Simulation of Business Systems
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Lecture – 09
Basic Simulation Terms and Illustrative Examples

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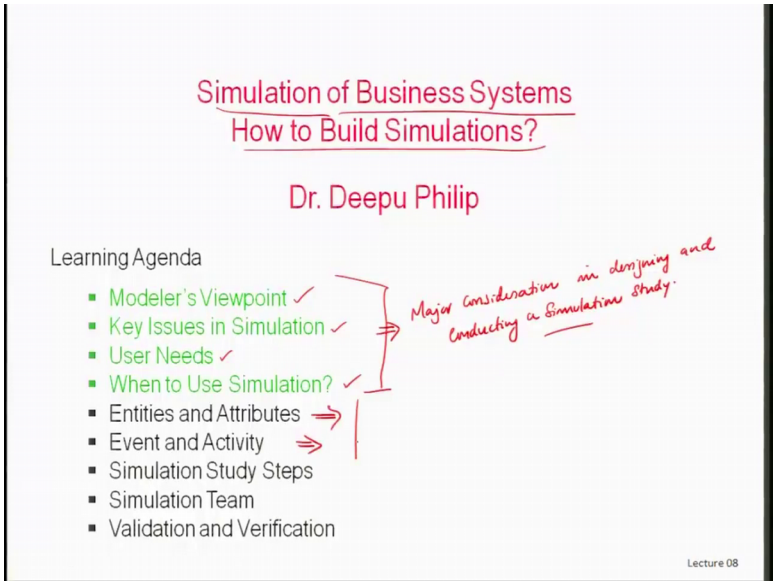

Good evening students. Welcome to once again to the course on Simulation of Business Systems. And we were discussing the topic how to build simulations. And we have already seen one part of this lecture, the lecture that we have already seen is the modeler's viewpoint, why it is important to have the viewpoint, and why is it important to understand that what are the key issues related to simulation.

And how different type of users have different user needs, and how depending upon these user needs the different simulation models are built. And then lastly we talked about when to use the simulation or whatever right scenarios in which the simulation is to be used. So, these are the what we can think about the major considerations in designing and conducting a simulation study ok. So, this we have already seen through.

Now, we are going to look into is that some of the new aspects. Today in this current lecture, we will look into the some of the major definitions of the terms. Then we will look into entities and attributes, then we will talk about event and activity, and then we will also see if time permits, you will also see: what are some of the simulation study

steps in the process ok. But, at least we will go through these two in the today's lecture ok.

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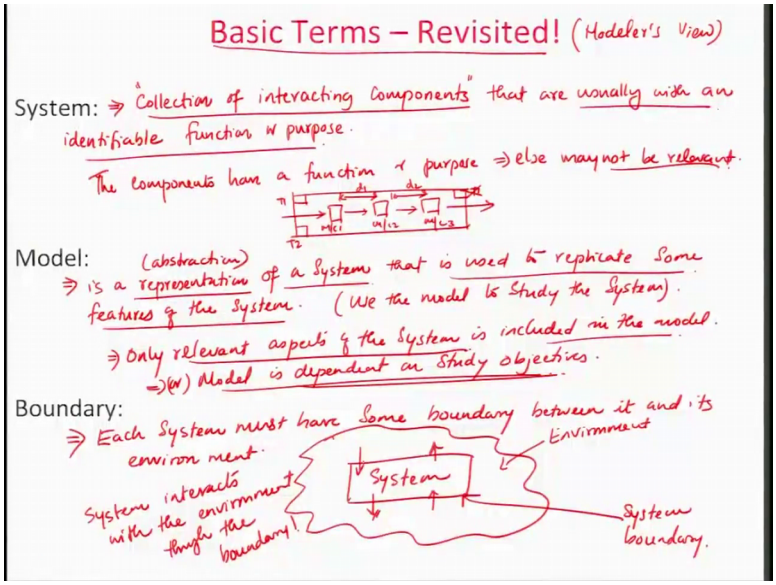

So, let us talk about the basic terms today ok. Some of the terms we have already seen a detailed definition; but we are defining, we have just relooking into these terms once again ok. So, the first term that we are going to talk about the system. We studied system in many terms; we keep on repeating the term system, system, system, so many times. So, for now from this ok, so this we will look into the modeler's viewpoint ok, what should be the mod these new terms from the modeler's view point ok.

