Principles of Engineering System Design
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Lecture - 30
Decision Making in System Design (Continued)

Dear friends, in the last class we discussed about the decision making process in system engineering and we saw few methods of using graphical tools to make the decision based on the probability and other aspects. We saw one example also.

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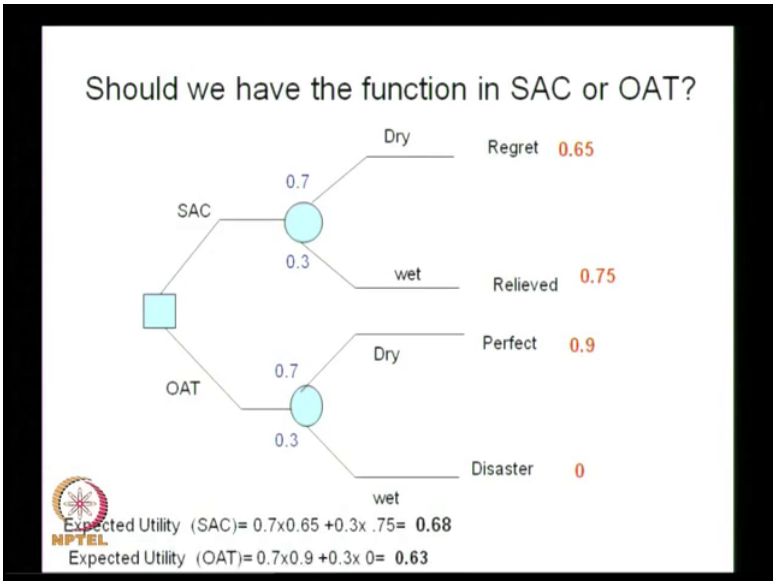

So, today will try to see few more examples. So, in last class we discussed about this problem of whether to have a function in a SAC or OAT, depending on the weather condition and if you know the probability of this conditions how do you make a decision about having a function in a particular venue. That was a decision making process, of course, it was not a very complex decision making process, a simple decision making process where we use the probabilities as well as the non chances and use this to get a proper decision. We will see another example today, which is slightly more complex than this.

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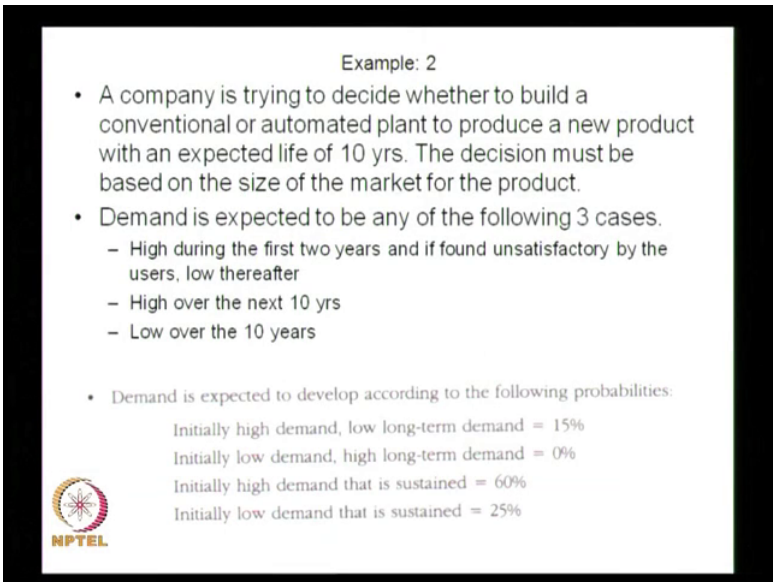

So, this is basically a company is trying to build a plant for a particular product and they have to make a decision whether to go for a fully automated plant or go for a conventional plant. And if they go for a conventional plant then they have an option of upgrading this to a automated plant at a later stage depending on the market demand for the product. So, here the company has to make the decision before really getting the actual product or really getting some real data about the sales. They need to depend on various factors like the probability of success of the product and for 10 year period what will be the changes in the sales or how much revenue they will be able to make. So, based on all this information they have to make a decision at this stage whether to go for a automated plant or a conventional plant.

So, the problem statement is given here the company is trying to decide whether to build a conventional or automated plant to produce a new product with an expected life of 10 years. The decision must be based on the size of the market for the product. Simply look at the market and then decide whether to go for an automated plant or for a conventional plant.

And they have some values or some approximation or estimations based about the sales. So, the demand is expected to be any of the following 3 cases. So, they have identified 3 cases, the demand is going to change. The first one is, demand is very high during the first 2 years and if found unsatisfactory by the users then it will be very low thereafter. So, initially 2 years they will be getting very good sales, but then depending on the product, if the product is not satisfactory then the sales will go down. And the other possibility is that the demand will

be high over the next 10 years. So, they are expecting that the demand will be very high over the next 10 years or the third possibility is that the demand will be low over next 10 years. So, this are the 3 possibilities and again we need to find out what is the probability of this 3 events occurring and based on this and the revenue they need to find out what should be the decision whether go for an automated plant or a conventional plant.

And the investment for this 2 that is for the conventional or automated plant will be different. So, now, we have to have some estimation of the demands, the probability of various demands. We will identify what are these probabilities and then based on this we will try to make a decision tree and then using the decision tree we can arrive at a particular decision.

