Data Analisys and Decision Making - II
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Lecture - 51
GERT

Good morning everybody, good afternoon and good evening to all of you. Welcome back to this DADM-II, lecture series under NPTEL MOOC. And, as you know this is the Data Analysis and Decision Making-II course and we are in the 11th week.

And as you are aware which I do repeat before the starting of any class for this DADM-II, this is a 12 week course; that means, we have the 11th week and the 12th week to complete before we wrap up this course. Total contact hours is 30, total number of lectures is 60 because each lecture is for half an hour. And after each week we have assignments after 5 and as you know in each week we have 5 lectures after which as I already mentioned just few seconds back; we have assignments. So, you have already completed 10 assignments, so with the end of the 11th week, you will have the 11th assignment.

And, my good name is Raghu Nandan Sengupta from the IME Department and IIT Kanpur. So, if you remember we were discussing the GERT and the Q-GERT process, general evaluation review technique and queuing concept being utilized in Q-GERT or GERT. Now, in this GERT method and Q-GERT method, you have different type of logic gateways to be utilized AND, OR, NOR and so on and so forth and based on that you have different ways of how you implement that. So, we did discuss at the last few minutes for the ending of the 10th week and based on that we will proceed into the further discussion.

So, what we will do is that in the GERT process we have some simple steps how you basically will implement it. So, we will discuss that first and then go into the analysis. So, you will convert a qualitative description of the overall system on the problem to a model in a network model. Where the network models, as I mentioned that if you consider the pot and CPM; there would not be any looping back, but in GERT and Q-GERT you will basically have the looping back concept there.

So, based on this assumption you will basically what are the informations are given like process 1 precedes process 2 by 2 minutes or say for example, process 2 can only be started when process 3 has also started or say for example, after process 4 finished; you will be say recheck it and it comes back to process 2. So, all these qualitative statements which I mentioned for the problem would be incorporated in the GERT or GERT concepts.

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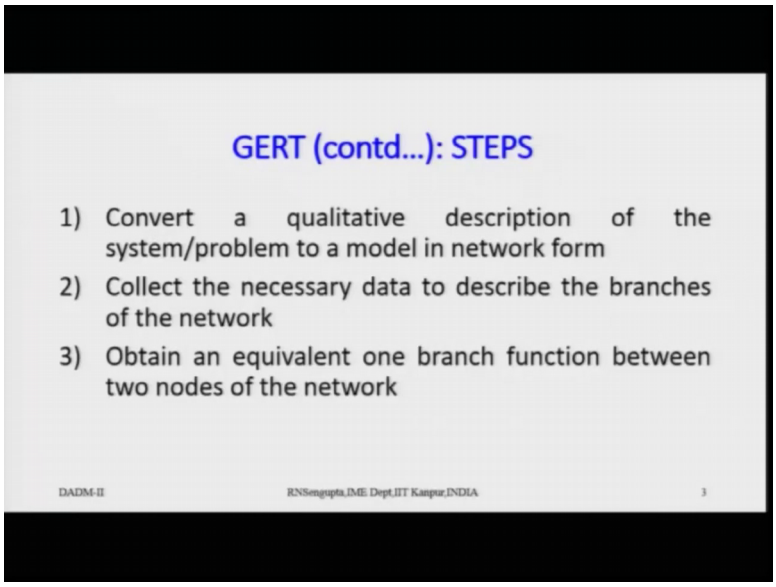

So, you will collect the necessary data to describe the branches of the network. So, if you remember the branches of the network would basically have a probability and the time period. So, time period and probability would be such that it will consider that if the process follows any path it will have a probability and this probability would be given by a certain distribution. And the time would also be considered in order to find out the cumulative time from the process from the source to the sink considering the source is on the left hand side and sink on the right hand side.

You will obtain also an equivalent one branch function between the two nodes of the network. One branch function means this AND, OR concepts you will combine them probabilistic and deterministic and all these combination would be done based on this you will basically formulate the network or the whole process a project network into the GERT logical network such that it will be easy for us to solve.

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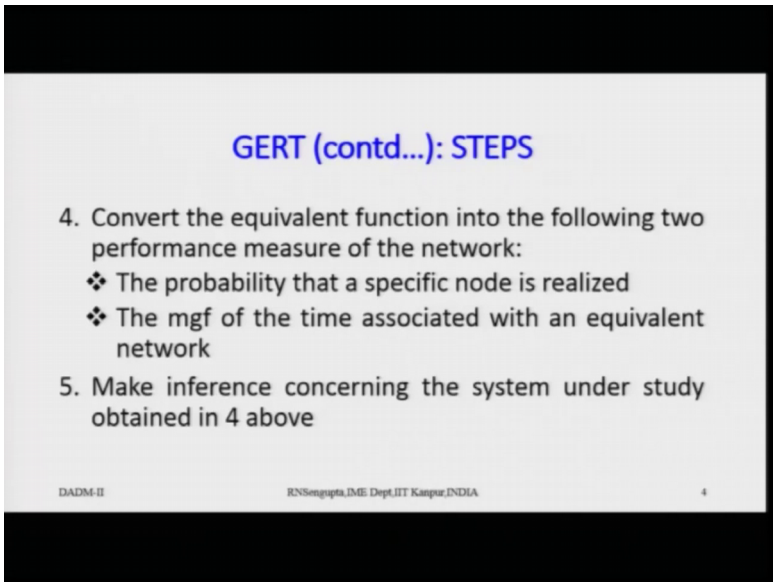

In the fourth steps we will convert the equivalent functional form into the following two performance measures of the network. So, if you remember I did mention time and again that probability and time important and we will basically utilize this concept of probability and time to basically find out the overall metric based on which you will analyze the overall network. So, one would with the probability that a specific node is realized and obviously, you will have the time period for the realization.

