Real Time Systems
Professor Rajib Mall
Department of Computer Science and Engineering
Indian Institute of Technology, Kharagpur
Lecture 07
Types of time constrains

Welcome to this lecture. So, far in this course, we have looked at some very basic concepts in real time systems. And then in the last class, we were looking at various types of real time events that are possible with some examples, the main motivation is that if we know, what are the different types of events that can occur in a real time system, while developing a real time system, we can look for those or maybe if you are trying to understand the behavior of a real time system, then we can better appreciate if we know, what are the different types of events that can occur in a real time system.

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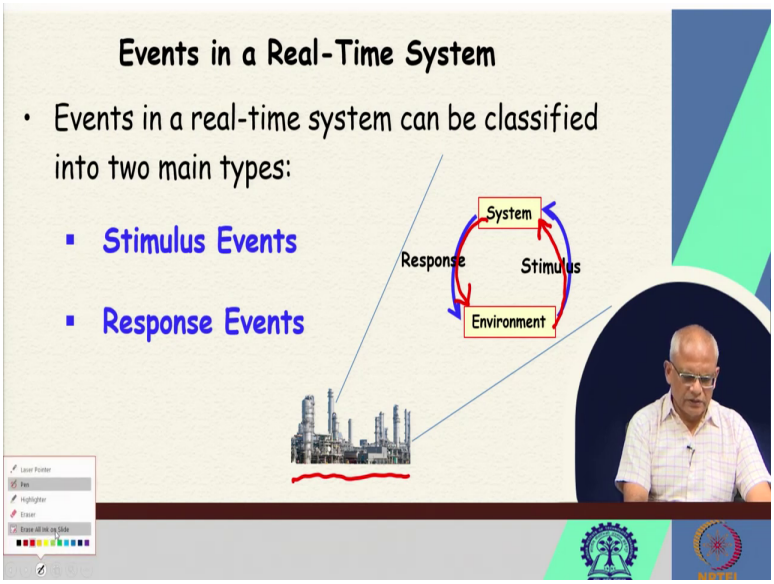

Now, let us continue from that point. Just to summarize, what we had discussed last time, the different types of events in a real time system can be classified into two main types. One is called as the stimulus event and the other is called as the response event, if you remember in a plant like this, this is the embedded platform and in a plant like this in a plant like this, we have two things, one is the real time embedded system and the other is the environment.

Now, the system generates some commands for the environment based on the events that occur in the environment. So, the events that occur in the environment, we call that as the stimulus, there can be many types of stimulus events. For example, in the chemical plant that are shown here, we might have, let us say the chemical concentration increasing beyond the threshold and then the system might generate an event which we call as the response event, which might be to stop the chemical flow.

So, in any real time system, we can broadly say that there are two types of events the stimulus events and the response events, the stimulus events are generated by the environment which the system, the real time system senses and then it carries out some actions or response. So, there are stimulus events and responses.

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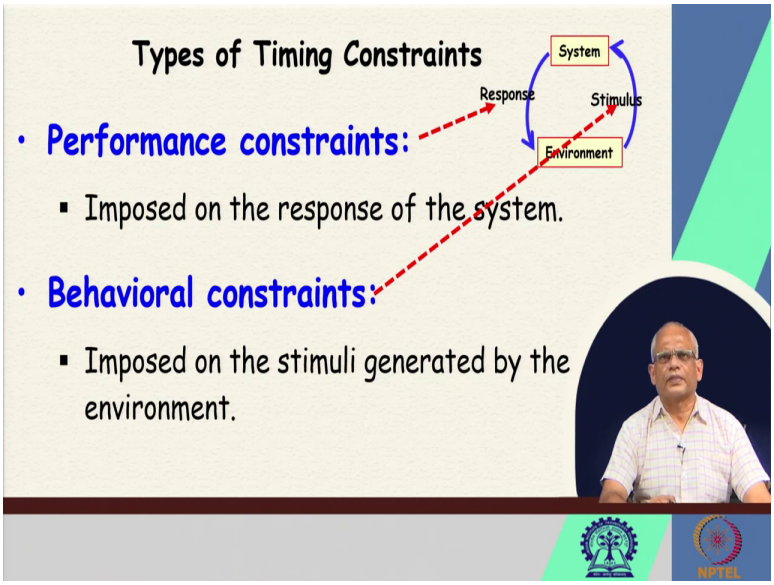

Now, let us look at the types of timing constraint that can be there on these two events, the stimulus event and the responsible, one constraint we call it the performance constraint that applies to the response, what is the performance of the system, the performance constraint apply on the response of the system. On the other hand, we have behavioral constraints; these apply on the stimulus generated by the environment.