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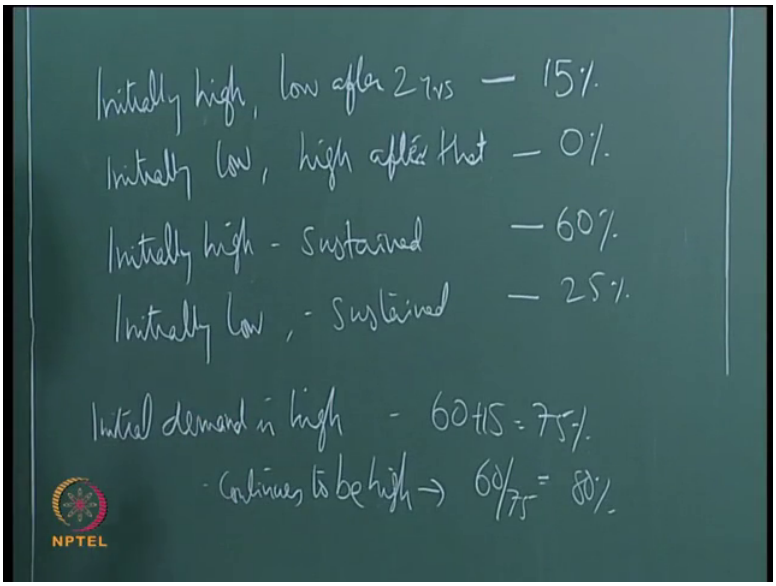

So, let me give all the values of the probabilities of various sales scenarios, that is, we have 3 scenarios identified. We have this initially very high demand initially high demand and low after 2 years, that was one case; there we have this probability of 15 percent or we can put it in percentage 15 percent is the possibility of this situation. The other one is, it is initially low, the demand will be initially low and be high after that. So, this is our there is no possibility of this is not identified. So, that will be a 0 possibility for this one, then initially high. So, initially you have very high demand and this is sustained over the next 8 years. So, this possibility is around 60 percent.

Then, we have this initially low and it continues to be low and this is sustained. The low demand is continuing that is another possibility and this probability of this one is 25 percent. Now, using these values we can actually identify few other scenarios and find out what will be the probability of those events happening. So, chance that initial demand is very high. So, we have condition this is initially high and this is also initially high and this 2 are initially low. So, these are 2 conditions where we can have initially high demands.

So, this probability will be 60 plus 15, 75 percent and then this initial demand high and it continues to be high. The probability is actually initially high and sustained is only 60 percent. So, this will be 60 over 75 it will be 80 percent. So, if initially this high the chances of it continuing will be around 80 percent. So, here now we have to look at the income from these plants.

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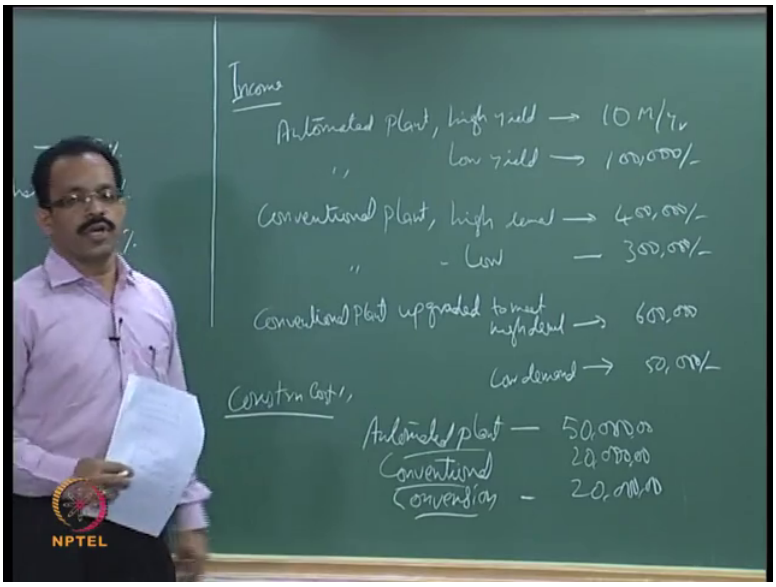

Suppose we have a plant, what is the possible income from these plants under different situations? So, if you have an automated plant and it is giving high yield I mean high outputs then the revenue will be around 10,000,000 per year. So, that is the expected revenue. These are all estimates, so, we do not we are yet to start the industry. So, this are the estimated revenue and you have an automated plant, but the low yield; that means, lower sales then the revenue will be only 100,000 per annum. We need these values to calculate the expected value of the different scenarios. And if you have a conventional plant; we have 2 options automated and conventional, so we have a conventional plant and the high yield high demand

or high yield then it will be 400,000 and if it is low, it will be 300 per annum. And if you want to upgrade the conventional plant or if conventional plant upgraded to meet high demand will be 600,000; that means, after 2 years if you change this to automated plant and the this 400 will become a 600 with high demand

And the same situation, low demand, we will upgrade it, but the demand is low then the revenue will be. So, these are the estimated revenues and the construction cost this is the revenue and say construction cost, automated plant be 50,000,000, then this will be conventional be it 20 and if you want to automate after 2 years, that is conversion or upgrading of conventional plant again it will be another 20,000,000. So, these are the cost involved in setting up the plant. So, if you have a automated plant, conventional plant or conversion of the conventional plant to in automated plant. So, these are the data available for decision making.