And, another would be the moment generating function on the time associated with an equivalent network such that based on the moment generating function, you can find out the average time, the variances the expected value so on and so forth such that it will give us a whole lot of information about the network from the time point of view. Because time taken for a information flow or for a project flow from i th to the j th one; if you are moving from the left to the right and obviously, this if we took and from the right to the left also considering there is a looping. So, this time period would help us in order to find out the overall average time taken to finish the project based on the concept of GERT and Q-GERT being utilized.

You will make inference concerning the system under study obtained in 4 above. So, 4 above was basically you will have the moment generating function based on the time fact and you will basically have the probability that a specific network or a path would be

traversed. So, one is probability, its distribution function, one is the time which will be found out using the moment generating function.

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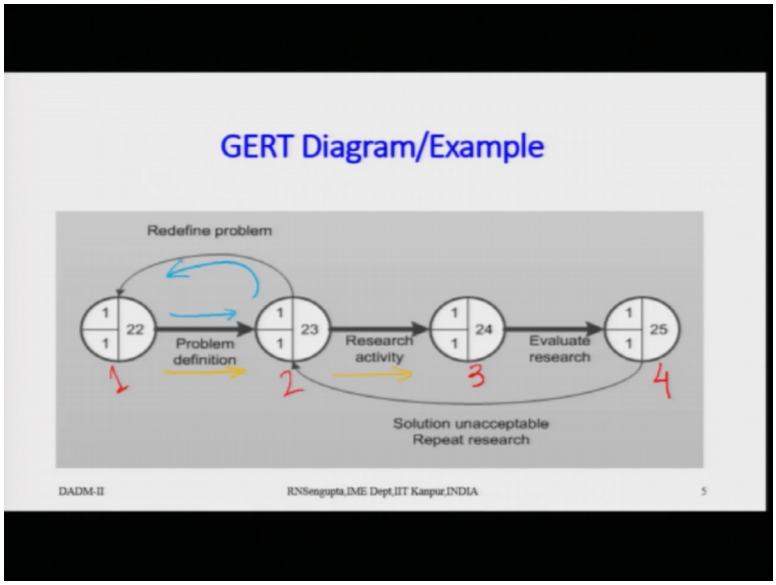

So, consider this a very simplistic version of the GERT network. So, you will basically have the; you are doing some process whatever the process is. So, consider I start from the left most node and let me give a number 1, 2, 3, 4 which for this diagram is 1, 2, 3, 4, but consider in the overall description on the problem; they are mentioned at node number 22, 23, 24, 25. Obviously, they can be other nodes also going out from 22 or coming to an 22 similarly going out from 23 coming into 23 and so on and so forth. Now consider that I will only consider the networks and the diagram in the arrows in which the network is connected.

So, you will basically define the problem. So, and definition of the problem what you want to do say for example, at 22nd stage you obtain the raw materials. And based on the processing work which you do on a lathe machine, on a drilling machine, on a shaper, paner, CNC machine whatever it is; you reach the 23rd stage which is state number 2.

But, it may be possible that the overall working on the raw material based on the fact that you have to do some grinding, drilling whatever was not perfect. So, obviously, the metric machine the work can come back to stage 1 to be tested such that you can find out the dimensions based on the fact that whether dimensions right, again it need to be processed or processed.

Now, once the 23rd stage is complete with looping, being they are considered. So, it may problem the overall movement can be in this direction. So, there is no reprocessing it goes back. So, there is a probability of how many such sets of in a particular unit of time what is the probability that it will proceed straight forward without any looping. And, in the case if there is looping; we will find out that what is the probability based one is the loop is formed and till what stage the loops will continue.

So, once 23rd state is complete we go in to say for example, the next step is basically the research activity; research activity gives an output on the stage 24. So, we will basically find out; research means that consider here build up you have developed a molecule for a drug or say for example, found out a good chemical composition of some fertilizer which can be utilized in the fields; you will basically evaluate the overall output which you have obtained. So, here it will come the evaluate the research; research means the overall work which you have done based on the output which you will get; you will basically from reach the stage 25.

Now, it may be possible that the overall total quality measurements you are doing, the soil quality measurement you are doing considering that using a fertilizer, the productivity of the soil, the irrigation level which should be utilized in this soil everything is obtained at the end of the 25th stage. So, consider if it is perfect; so you will proceed further on depending on whatever the next steps are; considering it is not perfect again you will basically go into the research stage, try to change few of the parameters of the input; maybe soil nitrogen content, maybe water moisture which is there in the soil or the water content which is there in the soil or the compost quantities you want to add into the soil.

