the studios what they are saying you can only see or listen. Similarly, audio broadcasting, in radio from the studio they are what they are broadcasting only you can listen you cannot interact.

So, in those non-interactive the system such as television and radio broadcasting, what do they require? They require stringent bounds on the jitter but are rather insensitive to delay. So, there must be bound on jitter, what could the maximum permissible delay etcetera, but that is important. So, they require stringent bounds on jitter but are rather insensitive to delay, but if what about the other parameter delay, they, so these non-interactive systems are insensitive.

So, we have seen in case of for these, what in soft real time communication we have seen that parameters such as worst case packet delay, jitter and the worst case throughput they are not so important, but if you will see the non-interactive system such as a television and audio broadcasting etcetera, they require stringent bounds on the jitter but they are insensitive, but rather insensitive to delay, delay is not important for them. So, this is how we can see about which parameters are not so much important in case of soft real time systems.

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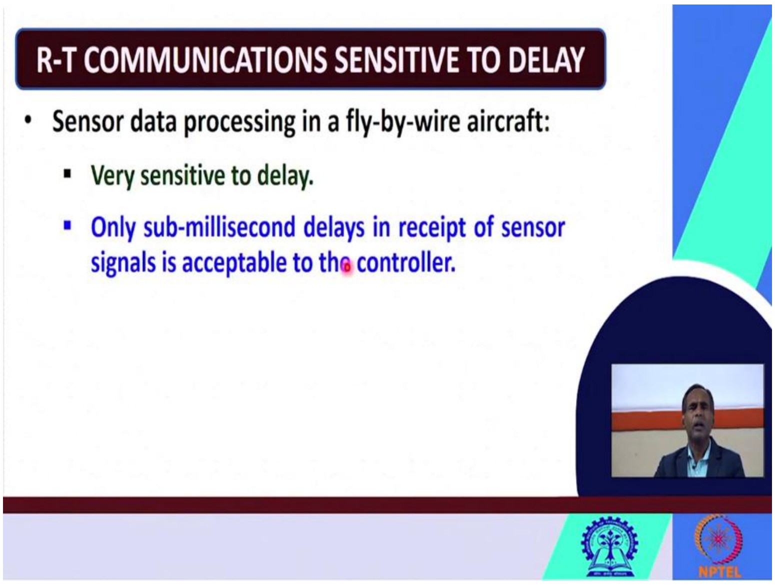

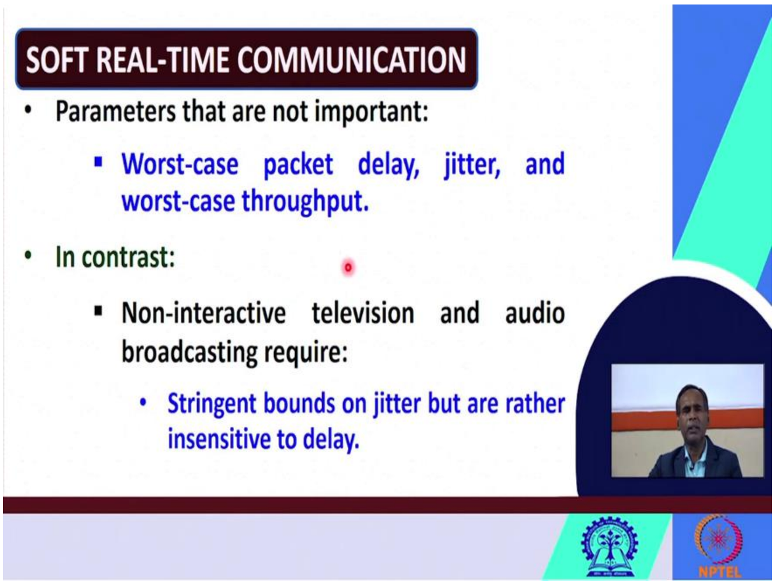

Now, let us say this real time communications sensitive to delay, how? I have they told you that the soft real time communication they do not consider few of the parameters, some of the parameters are not important for them, for as worst case packet delay, jitter and this worst case throughput.

But it will see that these real time communications, here you can see that some of the real time communications they are sensitive to delay. For example, the sensor data processing in a fly by aircraft say an aeroplane is flying, so the sensor data which is processed, the sensor data processing in a fly by wire aircraft is very sensitive to delay, very sensitive a small a fraction of the second if it is, there is some delay so in receiving the sensor data or in processing the sensor data what will be there? Its direction might change, it might what somewhere else what its velocity its direction maybe changed, it might collide with some other thing.

So, the sensor data processing in a fly by wire aircraft they are it is very much sensitive to delay. So, very fraction or millisecond it can just tolerate, so only a sub millisecond or a fraction of millisecond delays in receipt of sensor signals is acceptable to the controller, see millisecond how much it is what very tiny, so again fraction sub millisecond.

Only sub millisecond or fractions sub millisecond delays in receipt of the sensor signals is or may be acceptable to controller, otherwise it will not accept any of the delay of a millisecond it will not accept. So, this is shows how the sensor data processing in your fly by wire aircraft how much of this is sensitive, how much how it is sensitive to delay.