So broadly, we will deal with two types of timing constraint, one we call is the performance constraint which is applied on the response event and the behavioral constraints which are applied on the environment generated events, which are the stimulus, we will look at some examples of performance constraints and behavioral constraints.

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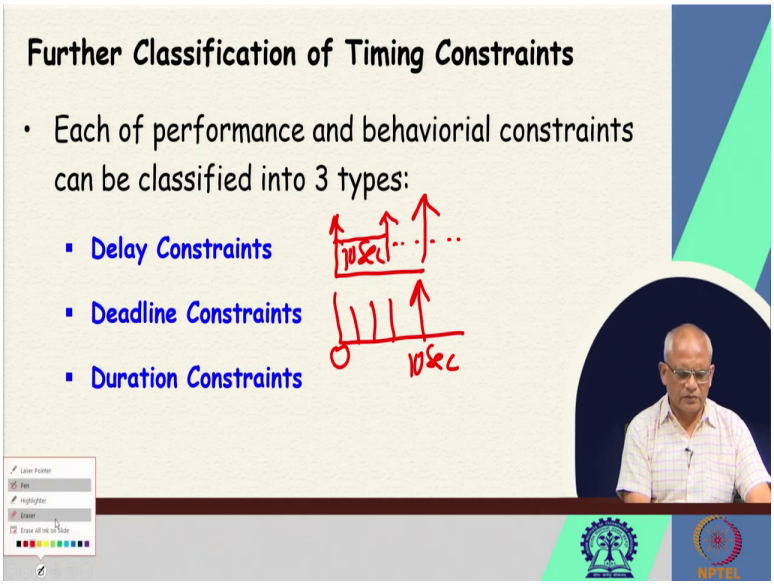

Now, the timing constraints can be three types, one is delay constraint, the delay constraint means that the event should occur at least after some time. For example, the delay constraint may be that after 10 second, the system should produce the response. So, this the 10 second from stimulus event after 10 seconds of the stimulus event, at least after 10 second, the system should produce the response. So, anywhere after the 10 second is alright, but it should not occur before 10 seconds.

The deadline constraint on the other hand says that the response for example, should occur before 10 seconds. So, here if this is the 10 second then the response can occur anywhere before 10 seconds. And this is a deadline constraint. And we can have a duration constraint where an event might occur for certain duration.

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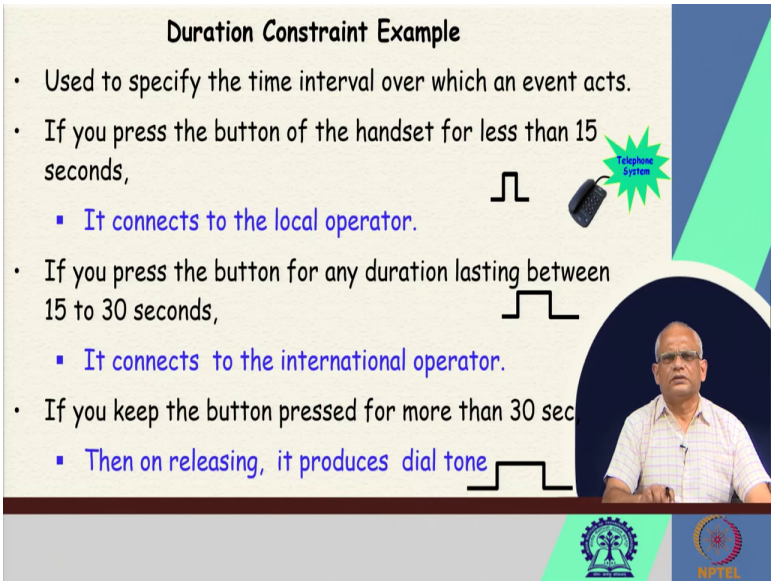

We had looked at the delay constraint and the deadline constraint examples in the last lecture. Now, let us look at a duration constraint example. Now, as we already mentioned that the duration constraint is about the duration or the time interval over which an event would occur. Again, we take the example of a telephone system. Here, if we press the telephone button less than 15 seconds, then it connects to the local operator who just lost the telephone button less than 15 second, we press it, and then it connects to the local operator.