So, all these things would be reevaluated and some things would be changed and based on that again we will complete the research activity and again evaluate the research. So, this loop will continue till we are satisfied to what level of competence of overall output we want from the research; research means the overall work which you want to do.

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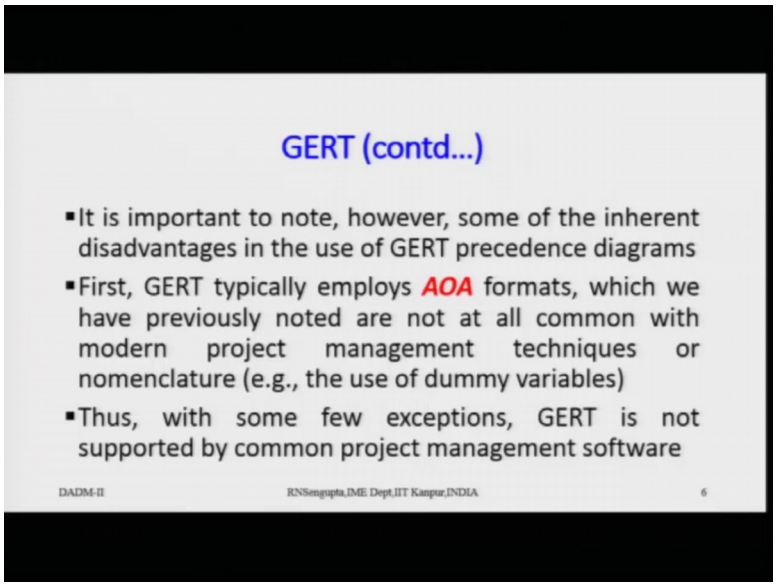

So, it is important to note; however, some of the inherent disadvantages which are there when you use GERT process. Obviously, it is an advantage with respect to pert CPM, but and it has some disadvantage or else if there was no disadvantages; then GERT would definitely would have been used in a very big way or Q-GERT or Q-GERT should have been utilized in a very big way in place of PERT and CPM.

So, what are the disadvantages and what are the so called bottlenecks? First, GERT typically employs activity on arc format, which you have previously noted are not at all common with modern project management techniques because the use of dummy variables then comes into the play based on the fact that you are using the activity and arc concept. Now, you are trying to utilize the activity in node concept then obviously, trying to draw the GERT network is not possible.

So, thus with so few exceptions GERT is not supported, ok; moreover which I should have mentioned before the beginning of the other GERT concept; GERT somehow has lacked the overall input which should have come from the industry based on which different type of softwares and tools could have been developed, but unfortunately it did not happen.

So, one is basically the activity on arc concept, why it is used and why generally activity on node would be conceptually much better in order to analyze PERT and CPM and

obviously, activity on node should also have been utilized for GERT, but as you know that GERT is only based on activity and arc; point 1.

Point number 2 that the considering this is it is basically a long drawn process where you find out the time, where you find other probability and the probability of taking any one path so, if and if they are very complicated network so, obviously, you need good software to basically solve that; those type of problems which where you use the GERT and the Q-GERT processes, but unfortunately the development of GERT software has not taken place as it should have been.

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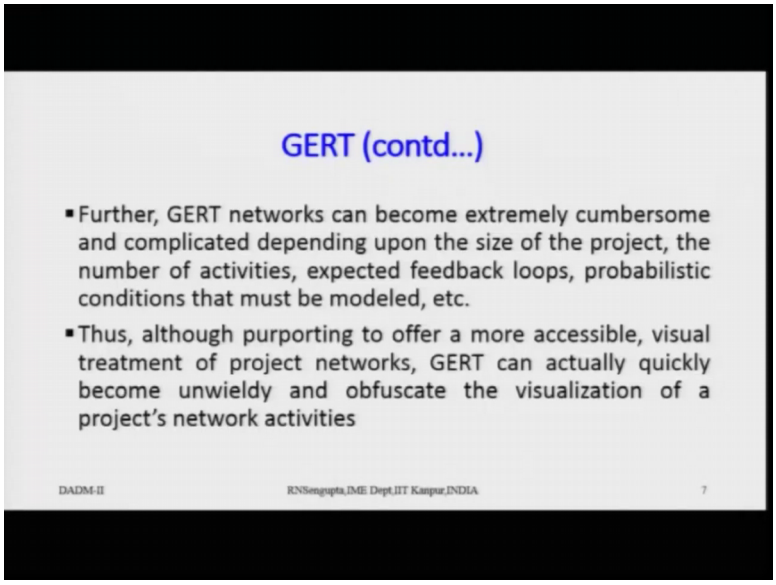

To continue this discussion further, so, GERT networks can become extremely cumbersome and complicated depending upon the size of the project, then the number of activities, expected feedback loops, how many feedback loops are there, the probabilistic condition that must be modeled, there is probability value, the time period value all these things are brought into the picture and within the whole set of project nodes and activities. So, it becomes very difficult to model them in the true sense.

So, thus all the purporting to offer a more accessible and visual treatment of project networks; GERT can actually quickly become unwieldy and obfuscate the visualization of the projects network activity. So, considering that it has loops, it has probability so on and so forth. So, even if theoretically it is best to have the GERT network to basically give us the best possible results for interpreted type of complicated project, but when you

see it in the practical sense it becomes too cumbersome in order to that to be implemented.

