Real Time Systems
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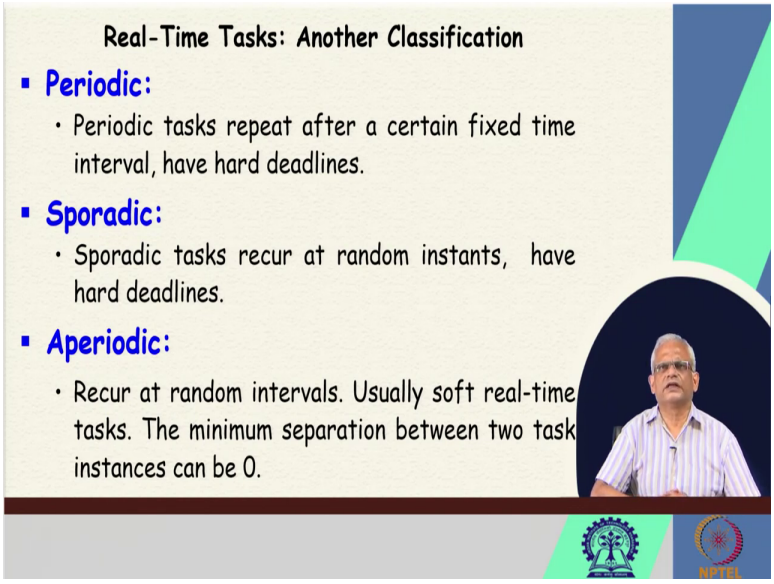
Lecture 06
Events in a Real-Time System

Welcome to this lecture, we are still at the introductory part of the course; we are looking at some very basic concepts in real time systems. In the last lecture, we looked at one way to classify various types of real time tasks. We classified that into hard real time, soft real time, firm real time. And we looked at some examples of those tasks and the characteristics of those tasks. Now, let us look at another way to classify the different real time tasks in a embedded application. (Refer Slide Time: 0:52)



Let us brush it, we can classify the tasks as periodic, sporadic or aperiodic, the three ways in which you can classify real time task, the periodic tasks, these repeat after certain fixed interval of time, typically the hard real time tasks are periodic in nature. One important example of a periodic hard real time task is sensor input, the in a chemical plant, the inputs from the sensors like temperature sensor, chemical concentration, pressure, and so on, these are monitored periodically with a clock signal. And these must be the processing of the signals must complete before the next sampling takes place.

So, this is a important category of real time tasks in many of the embedded applications, another type of task is the sporadic tasks, the sporadic tasks, they occur at random instance, and have hard deadlines. For example, let us say suddenly, there is a fire condition or an abnormal condition noticed in a chemical plant.

There are sensors, which detect these, that the threshold has become alarming. The threshold has exceeded and the situation is alarming. And we do not know when these events will occur. But then as soon as these events occur, they must be handled on a priority basis within let us say 100 millisecond. A fire alarm must be handled maybe by switching on a water shower. So, the sporadic tasks occur at random time, but have hard deadlines associated with them. These are hard real time tasks.

The third categories of tasks that will come across are the aperiodic tasks. The aperiodic tasks also occur in random times. But they do not have hard real time constraints on them. Just to, these are typically soft real time tasks. Just to give an example. Let us say a user queries certain things to the task, let us say the user tries to find out the various parameter settings for the chemical plant or wants to change the setting of some tasks, because the human response time is of the order of 20 seconds and there can be variation.

So, these tasks are typically soft real time tasks. And also, different users may initiate operations at the same time, almost at the same time. So here, the minimum separation between two task instances can be 0. And this is another reason why hard real time guarantees cannot be given to these types of tasks. So, we have hard real time requirements and periodic and sporadic tasks and for aperiodic tasks which occur at random intervals.

Because the user may give a query any time and the next query of user we do not know when he will be able to give the query. So, these occur at random intervals and typically soft real time tasks. And another characteristic is that the minimum separation between these two task instances can be 0, whereas for the periodic and sporadic, for periodic we have a constant time interval. And for sporadic we have a nonzero time interval, there must be at least some separation, a minimum separation between two sporadic tasks.

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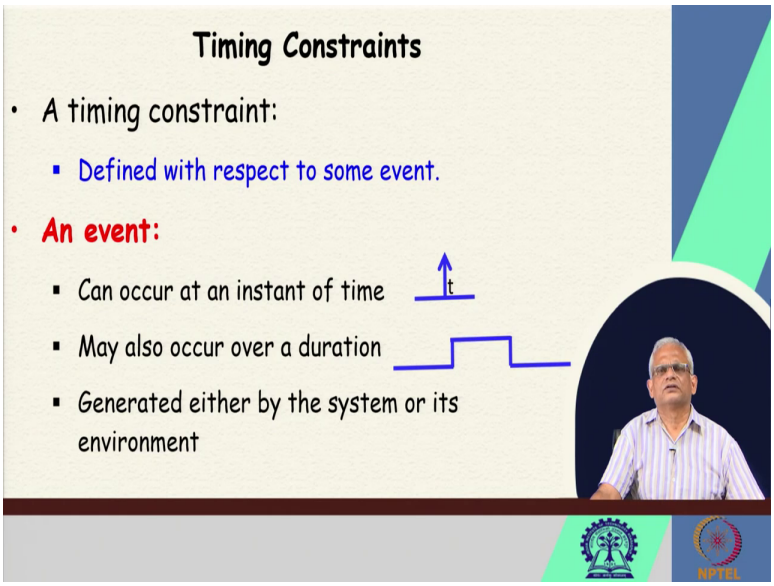