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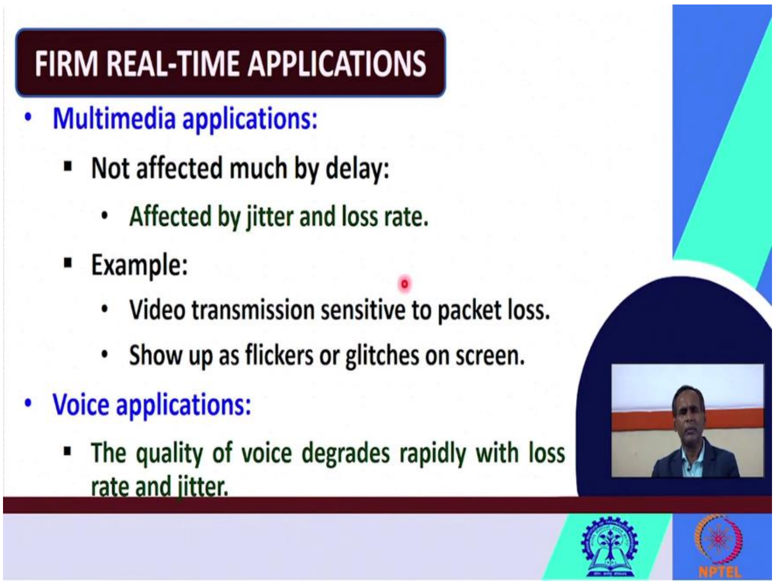

Then we have already seen the soft real time systems then we will see about something firm real time applications, how these real time communication is what addressed here. So, let us see the example or the cases of the firm real time applications where the real time communication is applied how it is applied. So, you know the best time examples of firm real time applications are what? The multimedia applications, voice applications etcetera.

So, what happens in multimedia applications? It is not affected much by delay. If you will see any multimedia application here those multimedia applications they are not affected the much by the delay, they are affected by what? They are affected by the jitter and the loss rate. So, what is the maybe this packet loss rate etcetera, so these systems are very much affected by the jitter and loss rate.

So, examples of multimedia applications are what? The video transmission you can see it is very much sensitive to packet loss when suppose about you are observing this cricket match, so this video transmission is very much sensitive to packet loss, if some packet is lost what will happen? Immediately it will show up as some flickers or glitches on the screen, when some packets you will lost you might have already experienced in the TV, what will happen? It will show some flickers will show some glitches on the screen.

So, these video transmission systems or these video transmission activities, they are very much sensitive to packet loss, if a small even one packet is lost or few packets are lost, then it will show up what flickers or glitches on the screen. Another example of firm real time application is voice application. So, here in case of voice applications, the quality of the voice decrease rapidly with the loss rate and the jitter.

So, if this loss rate and this what jitter it will increase than the quality of voice it will degrade much rapidly, just the speaker is saying something, maybe in the radio system and what will happen there is a much loss rate or the jitter, what will happen? The voice quality it will degrade much rapidly; the voice quality will degrade much rapidly. So, whenever the is loss rate and jitter and if they increase then the quality of the voice degrades rapidly, this is how the real time communication concept is applied in this firm real time applications.

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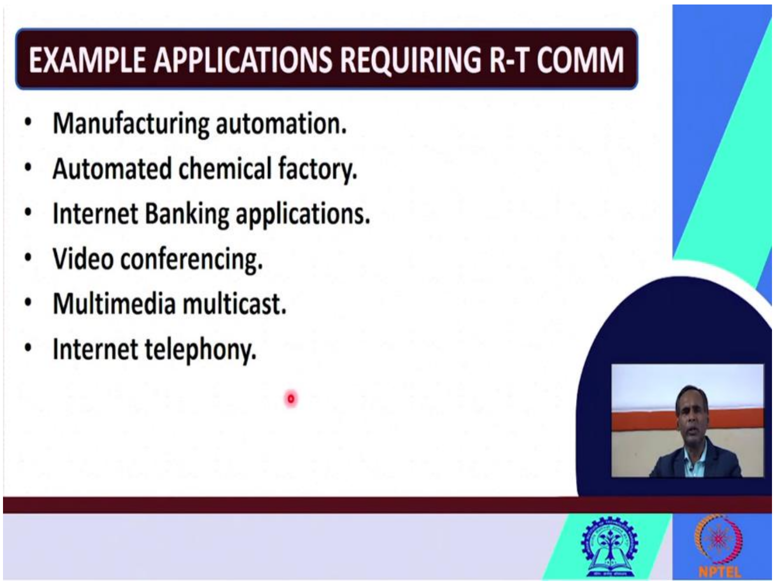

We will discuss some of the examples of applications which require real time communication, many such examples are there, but some of the common applications where real time communication is required I have listed below for example manufacturing automation, automatic chemical factory, internet banking applications, video conferencing, multimedia multicast and about internet telephony.

So, those are very common applications which require real time communication, I will discuss a little bit in detail about how these in manufacturing automation this real time communication is used and similarly for others like automated chemical factory, so these automated chemical factories, they are coming under one broader type of systems call as what we will see there are some chemical plants out there, in those chemical plants how these real time communications they are occurring.

Then internet banking you are already using, so in case of internet banking also the concept of this real time communication is used. Then video conferencing I have already the example, multimedia multicast, also I have already told the example, and similarly internet telephony, so these are some of the examples which they require the real time communications, I will discuss only one others you can see from book or any other sources. So, let us discuss how real time communication is required in case of this manufacturing automation.