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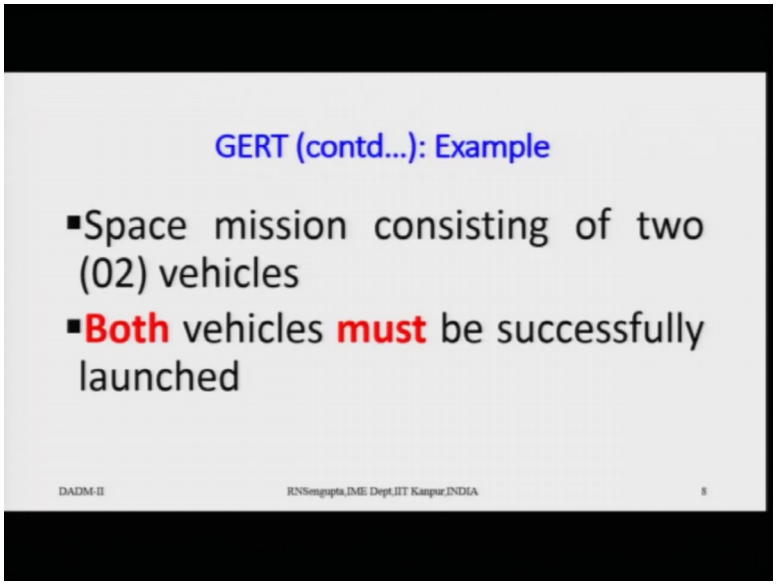

So, consider a very simple example. So, there is a space mission which consists of two vehicles, two launch vehicles both vehicles must be successfully launched such that the space mission is successful.

So, consider there are two booster rockets and both of them are needed because one booster rocket would help the overall space spacecraft to go to a certain distance of say for example, 100 kilometers. And then in the next 100 kilometers considering that it has to traverse a total distance of 200 kilometers that second booster rocket should be working. So, that means, both of them should be operational for this space mission which we are going to consider in the example.

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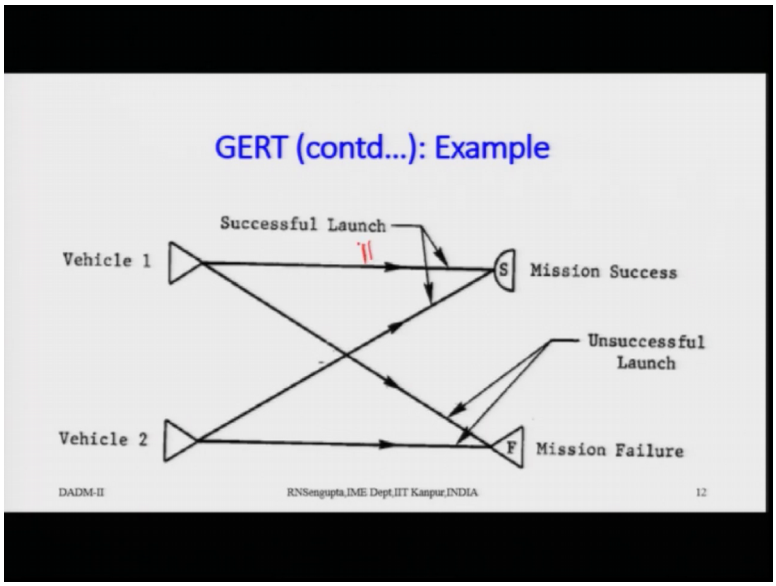

So, consider those booster rockets as vehicle 1 and vehicle 2. So, in this vehicle 1 and vehicle 2 so, we will consider that the working principles would be; so, let me take out I think it would be best if I copy. So, give me 2, 1 minute I will copy that logical networks I will copy it here I have this.

So, it would be easier for all of us to because I thought I will just go at one pace then I change the speed depending on that how the problems caused. So, these are the levels of information which I would have and one of these; so we will copy these also. So, for better understanding of the overall problem; I will just try it, so that we are all in sync, ok. So, we are all set.

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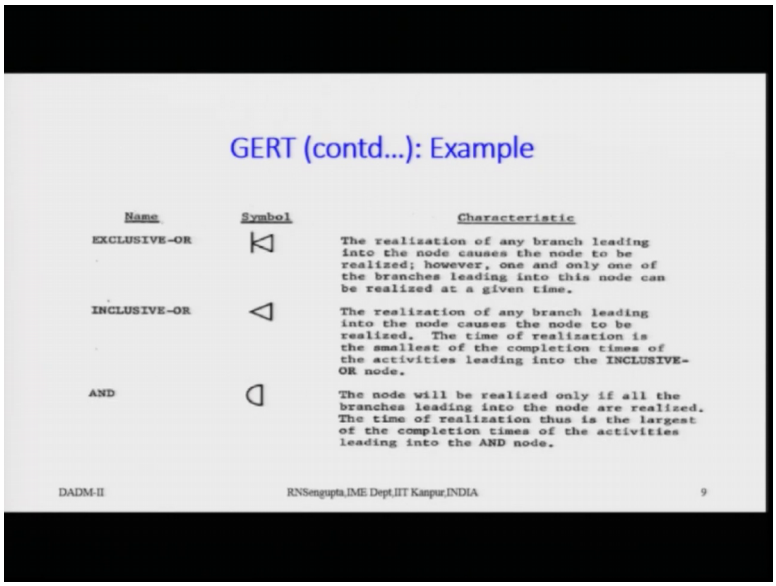

If you remember; so, these are the simple examples first exclusive I am just repeating what we are done EXCLUSIVE-OR the concept logical network or gateways, INCLUSIVE-OR, the third one is AND and the characteristics are all given on the right.