Now, let us look at these time constraints, the time constraint on a task is defined with respect to some event for example, a clock event a timer or maybe a sensor input was read or maybe the user gave input. So, the task handling these events, the constraint on the task is defined with respect to these events. So, always a timing constraint is specified with respect to some event and an event characterization as an instant of time, event occurs at a certain time instant.

Just look at here this task this event occurs at time t, but, they may occur also over a duration. So, here the timing occurs for duration for example, you must press a switch pressed for some time and there the event occurs for this duration. And also, these events are generated either by the system or the environment.

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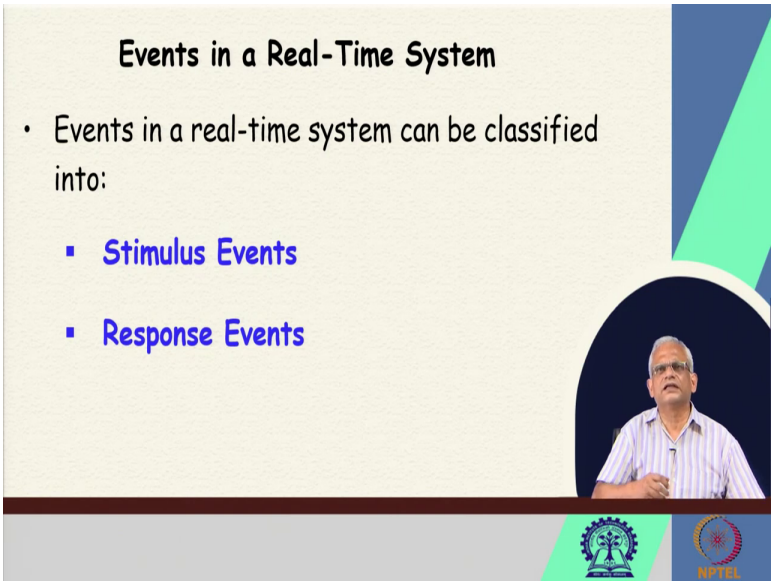

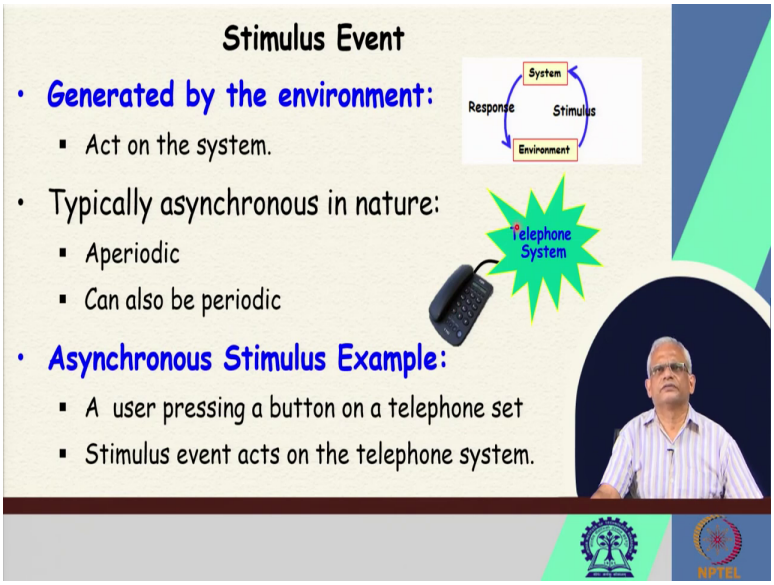

Now, let us look at the events in a real time system. The events in a real time system are classified into stimulus event or response events, the stimulus events are generated by the environment. So, these are stimulus to the real time computer under the real time system. Whereas, the response event is the event generated by the computer system, see here the stimulus is generated by the environment and is input to the system the stimulus is given to the system and in the system processes this stimulus may be a sensor input, let us say the environment be a chemical plant and the temperature is sensed by a temperature sensor.

And that is a stimulus to the system and maybe the temperature has fallen below the stipulated value and then the system will generate a response that is start the heater system. So, the environment generates stimulus processed by the system and the system generates a response, the stimulus event generated by the environment which acts on the system, the system processes the event and then generates response and the environment generates these stimulus events asynchronously typically.