So, we have to make a decision whether to go for a automated plant or a conventional plant and the options are that you can if you start an automated plant you can get a various sales, you can have a continuously high demand for the product or we can have a high demand for initially and then low demand. So, if you go for conventional plant then again you have a initially high demand which is sustained and initially low demand it is sustained. So, these are the probabilities of having these kind of sales and we can again identify the other chance that initial demand is high is only 75 percent, but it continuous to be high will be 80 percent.

So, these are the various possibilities of sales and these are the revenues expected from these plants under various situations; that automated plant high yield, low yield; conventional plant high demand, low demand. Similarly, conventional plant upgraded and these are the cost required for establishing the plant or conversion of the conventional plant to automated plant.

Now, based on this information we need to make a decision tree which will actually depict all these values and then tell us what are the chances, what are the decision we can make and what will be that expected utility or the expected value of various decisions.

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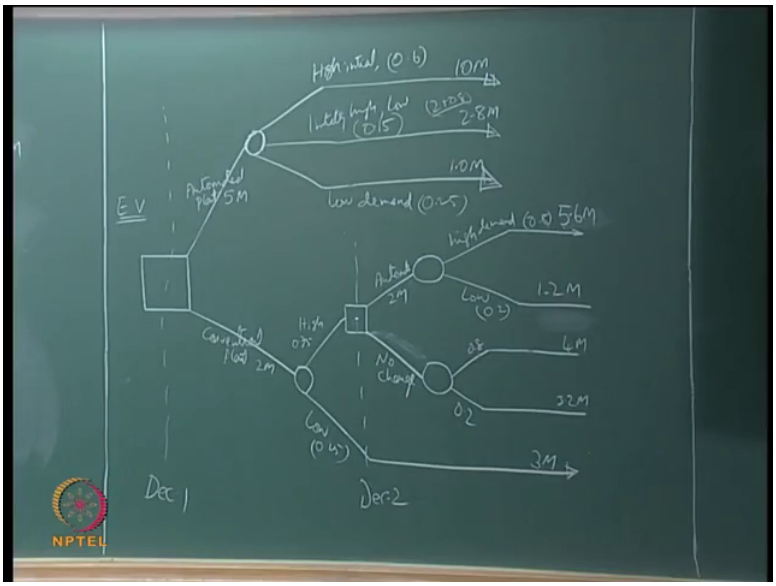

So, here as you know that in decision trees we have a decision node. The decision node is represented by a rectangle. So, this is the decision nodes and in this case we will be having 2 decisions; this is decision one, whether to go for a automated plant or conventional plant, then the second decision will be if you have a conventional plant whether to automate it or not, whether to update it or not, that will be the second decision. So, here in this decision we have 2 options, 2 chances; that is, you have a chance node here and you have a chance node here.

So, this is automated plant, build an automated plant is one with investment of 5,000,000 and then you have this conventional plant with the investment of 2,000,000. Here, once you have this we have 3 chances again, we have these 3 chances like various sales, you have initially high demand and then it is sustained or initially high demand which is reducing or low demand throughout.

So, we can actually represent all this. Here we have one decision, one chance, this is another one and then you will be having this situation. So, this is basically high initial demand and it will be getting then we have low thereafter and here the low average demand, this is the low demand and here the probability is given as 0.6. So, we can get here this initially high sustained is 0.6, so this is the high initial and sustained is 0.6 and this is low demand which is 0.25 and this is 0.15, initially high and then reduces low after 2 years. So, it is initially high

low after 2 years that is 15 percent that is the probability 0.15 here. This is initially high, then low. These are the 3 chances here.

We know the revenue what is going to be for this various situations, so we will write down this revenue also here. The revenue is 10,000,000 for 10 years. So, the plant life is assumed to be 10 years and so, 1,000,000, per annum we assume that the total revenue is 10,000,000. Now, here the revenue is 2.8 million for 8 years. So, this is 2.8, initially 1,000,000 per year for 2 years and so, it is 2 plus 0.8, so, 2.8 million for these first in 2 years initially very high. So, 2,000,000 and then it is very low it will be 0.8 million. So, 2.8 million is the revenue and this is only 1,000,000 is the revenue. So, that is the output here. So, this automated plant with an investment of 5,000,000 and we have the 3 possibilities here, high initial demand and it is continued with an output of 10,000,000; initially high, but then it is reduced 2.8 million and low demand 1,000,000. So, these are the 3 possibilities over there.

Now, look at here this conventional plant, you have high initial demand and low initial demand. So, if you have high initial demand for the first 2 year this is low. So, when you have a high initial demand the first 2 years, we will actually go for this possibilities, 0.75 high initial demands and then in that case will take a decision whether to go for an automated plan or upgrade it or not. So, this again a decision node this is the decision 2.

So, we have another decision to be made here and again you will be having all the 3 possibilities. So, you automate the investment. So, this is chance node automate, is an investment of 2,000,000 or you can go for the yeah. So, this is the other one go for the conventional one, no change. This is no change. So, this decision node will take a decision whether to automate the plant or not. So, one option is automate with a 2,000,000 investment other one is no change and again will be getting this is a initial high.