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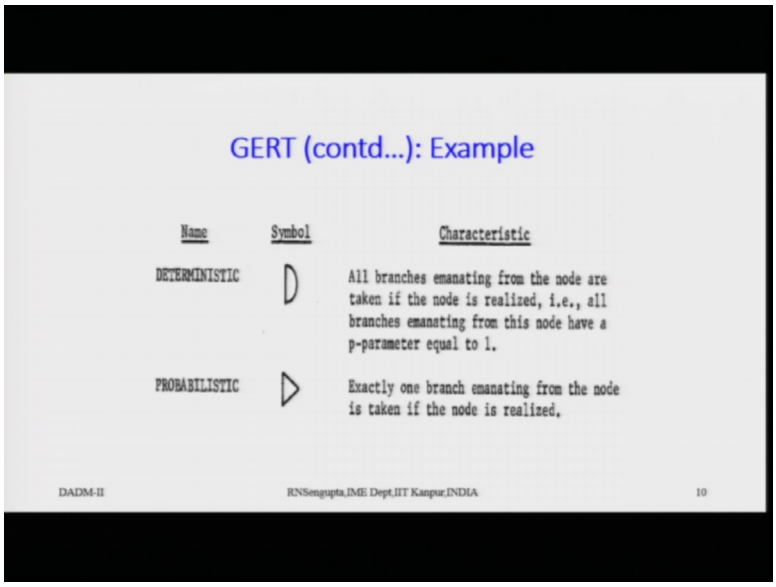

Then you have the deterministic and the probabilistic so and the combinations are given. So, let us go one by one. I will come back to these slides quite often as we proceed.

So, if you consider vehicle 1 and vehicle 2 the symbols are diamond. So, what is the diamond? I know that all of you are aware of what is the diamond is the probabilistic

one, but still for sake of all of us to understand this diamond means the probabilistic network; that means, exactly one branch emanating from the node is taken if the node is realized.

So, it is only one, either success or not success it cannot be both. So, when the vehicle 1 is launched it is successful; that means, it will take the spacecraft from 0 to 100 kilometers and if weight here 2 is also successful it will take it from 101 to 200 kilometers.

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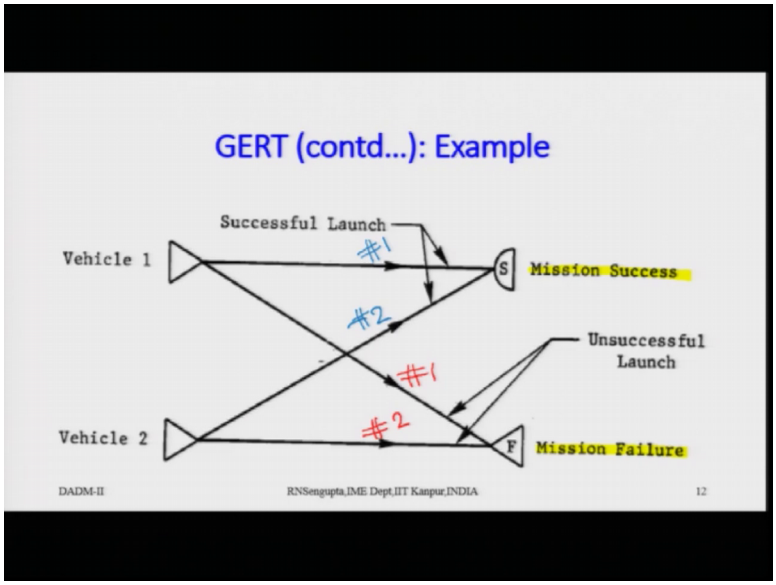

So, vehicle 1 successfully launched. So, this is for one let me use the blue colours and red colours. So, I am rooting for vehicle 1, this is for vehicle 2. Now, I use the red colour unsuccessful vehicle 1, vehicle 2. So, now let us see how it is. So, vehicle 1 is successful and vehicle 2 is successful, the mission success is there. Vehicle 1 unsuccessful, vehicle 2 is unsuccessful, the mission is a failure because these are unsuccessful launches. And consider that if you have mentioned that any one of the booster rocket working it would be; it will make the project successful which means that in this case we will basically have the concept that.

So, in these combinations we are not going to take successes and unsuccess that means, we are not going to take the concept that 1 is a success and 2 is an unsuccessful one; that means, blue 1 and red 2 would not mean that the whole project is a success or if I consider this concept of red 1 and blue 2 also does not mean that it is a successful launch.

So, only combination would be yes, for success for 1; yes, for success for 2, any other combinations are unsuccessful. So, we will basically proceed on this concept.