So, from a modeler, a system is a collection of interacting components, it is a collection of interacting components that are usually with an identifiable function or purpose. So, it is a collection of interacting components, we are talking about a bunch of components that are interacting that are usually they usually have a identifiable function or a purpose.

So, the components have a function or purpose else may not be relevant. So, for example, is that if you are building studying a factory, so if you are looking into a factory like this, this is the big factory. And let us say there is a machine 1, machine 2, and a machine 3, (Refer Time: 03:54) machine 1, machine 2, machine 3, and parts come in and they go to these three machines and get out.

And then this is what you are studying as a simulation, and there is a toilet here, and then there is a toilet here, it does not matters whether the toilets here or here or either it is called this as T 1 and T 2, these are toilets T 1 and T 2. Whether T 1 and T 2 is here or the T 1 is here and here, it does not matters where it is, because that is not part of the study ok. So, it may not be relevant at this particular case, but this distances the these aspects, they are all relevant to the d 1 and d 2 are all relevant to what the studies are more important. So, the collection of interacting comments that are usually identifiable, they have a purpose, then that is what we call as a system.

Then model, we see we said that the assumptions that are used in studying the system becomes the model and those kind of things. So, here we say it is a model it is a representation of a system, representation of a system that is used to replicate some features of the system ok. So, what is model in this case, it is a representation or it is an abstraction, some people call it as an abstraction ok, but let us call it as a representation. A representation of a system that is used you are why you do you build a model, because you want to use that model to replicate some features of the system or you want to use this model in other way to use is use the model to study the system, to study the system that is what we talked about as a model in this regard.

Then we talked about so like an example is only relevant aspects of the system is included in the model or model is dependent on study objectives. So, if you are trying to study about a system, only the relevant aspects of the system, you are not going to include everything, only the relevant aspects of system are included in the model, because why, because the model is dependent on the objective. So, if you are trying to study a system, and I said (Refer Time: 07:04)747. And you are interested in studying the impact of two engine failure, then obviously you will probably be looking into studying that aspect of it rather than you might not be interested in studying what is the paint of the aircraft at that point ok; so, only those relevant only whatever is relevant to the study objectives are included in the model.

Then comes the last the third term called as boundary, we heard about system and boundary. So, we say each system must have some boundary between it, and its environment ok. So, one way to think about it is if you think about this as the system that is called this as a system, and let us call this as the environment ok, so then this component becomes the system boundary ok. And obviously, the system interacts with

the environment, system interacts with the environment or with its environment through the boundary. So, the boundary is the point at which the system interacts with its environment ok.

So, these are the interactions with the and obviously, the interactions can be this way also with the environment to the system and the system to the environment. So, in a manufacturing system and example of would be electricity will be from the environment to the system. And whereas the manufacturing, we store the use the coolant will be from the system to the environment that would be an example of the boundary of system or how interactions happen between system and such boundary.

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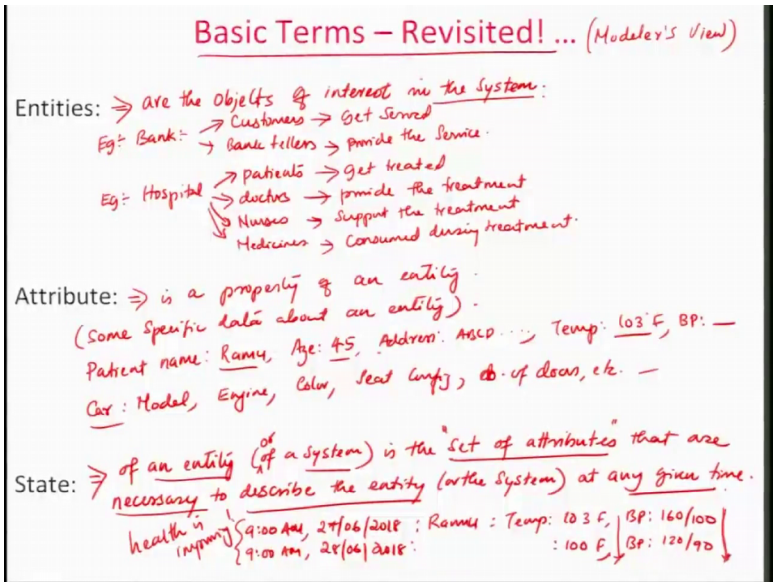

Now, let us look into some more of the basic terms. We have already seen these basic terms, but we would like to enhance this further and look it from again as I said is from a modeler's viewpoint. So, entities we talked about entities. And from the this modeler's viewpoint entities, they are the objects of interest they are the object of interest in the system ok.