These may be periodic or aperiodic this can be periodic for example, periodic sensor inputs. So, these are periodic stimulus, but this may be aperiodic for example, a user is pressing a switch. That is an example of aperiodic event. And asynchronous stimulus example is a telephone where a user is pressing a key here and that is an asynchronous stimulus example, user pressing a button on the telephone set and this stimulus event acts on the telephone system.

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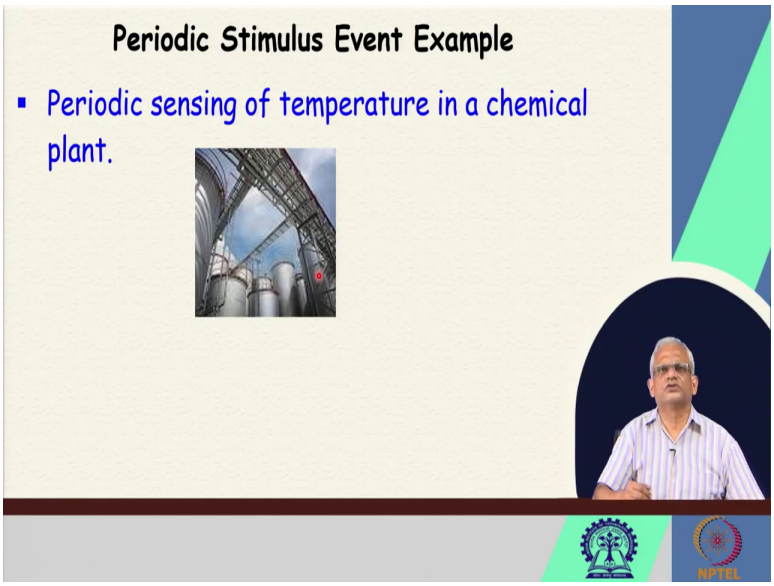

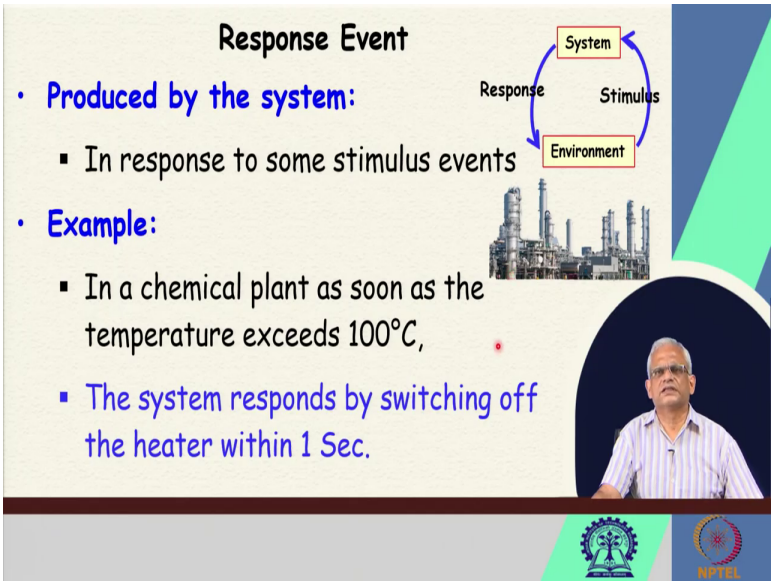

Now, let us look at periodic stimulus, the sensing of the temperature in a chemical plant like this. This is an example of a periodic stimulus event. So, the stimulus is generated by the environment. This can be periodic like a sensor input, aperiodic like a user pressing key, this can be also sporadic. For example, alarm systems, intrusion detection and so on. Now, let us look at the response event, the response event is generated by the system. And typically, in the form of some actuator is enabled and the actuator generate some action which works in the environment which acts on the environment.

And in response, the environment may generate stimulus event which is processed by the system, which again generates a response event. So, there is an ongoing interaction, stimulus and response between the system and the environment. The response event is produced by the system usually in response to a stimulus event. One example is that as soon as the temperature exceeds 100 degrees centigrade in a chemical plant, the system gets a stimulus event and the system may act. So, this is the chemical plant and the system act by switching of the heater within one second.