So, after initial high you will be having 2 options; one is sustained, other one is low. So, this is a sustained high demand continuous high demand probability is 0.8 here and this low demand, it is 0.2. This will be 5.6 million revenue and this will be 1.2 million and similarly, here also you will be having high and low again the possibility is 0.8 and 0.2 high and low, but here the revenue will be 4 and 3.2

So that is about this decision and here again will be having the same situation be going as this output. So, here you will be having 3,000,000 revenue and this is the low initial demand, the probability is 0.25. So, these are the decision nodes; 2 decision node and this are the chance

nodes. As we can see here, we have the initial decision to be made, whether to go for an automated plant or a conventional plant. For automated plant the investment is 5,000,000 and conventional is 2,000,000 and when we go for an automated plant. The possibilities of sales are here, 3 possibilities; high initial demand which is sustained, initially high, but it is low thereafter after 2 years and low demand throughout the probabilities are 0.6, 0.15 and 0.25. Again the revenue is calculated as 10,000,000 for this situation 2.8 million for this and 1,000,000 for this.

So, there is the first situation when you have an automated plant. But, when you have a conventional plant if there is a very high demand for the first 2 years, the company can decide in such a way that they go for a conventional plant initially and depending on the demand they will try to change it to a automated plant. So, here the conventional plant 2,000,000 investment and the demand very high is 0.75 for the first 2 years, if that is the case then actually they can decide whether to go for an automated plant or to upgrade it to an automated plant or not. So, these are the 2 chances upgrade or not the upgrade is the investment is 2,000,000 and this year the investment is not there no change and again the high demand is continuing it will be getting 5.6 million. If it is not continuing it will be getting only 1.2 million. So, that is the revenue.

So, in this case the no change then again if high demands 4,000,000 otherwise 3.2 million and if this not changed then it will be the revenue will be 3,000,000. So, these are the data available to make a decision. Now, as we discussed previously we need to find out what will be the expected value of this decisions. So, we have a automated plant decision or conventional plant decision, we need to look at what is the expected value of this decisions. We have the investment and we have these probabilities. Looking at this probability and the other revenue values we will find out what will be the expected value of these 2 decisions first.

So, as you know the expected value is basically the probability multiplied by the utility of the event happening as well as the event not happening, add them together and you will be getting the expected value of the decision. To find out the expected value of the first decision we need to find out these expected value of this decision and expected value of this decision.

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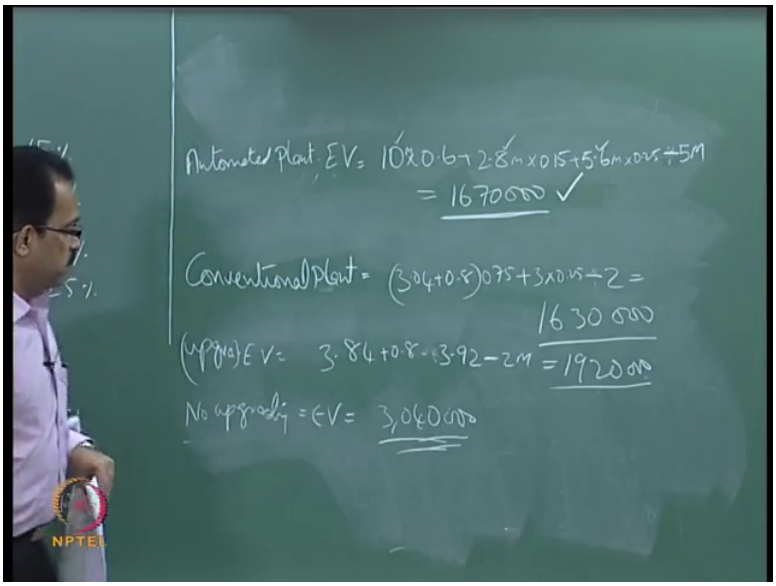

So, the expected value of the automated plant, if you go for an automated plant expected value can be obtained as 10,000,000 into 0.6 that is the revenue for 10,000,000, 0.6 plus 2.8 million into 0.15 plus 5.6 million multiplied by 0.25 minus 5,000,000. So, this 5 is the investment and these are the revenues, these are all the revenues for the 3 cases and its probability and that will be equal to. So, this will be the expected value of the first decision.

Similarly, for the conventional plant the expected value will be 3.04 plus 0.8, because we have 2 years revenue plus the other revenue. First 2 years will be having this revenue and then other revenue. So, 3.4 plus 0.8 multiplied by 0.75 plus 3.25 minus 2,000,000. So, this will be the expected value of the conventional plant and it will be given as 1,630,000. So, these are the expected values of these 2 decisions, whether you go for an automated plant or a conventional plant. This actually tells you what is the expected value of these 2 decisions and from there we can see that this has got a high expected value of the decision therefore, can go for the automated plant. That is the first decision whether to go for automated plant or a conventional plant.

But, in case, the company decides to go for the conventional plant then again the decisions to be taken whether to go for the upgrading or not, that also again to be calculated. So, we need to see what is the choice here whether upgrading or not upgrading and how do we take a decision at this point. Here, again we have to take a decision whether to upgrade the plant or not. This is done by looking at the high average demand the possibility of 0.8 and this is 0.2

and here we have this again 0.8 and 0.2. We can actually get the expected value here is, expecting value of decision whether to automate or not that is upgrading. So, this is upgrading, expected value will be given as 3.84 that would be 3.84 plus 0.8, it will be 3.92 minus the 2 investment 2,000,000. So, it will be 1,920,000 that will be the expected value of the first decision to automate it after 2 years.

And if it is not upgrading, no upgrading then the expected value is 3040. So, this will be the value of the of course, you will have 1 million, 3.04 million. So, therefore, you can see that this expected value is very high in this case. So, here the expected value is only 1.92 here it is 3.04. So, if the company decide to go for a conventional plant initially and then whether to go for a automate upgrading or not it shows that not upgrading then it is the expected value of the conventional plant itself will be very high compared to the expected value of the upgraded plant.

