

Project Management
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Module No # 08
Lecture No # 37
Graphical Evaluation and Review Technique (GERT) III

A very good morning, good evening, good afternoon, to all my friends and students, dear students. This is the thirty seventh class so we will have thirty seven, thirty eight, thirty nine, fortieth and that would be the end of the project management and as you know that I mentioned that GERT, QGERT it would be the last portion of these lectures. So, I did mention it quite long time back when we were in the initial stages.

And in the last class or last class both the classes we were discussing about GERT, the exclusive or the inclusive or the, and gates the logics and how the logics could be brought into the picture for the GERT concept and how it is different from the PERT and the CPM. So, just to recapitulate even though I am sure all of the students are very intelligent enough they have gone through the lectures they have understood the concepts thoroughly.

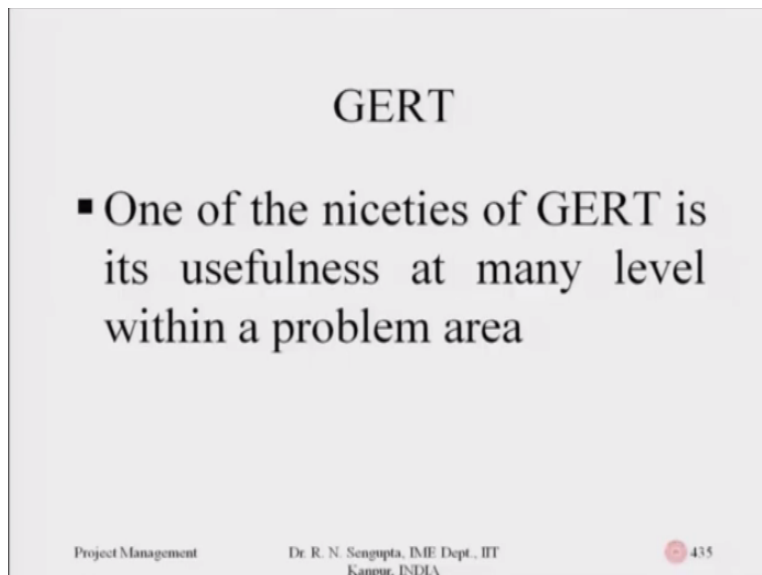
So just the basic point is that if you remember in critical path method that time was fixed deterministic based on that we found all the time, IN PERT time was stochastic with a certain distribution and based on that we found out the time for the critical path, then hence this was constant when they came it was necessary for resource leveling resource scheduling and how we use the central limit theorem to find out certain time to finish a certain number of days.

This completed that what was the probability of finishing a certain percentage or vice versa in the sense that I want to finish certain percentage. What was the date based on which I could and please pass some comments related to that. Then the third point was that how the crashing could be done for each and every job on activity or collectively such that we could aim at minimum requirement of resources in the concept of time.

Then when we came to JERT or GERT whatever you call it, we considered another important aspect was time was probabilistic but the probability of whether a path would be taken was also probabilistic. So there are two attributes or two characteristic based on which we started discussing then we discussed about the launching of a satellite of a rocket and how it could be made much more realistic in the sense that they would be different type of issues related to the jobs and activities taking place.

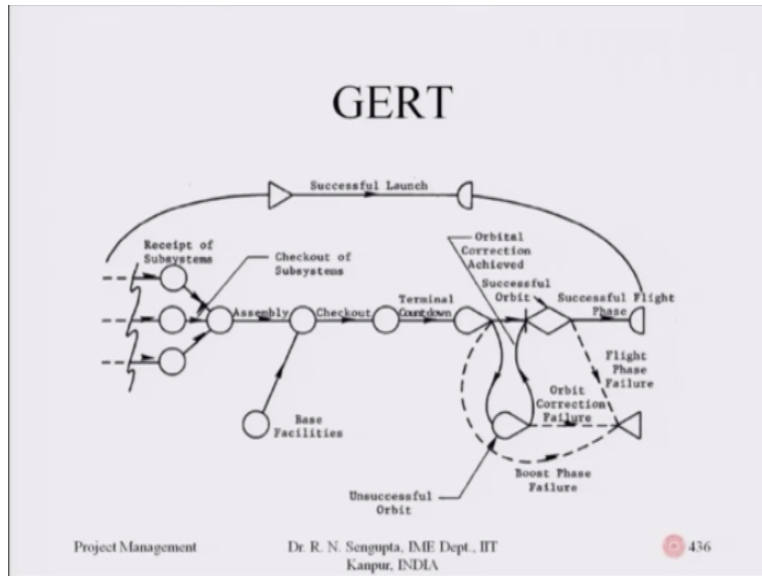
Not taking place with certain probability levels. So, continuing with the discussion so we will try to discuss in more details in this thirty seventh class and then and the fag end of this course try to go into detail about a problem.