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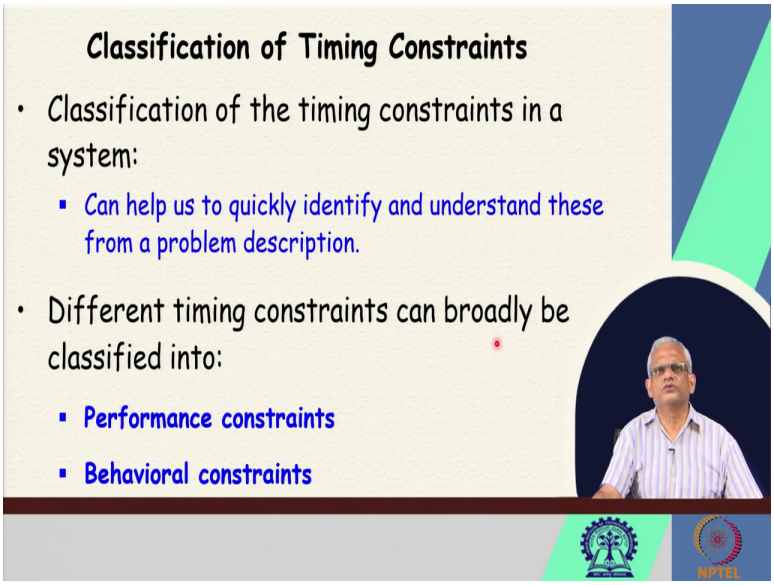

Now, let us try to classify the timing constraint. If we can classify the timing constraint that applies on the tasks when we deal with a real time system, we can understand the type of the timing constraint that occurs in the problem description. And if we know what are the types of timing constraints that may occur, we can identify the exact type of the timing constraint that is occurring.

The different timing constraints can broadly be classified into performance constraints and behavioral constraints. Now, let us look at the performance and behavioral constraints, there are two important type types of timing constraints.

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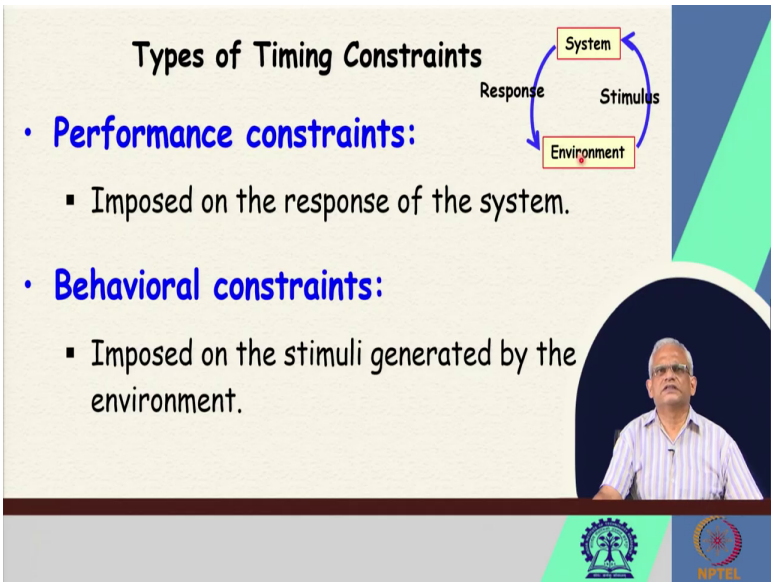

The performance constraint applies on the response event. So, that means once the temperature exceeds 100 degrees centigrade, the system must switch off the heater within 1 second. So, that is a performance constraint on the response of the system. On the other hand, the behavioral constraint applies under environment these are imposed on the stimuli generated by the environment. For example, once the temperature is read or input to the system, the next temperature input will occur only after 100 milliseconds. So, that is a constraint in the environment.

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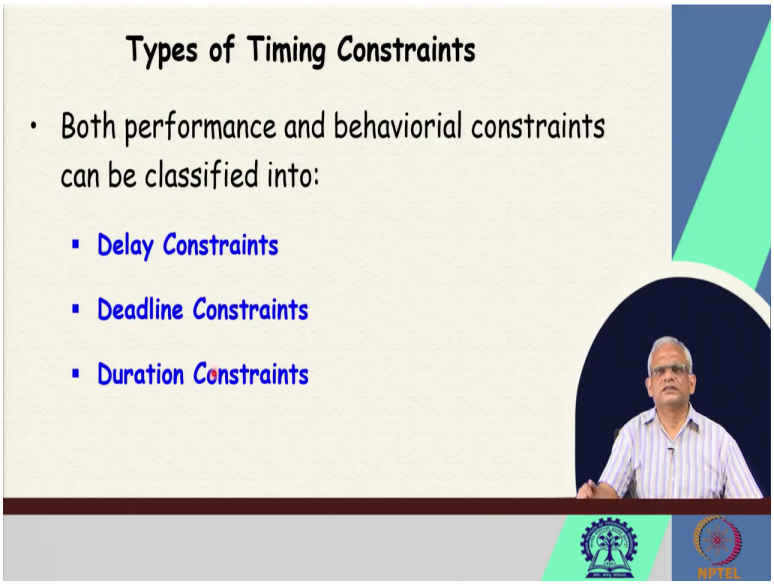

And again, both these performance and behavioral constraints can be classified into delay constraints, deadline constraints and duration constraints. So, each of these performance constraints which appear under which are apply the performance constant apply and the response of the system and the behavioral constraints are actually how well behaved is the system is, the environment is so, it applies on the environment the behavioral constraint applies in the environment and the performance constraint applies under real time system.