So, therefore, the company can decide not to upgrade even after 2 years because that expected value of non upgraded plant will be much higher than the upgraded plant. So, using this expected values basically we look at the various probabilities of sales and then we will find out the revenue its estimated revenue and we will calculate the expected value of various options and based on this expected values we can take a decision whether to go for a particular type of plant or not.

So, that is the alternate of using decision trees and this is how we make a decision based on the available data. All this data whatever we assume here they are all estimated values they are not the real values. So, based on the estimated values we can find out what will be the expected value of this particular decision and based on the proper decision can be arrived at. This is how we use the decision trees to make a decision in a system design. So, that was about the decision trees.

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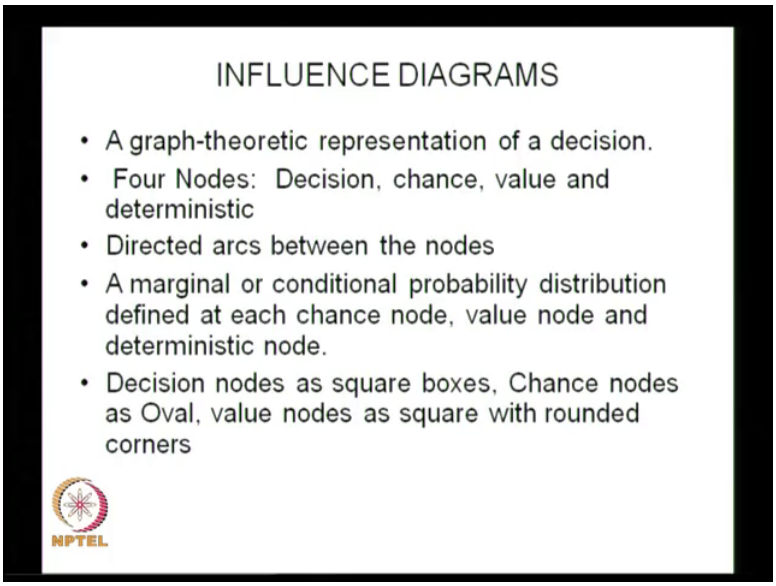

Another tool we normally use for decision making is influence diagram. So, this influence diagram also basically give similar information or it can be used for same purpose of making decisions, but they actually give you better information, basically the dependability of the decision on what is the kind of dependency existing and what kind of relationships are there, how it is related to a particular decision or how much it can influence the decision. So, that is shown in the influence diagram.

Next, we can see here it is a graph-theoretic representation of a decision. So, it is a more of a graphical representation and there are 4 nodes; a decision node, a chance node, a value node and a deterministic nodes. So, these are the 4 nodes normally used in influence diagrams and there are directed arcs between the nodes. So, this directed arcs basically shows the kind of relationship, which one is depending on the other one; that is shown using the directed arcs. And then a marginal or conditional probability distribution defined at each chance node, value node and deterministic node. So, we can actually defined some kind of probability for this nodes and that can actually be incorporated in to the influence diagram which will tell you how much dependency is there between different nodes.

Here, the decision nodes are square boxes, chance nodes as oval and value nodes as square with rounded corners. So, this is how we actually represent the influence diagram using these nodes. I will take few simple examples and explain how do we use the influence diagram to

represent the dependency of various decisions and how the inter relationship and how the directed arcs actually represent the relationship in a influence diagram.

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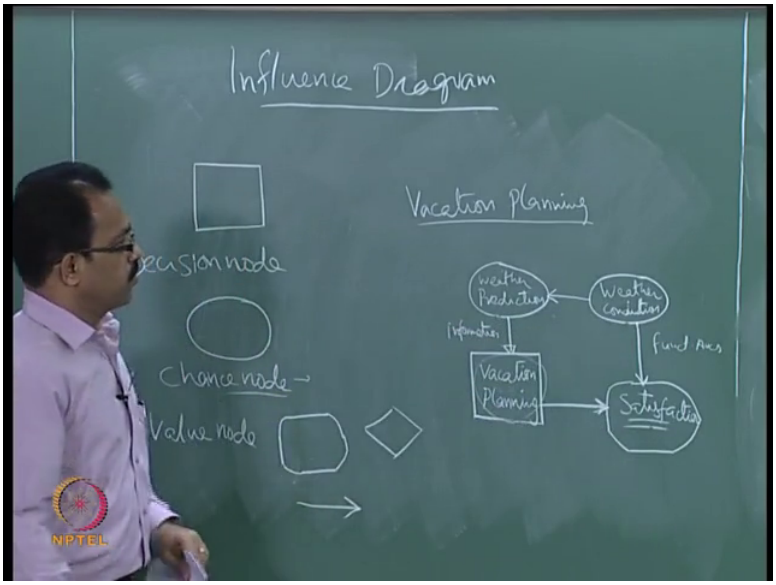

So, as I mentioned it has got a node square box as a node a decision node. So, this is the decision node and you can actually have discrete number of events attached to the decision node. You can have any decision discrete, number of decisions coming out of the decision nodes or discrete number of states. We can say decision node can have discrete number of states.