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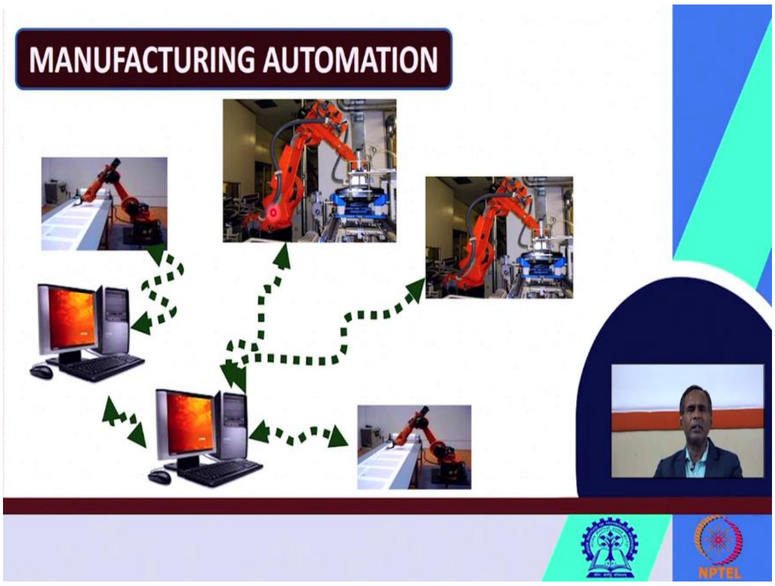

You know any manufacturing automation what happens? This is an example of a manufacturing automation system, where several robots are there, these are all examples of several robots. So, there are several robots they are placed at different locations in within a small geographical area. And these robots you know they can they communicate either with each other or they as a coordinator. So, it is controller you can say, these robots they may communicate with the controller. So, during the communication they should follow about what? This real time communication protocols, so let us see.

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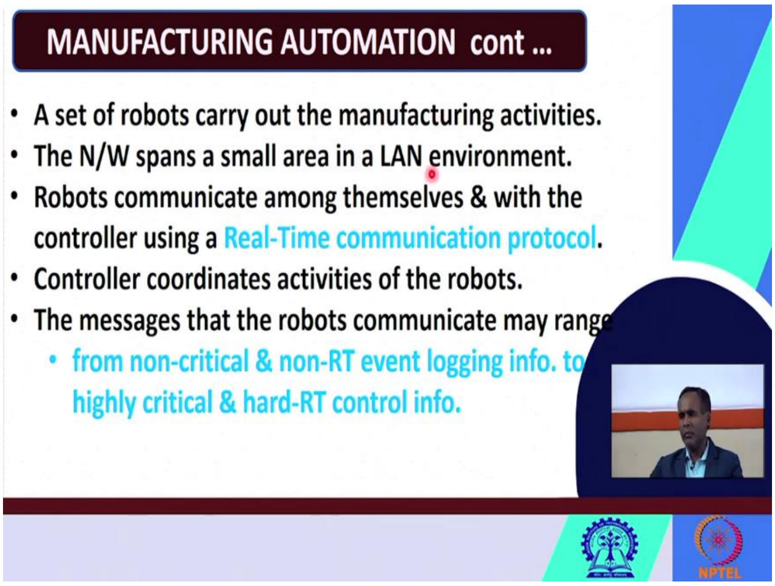

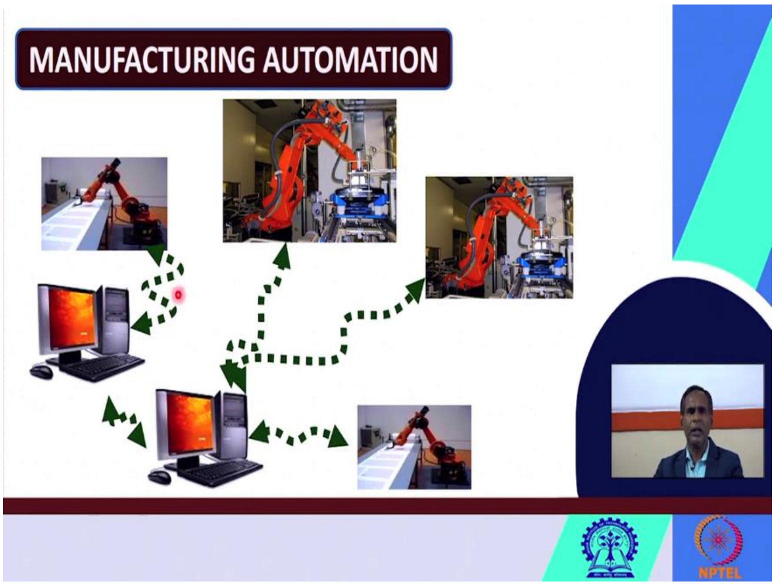

So, let us see how they in detail how these have been appearing I have already told you in manufacturing company what happens, or in manufacturing automation a set of robots they carry out the routine manufacturing activities, the network it spans a small area in a LAN environment, because it is a small company, so these robots are placed at the different locations.

So, within a small geographical area, so the network spans a small geographical area in a LAN environment. The robots they communicate among themselves as well as with a controller using a real time communication protocol. So, these robots they communicate either through themselves or through a coordinator. Suppose this is the coordinator, so they will communicate through the, through themselves or through the controller using what? Using a setup of real time communication protocols.

I hope communication protocols you have already seen in your networking paper, here we will specifically take up the real time communication protocol, in some of the next classes we will discuss few of the real time communication protocols. So, the robots they communicate among themselves and with the controller using a real time communication protocol. And this controller it does what? I have already told robots communicate among themselves and as well as with the controller.

So, the controller it does what? As its name suggests the controller it coordinates the different activities of the robots. Now, the messages that the robots communicate with the controller it may range from non-critical or non-real time event logging info to highly critical and highly real time control information.