But if we press it slightly longer, we hold it and then after some time we release it, which is between 15 to 30 seconds, then, let us look at the larger duration for which we hold the button within 15 to 30 seconds, and then it connects to the international operator. But if we keep it pressed for more than 30 seconds, maybe 45 seconds or a minute or something and then we release it, then it connects, it produces a dial tone. So, this is an example of duration constant where the event acts for some duration.

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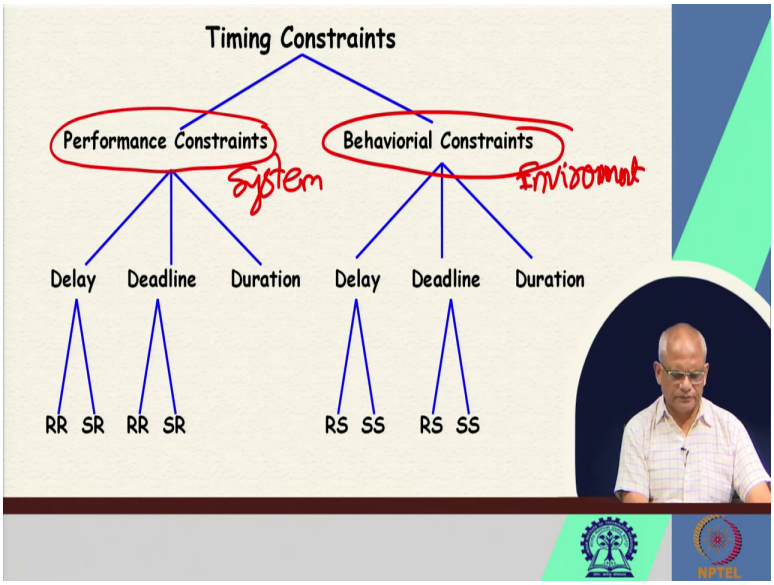

Now, to summarize the timing constraints because timing constraints is an important thing in real time systems, because the behavior to describe the basic behavior itself, we need timing constraints and letter to design and to implement in all these cases, timing constraint is one of the most important things in real time systems. The timing constraint, we had seen that they can be broadly classified into performance constraints and behavioral constraints, the performance constraints apply on the response produced by the system.

So, this applies on the system whereas the behavioral constraints, these apply to the events produced by the environment and then we had classified both these types of constraints into delay deadline and duration. And here again, we had seen examples of the delay constraint between two response events. So, from one response event, the other response event must occur after some delay.

And then we had also looked at example of a SR type of delay. That is, that was in the last lecture, where based on a stimulus event, the response occurs after some delay, and we had also looked at the deadline constraints where from one response event, the other response event must occur before a deadline. And similarly, the SR type of deadline constraints where, we had said that once a stimulus event occurs from the environment, the response must be produced before

the deadline. And similarly, we had the behavioral constraints which apply under events produced by the environment.

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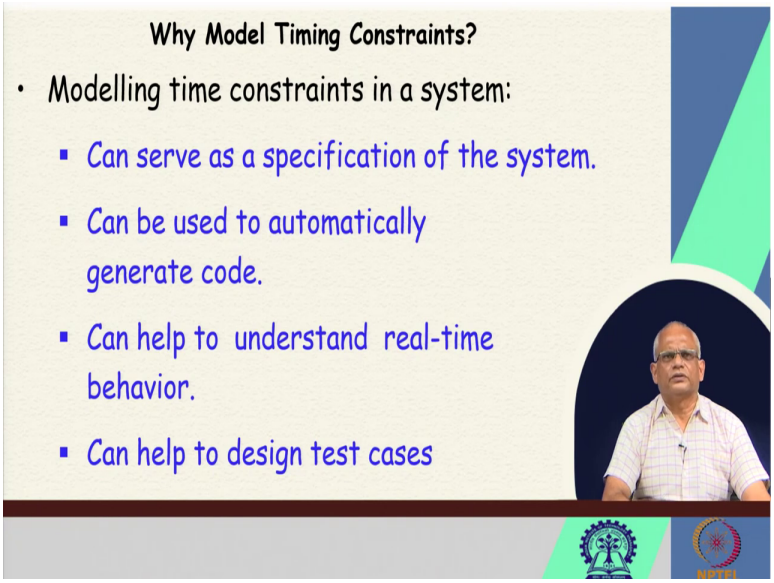

