Practitioners Course in Descriptive, Predictive and Prescriptive Analytics

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Lecture – 04
System, Models and Modeling Process

Good afternoon, today we welcome you to the another lecture in the course of applied analytics. And we are continuing in this course in the way of understanding the need for rational decisions and how analytics both the descriptive prescriptive and as well as the latest advanced predictive analytics then how with actually helps in a decision maker to make the right decision for the organisation.

And today we are going to get into the concepts of systems models and the modelling process we will look at brief overview of this and then we will take them much advanced stuff. So, today we are discussing systems first in a brief this way then models and then the modelling process and I am Doctor Deepu Philip and I am from IIT from Kanpur.

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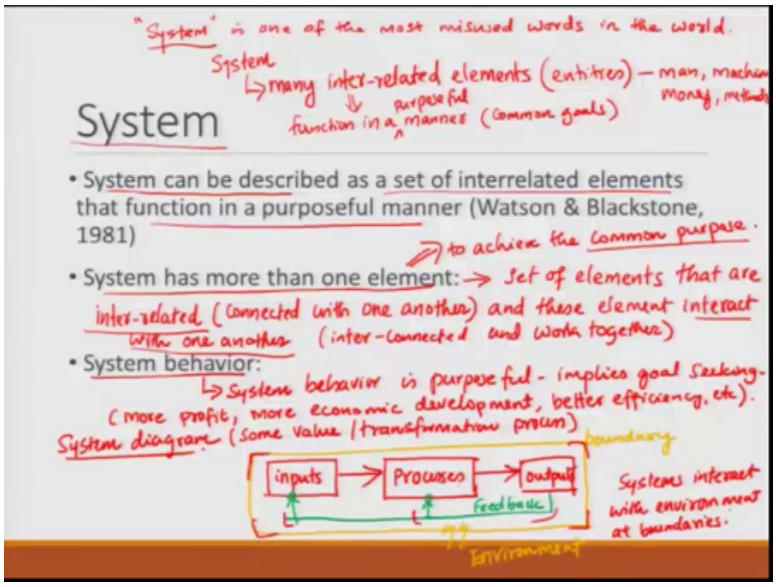

So, let us talk about the first thing called system now there. So, lo lot many ways people think about system.

So, I would say the first thing is system word; the word system is one of the most misused words in let us say that is in the word for the time being are there many many understanding another things about it. But in our case today when we are talking about system in the price of analytics, in the context of analytics we can we can derived system we can describe system ok.

Let us describe system as set of interrelated elements that function in a purposeful manner; this is what wall Watson and Blackstone kind of certain time 1981. So, system the main aspects of a system is system has number 1; many interrelated elements some people would like to call this as entities these typically include man, machine, money, methods, money, methods etcetera; these all parts of the interrelated elements of a system.

And all this interrelated elements what do they do? They work or they function in a manner in a purposeful manner or in a better way say is this a; this goes towards a common goal of common goals. So, system has common goals in which all the entities of the system or all the integrated elements of the system work together to achieve that goal or the goals.

So, ah; obviously, system the first important is a system has more than one element this is one thing that people we all should understand. System with more than one elements means, it is typically a set of elements; let us think about set of elements more than one element. And these set of elements set of elements that are; they are these elements are interrelated ok, they are connected to one another ok.

So, when we saying that connected with one another ok; this is the important aspect of the interrelation these elements of the system that connected with one another. And these elements interact with one another. So, they are interrelated and they also interact; so, one way to think about this day are interconnected and work together ok. Why do they do all of these? To reach to achieve the common purpose ok.

So, all these elements; that these interrelated elements that interact with the one another. The reason these inter related elements interact with each other is to achieve the common purpose of the common goal. So, as I said earlier system behaviour always remember this; system behaviour is purposeful. System behaviour is purposeful which also means

that implies; this implies what does it commonly means? It is a goal seeking behaviour, it moves towards a common goal.