So, for example, if you are talking about a example talking about a bank, then the entities could be the interest would be customers, bank tellers ok. Customers on they are the ones, who get served in the bank, these are the people, who provide the service. If you are in a hospital, the entities could involve patients, it could involve doctors, nurses, and support staff etcetera, it could also involve sometimes medicines ok. So, these are all so

the patients are the ones, who get treated. Doctors are the ones, who provide the treatment. Nurses are the one, who support the treatment. And medicines are one that are consumed during treatment. So, entities does not have to be live things also, non-living things can also be entities alright. So, entities are simply objects of interest within the system.

Now, we talked about attribute ok. So, attribute is a property of an entity ok, it is some data can say about some specific data about an entity. So, let us say somebody comes in and says patient name is Ramu, age 45, then address something ABCD something like this, then temperature 103 degree Fahrenheit, I believe its Fahrenheit not Celsius obviously, then blood pressure something like this. So, all these aspects, these are attributes; the temperature, the blood, these are all attributes that are pertaining to the entity of the patient.

If you are talking about a car that is being manufactured, car, then you have the model, then engine, color, seat configuration, then number of doors etcetera. These are all attributes of the particular entity called a car ok. So, any entity has a property, and this property we use in the study the simulation to study more about the aspects of the entity.

Then we talk about what we call as a state ok, state can be defined as a state of an entity ok, it can also be of a system also, it can be of an entity or of a system is the set of attributes, the set of attributes that are necessary to describe, that are necessary to describe the entity or the system at any given time. So, it is a state of an entity or you can talk about the state of a system, it is that set of attributes a particular set of attributes that are necessary, you require these attributes to describe the state of the entity or the state of the system at any particular given time at any given time.

So, like as I said at 9 am on 27 6 2018, Ramu had a fever of Ramu temperature is 103 Fahrenheit, BP is 160 by 100. Then at 9 am on 28 6 2018, Ramu's temperature is if you say temperature is 100 degree Fahrenheit, and BP is 120 by 90, then you can obviously say that Ramu's health condition is improving in this regard ok. So, the state of the system the state of the entity called Ramu is in the condition that the BP is reducing, the temperature is reducing, so the health is you can conclude that health is improving ok. Such an example or such is called as the state of the system or state of the entity.

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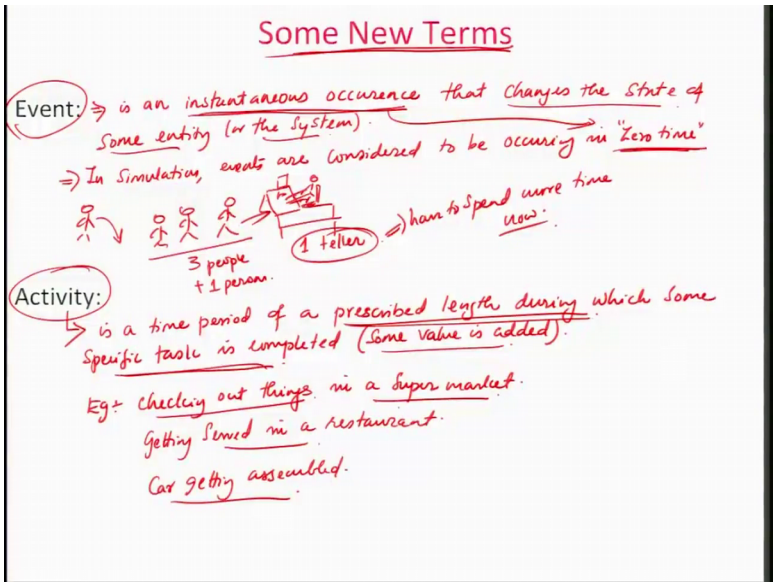

Now, we are going to get into something called as the new terms ok, some of the new terms that we want to talk about today. So, the entities and attributes to an extent, results in some new concepts and the first one is the term called event. An event is an instantaneous occurrence, is an instantaneous occurrence ok, it is an instantaneous occurrence that changes the state of some entity or the system ok. So, it is an instantaneous occurrence, it happens at a particular instant of the time that changes the state of the entity or the state of the system.