So, I am repeating again, the robots they communicate with the controller through sending some messages, these messages for example, they may vary or they may range from non-critical and non-real time event logging info to very much highly critical and highly real time control info. In this way the messages can vary. So, all those communications they use real time communication protocol.

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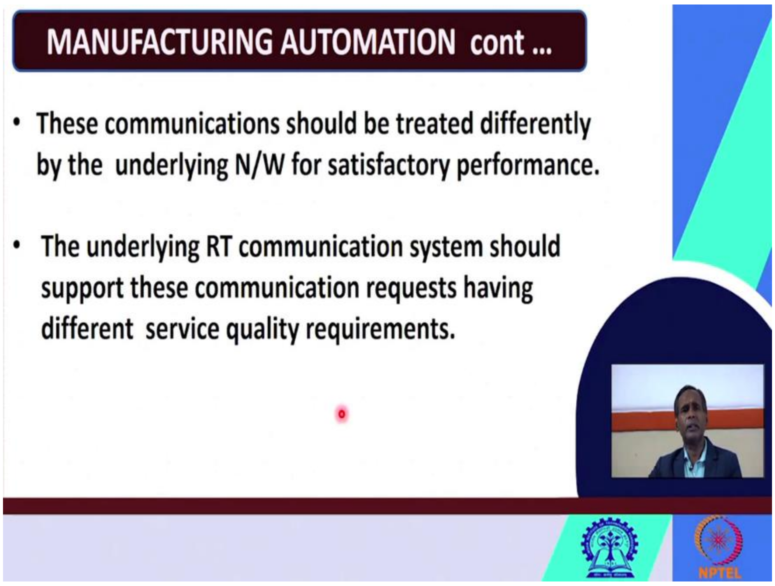

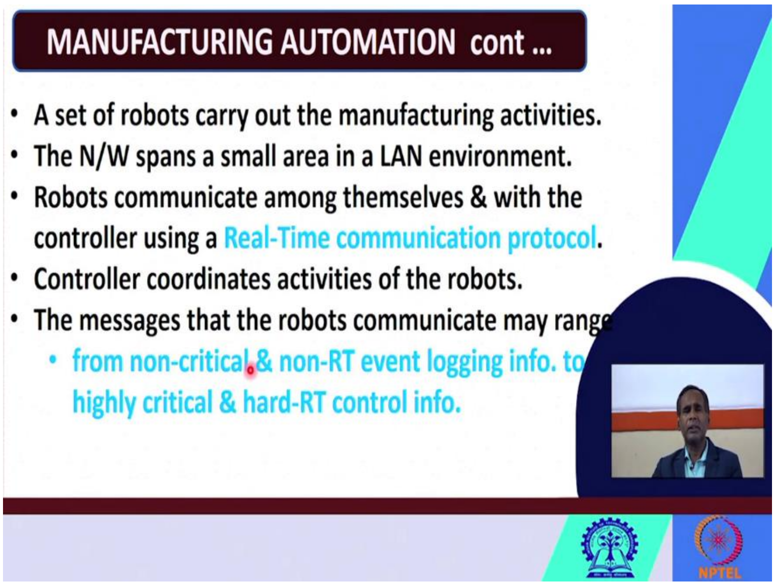

So, these communications should be treated differently by the underlying network for satisfactory performance. So, as I have already told you these messages they are varying from non-critical to, non-critical and non-real time event logging information to highly critical and highly real time control information, these communications should be treated differently they cannot be treated as same.

These communications should be treated differently by whom? By the underlying network for having satisfactory performance, the underlying real time communication system it should support this communication request having different service quality requirement. In that particular real time communication system, the underlying real time communication system it should support all these communication request from these robots.

Now, which have different or wide range of service quality requirements. So, in this you we have seen how in manufacturing automation this real time communication it is applied. So, similarly for the other examples you can see from the net or from this book.

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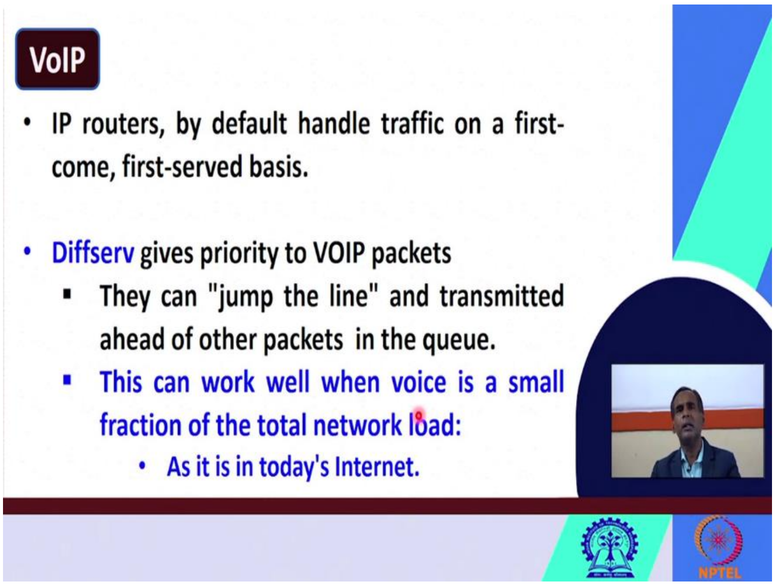

Now, let us see what is about VoIP, you know that VoIP stands for voice over internet protocol. So, what is internet protocol I hope you have already read in case of these networking subjects. So, you know that the internet protocol routers by default they handle traffic on a first come first served basis. So, in the IP routers, by default they handle the network traffic on a which way on which basis on a first come first served basis.