Now, let us look at how to model these time constraints. We had looked at the different types of time constraints with some examples, mainly with respect to a telephone system. But then, let us try to model these time constraints. Then naturally, the question comes is that why model time constraints? What is the motivation? And we identify four major motivations. One is that, if we want to specify a system, we want to design a system, and we want to describe it to the developers, we need to specify the system and if we can develop a model that will be accurate specification of the system.

And the designers will understand well, what is required of the system. And also, if we have this model correctly done, we can even generate code from here. There are case tools, where if we design the model properly, it can generate the code. And also, if we have a model of the time constraints, anybody can understand the behavior of the system unambiguously.

And also, if we have a model of the timing constraints, the test cases can be generated automatically if we have a case tool, and if we do not have a case tool, by looking at the model, we can mechanically generate the test cases. So, modeling the time constraint is very important.

Fortunately, it is very simple to model a system; you will be surprised to see how simple it is to model the system. We will just take some examples and we will model and I am sure that given any arbitrary timing constraint specification at the end of the lecture, you will be able to develop a model on your own.

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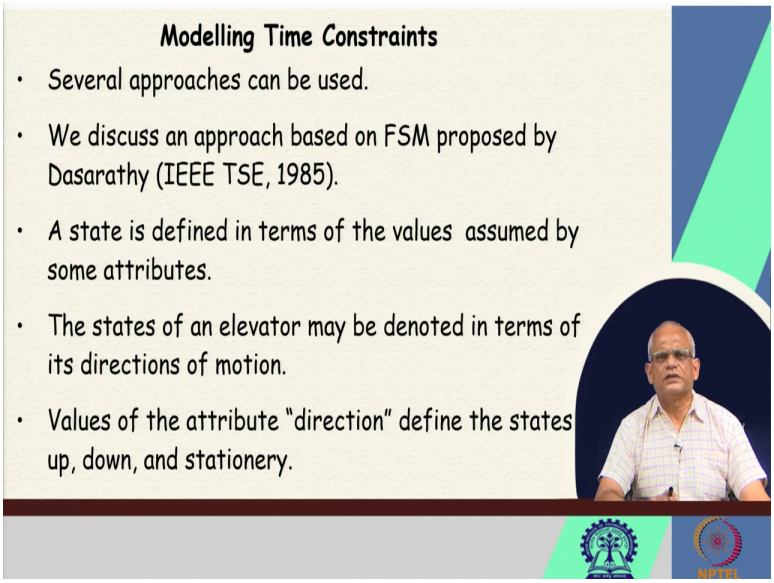

Now, let us see the basic notation which we will use, extremely simple notation with which you might be already familiar to a large extent there are several approaches at modeling we will use a finite state machine based approach originally proposed by the Dasarathy in the IEEE Transaction on Software Engineering paper 1985. Here the state of the system is implemented in the program in the form of some variables having some values, if the variable as we call those a state variable, if the state variable had certain values, then it is in some state.

If the values of the state variable changes, then it transits to another state and so on. Just to give an example, let us say we are modeling a elevator. And here the state variable is the direction of motion. If the direction motion is up, then it is in the upstate, if the direction of motion is standstill, then it is in the standstill state, if the direction of motion variable is indicating down movement then it is in the going down state. So, the attribute direction in this example, defines

the state of down or stationary. Similarly, any system, we can have some state variables which will specify the state in which it is the system is at present.