And in simulation, events are occurred or are considered to be occurring in zero time, which means the time taken for an event to occur is pretty much zero, which means its instantaneous occurrence, this is what we talk about it as the zero time. So, if you think about the scenario, where there is a bank teller ok, let us assume that this is a bank table ok, and here is a PC ok, and you have a chair, and there is a human being sitting here working on this one. And people are standing in a queue in front of the teller ok. So, this is a queue in front of them waiting to get served.

So, as of now, there are 3 people 1 teller or 3 customer and 1 teller, they are all waiting to get served. So, when one more person the 4th person comes into the system, it happens at a one particular instance of the time. And suddenly the state of the system changes, it becomes 3 plus 1 person ok, and the teller will now have to spend more time now, because the 4th person come in ok. So, that kind of a system, so that the system changed

system state changed or the state of the system has or the state of the entity has changed. In this case, the teller state has changed, also the system state has also changed, so that kind of an occurrence is what we call it as a event ok.

Then we talk about what we call as an activity ok. Activity is a time period of a prescribed length during which some specific task is completed, some people say this has some value is added. You can this is not to be a value addition, but some specific task is completed within a prescribed length of time period ok. So, some examples of this will be checking out things in a supermarket. So, you bought things, you took them to the cashier, and you are checking them out in the supermarket. Then another one is that you know you are being getting served in a restaurant. You are waiting in a restaurant, and you are getting served by that particular person, so it will take you some particular time to do that ok; car getting assembled ok. These are all examples of various activities that are happening in the in a system.

So, we now know what is an event, and we also now know what is an activity. And event is an instantaneous occurrence that changes the state of the entity. And then event is always considered to be occurring in zero time that means, the time taken for the event to happen is instantaneous, it does not take too much of a time. Whereas, an activity, it has a prescribed length of time during which a specific task is completed, some people say that at which a value is being added to the system. Even if there is no value to be added to the system, but still it is important, because a specific task gets completed.

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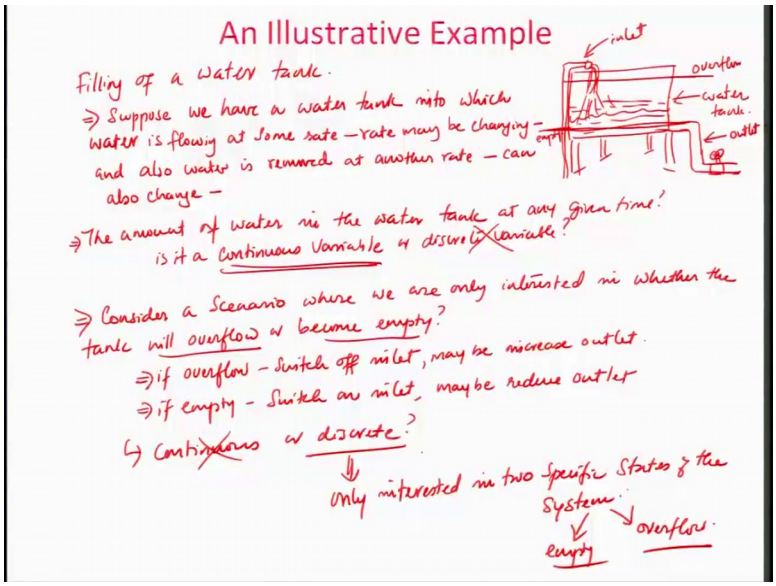

So, let us take a simple illustrative example ok. So, let us talk about filling of a water tank ok. So, let us assume that there is a water tank ok, these are the 4 pillars of the water tank. Now, it is kind of not a good diagram, but yes this is a water tank. Assume that this is a water tank ok, and you have a water pipe that is coming in and brings water into it, and water falls into this ok, and there is some level of water into this, and water falls into the water tank alright.

Now, so let us assume that suppose we have a water tank into which water is flowing at some rate ok, and rate may be changing, do not be a constant rate, it can be changing, and also water is removed at another rate can also change, this rate can also change. And so, assume that there is another place, where you are removing the water, and the water is going out, and here is a you know valve for controlling the water that is going out. So, this is where the this is the inlet, and here is the outlet, where the water can is being consumed. People are taking the water out through the outlet, and that rate of consumption can also change ok.