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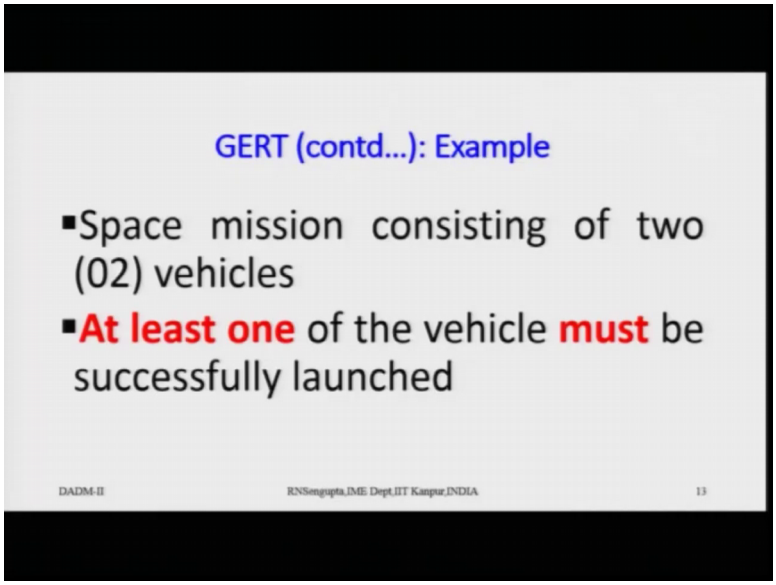

Now, consider the space mission consists of two vehicles again, but it now mentions that at least one of the vehicle must be successfully launched; that means, one is success other may be an unsuccessful one. So, you will basically have blue 1, red 2 or blue red 1 blue 2, these are possible it is a success and also already we have that blue 1 and blue 2 would do a success. So, out of the four combinations three are yes, one is no. So, let us see this common concept.

So, it will become a more so called involved diagram.

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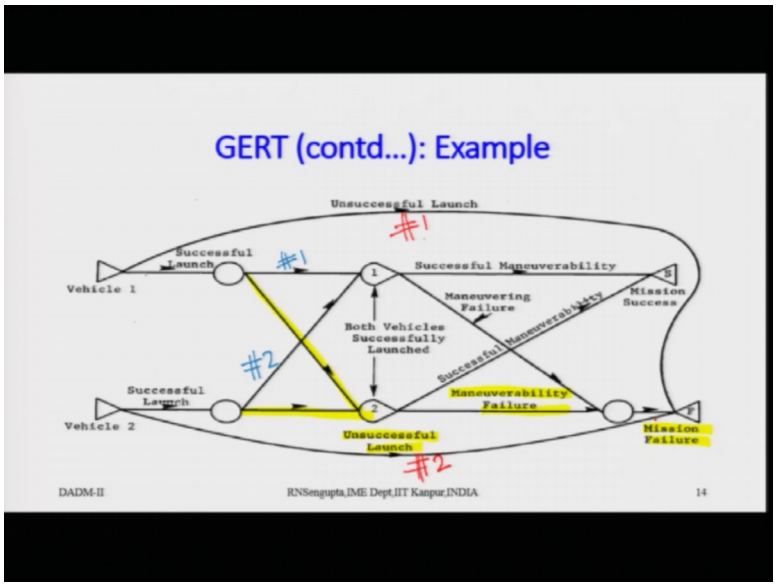

So, vehicle 1 I will use the; I use the same concept of the colours, blue for success and red for unsuccessful one and then highlight it accordingly. So, vehicle 1 and launch is success. Now, if it is a success we have a vehicle 2 also success; so both of them are success, so let me use blue colour. So, this is 1, this is 2, this is 1, this is 2. So, let us go from the extreme where both as unsuccessful; I am starting from the extreme case such that it is easier for me to proceed and explain.

So, this is unsuccessful this is unsuccessful; so you have unsuccessful launch. So, it will basically be a maneuverability failure is there and the whole mission is a failure. So, if it is a mission is not failure, so, is an unsuccessful launch. So, you will basically go back to this stage that they are not helping the overall. Now, only just this I this diagram would have been much better if I basically combine it accordingly. So, this is success ; so yes so this is also a success this is.

So, consider that this combinations was such success and success are combined. So, in this case both vehicles are successfully launched; if that is the case then they can be two states of failure later on one is maneuvering failure for vehicle 1 and this maneuverability failure for vehicle 2. So, if I combine both of them; so even if they are success later on maneuverability failure would lead to the mission failure as marked here as I am highlighting. And, in case maneuverability failure is yes for 1, no for 2, no for 1, yes for 2 it will be a success for the whole project and obviously, if the combinations are

success maneuverability are yes for both of them, it is an yes success for the overall project.