And each of these can be further classified into delay constraint, deadline constraint and duration constraint. Let us try to understand these three types of timing constraints. So, that when we are asked to design a system, we should be able to identify what is the type of constraint that is required for the specific system.

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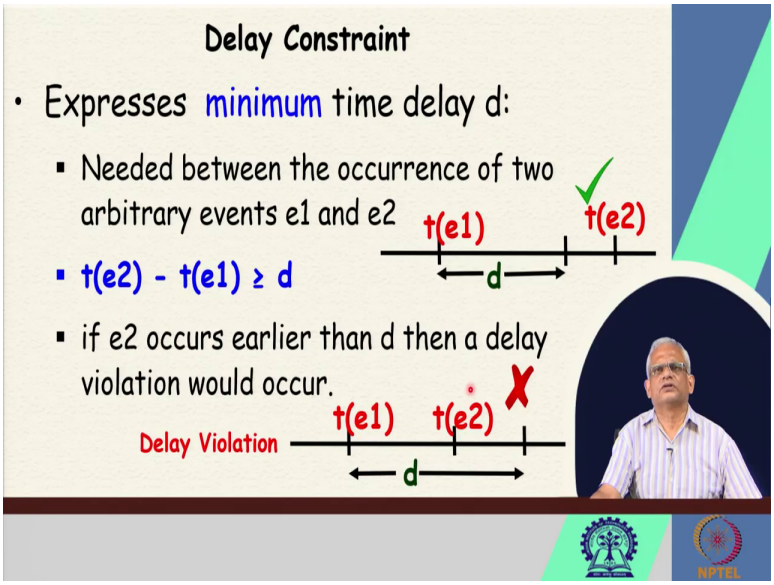

The delay constraint is that there is a minimum delay. Once event of interest occurs, there must be a minimum delay before the response can occur. For example, if the event of interest is e1 and the time at which the e1 occurs, we represent as t(e1) and this is the delay that must occur then the response must occur after the delay, so, t(e2) must be greater than t(e1) + d or t(e2) – t(e1) must be greater than d. So, t(e2) – t(e1) must be greater than d can occur any time after d.

So, this is a correct satisfaction of a delay constraint but, if e2 occurs less than d then there is a violation, see here the delay constraint d is the delay and the response occurred before d and this is a delay violation, the system would fail if it is a hard real time task and there is a delay constraint and the response is produced before d.

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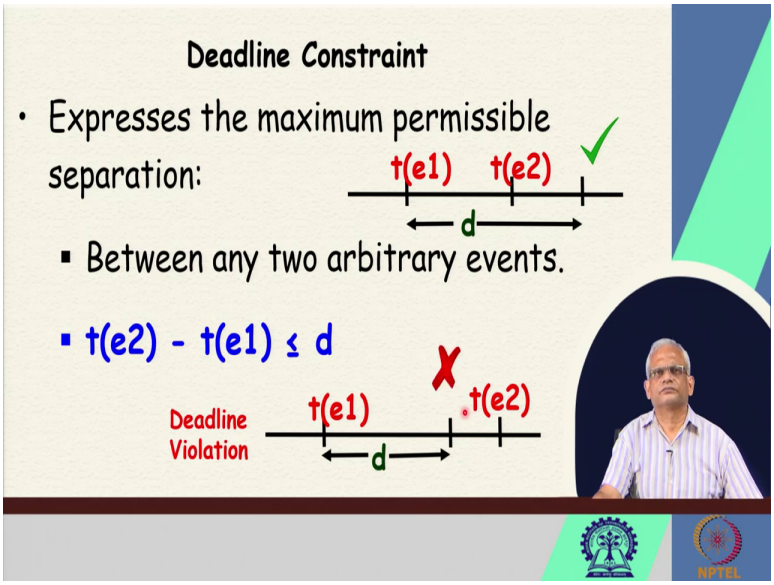

Now, another type of constraint is the deadline constraint here this is expressed in terms of the maximum possible separation between two events. So, once t(e1), e1 occurs and the time of occurrence of e1 is t(e1) then the time of occurrence of e2 must be less than d. So, before d time passes e2 event must be produced or in other words t(e2) - t(e1) must be less than d. So, this is the satisfaction if this is the occurrence of e2 which occurs before the deadline elapses then we say that the system is behaved correctly. But if e2 occurs after d that is t(e2) – t(e1) is greater than d, then we say that there is a deadline violation the system would fail if it is a hard real time task.