So, the diffserv this gives priority to VoIP packets, I have taken a small example, diffserv it gives one the priority to whom? Priority to the voice over internet protocol packets, so they can jump the line, so these packets they can jump the line and they can be transmitted ahead of other packets in the queue, you know in a networking so all those packets they will be arranged in a queue, as I have already told you diffserv it gives priority to what? To the VoIP packet, voice over internet packets.

So, these packets they can jump the line and they can be transmitted ahead of the other packets present in the queue. This can work well when voice is a small fraction of the total network load. So, this can work well when? When the voice is a small fraction of the total network load as it is in today’s internet. So, today's internet this is happening. So, this can work well when the voice is a small fraction of the total network load.

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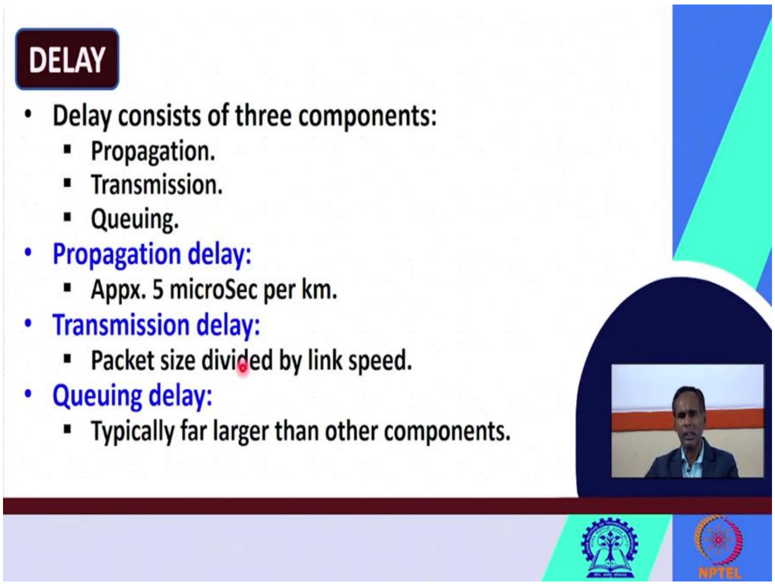

Now, let us see some of the important parameters that we have discussed in this or some maybe some important quality of service parameters in real time communication. First let us discuss about to delay. So, in real time communication the delay consists of three important components; one is propagation, next is transmission, next is queuing delay. So, propagation delay, transmission delay and the queuing delay.

So, propagation delay normally it should be 5 microsecond per kilometer, we are discussing about the delay in case of real time communication. In real time communication the propagation delay should be approximately 5 microseconds per kilometer. Similarly, transmission delay is defined as the packet size divided by the link speed, and the queuing delay normally it is typically far larger than the other two components. Queuing delay is larger than the propagation delay and the transmission delay.

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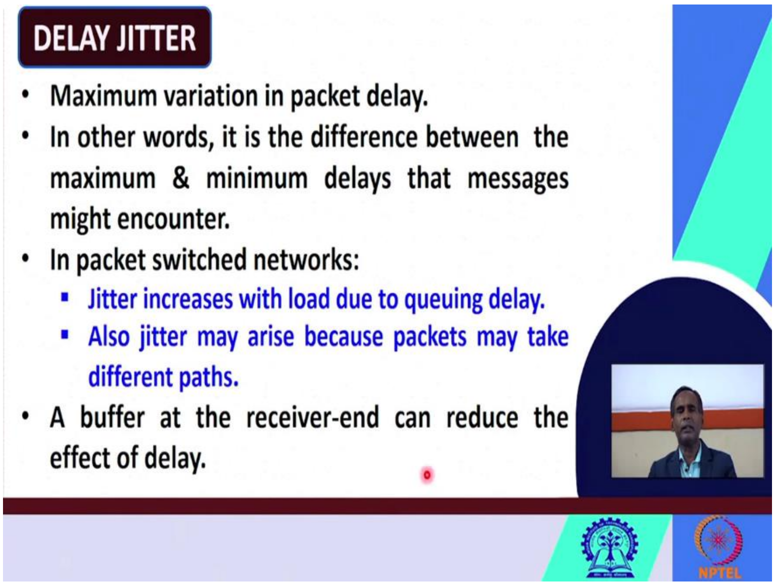

And then you will see something delay jitter, very much important in real time communication. Delay jitter is defined as the maximum variation in packet delay delay jitter is defined as the maximum variation in the packet delay, in other words you can say that it is the difference between the maximum and the minimum delays that the messages might encounter. So, if we will see say in other words, in other words this delay jitter is defined as the difference between what? The difference between the maximum delay and the minimum delay that the messages may encounter.

I hope in computer network paper you must have studied packet switch networks and other types of networks. In packet switch networks the jitters increases with load with queuing delay, normally in the packet switch networks, the jitter it increases with load due to the queuing delay. So, since the you know the packets are arranged in a queue and there must there is some queuing delay and packet switch networks the jitter increase with load due to the queuing delay.

So, also the jitter why it may arise? Also the jitter may arise because the packets may take different paths, because in a what the communication when the packets are transmitted, the packets may take different paths, so due to that reason also jitter may arise. Two important things we have seen in case of packet switch networks, in packet switch network jitter increases with load or as load increases due to the queuing delay, also jitter may arise due to or due to the fact that the packets they may take different paths.