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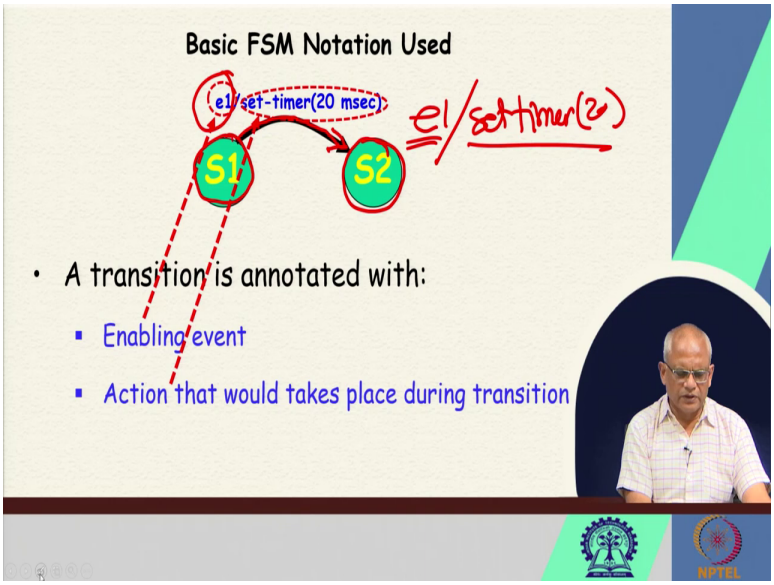

The notation is extremely simple we use circles with the name of the state S1 and S2 these are the two states of the system, very simple notation, the states are a circles and then we have the arrow as the transition between the two states and then we annotate on the transition two things, one is the event in this case e1 is the enabling event if e1 occurs, then it will transit from S1 to S2.

But in the process, it might do some action; it will carry out an action during the transition. And the action that occurs here it set a timer to 20 millisecond. So, the notation is very simple states and transition and under transition we write event and then we write the action that takes place, set timer etc. set timer 20 etc. So, this is the action part and is the event part. So, that is the notation, very simple notation, we will follow that in modeling the time constraints.

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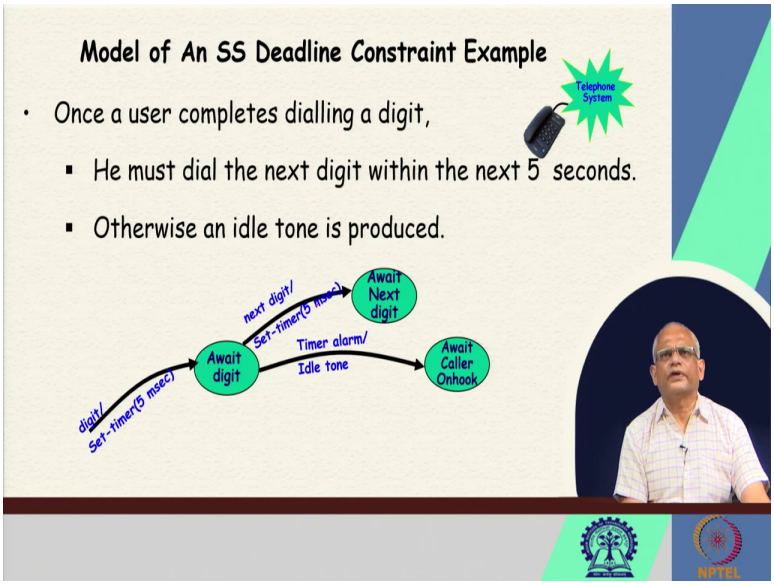

Now, let us first model an SS type of deadline constraint. And you might remember that an SS type of deadline constraint is one where after a stimulus event occurs, the next stimulus occurs at least after, ok it before sometime it is a deadline constraint. So, once the simulations, stimulus event occurs, the next stimulus event occurs before a deadline, example of that is that once a user completes dialing one digit, the next digit you must dial before 5 seconds, if he delays dialing the next digit more than 5 seconds, then it will produce a idle beeping tone.

So, this is two stimuli one is the user dialed one digit. And from that stimulus event, the next stimulus event is dialing next digit, it must occur before 5 seconds, otherwise it will timeout and produce a idle tone. Now, this is the FSM model of this. So, await digit after a stimulus event has occurred since await digit state and so, the set timer to 5 millisecond, the digit is dialed and it is the action part of that is timer reset to 5 millisecond.

And here once it is in the await digit state. If the timer event comes first, then this transition will be taken where it will produce the idle tone that is the beeping sound and the sound will continue until the caller keeps the phone on hook. On the other hand, if the next digit occurs before 5 second then it goes to await the next digit and again set timer 5 millisecond for the next digit to be dialed.