So, the goal seeking could be you know more profit, more economic development and ok; it could be better efficiency etcetera. So, this goal will remain common; multiple goal it can be different type of goals, but the system will typically will work towards a common goal that is the most important aspect of it. Now if you draw; a system, a system diagram if a diagram a system many ways people diagram the system.

And one of the diagram that I like the most; which is originally proposed by Watson and Blackstone is system is can think about that you know some value addition, some transformation; value addition slash transformation happens process happens there is some process involves. So, you have something called as inputs; you input various aspect into the system, this inputs go through what we call as processes is ok. And these processes will provide you what we call as outputs ok. So, once we say that these are the aspects of the system, I am going to change a colour to show you something elements.

So, the inputs the process is; the input resulting processing is will result in output. From here it could also have something called feedback; which you could go into. So, what we call as the feedback; so, output will decide tell this output was as per the requirement that not as per the requirement. So, if the processes need to be changed, it will change the processes; or if the input needs to be modified, it will modify the input.

Then along with this we will also have called as the boundary of system. So, if this is what we are focusing on to study the system; then the rest of it is what we can call it as the this is what we call of the boundary and through the boundary the system will interact what we call us environment . So, everything outside system boundary is the environment. So, in our case what we are basically focusing on is the system where the inputs gets translated into processes, the processes; the input is supplied to processes and these processes translates the inputs to outputs.

During this process, we have feedback and the feedback can at times go to; feedback is provided after the output to the processes. So, you think can be address in the processes, it will use here otherwise it will go to the inputs. And system has its own boundaries what we are talking about and these boundaries is that this is the boundary; within the

boundary is what we define to study the system and everything outside the boundary is environment. And systems interact with environment at boundaries.

So, the boundaries are the place where the systems interact with the environment hope this is clear. So, we will go to be next concept.

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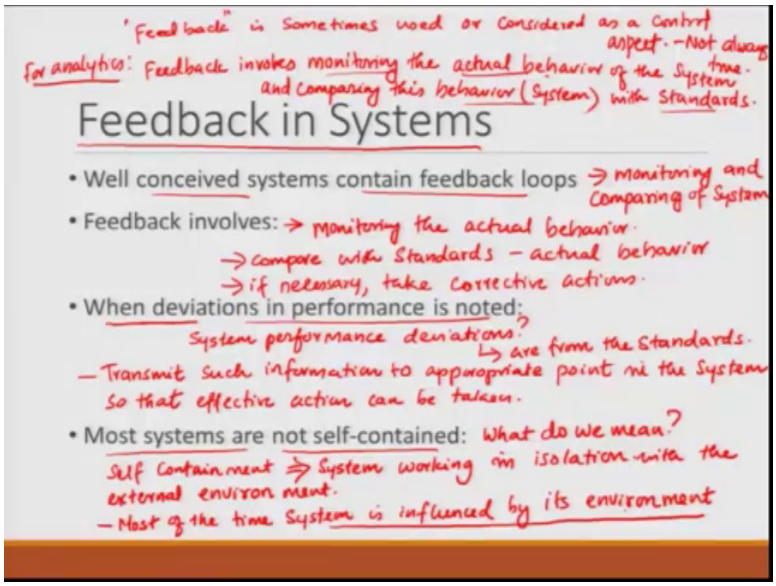

So, we talked about something called as a feedback in the system and feedback lot of the time people; people sometimes use feedback is sometimes used or considered as a control aspect ok. This is not true for us; feedback is not just this is not always true here we are talking about feedback in the sense that all the system; so, what we talk about feedback?

So, feedback for us, for analytics if you are considering analytics; feedback involves feedback involves what do we mean by feedback? It involves monitoring the actual behaviour of the system; the actual behaviour of the system ok. We are studying the actual behaviour of the system and comparing this behaviour comparing this behaviour whose behaviour? System behaviour ok; this behaviour of the system, it is compared with compared this I am comparing this behaviour with standards.