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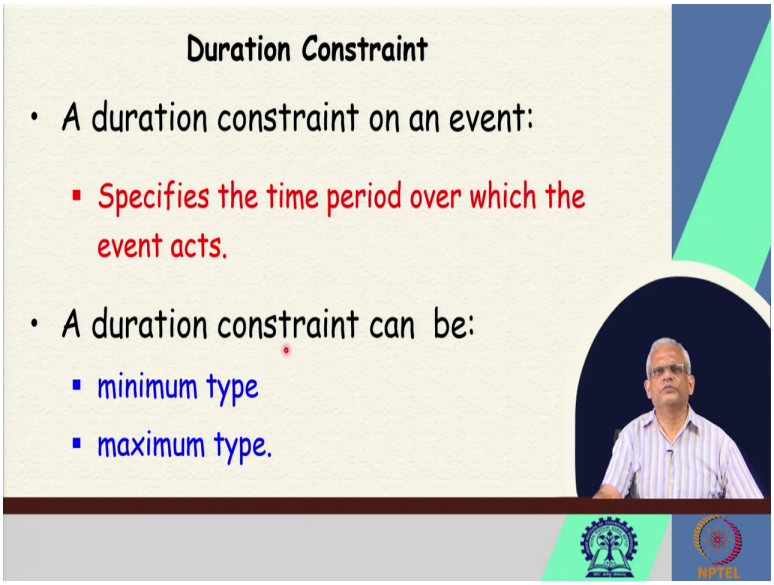

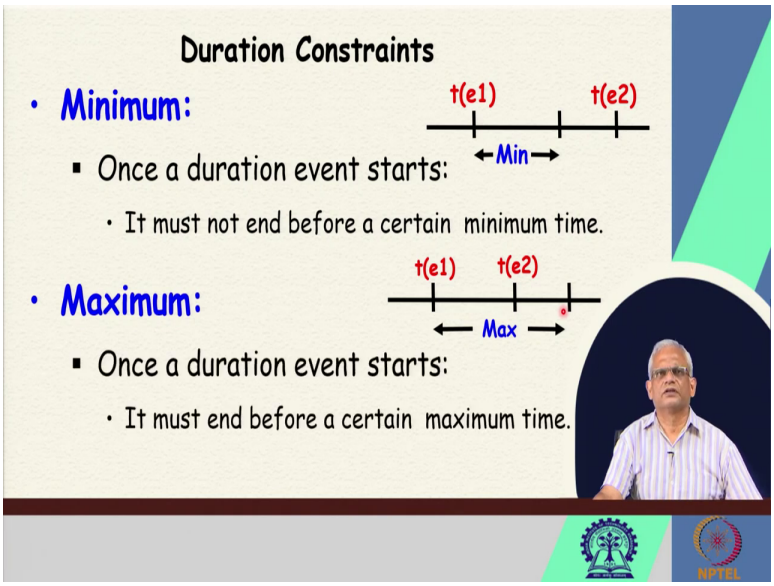

Now, let us look at the duration constraint. A duration constraint specifies the time period for which an event acts. And again, a duration constraint can be minimum or maximum. We will look at examples of a duration constraint where the event occurs for some duration and it can be for a certain minimum duration or a maximum duration.

Now, let us look at the minimum, in the minimum duration, the event must occur for some duration which is greater than the minimum, it can occur any time after minimum and then we say that the system is working fine and the event will be recognized. But, in a maximum type of

duration constraint the event must occur before a maximum duration. We will look at examples of the minimum duration events and the maximum duration events.

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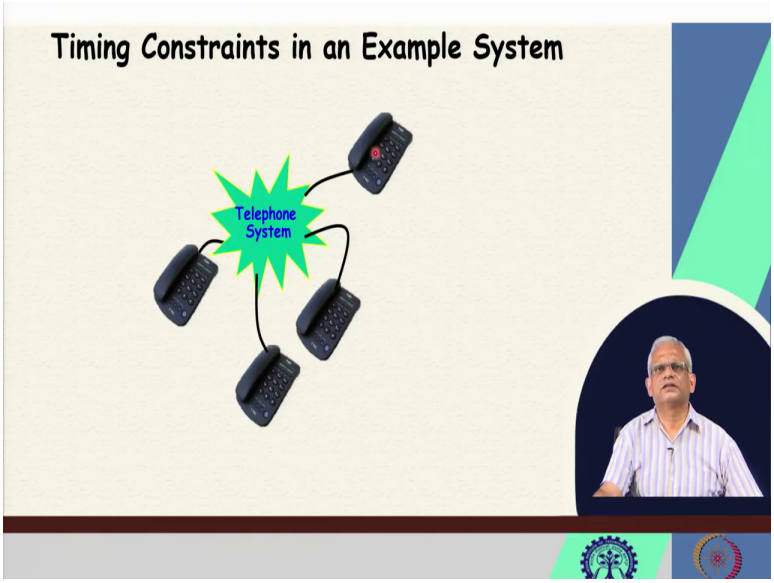