So, modeling an SS type of deadline constraint is simple. With the help of timer we set timer to 5 millisecond. And if the alarm comes first, timer alarms, then we know that 5 seconds have passed and the user has not dialed the digit it will go to, it will produce an idle tone. On the other hand in the next digit occurs first before 5 millisecond, then it goes to the await next digit, and again in the action there, we set time to 5 milliseconds.

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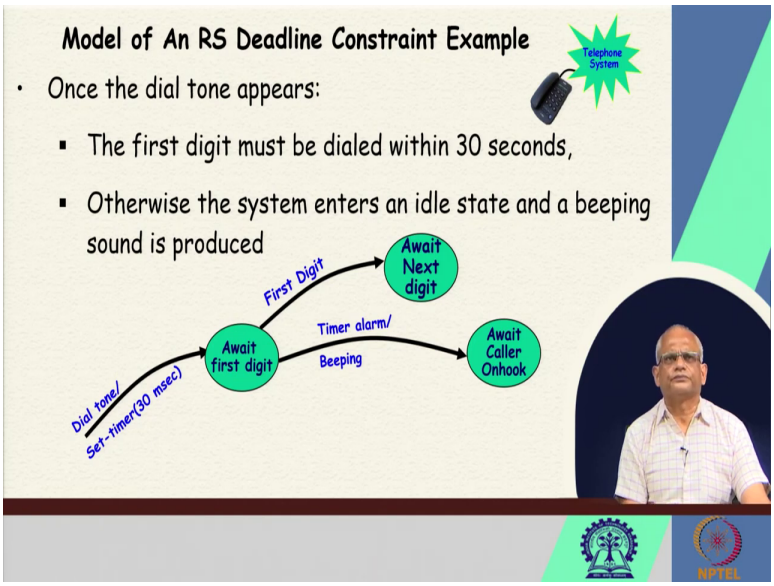

Now, let us model an RS deadline constant. So, here once the dial tone appears, the first digit must be dialed in 30 seconds. So, here the dial tone is produced by the system and therefore, we call it a response event, the dial tone production is a response event. And once the dial tone appears, the first digit must be dialed by the user in 30 seconds. So, this is the stimulus exam event and if the first digit is not dialed in 30 seconds, then the system enters into an idle state and beeping sound is produced.

So, here again, we use a timer once the dial tone occurs, set the timer to 30 milliseconds it goes into the await first digit state and if the first digit occurs before 30 seconds, then it awaits for the next digit. On the other hand, if the timer alarm comes first that is 30 seconds. The first digit does not come before 30 seconds and the timer alarm comes then the action produced is beeping and it goes into, the beeping continues until the user puts the telephone on hook.

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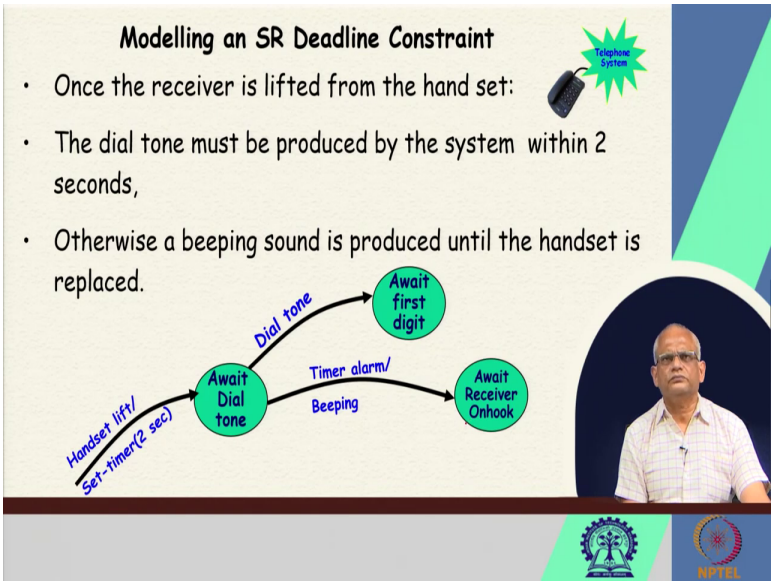

Now, let us look at an SR deadline constant example. Here once the receiver is lifted from the handset dial tone must be produced by the system within 2 seconds. So, here the receiver lifting the handset is the stimulus event. And based on this stimulus event, once the stimulus event is produced, the response event which is the dial tone is must be produced within 2 seconds. And if the system cannot produce the dial tone in 2 seconds, then a beeping sound is produced until the handset is replaced.