So, if you have a standard or you have it you have an expectation that the system should behave in this particular fashion, then we use this to basically established; we use, we monitor the actual behaviour in the system. And using this monitoring, we actually

compare the actual behaviour of the system or the current observed behaviour of the system is compared with the standard to see; how the system is working.

So, all well conceived systems will contain feedback loops. So, it allows were what we call as monitoring and comparing or you can also call as standardizing the system. Monitoring and comparing of systems is done very well through using feedback loops. It can be used for control, but it can also with there is no rule that it should be used for control [vocalized- noise].

So, what does the feedback involves. So, what happened is the; what happens in feedback. So, as said earlier what is the base in the feedback is it involves monitoring the behaviour of the system; monitoring the actual behaviour of the system ok. This we all know; this is the monitoring the actual behaviour and compare with standards; compare with standards what? Actual behaviour you have compared with the standards.

So, what now? If necessary take corrective actions ok. So, sometimes this taking the corrective actions falls under the realm of controlling the system. And hence sometime people says that feedback is also another way of controlling the system; which in some case is it is true, but it is not always true remember that. So, then when you find deviations what happen when you find deviations in the performance? When deviations in the performance of whom? When the; when deviations in the system performance system performance system performance deviations if you find deviations in the system performance what are you going to do?

So, from where do you find the deviations? Obviously, these deviations are from the standards you find some deviations from the standards; or the expected performance of the system; what do we do? The most important thing is transmit such information such information what information? The deviation from the standard such information to where do we transmit to? Appropriate locations appropriate point in the system appropriate point appropriate point in the system.

So, in the previous diagram we have seen that we are transmitting this to; to the process level or to the input level appropriate the system why do we transmit this? So that. So, that effective action can be taken action can be taken right. So, when you see when you find that the system is deviating when deviations in the performance from the standard is

noted transmit that information to appropriate point in the system so that corrective actions can be taken.

That is the one important of aspects of feedback in the system and also you should remember that most systems are not self contained ok. When we say that a system is self contained; what do we mean by it what do we mean what do we mean by self containment? The self containment he means; self containment implies system working in isolation.

So, which implies isolation means isolation with the external environment. Many people would like to do this, but the truth is that most of the time most of the time system is influenced system is influenced by its environment ; this is very important you should remember this that the system is influenced by self contain. Very rarely you get systems that are isolated, self contained system. Most of the systems are not self contained, they work in tandem with environment where the environmental factors the factors that are outside the boundary of the system do have its influence on to the system with that we talked about the concepts called system boundaries.

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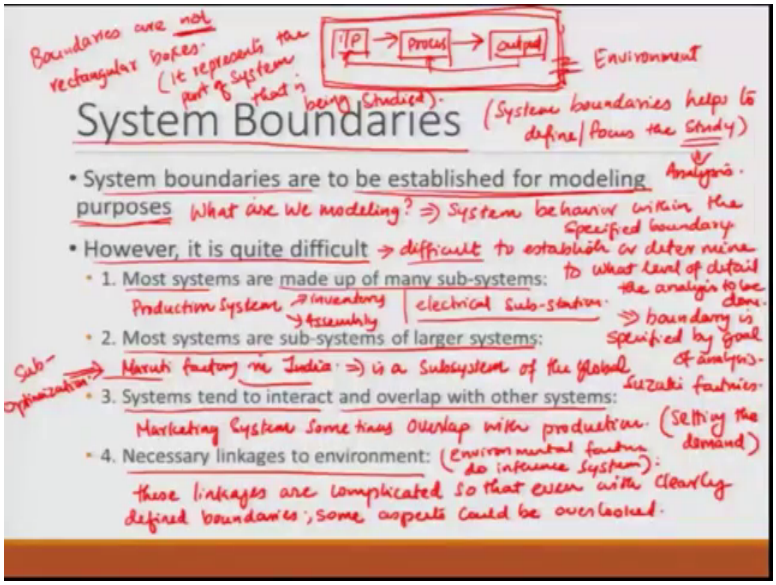

And we like system boundary; system boundary be being repeating this step. So, what is a system boundary? So, remember if you think about the diagram we draw kind of; this is the inputs from there we drew the process then we drew the output. And then we had feedback loops and other things which when like this as the feedback, then we drew the

boundary; some an imaginary kind of a concept and then we said it in interact with the environment here and we call it as boundaries.