So, how can we reduce this delay jitter? A buffer at the receiver end can reduce the effect of the delay. If we can put a buffer at the receiver end, then probably it can reduce the effect of the delay to some extent. So, by placing a buffer at the receiver end it can reduce the effect of delay to some extent.

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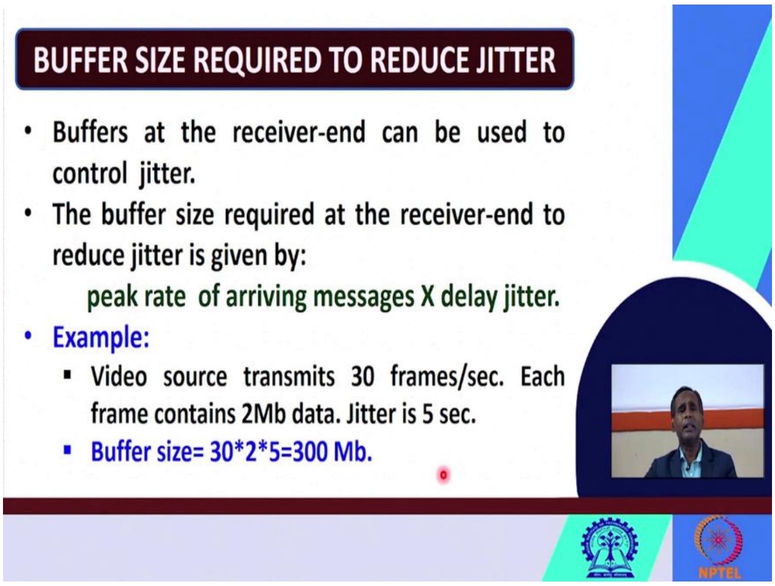

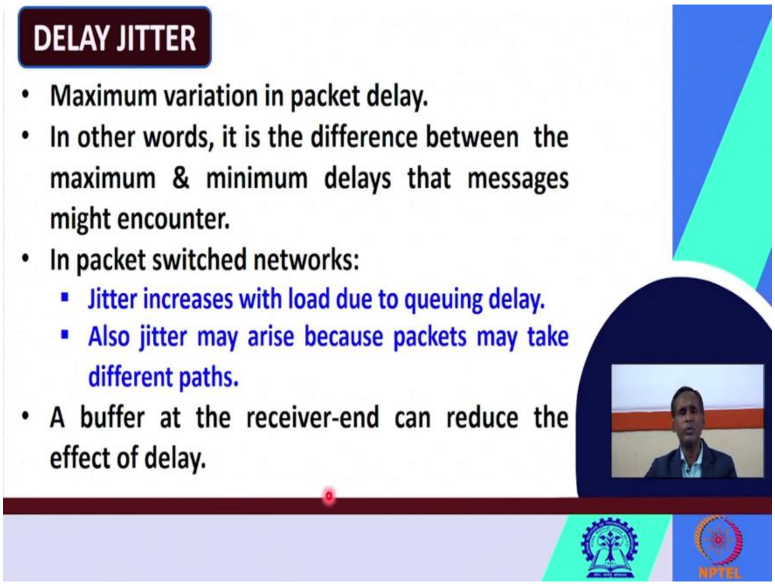

So, now let us see how we can estimate what should be buffer, size of the buffer that we want to put I have already told you, a buffer at the receiver end it can reduce the effect of delay, now then how we should know? What should this size of the buffer that will be put on the receiver end. So, that is a formula that we can calculate what should be the size of the buffer that is required to reduce the jitter.

Buffers at the receiver end I have already told you they can be used to control the jitter, the buffer size required at the receiver end to reduce the jitter is given by the following equation. So, what should be buffer size? The buffer size required at the receiver end to reduce the jitter is given by the following formula, it should be equal to the buffer size should be equal to the peak rate of arriving messages into delay jitter.

So, what is this of buffer size can be found out by multiplying the peak rate of arriving messages with the delay jitter. For example, let us take a small example, suppose we are considering a video transmission, let the video source transmits 30 frames per second, the video source it transmits 30 frames per second, each frame contains 2 Mb of data, the delay jitter is also given as 5 second, we are asked to find out what should be buffer size, very much straightforward.

So, buffer size as I have already told you it should be the peak rate of the arriving messages * the delay jitter and you know the video source transmit the messages at which speed, 30 frames per second. So, 30 frames per second and each frame contains how much data? A 2 Mb data. So, 30 frames will contain how much data? 30 * 2. And what is the delay jitter? 5. So, 30 * 2 * 5, so coming to be 300 megabyte. So, the buffers, so the size of the buffer that we should put at the receiver and should be up to of 300 Mb. This is how you can calculate the buffer size that is required to be placed at the receiver end to reduce the jitter.

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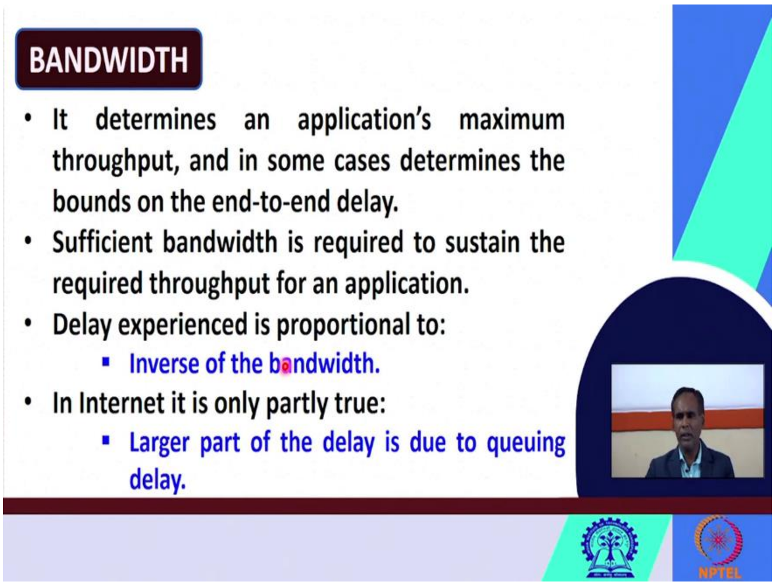