So again, we use the timer. Once the handset is lifted, set the timer 2 second and if the dial tone is produced before 2 seconds, then it goes to await first digit, if 2 second passes, the timer alarm comes and the dial tone has not yet come then the beeping sound is produced and goes into await receiver on hook.

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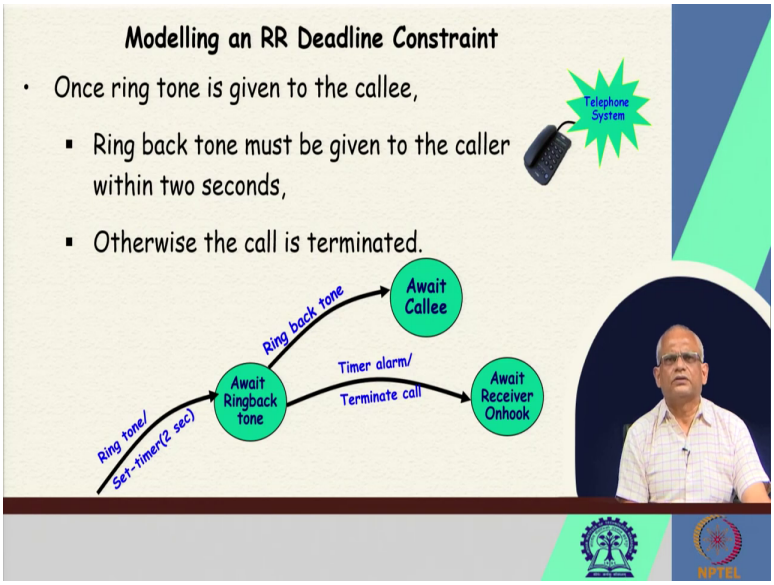

Now, let us look at an example of modeling a RR type of deadline constant again for a telephone system. This is the deadline of one response from another response. So, the response, your response event is ringtone is given to the callee and then the ring back tone must be given to the caller within 2 seconds. If the ring back tone cannot be given to the caller within 2 seconds, the call is terminated.

So, the ringtone is given to the callee. And then again, we use set timer here for modeling time constraints and await the ring back tone to be given to the caller. And if the ring back tone is produced before the timer alarm, then it awaits the callee to respond and the call is established. On the other hand, the timer alarm occurs first. Then the call is terminated and beeping sound is produced until the caller replaces the handset on the hook.

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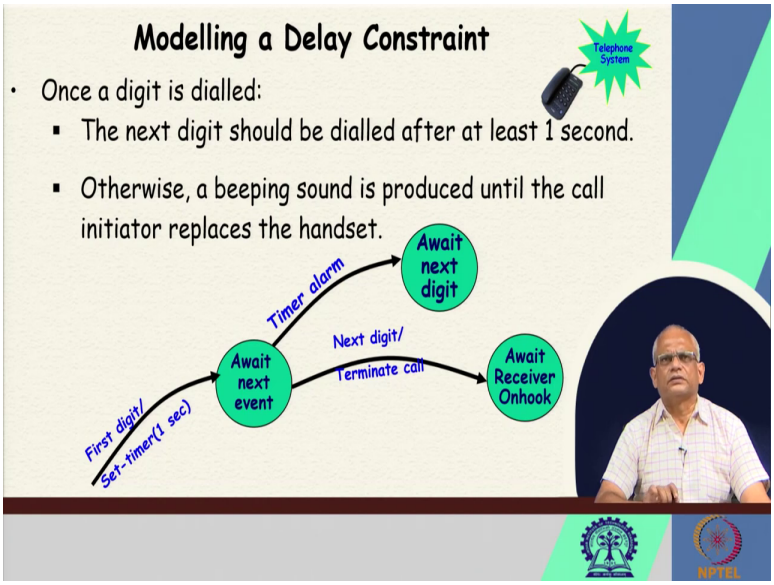

Now, let us see how to model a delay constraint. The delay constraint we had discussed was once a digit is dialed the next digit should be dialed after at least 1 second, if we dial the next digit too soon, that is before 1 second, then the beeping sound would be produced until the caller replaces the handset. So again, we model with the help of a timer. So, once the digit is dialed, you set the timer to 1 second. And if the next digit call comes before the timer alarm, then the call is terminated. But if the timer alarm occurs first, then it awaits for the next digit.