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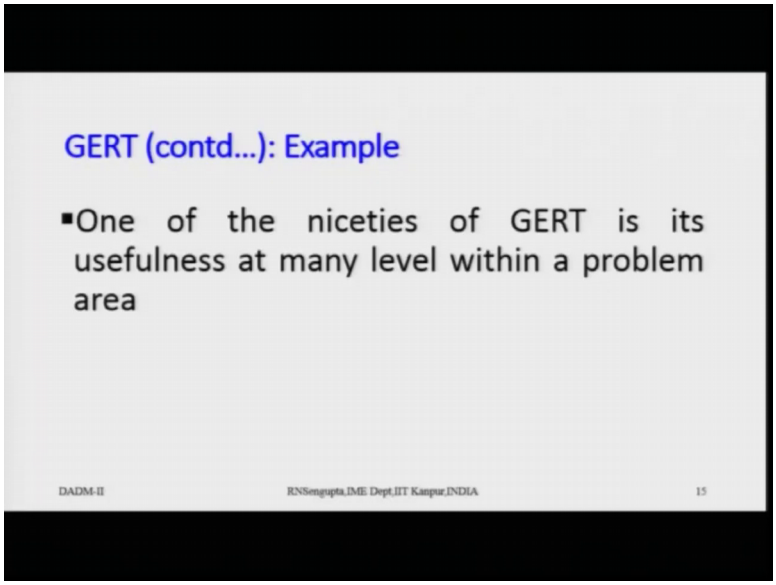

Now, one of the niceties of the GERT is its usefulness at many levels within a problem area because it is able to delineate all different combinations of the output diagram which are possible.

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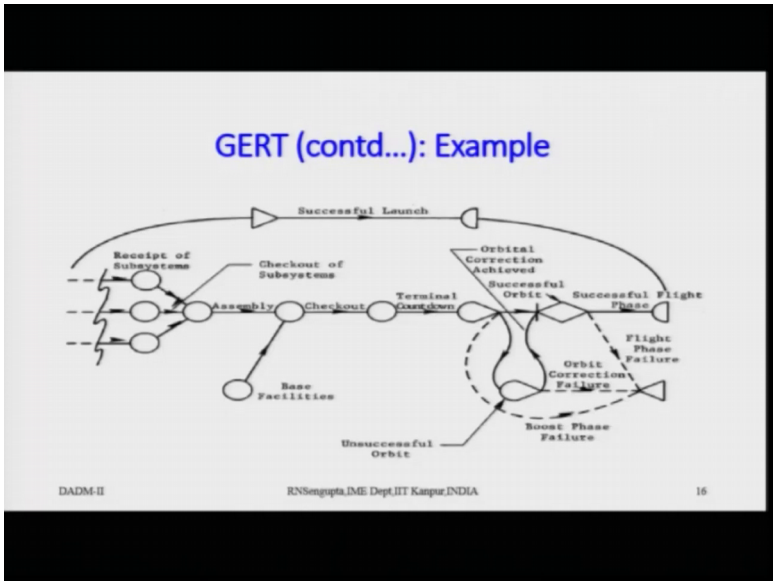

So, you will basically had a receipt of the; consider that now you have the subset subsystems. So, you have for a successful 1, on a unsuccessful 1 you will have different

stages. If you combine them and you are trying to basically formulate for this vehicle launch; it can be say for example, you are doing a big manufacturing work for a bridge or for a boiler or a for an aircraft or a for a car which is there are lot of stages and you can basically consider that all of the works at the sub stations are sub assemblies. So, you consider them as subsystems.

So, based on the fact that all the subsystems are worked on you will basically have the overall combination combined and which you would leave to the assembly checkout. So, here you will basically have in this case this is the pre processing work which you have been going on before the vehicle is launched and. So, launching would basically be a success. Now, if it is a success there would be combinations based on this which you will formulate the problem; so these are the combinations.

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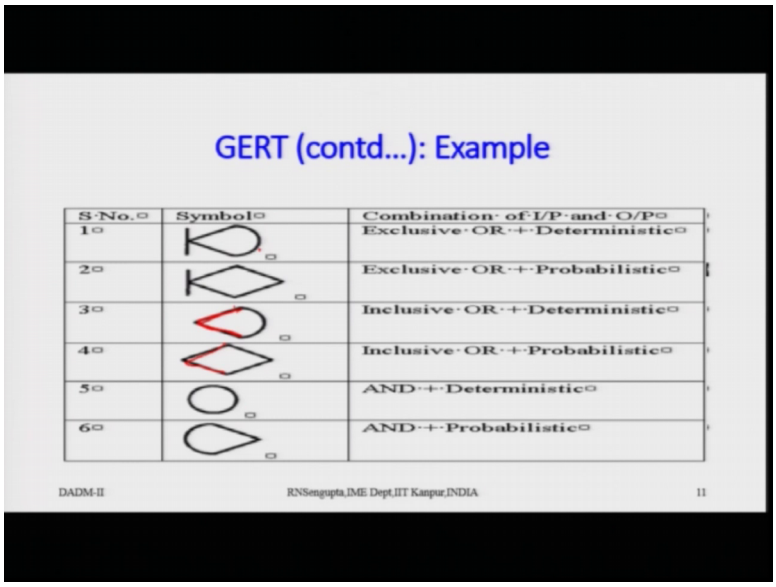

So, if I consider the combinations would be; you are basically combined in the input of the output. So, if it is an EXCLUSIVE-OR and a deterministic output; you have this in parachute shaped the lying down parachute which is a triangular part in a hemisphere so, that will give you an EXCLUSIVE-OR plus deterministic one and diamond one would be the EXCLUSIVE-OR on the probabilistic one with a base. So, 10 which is the EXCLUSIVE-OR and the INCLUSIVE-OR would definitely not have the base. So, in that case you will have the INCLUSIVE-OR the trying and the so called triangle; so this is the triangle which you consider the V, V shape.