So, boundaries are never really rectangular boxes ok; boundaries are not this is important not a rectangular boxes ok. It is just for representation purpose it is like, so it actually it represents the part of system that is being studied ok. The important aspect is that is that represent that part of the system that is being studied.

So, the major recent why we do the boundaries why are system boundaries used? They are used to established for modelling purposes because when your modelling, you do not want to study the entire system, you do not want to study the system understand; you want to focus your study . So, system boundary system boundaries helps to define or focus the study. In our case, instead of the study it is the analysis; so, we focus on analysis on the system using the help of system boundaries.

And hence once were establish the boundaries then we can using the boundary, you can model the behaviour system. So, what are we modelling here? What are we modelling? We are modelling the system behaviour system behaviour within the specified boundary all right. So, we are focus we are studying this within the specified boundary of the system and it is difficult to design ok.

So, we can always and you should understand the system boundary; it is quite difficult to establish. So, or it is difficult to establish or determine it is not just difficult, is quite difficult to establish or determine to what level of detail the analysis should happen analysis to be done ok. So, this is a major question difficult establish for determine to what level of detail analysis is to be done.

So, the boundary do help us in focusing the decision or focusing the analysis, but yes it is difficult to draw the boundary; why? Number one reason the reason is system most of the systems are made up of many subsystems ok. Because for example, ah let us take an example; a manufacturing system or a production system a production system has many sub systems; one is the inventory or the stores ok, it is an assembly line painting.

So, many aspects are there, but one aspect of it is also that there is also something that you require an electrical substation ok. So, now the question is; is this electrical substation part of the system is within the boundary or outside? So, it is a subsystem of

the production system, but it can be sometimes treated as a part of an outside system or the environment or it could be treated as part of the internal aspect as well.

So, because of these many sub systems; so, if your study is only focused on line balancing, balancing the assembly line to decide how fast the conveyor belt of the factory should move so, that the production; desire production can be reached. If that is the focus point then studying the electrical substation is outside the boundary of the system, but if you are studying have to achieve production with minimal use of energy; then the electricity electrical aspect is part of the system.

So, depending upon the study; so, this also tells us that boundary is specified by goal of analysis ok; this is an important aspect. Second part is most systems are subsystems of larger systems, the second reason why this becomes drawings this boundary is a big problem. So, like for example, let us say you are studying the Maruti factory in India ok. This could be treated as a system, if you studied in the Maruti Suzuki factory in India, but is also a sub systems of the is a subsystem of the global Suzuki factories.

So, the system that we are studying here in India as the Maruti factory is actually a subsystem of the global Suzuki factories. So, the system that we are considering at one point of; it could be sub system of someplace else; so, when you have subsystems then we get into this problem called if you study just focus on the optimisation or making the Maruti Suzuki factory in India is the best factory, then all you are doing is your not making Suzuki the best thing; you will end up doing something called as sub optimisation.

All system studies, all analytics do suffer from this problem we will see this in the complicated problems, but remember that a system that we studying today could be a very well be a subsystem of something else. Third part is systems tend to interact and overlap with other systems. So, here what we saying is that an example is the marketing system marketing system of a company sometimes tends to overlap with the production system; sometimes overlap with production how?

In what we call as setting the demand so, the marketing people are the one who tell what is the demand for a particular product. Once you know what is the demand for the particular product; that is when the production department decides how to produce, how to fulfil that demand? So, that is the place where the marketing system interacts with the

production system, but there could be other situations where production system is trying to figure out what is a line balancing or what is a optimal speed of the conveyor belt or which tool to be use to drill this particular whole; they are all need to interact with the marketing system at all.