So, one more definition we must see that is bandwidth. You know that bandwidth determines what? It determines the applications maximum throughput and in some cases determines the bounds on the end to end delay. Bandwidth normally determines the applications maximum throughput and in some cases bandwidth also determines the bounds on the end to end delay. So, sufficient bandwidth required to sustain the required throughput for an application.

So, to in order to sustain the required throughput for an application what do we require? We require sufficient amount of bandwidth, so sufficient amount of bandwidth required to sustain the required throughput for an application. The delay experienced is normally proportional to the inverse of the bandwidth please see, the delay experienced is normally is inversly proportional to the inverse of the bandwidth. So, delay is inversely proportional to the bandwidth.

But in internet applications it is partially true, it is only partly true, because large part of the delay is due to the queuing delay only. So, this relation that delay is inversely proportional to the bandwidth may not work. So, in internet it is only partly true, because a large part of the delay is due to the queuing delay. So, this what relation might not hold good in internet applications.

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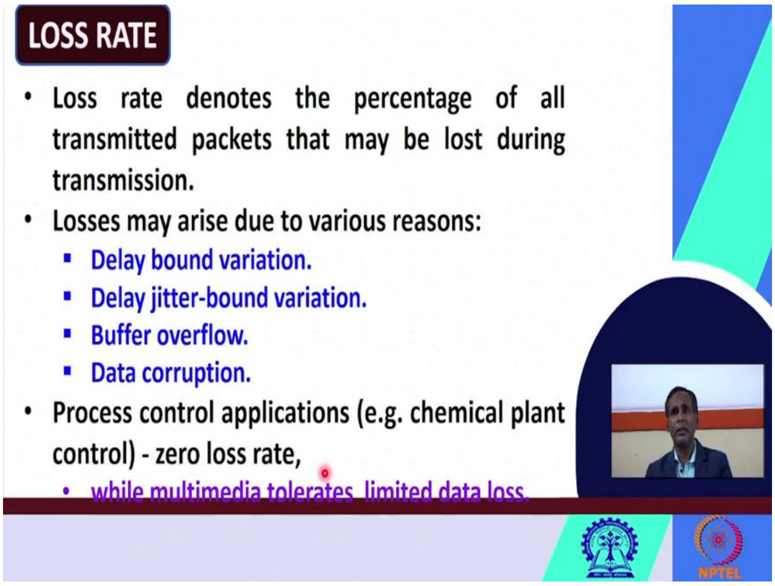

So, another quality of service parameter we will see that is one of the QoS parameter that is loss rate, how do you define loss rate? Loss rate denotes the percentage of all the transmitted packets that might be lost during transmission. So, during transmission, what percentage of packets they might be lost? So, if we can find out that that is that will tell us the loss rate. So, loss rate we define as the percentage of all the transmitted packets that may be lost during the transmission of the packets.

Now, let us see what are the reasons that these losses may occur. So, these losses may arise due to several reasons due to various reasons some of the reasons are given below like losses may occur due to delay in bound variation, losses may arise due to delay in jitter bound variation, losses may arise due to buffer overflow, and the losses may arise due to data corruption.

So, several other reasons are also there, we have listed a few of the reasons due to which losses may arise. So, process control applications they are now let us see this may slightly vary, so you know process control applications different chemical plant control examples of process control applications are chemical plant control, I have already told you in process control applications also we require what? We use real time communication.

So, example of process control application is chemical plant control. So, in process control applications for example chemical plant control, so there should be zero loss rate, no loss rate is allowed, why? Because if there will be some lose say in chemical plant control the data you are sensing maybe the temperature, pressure, volume etcetera, so if some data is lost then what will happen? The chemical you are making that will be completely, its behavior will different its features will be different.

So, in process control applications, zero loss rate is allowed, no loss rate is allowed. So, it supports zero loss, but if we will see other applications such as a multimedia application, they can tolerate a limited data loss. So if a while a video you are transmitting if one or two data they are lost that can be because it will wait and it will wait for the next data frame. So, in multimedia tolerates, in multimedia applications, they tolerate very limited data loss.

So, like one packet is lost or one frame is lost, it will wait for the next frame. So, severe consequence will be there, so these multimedia applications they can tolerate few data loss but process control applications or this safety critical applications where say an aeroplane is flying and there is a small mistake, small data loss, it will just put to in several person’s life in what to danger. So, although the safety critical applications and process control applications, they support zero loss rate, no loss rate is allowed in those cases.