Then the amount of water, amount of water in the water tank, the question is it continuous, is it a continuous variable or discrete variable. The first question is the amount of water in the water tank at any given time, is it continuous or discrete, obviously it will be a it can be thought about as a continuous variable, it is not a discrete

variable. As time progresses, this value will keep on changing. If this rate is less, then the water will keep on rising. When this rate is more, the water will keep on decreasing.

Now, consider a scenario, where we are only interested in whether the tank will overflow or become empty? Ok, if that is what a scenario we are interested in, we are only interested in a scenario where the water is. So, let us say the water reaches this level, this is called as overflow level. And if the water reaches this level, then it is considered as the empty level ok. So, if you are only interested in this, whether the water is overflow. So, if overflow switch off inlet ok, if empty switch on inlet, maybe reduce outlet, maybe increase outlet. So, this is possible, you might more be interested in this.

Now if you are just only looking into this, whether if the system is overflow or empty that is the case that you are looking at. Now, is it continuous or discrete? So, in this particular case, it is no longer continuous, it is a discrete system, because you are only interested in so, here only interested in two specific states of the system ok. The two specific states that you are interested in is empty or over flow, everything else is immaterial to you, whatever the water level is in between, you do not care. So, when so this is where you have actually now discretized a continuous system ok. So, this is an example of how sometimes you study a simple system.

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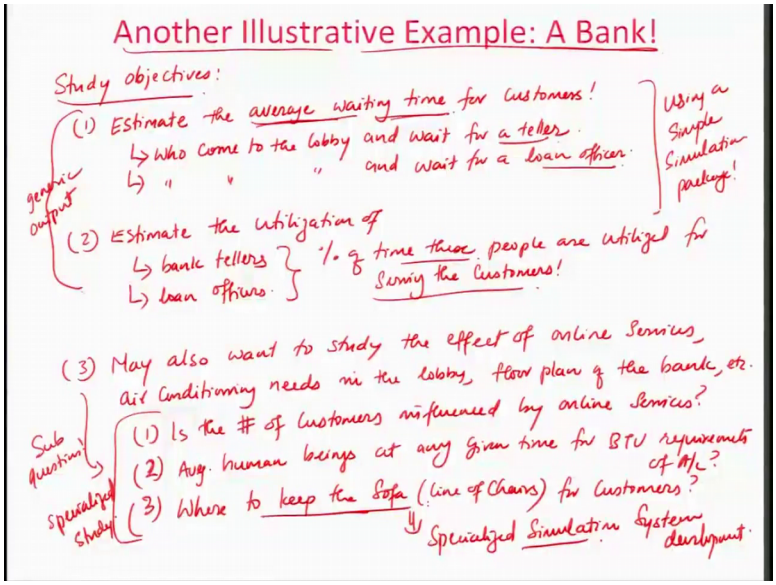

Now, let us take a another illustrative example. This is a very common, and people use this example to illustrate the use of a simulation, and then it is an another aspects in it.

And what this is called as it is a bank ok. A bank is a place, where you go to or deposit your money or get a loan or get financial services stuff like that. So, let us define some study objectives to begin with.

So, you want to study a bank, and for the time being, our study objectives in this case is the 1st study objective is to estimate the average waiting time for customers ok. You are interested in finding out the average waiting time, how long does the customer have to wait before getting served ok. And in this the two type of customers, who come to the lobby and wait for a teller, who come to the lobby and wait for a loan officer. You have two type of customers, some of them will come to the lobby and wait for a teller, some other will come and wait for a loan officer. Then in both cases, what is the average waiting time for the each type of a customer ok.

Then second one is estimate the utilization of bank tellers and loan officers ok. So, here is percentage sorry of time, these people are utilized for serving the customers, so that aspect we are interested in estimate the utilization of bank tellers. How long, what percentage of the time, the teller and the loan officer are serving the customers.

Then you can say 3, may also want to study the effect of online services, air conditioning needs in the lobby, air conditioning needs in the lobby ok, floor plan of the bank etcetera ok. So, you might want to do that. So, you might want to say whether the number of so, you can maybe some of the question is, is the number of customers influenced by online services ok? Second one is average human beings at any given time for BTU British Thermal Unit requirements of air conditioner ok? So, these kind of things you know how what is the floor plan, which is the best way to keep, where to keep the waiting area and those kind of things; or maybe where to keep the sofa or line of chairs for customers ok?