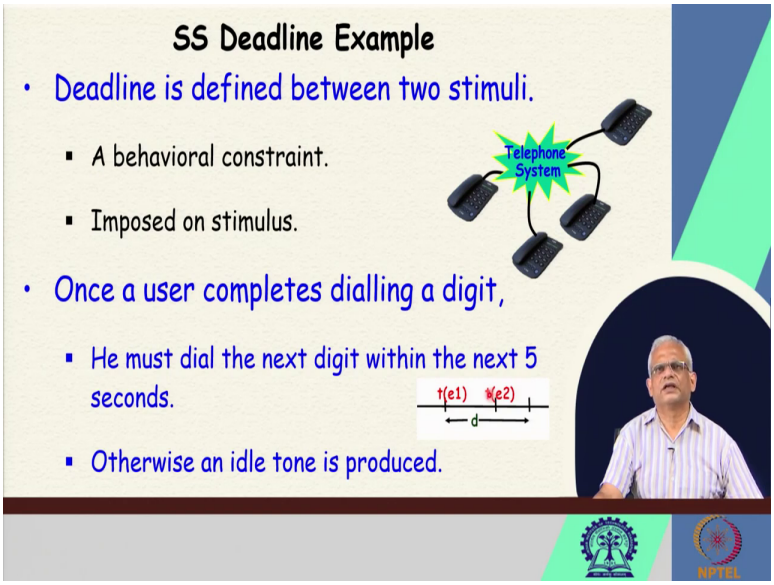

We will explain with respect to a telephone system example. In a telephone system example, we have different users having different telephone sets and the telephone user can call another user interact and so, first let us look at a deadline example. And this is the SS type of deadline; SS stands for stimulus to stimulus. We know that stimulus is the event generated by the

environment. And in a telephone system the environment is basically the user, the user inputs events to the telephone system.

So, the SS deadline example is between two stimulus events that is two events generated by the user and therefore, it is a behavioral constraint because it is defined on a stimulus event. One example of this is that once a user completes dialing a digit, he must dial the next digit within 5 seconds, otherwise, a beeping sound will be produced, an idle tone will be produced. So, once he dials, completes dials a digit, completes dialing a digit as that is the e1 event occurs at time t(e1).

The next digit must dial within certain time let us say 5 seconds. And as long as the dial the next digit t(e2) is dialing up the next digit is e2 and time of dialing that digit is t(e2) and as long as t(e2) – t(e1) is less than d that is less than 5 seconds, then the system works fine. Otherwise, we said that there is a failure in dialing and idle tone will be produced. So, here the deadline is on the second event, which is a stimulus event and therefore, we call this as a behavioral constraint.

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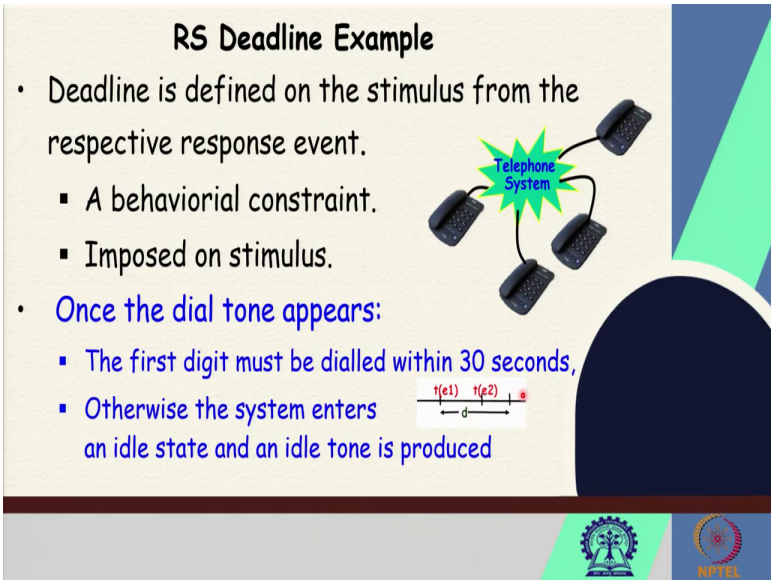

Now, let us look at another deadline example in the telephone system, which is RS type of deadline, RS type of deadline is the stimulus event S occurs from a response event R, the stimulus event occurs based on a response event. So, the telephone system produces a response

and the user acts on that, based on that it produces a stimulus and there is a deadline on it. The deadline is defined on the stimulus generated by the user in response to some event generated by the telephone system.

And since the deadline is defined on a stimulus, it is called as a behavioral constraint, because it is imposed on a stimulus, the stimulus must occur before some time and therefore, it is a behavioral consultant. Now, one example is once a dial tone appears, so, the user lifted the telephone set and then after some time, we got the dial tone, and once the dial tone appears, the first digit must be dialed within 30 seconds.

So, t(e1) is the time at which the user got the dial tone, and he must dial the first digit before 30 seconds. So, d is equal to 30 seconds here and as long as you dial the first digit, that is e2 the time of dialing first digit is t(e2) as long as t(e2) – t(e1) is less than 30 seconds, then the deadline is met. But if the user delays more than 30 seconds, then an idle state and the idle tone is produced.