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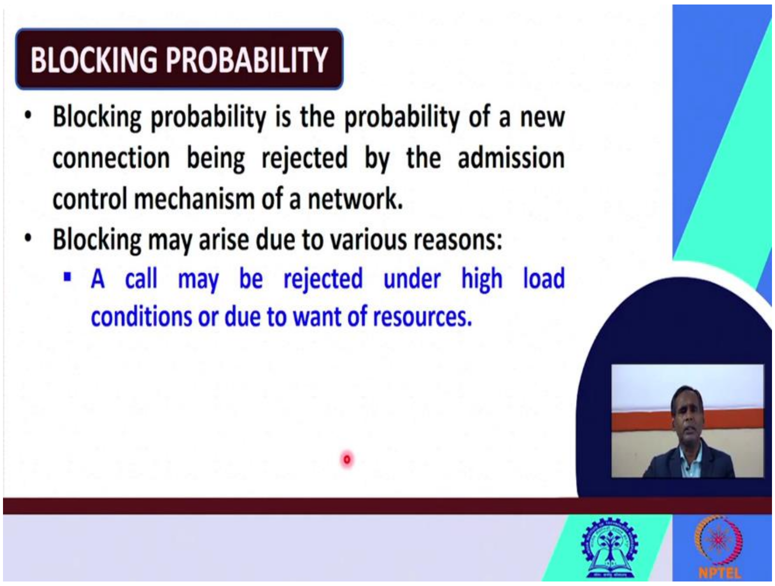

We will see one more case parameter that is blocking probability. Now, let us see how blocking probability is defined. Blocking probability is defined as the probability of a new connection being rejected by the admission control mechanism of a network. So, what is the probability that when a new connection is being set up and it is rejected by the admission control mechanism of the network, that is we call blocking probability.

I am repeating again, blocking probability is defined as the probability of a new connection, suppose you have set up a new connection, what is the probability that the new connection will be rejected by the admission control mechanism? So, that is known as your blocking probability. So, the blocking probability is defined as the probability of a new connection being rejected by the admission control mechanism of the network.

So, why do this blocking may occur? Blocking may arise due to various reasons, several reasons are there, one such reason you will see here, a call may be rejected under high load conditions or due to want of resources. So, a call may be rejected maybe under high load the load is very high, that is why your call is rejected. A call it may require some resources, it may require some resources due to the want of some resources, a call may also be rejected. A call may be rejected under high load conditions or it may be rejected due to want of some resources.

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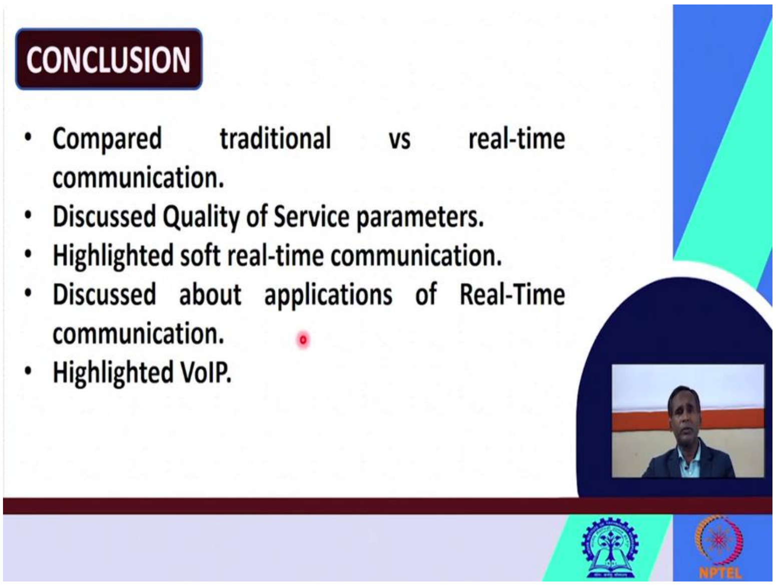

Today we have discussed the basics of real time communication, we have seen how the real time communication is different from the traditional communication. We have discussed a few quality of service parameters such as a delay and this packet loss jitter delay, blocking probability etcetera, we have discussed a few quality of service parameters.

We have highlighted the soft real time communication, also we have seen how real time communication is addressed in firm real time systems, we have discussed about some of the applications of real time communication such as your manufacturing automation system, chemical plants, internet banking and internet our telephony etcetera. We have little bit to highlight today about VoIP that is the voice of internet protocol.

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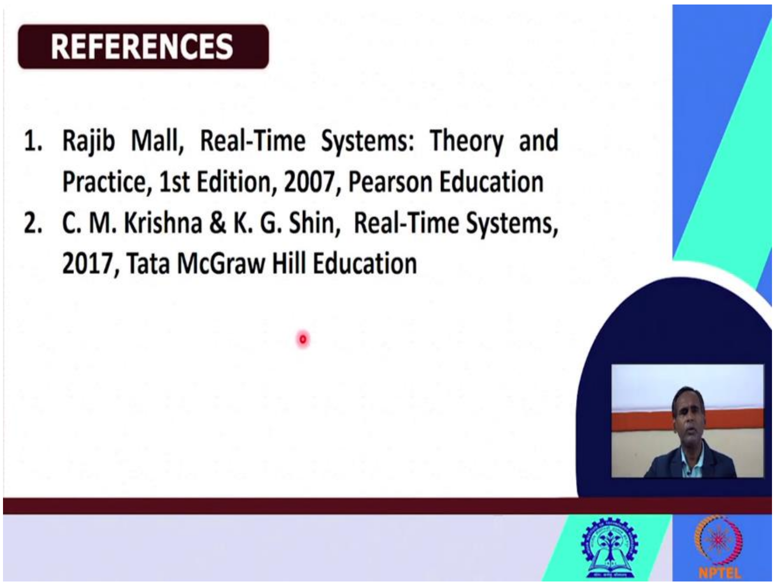

We have taken all those things from this two books. Thank you very much.