So, these kind of questions can also be studied as part of the so, these are sub questions of this might be something that is not. So, these are typically what we call as generic output, and this could be specialized study. So, depending upon the objective of this study, you might end up using a general purpose simulation language or a specialized software, it is up to you.

So, if you are looking at generic output, it is probably not much important too. So, here in most these studies, you might end up using a simple simulation package ok. So, you might just take a simple simulation package and simulated model the system and study

this whereas, here you might require a specialized simulation system development. So, you might end up developing a specialized simulation in this particular case, because you might the standard simulation software available, might not help you in identifying the or incorporating the floor plan of the particular bank to decide where to put the chairs and other things ok.

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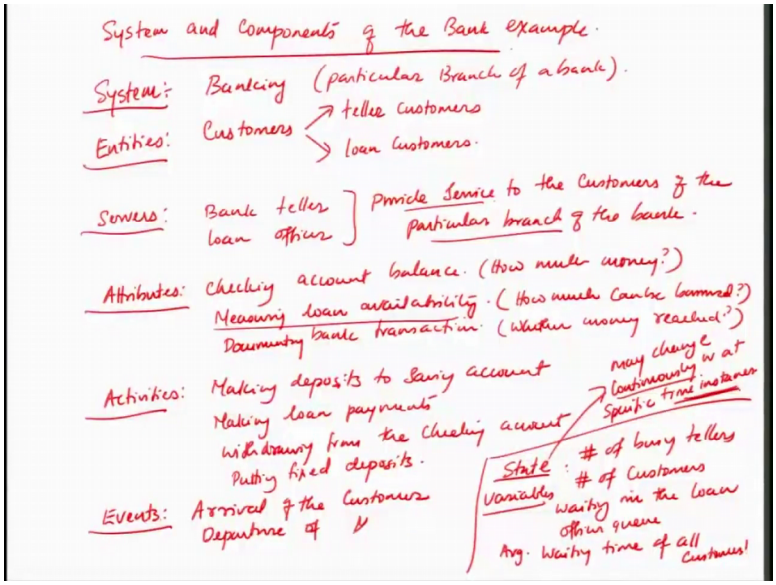

So, with that, now let us take a look into the you know various system and components of the bank example. So, let us take a look into what are the systems and components of this bank example. So, the what is the system of study here as banking, you are studying the banking system a particular for more specific it is a particular branch of a bank that is what the system that you are interested in studying.

Then what are the entities in this, entities you can say there are customers. You want to be more specific, you can have two entities, they are the teller customers and loan customers ok, you can think about it that way. So, you have two types of customers in this regard. Then there is another entity is also in this regard. So, these are the people, who move in the system.

Then they are the servers that will be bank teller, loan officer ok, they provide service to the customers of the particular branch of the bank. So, these are the people, who provide the service whether it is a teller service or a loan service to the particular the customers of a particular branch.

Then some of the attributes of the entities can be think about checking account balance ok, measuring loan availability ok, verifying bank transaction. So, there are many attributes that you can think about ok. So, in this case is instead of verifying, you can say documenting. So, here is checking account balance is how much money is there in the bank ok? Measuring loan availability means, how much can be borrowed ok? Documenting bank transaction is whether money reached ok? So, those kind of things. So, these are the attributes of a particular individual.

Then we can talk about activities ok. So, some of the activities we can think about is making deposits to saving account. Then we have is the making loan payments, withdrawing from the checking account ok, putting fixed deposit, so deposits. So, these are all activities various type of activities that the customer can do with the help of the servers in the bank in the depending upon what they are there for the bank.

Then we can think about the events in this case. The major events in this case are like arrival of the customer now the customer, departure of the customer etcetera of the customer etcetera right. And then the last aspect is the state variables the system state variables that includes the number of busy tellers, how many tellers are busy, number of customers waiting in the loan officer queue ok, then average waiting time of all customers etcetera ok. So, these are the state variables.

So, if you think about it, the system here is a banking system. And the entities are two type of customers, the teller and the loan customers. Servers are the bank teller on the loan officer, who provide services the customers. Attributes are like checking account balance, how much of money is left out, where how much of money I can borrowed or the measuring the loan availability, documenting the bank transaction whether the money is reached yes or no kind of a thing.

Activities can make deposit into your savings account, you can make loan payments, you can withdraw from the checking account, you can put fixed deposits, those kind of things and events these arrival of the customer, departure of the customer. And state variables includes how many tellers are busy, how many customers are waiting in front of the loan officer, what it is average waiting time of the system.