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So one of the niceties of GERT as the slide says is the, its usefulness at many levels within a problem area. So we will be switching the slides due to the fact that we will try to bring the concept of exclusive or inclusive or and corresponding to the fact that they can with three different ways of trying to analyze the input criteria or the input characteristics with respect to the outer output characteristics were two in number so all the combination if you remember I did mention time and again it was three into two, so it was basically six. So consider the problem in much more details.

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So what we have if you note down we have the assembly and then the receipt of the subsystems are there so when you are assembling they could be different type of subsystems which are being assembled in order to get the product, mean like, I am trying to build up the cryogenic fuel tank or the solid fuel tank and they would be inputs, like say for example what would be the engine which will basically give the first trust then the other thing can we say for example, how that this heat dissipation can be done.







Third could be how the different levels of pressures could be monitored using some very sophisticated pressure valves, so those can be the issues and those are the subsystems which should work properly one afternoon and are in such a way that the overall the assembly is done properly. Then once the assembly is done it goes into the base finished facility, so what we are trying to do that we are trying to expand the overall analysis on the project into more details.

So we can understand the different type of jobs or activities or tasks which are necessary. Then after the assembly we basically get all the facilities from the base station whatever it is can be manpower it can be you are trying to utilize some different type of CNC machines different type of robots, which may be required for doing some sophisticated work. So all these things are basically conglomerated.

And one thing is done you basically check it out that, things are working properly on a standalone basis combine them and then go for the terminal countdown. So, if you notice this the diagrams I again come in to the description in more details if you notice these diagrams, they are a conglomeration of these six different concepts of input output combined so three of input and two of output combined so let me again recapitulate and go back to the slides.

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GERT

| S.No. | Symbol | Combination of I/P and O/P |
|-------|---|------------------------------|
| 1 |  | Exclusive OR + Deterministic |
| 2 |  | Exclusive OR + Probabilistic |
| 3 |  | Inclusive OR + Deterministic |
| 4 |  | Inclusive OR + Probabilistic |
| 5 |  | AND + Deterministic |
| 6 |  | AND + Probabilistic |

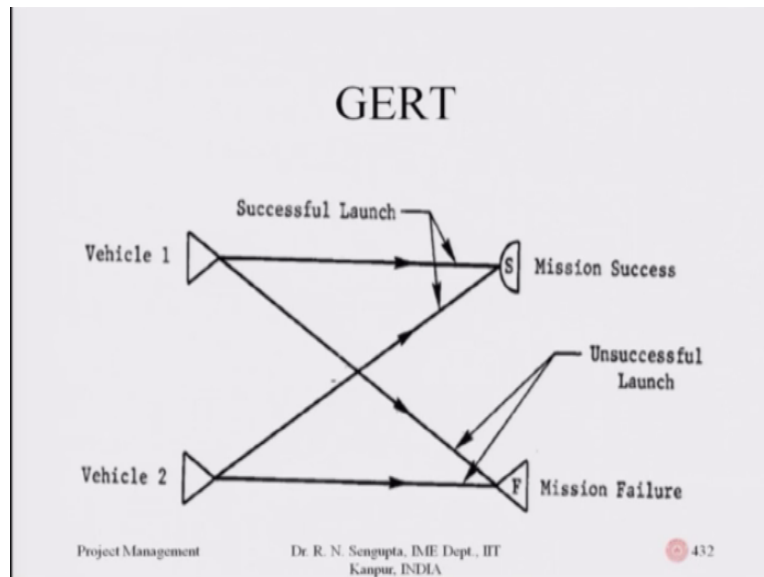
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Okay, so the combinations were so this chart if you remember, we had discussed that considering the different type of inputs outputs, the first one is the exclusive OR plus deterministic one, exclusive OR being the input and determining in the output, then you are the exclusive OR, or probabilistic then again input output. So the first one is the input second one is the output.

So you remember that but just I am mentioning that for our own convenience then use the inclusive OR deterministic one the fourth one is which is basically a the rhombus is the inclusive OR plus probabilistic output. Then you have the AND the deterministic can mean the input and the deterministic output any of the AND and probabilistic output. So if you consider that AND, I will just pause here for another few seconds.

So the students can have a good look at all the combinations which are there. So the one, two, three, four, five, six, which is three inputs multiplied by two outputs combinations you get these diagrams.

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So coming back to our problem this description more in a quality refrain boxers that the idea gets much, more clear. So, you have the terminal countdown when I am pointing my finger and based on that we have the concepts where it goes to the orbital correction achieved and the successful orbit being achieved. Then you have the boost phase of the rocket, and one of them if you see here there is the unsuccessful orbit being achieved.