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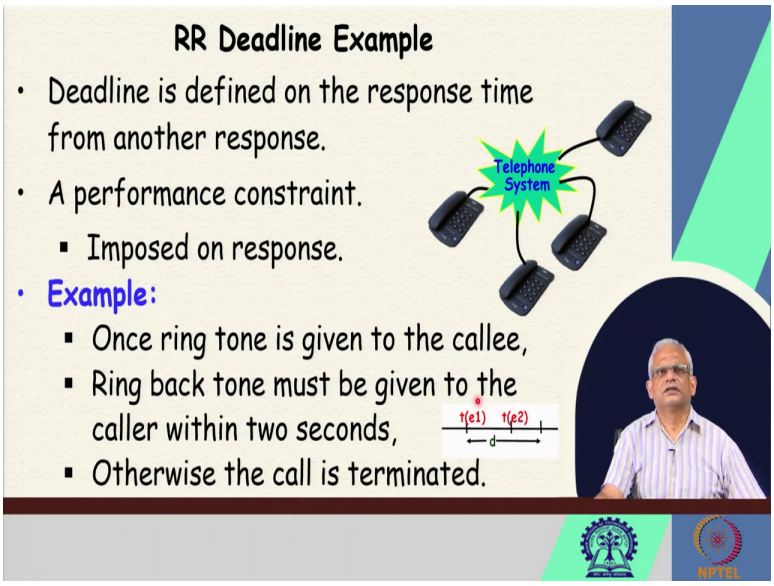

Now, let us look at a third type of deadline constraint which is the RR type of deadline constraint in RR type of deadline constraint, the constraint is on the response event generated by the system. And this event is defined with respect to another response event. So, that is why it is RR

type of deadline example. So, the deadline is defined on the response time of the system from a previous response and since it is defined on a response, it is a performance constraint, because the constraint is imposed on the response.

One example is that once the ringtone is given to the callee that is the person who has been called, once the ringtone is given to the callee. So, t(e1) is the time at which the callee has received the ringtone, the ring back tone must be given to the caller within 2 seconds. So, this is the performance constraint on the telephone system that once the ringtone is given to the callee, the ring back tone must be given to the caller within two seconds. Otherwise, the caller might think that the callee has not yet, the phone is not yet ringing there and he may just think that something is wrong and he may replace the telephone.

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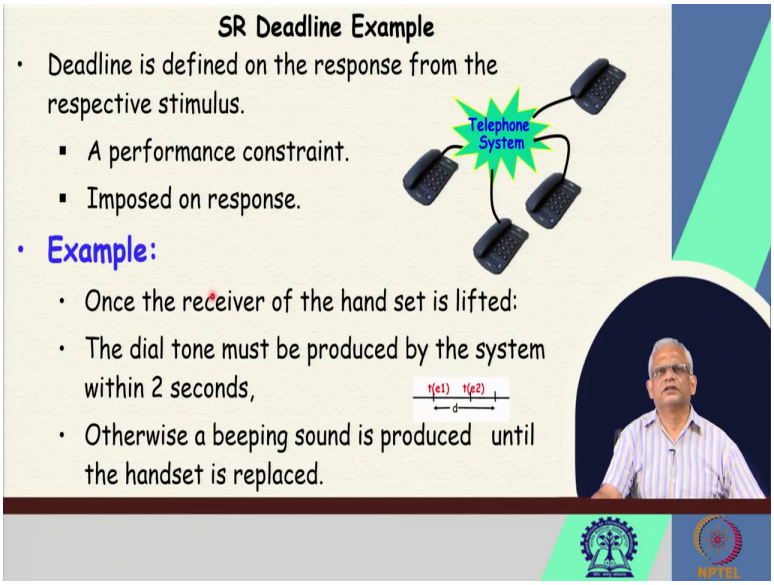

Now, let us look at another, the last type of deadline example, SR deadline example. In a SR deadline example, the constraint is under response event which occurs based on some stimulus event. And since it is imposed on a response event, it is a performance constraint. One example here is that once the receiver lifts the handset, so, that is a stimulus because it is done by the user, the user has received the handset and then the dial tone must be produced by the system within 2 seconds.

So, t(e1) is the time when the receiver handset was lifted, but the user must receive the dial tone within 2 seconds. Otherwise, there is a failure of the system. And the beeping sound will be produced until the handset is replaced. So, we just looked that several examples of deadlines in a telephone system, we looked at the SS type of deadline which is a behavioral constraint, the RS type which is also a behavioral because these are on stimulus events, the RR and SR type of deadline, we looked at examples and these are performance constraints because these apply on response from the telephone system. We are at the end of this lecture. We will stop here and we will continue from this point of identifying various types of time constraint in a real time system in the next class. Thank you.