Then we have the chance nodes, it is represented using a oval. This is the chance nodes and again this will be a random discrete random variable can actually find out what are the number of chances are existing. And then we have these value nodes. They are represented as round tangles with rounded corners or you can actually represent it as a diamonds also. These are the value nodes. Then we have the arc which actually determines the dependency. So, arc is nothing, but the arc which actually represents the dependency between these nodes. So, these are the basic construction elements for influence diagram. So, these are the influence diagram elements.

Just take a very simple example to show, how do we use the influence diagram to represent a particular decision making scenario. So, of course, this will not give you a decision directly, but we can actually represent the inter relationship between various nodes and choices and

the decision making process, how actually they are related and what kind of influence a particular event makes on the decision.

Let us take a very simple example of a vacation planning. So someone is planning to have a vacation, basically a short duration vacation. They are planning to go to a out station, basically a place where the tourist location, but there are so many factors which actually affects this decision. So, here we can represent the decision node as vacation planning and then there is a value node which is represented by a round tangle. So, the value node is what, is actually the outcome of that particular decision. So, we have to plan a vacation and the value is basically what actually we achieve through that particular decisions.

So, here basically the satisfaction of going for a nice vacation is the value. So, that is the value here, but then we will consider one scenario or the one chance, but that the weather condition which actually U turns the vacation planning. That is one chance. This is the weather condition. The weather condition can actually influence the satisfaction and your vacation planning. That is why we can actually show in the influence diagram weather condition and then weather condition actually can be obtained from and there possibilities are you can actually have the weather prediction data. So, weather prediction may be available which can actually used for decision making. That is the weather prediction.

So, these are the 2 chance nodes and this is the value node, this is the decision nodes. Now, we can see that there are 2 functional arcs. So, actually one is this, the satisfaction and this is the satisfaction. So, the vacation planning can actually the satisfaction it is a functional arc to satisfaction because this actually leads to satisfaction and this weather condition also actually influences the value here, the satisfaction that is why you have to functional arcs here. That is the functional arcs of course, we can actually add to these the probability distribution then it becomes easy for the decision maker to find out to make a decision, but we are not going to the that part we are just showing how to represent that decision making process using a influence diagram.

So, here and then we have an information arc here. So, this is in information arc, you can see that this weather information is used for the vacation planning that is why there is an information arc which actually influences the decision of vacation. Depending on the weather prediction the vacation planning will be done and then lead to the satisfaction depending on the actual weather condition. So, this is the predicted information, but the satisfaction actually

depends on the weather condition. It has now relation to the weather prediction and similarly, vacation planning has nothing to do with the weather condition because we do not know the weather condition. So, there is no influence on the weather condition on the vacation planning.

So, this actually shows that what actually is going to influence the vacation planning. It is not the weather condition which is going to influence; it is going the weather prediction which is going to influence the vacation planning. So, that is why we are having an information arc over here and the satisfaction or the value of the vacation basically depends on the weather condition. It has nothing to do with the predicted weather and what is the weather condition that actually decides the satisfaction level of the person who actually plans for the vacation.

So, this kind of simple diagrams can be used to find out the dependency of these decisions. As you can see the vacation planning has nothing to do with the actual weather condition, that is why there is no arcs over here, which shows that there is no relationship between the actual weather condition and the vacation planning. So, that was a simple example.

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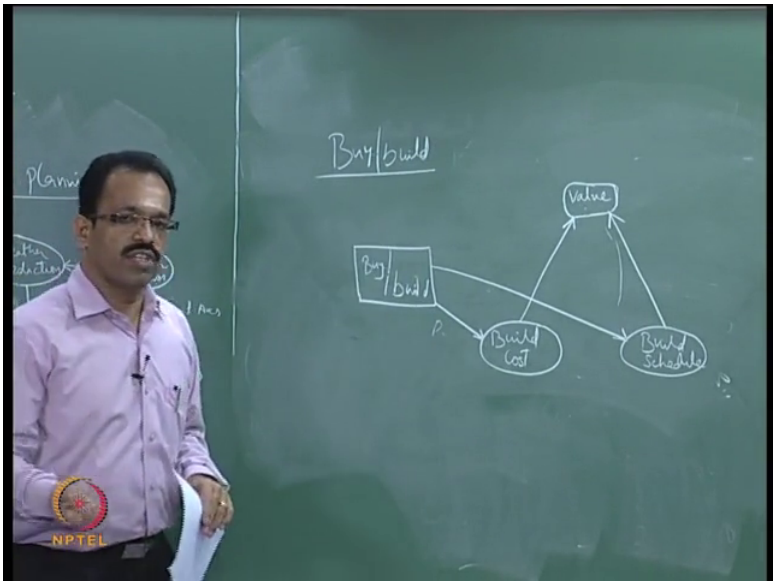

I can show you another example, where company wants to make a decision on buy or build. So, we actually developed a decision tree for this particular case. In the last class we discussed how do we actually decide a or make a decision tree for this buy build decision. Whether the company wants to buy a particular product or they want to make the product

themselves. That is a decision they need to make, which can be actually be represented using the decision tree and then decision tree can actually have all the values, the probabilities as well as the cost and other factors. In decision tree of course, we can actually add those parameters also, but for the time being will be just showing, how do we actually make the decision tree for this particular situation.

So, here the decision node is basically buy versus build. So, that is the decision node here and there are 2 factors which actually affect, the value is basically the value it gives to the company. So, that is the value node here, what actually the value it brings to the company is the output or the value node here something like satisfaction and the 2 factors or the 2 chances are that it may actually lead to build cost and the build schedule. So, build cost and build schedule these are the 2 chances; build cost and build schedule.