Which means there would be an unsuccessful stage there, and based on that the failure phase, slight failure, phase inputs, which take place because you remember just not to disturb the flow of this discussion if you remember, I did mention time and again that the concept of looping is not their importance CPM but that is a big negative point in the practical sense that looping is necessary many the projects and many of the network flows.

So if you bring that concept into GERT or JERT or QGERT or till later on so you will find that looping concept is a part and parcel of the discussion such that it makes sense in order to implement many of the practical problems in a very nice way, So, on the other hand if you had

no such problems, so the first the base diagrams which I am showing if there are no such problem they would be notice the topmost the node set of nodes.

So called nodes, and the asset there is a successful launch and after the inputs which are taken care in the lower half there is a successful one. Because feedback loops would basically help in doing that. So what you are what we are actually trying to highlight in this diagram is that the nitty-gritties of each state can be made to the maximum possible extent considering the looping and the six different combinations of three inputs and two outputs are done the best possible manner such that any level of complications can be considered in the GERT diagram.

So, we will basically continuing the discussion with related to this diagram and the discussion which we had in the last class related to the successful launching an unsuccessful launching of the spacecraft on into the orbit.

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GERT (discussion of diagram)

- AND node plays a predominant role in the activities up to and including the terminal countdown.
- This is due to the fact that all activities must be performed before lift off
- After the terminal count down either possibilities are presented

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So the first point is that AND note plays a predominant role in the activities up to and including the terminal countdown. So whenever you are trying to analyze their problem not this only for any problem they would be that say for example a process with work, or say for example a stage will start depending on the combinations of the activities which are there beforehand, now the combinations of activities can be either based on the AND.

That means both have to be basically performed such that you can get the output and it can also happen on the case that one of them is possible then basically, you achieve the target so consider this stage like in an example very simple example is not related to a project, but basically consider this logic. You are taking an examination and there are two papers, now consider its states that you can only get the pass mark provided you have to pass in both the examination.

That means paper A and paper B, that means your requirement would be you graduated paper A and as well as people B, another combination can be that you graduate the examination there can be scenarios, I am just trying to basically highlight the hypothetical example another scenario would be that you will graduate the examination, the moment you graduate or pass in any one of them say for example the pass mark is for any examination is for both case one and case two example which I gave is forty marks out of hundred.

So even if you get twenty five in paper B and get say example forty or forty one in paper A, you will graduate in the examination considering the scenario two so, obviously it would be a situation where either paper one or paper two would basically qualify for your case where you basically pass the examination. In the first example or case one which we stated which means that you have to achieve forty minimum in both paper A and paper B in order to graduate into the examination.

So this concept of AND or OR would basically depend or if you basically go into details of exclusive OR or inclusive OR as we had mentioned in the diagrams with the so called tables of true and false so those truth tables only considering A and B as activities or A and B as the switches, based on that we can basically make our diagram as complicated as possible provided we are able to bring all the practical applications into the picture.

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GERT (discussion of diagram)

- AND node plays a predominant role in the activities up to and including the terminal countdown.
- This is due to the fact that all activities must be performed before lift off
- After the terminal count down either possibilities are presented

So, in this diagram so if you go back to this diagram which we have just discussed about nitty gritty of how the countdown and all the complications can be achieved, so this is AND node it plays a predominant role this is due to the fact which is the second point I am leading this is due to the fact that all the activities must be performed before lift off which means they all have to be performed all have to be done successfully if and only if all of them are met then only the next stage basically is achieved.

So as I mentioned in the examination taking case of a few as a student so you would only graduate if you pass both the examination so this at work or this launch can only happen if the precedence jobs and activities all of them are completed. After the terminal count on either possibilities are presented so after its done, so if you can only go for the launch, if all the work is done, point one, point number two when you launch the success of that project would be either yes or no.

That means either the launch can take place or the launch cannot take place, so if it collectively the launching of that satellite or that rocket it would mean that there would be some combinations of AND, some combinations of exclusive OR some combinations of inclusive OR. So the collectively all the logic gates or the logic would be into the, consider into the diagram in order to give the best picture for the practical problem which you are trying to solve.