Last one is last aspect of this is the necessary linkages with that of the environment ok. Many a times these linkages are complicated ah; so that even with clearly defined boundaries some aspects could be overlooked ok.

So, because lot of the things the environmental factors; mental factors do influence system. A classic example of this is the price of oil set by the opec countries do influence the cost of production of petrol and diesel from the Indian oil companies. Indian oil corporation, Bharat petroleum limited they all decide the production another aspect depending upon the price of oil set by the countries in the middle east ah; that is an environmental factor the price set by the opec nation is an environmental factor which influencing the internal aspect of the system.

Let us say if you are studying IOCL corporation as an example ok; so, it is not straight forward in that regard, but yes it is the reason this system boundaries difficulties because of all these kind of different considerations. But still you have to do the best as you can to define the boundary of the systems so, that you can do some sensible analysis out of it.

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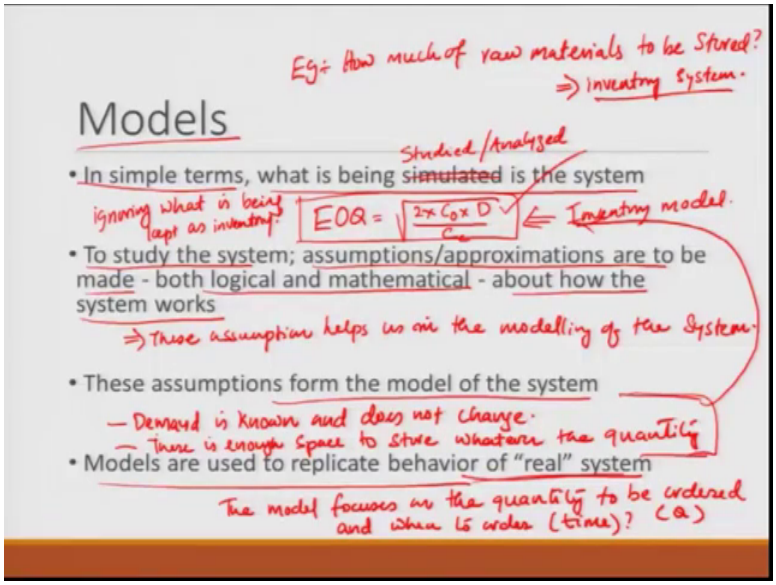

Then let us talk about models ok; the model is a in the way in the say word that is very complicated, but still in the most simplest terms what is being simulated is the system or what is being instead of using the word let us study what is being studied or what is being analysed the simulated might be a wrong time here.

We will say that what is being studied or analysed is system, whatever you have studied let us think about it that way ok; what you are studying is a system. So, in this case an example of a system will be if you are looking at how much of the product to be stored; how much of raw materials raw materials to be stored raw material to be stored.

This focuses on the inventory system inventory system. So, the inventory system may not be something that you might not study otherwise if you are worried about the raw materials to be stored ok. And how does that influence the rest of the system that say complete the different story all together, but you probably get an idea. So, if you are just studying inventory system then you look at the inventory model and then you sometimes find the EOQ model where you will say that is the root of two times the ordering cost times; the demand divided by the carrying cost, if you might be look at a mathematical equation like this where we studying in the inventory.

And this is the in what we call as the inventory model. So, we are studying how much of a how much quantity is to be kept in one particular place and this is a mathematical way of modelling that; so you are just focusing on that aspect of the system. So, is to studying you are not worried about what you are storing, you are only worried about quantity of whatever is to be stored. So, here we are ignoring what is what is being kept as inventory ok. It could be nut, it could be bolt, it could be missiles, it could be guns; does not matters; you are just worried about the inventory at this point you just worried about the number the quantity that is all you are worried about.

So, to study the system assumptions and approximations are to be made; we make assumptions and approximations; more the logical and as well as mathematical; how the system works. So, these assumptions to large extent become the help us making the models. These assumptions this assumption helps us in the model or modelling of the system ok.