So, these are the 2 chance nodes and then we can represent this as actually influences this and this actually leads to the value. These are the 2 chance nodes, this is the decision node and this is the value node. So, what I actually determines the value is basically the build cost or the build schedule and the decision has not direct influence on the value here, because depending on the build cost or build schedule if the depending on the probability of this increasing or decreasing that actually leads to the value of that particular decision.

Now, if you actually add the probability of the cost increasing or the probability of schedule delay accordingly we can actually calculate the value and then make a decision based on that which one actually gives you the highest value so that, decision can be taken. We can actually choose a particular decision based on that. So, this is how we use the influence diagram to represent the buy build decision. Again, this is a very simple example, but we can actually go for complex cases and then see, how do we actually develop the influence diagram for such cases.

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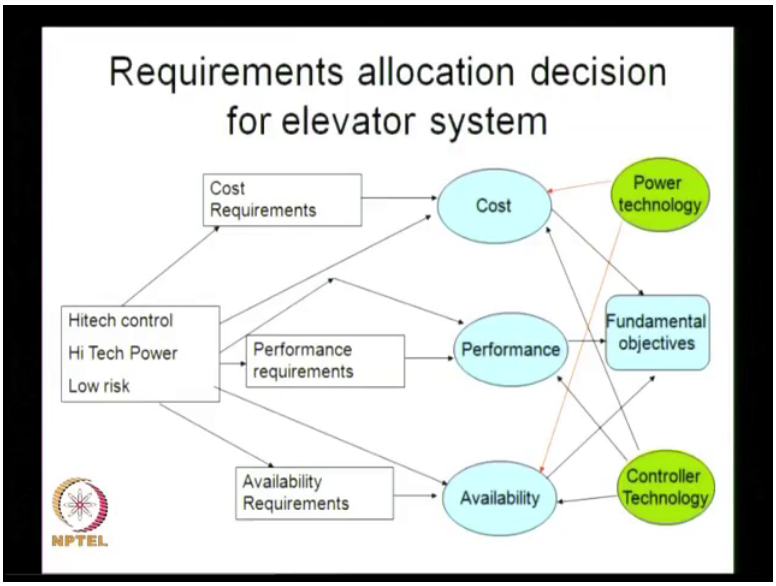

I will just show you one particular case. This is basically the requirements allocation decision for elevator system and we studied about the elevator system and we know that there are many factors to be considered when we design the elevator and there are many requirements for the elevator. And other requirements allocation actually depends on the particular decision whether the cost is important or the performance is important or what actually the overall objective of the design.

So, in this case what you have shown in the diagram, you can see here that the designer basically looking for Hi Tech control or Hi Tech power, but of course, a low risk one. So, that is the decision to be made; go for Hi Tech control or Hi Tech power. We can see here that the main decision box or this box has got 3 parameters, Hi Tech control or Hi Tech power. And then the 3 chances any one of these we take any decision over here that actually going to affect the cost performance and availability.

So, these are the 3 chance nodes we have here. This is a decision node this is a chance node, cost, performance and availability. And of course, we have this value of the fundamental objective to be met. So, fundamental objective is basically the design objective where the purpose which the design is begin made or the elevator is being made. So, that fundamental objective to be met whether you go for Hi Tech control or Hi Tech power we need to meet the fundamental objective of the system design.

And then we have the other chance like power technology and controller technology. What is the availability of the power technology and what is the availability of this controller technology these are the 2 chances we have. So, we have this cost, performance and availability and then power technology and controller technology as the chance nodes. Based on this actually we need to take a decision, but actually influence is this particular decision is the cost requirement. We can see here, again there is a decision box here cost requirement, performance requirement and availability requirement. Any chance or any decision on this cost is actually a decision on the cost requirement. So, we have the cost requirement. The decision has to be taken based on the cost requirement, performance requirement and availability requirements. So, these are again becoming the decision nodes.

Again, basically this availability and cost they are actually again depending on this chance of power technology. Availability of the power technology and the cost of the power technology also influence the decision to be taken here. So, the influence of these chances on this decision is represented by these arrows here. Similarly, the control technology, the availability, performance and cost, all these 3 are actually influenced by the controller technology. So, that also is shown as arrows over here. So, this actually shows that the performance, cost and availability all depends on the controller technology available and then we have to take a decision based on the cost requirement, performance requirements and availability requirements.

So, this way we can actually represent the all the parameters involved in the design basically looking at the objectives and the requirements and the chance nodes existing. So, whether you want to go for a high cost one or a low cost one and what kind of performance you are looking for and what kind of availability is there for the technology or the controller technology or the power technology. So, this kind of diagrams basically shows you the influence of the chances on the decision making, how much influence that has got in the decision making process. So, those parameters can be easily represented using the influence diagrams. That is the importance of using a influence diagram in analyzing the decision making process. Any decision making process as we know that purpose is to basically avoid the risk involved in decision making. So, minimize the risk involved in decision making and many people or many designers actually follow different ways of avoiding this risk.