So, in this case, you should think you should understand that state variables they may change continuously or at specific time instances. So, if they change continuously, then

we are talking about a continuous simulation or continuous system. And if they change only at a specific instance, then we are talking about a discrete system. As I showed it to you how a continuous system and can be studied as a discrete system, and a discrete system currently, if you take in a particular fashion, we can also study things in a continuous fashion.

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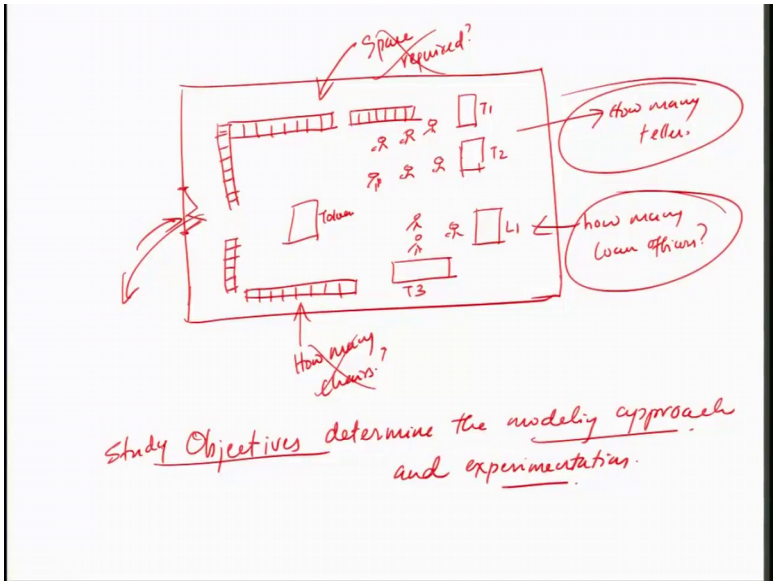

So, with this, what we what I am so if you take a look into this again, as I said earlier if you think about the bank let us say you are assuming that the people are coming to the bank in a so, here is a teller 1, teller 2, and you have loan officer 1 ok, and let us say you have a teller 3. If they say this is the arrangement, then the people come into the system. So, here is the door of the bank let us say this is the door of the bank ok, people come into the system. And people can this is probably let us say the waiting space for the lobby, where people are sitting waiting for. So, here you have let us say you have waiting space available right here, think about it does a bench in which people sits or bench or a sofa anything of the sort, people have places to sit.

And then the or you can think about people being standing in a queue also whichever way you want, you can think about it. There could be a scenario, where people will be making lines in front of the tellers like this, there might be one person waiting in front of the loan officer, there might be two people waiting in front of this teller; or there could be people coming to one location, there is a token system available, and people sit here,

and token numbers are called. There are many ways; the queue management will be taken care of.

But then, you have you know then once it is done, then the people will come in and then they will get out also through this bank. So, this case, you can think about how many chairs are required, how many chairs you know, then you can think about us how many tellers, how many loan officers, all these things ok. We can talk about is the space required?

The quite a lot of analysis we can be done using the simulation. But, at the question here is how much, what are the details you are going to study. If the goal is to decide how many people have to be employed, then you do not need to worry much about how much of any how many chairs, and how many space requirement, might not be a big issue. But, if you are more interested in the air conditioning, then you might want to find what is the space requirement, how many people are there and those kind of aspects.

So, in another way the objectives determine the modeling approach and experimentation. So, the experiment the simulation experiment and the modeling approach is determined by the objectives or what objectives study objectives, what are you interested in studying. The study objectives determine the modeling approach and the experimentation in simulation.

So, with this, we come to a conclusion of today's lecture on this particular topic. I hope that it now the concepts are very much more clear to you. Now, to in the next class, we will study the, we will look at the formal step by step approach of how to conduct a simulation experiment. When you build a model, how to do experimentation using the model; and from there, we will move forward and identify how to do the rest of the aspects.

So, thank you for your patient listening. And then the do not forget to read your daily lessons and as well as the assigned reading, and keep doing your homework, practice things, because this is a new topic to you. Without practice, you will not be able to understand this better. And once this is done, we will now get into the learning of how to use arena to do various simulations, and that will result in few assignments to you, and you will have to do that as part of your probably as part of your exam as well. Thank you for your patient listening, and I will see you guys later some other day.

Thank you very much.