And, again you have the deterministic in the probabilistic so called output and for the AND deterministic and the AND probabilistic one you have the circular part with the probabilistic and the deterministic concept. So, in the deterministic concept so, no change in the and the overall structure occurs and the probabilistic one you have a triangular or V turned anti-clockwise 90 degree.

So, you have to check out of the system assembly check out, the terminal count down the successful launch and that will leave to the orbital correction achieved or the successful launch has been done such that you can say the overall project has been successful depending on the combinations which you have. For a yes yes; the number of diagrams are much low; for a yes yes been successful and yes no, no yes also being successful; the total combinations would definitely increase.

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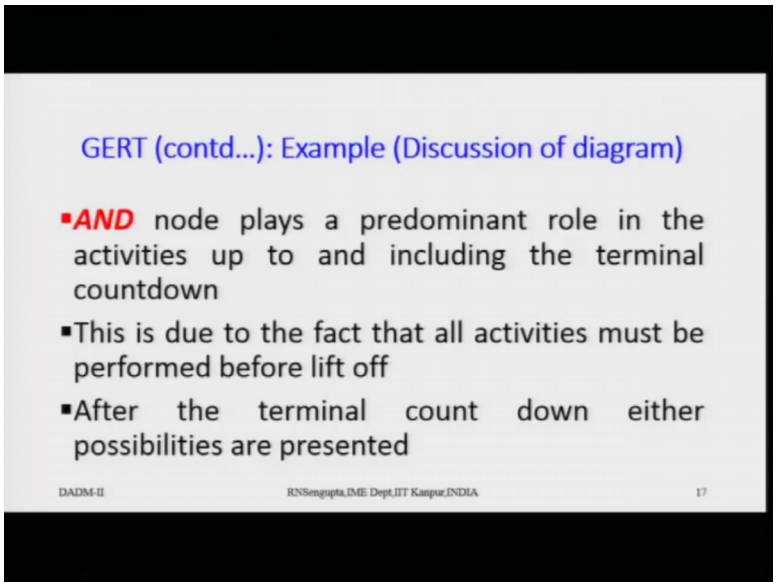

Further continuing the discussion; so for the AND node it plays a predominant role in the activities up to and including a terminal countdown. So, this is due to the fact that all activities must be performed before lift off; obviously, you have to finish the processing, the part, the checking the electronic system, if any repair has to be done everything has been checked that whether the cryogenic fuel has been filled properly, whether the booster occurs a protein properly everything has to be checked and thorough before the launch.

After the terminal countdown either possibilities is possible; that means, it is a success and an unsuccessful one, but the success and in unsuccessful ones are combined for each and every stage which you have already considered.

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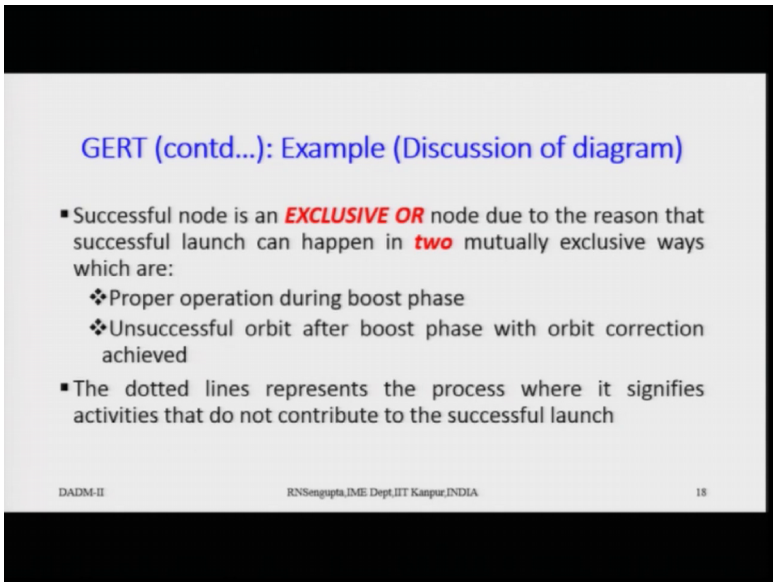

Successful node is an EXCLUSIVE-OR node due to the reason that successful launch can happen in two mutually exclusive ways which are proper operation during boost phase such that it is a success later on and unsuccessful orbit after boost phase with orbit correction being achieved. So, there has been some answers will later stage at the boost state, but you are able to correct it. So, obviously, that is the rocket or the satellite whatever was being planned to put in the orbit has been put there as required.

The dotted lines represent the process where it signifies activities that do not contribute the successful launch. So, if you consider the dotted lines; that is the flight phase failure and the boost phase failure technically would mean that any such failure would signify that they do not give any impact on to have any impact on the successful launch.

So, with this, I will end the first lecture for the 11th week and continue to discuss more about and GERT in the subsequent lectures for the 11th week.

Have a nice day and thank you very much.