So, the assumptions are form the help us to form the model of the system. So, in the EOQ system we assume that demand is known and does not change. So, you assume that

the demand is known and it will not change, we also assume that there is enough space to store whatever the quantities. So, there is no space constraint as we think about it.

So, these assumptions based on these assumptions; we study how to store some item in a factory and for that we develop a mathematical model ok. So, these assumptions help us in forming this model and why do we use models? Because, we can use models to replicate the behaviour of the real life system.

So, in a inventory the model focuses on focuses on the quantity to be ordered which is the Q and when to order; which is the tie. So, we are worried about the quantity and the time specifically in an inventory system. And to do that we take assumptions and these assumptions about the system and assumptions helps us in forming the models.

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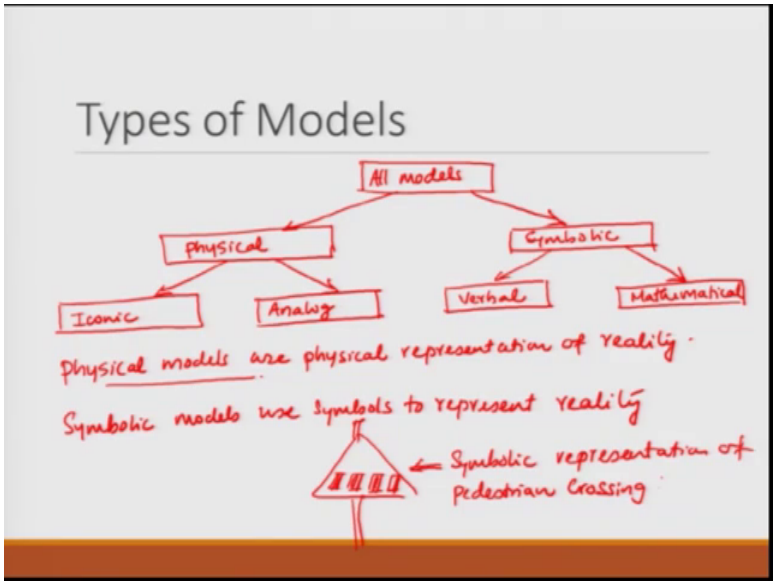

So, there are multiple types of model and we will quickly go over the type of models ok. So, all type of models let us think about it this way ok; all models let us take about it and it can be divided as for as by Blackstone another people can be divided into two. One model can be called as the physical model and other one can be called as the symbolic models ok.

Models can be either physical or it can be symbolic and the physical models are further divided into two and this is called as the iconic models and it could be the analog

models. And the symbolic models are we will study what each one of them in detail; the symbolic models can be a verbal model or it could be a mathematical model ok.

So, in way when we talk about this we have to study; let us first talk about what is a physical model? That is easy to understand physical models are physical representation of reality; representation of reality ok. You are physically representing the reality of the system where as what is a symbolic model? Symbolic models use symbols to represent reality.

So, an example is if you see a road sign something like this if you see a road sign like this which says upon on sign is kept some place then; that means, there is a pedestrian crossing ok, it is a symbolic representation of pedestrian crossing which means I had some place there are people who are going to go across the road; so, that is what a symbolic example is. So, let us look into the definitions of each one of this iconic, Analog, verbal and mathematical and see what it amounts to ok.