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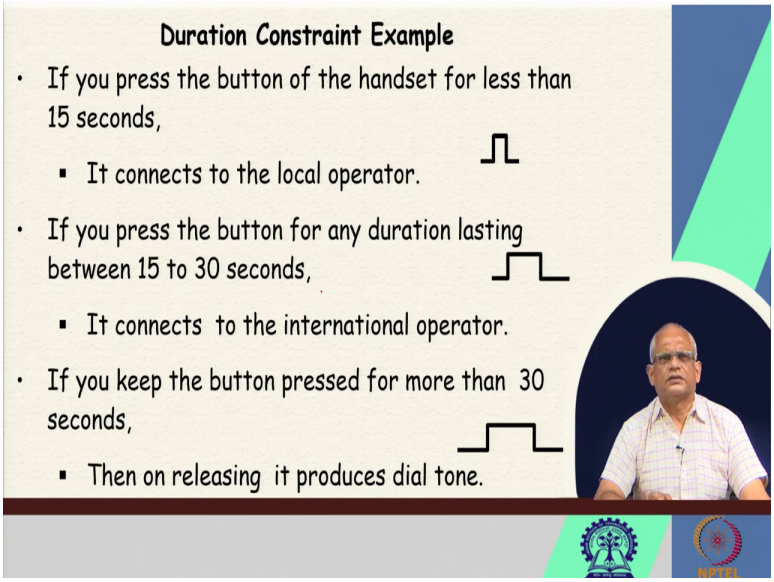

Now, let us look at the duration constraint example, the duration constraint example we had discussed is that we press the button for less than 15 seconds it connects the local operator we press for any duration between 15 to 30 seconds it connects to the international operator. And if we press it more than 30 second it produces the dial tone.

Now, if we look at this description, the duration constraint. So, here the handset should be pressed less than 15 second, and then it connects to the local operator. But if the delay is more than 15 seconds, and it is less than 30 seconds, it will connect to the international operator. So, there is a delay constraint and a deadline constraint.

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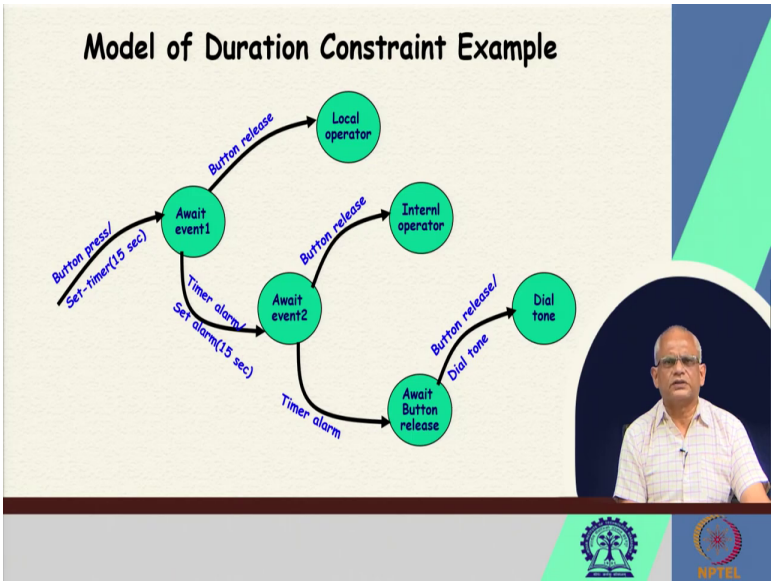

So, let us model this. So, the button press event occurs, and then we set timer to 15 seconds. And if the button release occurs before the timer event, then it connects to the local operator. And if the timer alarm occurs first, then as action we set alarm to another 15 seconds. And if the button release occurs first that is between 15 to 30 seconds. Then it connects to the international operator. Otherwise, it is more than 30 second that is the timer alarm occurs then on a button release it produces a dial tone.

So, here it is a combination of delay and deadline constraint requests you to find out on which events the delay constraints apply and on which event the deadline constraints apply. Just think about it. We will stop here and continue from this point in the next lecture. Thank you.