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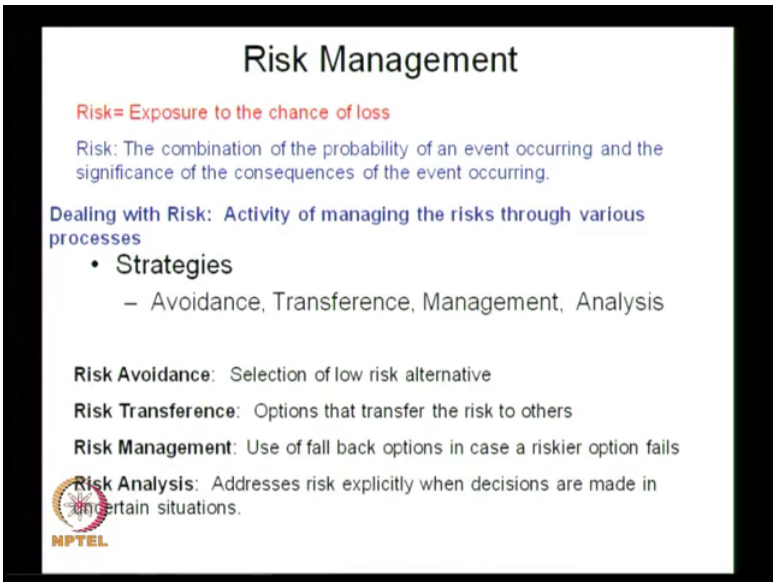

So, let us see briefly what kind of risk management techniques are being employed by the designers in order to reduce the risk in taking any particular decision. So, as you know the risk is actually the combination of the probability of an event occurring and the significance of the consequences of that event occurring. So, if we have a probability of a particular event and then you have some significance of the outcome of that event, this actually the risk is basically a combination of both this 2.

So, you can have a probability of something happening, but the influence of that is very minimal in your design or in your that particular system behavior then the risk is less even if that it is high possibility of that event happening, if the influence is or the outcome is not so significant, we can actually say that the risk is very low. So, it is a basically a combination of the probability of event happening as well as the influence of that event on the system performance.

So, to deal with the risk we have the many methods that the activity of managing the risk through various processes is known as the risk management strategies. So, we have different strategies like avoidance, risk avoidance, risk transference, risk management and risk analysis. Basically, risk avoidance is, how do we actually avoid a particular risk over you just go for a low risk alternative, that is, you are avoiding the high risking and taking for a low risk or going for alternatives.

The other one is basically the risk transference. Basically, the option that transfer the risk to others; basically something like you when you have a car you have a vehicle insurance basically you do not want to take the risk yourselves. So, you are actually transferring the risk to a insurance company, that is the risk transference. You manage your risk to or you transfer it to someone else. And then is the risk management basically the use of fall back options in case of riskier options fails. So, you have more option so that, if something fails you will have another option.

And next one is the risk analysis basically it addresses the risk explicitly when decisions are made in uncertain situations. So, risk analysis is basically do find out the possibility of that risk and it influence and then make a decision based on that. So, analyze the risk in a detailed way and get the output that is risk analysis and there were many ways for doing the risk analysis. Again, we will have another lecture on this part the risk analysis and how do you avoid the risk, this I just want to tell you when you take the decision the basic idea is to reduce the risk. So, that is why I just introduce this topic to you more detailed discussion on this risk will be done at a later stage.

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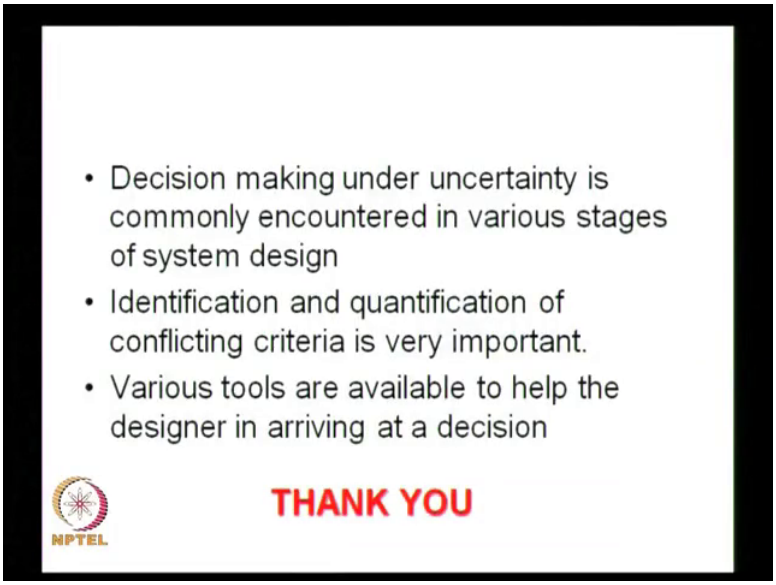

To summarize whatever we discussed in the last 2 lectures on how do you make decision, we found that decision making is a process where actually a lot of uncertainties are there. So, we need to reduce or we need to identify this uncertainties or the decision and try to find out what kind of or who do we actually quantify this conflicting criteria and decision making.

That is one important part, how do you actually identify and quantify the conflicting criteria in decision making.

And there are various tools for doing that. We saw few tools like influence diagram, decision trees and other methods where we actually modeled the decision scenario and try to analyze the expected values of various decisions and based on that we will take a decision appropriate for that particular scenario, based on what all the information is available. Your decision, final outcome of the decision, the actual impact of the decision will be known only after when you really make that implement that decision, but even before that we need to have some kind of an idea what will be the influence.

So, that is why we do the analysis and try to find out the impact of a various decisions and then based on that we take a decision. So, that is basically the decision making under uncertainty. So, with that I conclude today's lecture.

So, till we meet again, good bye to all of you.