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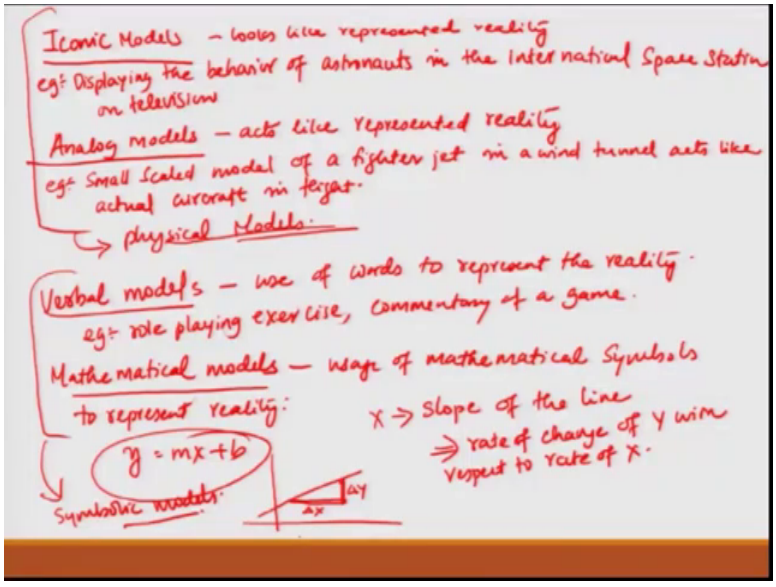

So, the iconic models when we talk about it what are iconic models? The iconic models are they looks like represented reality ok. So, an example is reality shows; so ah displaying the behaviour. So, here is an example is like the behaviour of astronauts in the international space; international station, international space station on television ok; this appears this is what we call as an iconic model, it is a represented reality of what is

actually going on. You are not seeing what is going on this system, but actually seeing on a TV screen; what is going on there.

So, that becomes an iconic models now let us talk about something called as an analog model ok; what an analog models. So, analog models they acts like represented reality; the previous case it looks like the represented reality; in analog model it acts like represented reality. An example of this is a small scaled model of a fighter jet in a wind tunnel; acts like actual aircraft in flight that is what we talked about here in analog model. The iconic model both are is both this cases, they are actually the physical system models ok; you are actually seeing the physical system, you are observing; in iconic models your observing is through a television, in an analog model you make a small model of it and that model excuse me act like they represented reality.

So, these two together becomes what, we call as the physical models ok. Now let us talk about what we call of the verbal model, a verbal model or verbal models they are use of words to represent the reality ok. So, an exam is examples of these are role playing exercises or it is the commentary of a game. So, when somebody says like if we are talking about a soccer game, you can say that the soccer game between Germany and Brazil is going on and you say that how the currently the ball is being moved forward to the a Brazil half by Philipp Lahm and like that.

Then; obviously, then you will see the have in your mind the football court and the court the ball is not passed the central line and now it is in the side in which brazil is playing. And Philipp Lahm is pushing the ball forward that is how you will look at. So, when somebody is using words to describe what is actually going on that becomes a verbal model.

Lot of the commentaries about of the game is an example of a verbal model. Then let us talk about the last one which is called as a mathematical model; mathematical models. Mathematical model means this is the usage of mathematical symbol mathematical symbols to represent reality ok.

So, for example when you do an equation something like this y is equal to m x plus b so, in this case x represents this slope of the line or it actually represents is rate of change of rate of change of y with respect to q; rate of change of x right. So what delta y by x? How is the y changing with respect to x? So, in a realistic scenario; you can think about

you draw a line something like this is what we are talking about delta y is the raise increase the raise in change to that of delta x the change of x.

Physically if you have ah a mountain then that slope of the mountain can be very well be expressed by this particular equation. So, you are not seeing it was a mountain, but you are seeing it was a line a stray line with a particular slope. And so if you ah; so, using that you can decide if you want to climb this know how much of effort is required on all another aspect of this.

So, these two things what we talked about it these are what we call as the symbolic models ok. Either we are using verbal symbols or we are using mathematical symbols ok. With this, I hope you guys have understood and I have an overview of what is the model? What is the process of modelling? How is it related to the system? What is the boundary of system and how it helps in modelling? And what are the different type of models?

For each one of these cases, we mostly will be focusing on what we call as mathematical models as part of analytics. We will see in the next class on the some on asp advanced aspects of this for analytics or how the decision process in analytics are taken or considered together. And how analytics leads to different type of decisions and different decision layers that we covered yesterday and then we will go from there.

Thank you.