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GERT (discussion of diagram)

- 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
 - ❖ Unsuccessful orbit after boost phase with orbit correction achieved
- The dotted lines represents the process where it signifies activities that do not contribute to the successful launch

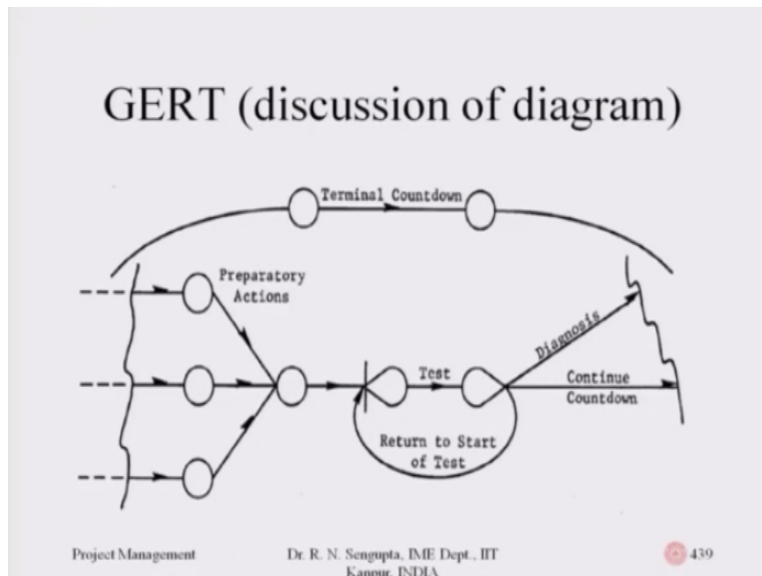
Again and I am continuing our discussion for this diagram, successful node is an inclusive OR node due to the reason so when you basically consider the diagram is so that is an exclusive OR node or the job which we are considering due to the fact or the reason that the successful launch can happen in two mutually exclusive ways. So which I just mentioned the just few seconds back so what are those reasons.

Proper operation during boost phase so the boost phase is basically just before the take off when the cryogenic rocket or the full tank and all the frills are basically ignited, as per the technical norms and left off. Once basically meets all the criteria, and another one is that unsuccessful orbit after boost phase which with orbit correction achieved so you are considering, now different stages once you left of the rocket so left of the rocket means you have been able to put forward the rocket into the space but, there are other work also like say for example.

If the rocket goes within satellite it may so happen that in the later stage the satellite may not be successfully launched into the orbit so if you consider the whole project as such is the failure, but the initial work our success, another scenario can be the satellite is successfully launched in its orbit geostationary satellite consider that that is put around the earth in the successful way but in that case all the stages has to be successful.

if you consider part by although in the whole holistic sense the success would be defined depending on what your actual target is, so in the initial case combining all the jobs in order to basically first put the spacecraft into its flight mode is or can be considered a success, if I consider the whole problem in a sense that even though if I am able to put that satellite, and into the orbit but the malfunctions obviously it would mean that collectively it is a failure.

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So if I basically go into the details just zoom in on to the diagram, so you have basically the preparatory actions if you remember the left mode past portion are trying to combine all the different jobs, and then basically you test it, now when you are testing it so that detailed discussion, I did not do when you test it they may some problems, so what will happen is that which is totally different from the PERT and the CPM network is they would be input loops again coming back to the combination of the stage.

Where you basically combine the different jobs in order to basically be prepared for the test phase. So, what you do and if you consider this loop is that you return to the test start of the test such that any malfunctioning of the whole process when it happens during the test can be included in the study says that they give a good picture that how the inputs can be utilized from the test and the how to outputs from the test basically acts as as a set of information for the inputs of the latest.

So this loop can continue till you are able to achieve the goal which is set for this for this initial stage which is a test stage for arc consideration such that once the feedback loop is complete in knowledge in proper implications, you are able to incorporate the feedback such that the test phase is successful then in the if you continue with the looping and go beyond that there could be a diagnosis based on how whether there is actual problem.

So there would be basically two types of problems, one is they are not that detailed they can be handled and this handling is done by the looping which is there so all the looping considers that the feedbacks are such that they are able to take care of this errors, and then obviously if you are able to take care of all the errors it goes into the continued and the count on stage and the later phase of trying to basically put the satellite into the orbit.

So obviously there would be other stages on to the right which is not shown which is cut here, another issue can be say for example when you are trying to analyze the problem they can be upon an issue which cannot be solved in the test phase so consider this a major flaw in the diagram or there is a major flaw in the design of the cryogenic fuel or they can be major problem in one of the valves.

So in that case you have to basically do a detailed diagnostic test get the feedback and basically go into the preparatory reactions such that those preparatory actions may now be affected depending on the feedback which you got. So internal feedback was not successful say hence the the issues of the feedback would basically be considered on a much bigger scale such that the P work which is needed before the test space which is mentioned here as predatory actions should be considered in more detail to take care of the problem.

And obviously if everything is fine you follow the set of nodes and arcs which is there on the top portion of the diagram where I am hovering my fingers so that will give you the terminal countdown and how the work starts.

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GERT (Basic Network Analysis)

- 1) All six nodes behave in the same manner if only one branch is received at the I/P side and one branch is emitted at the O/P side
- 2) Thus if two branches are in series and they are being considered then the node type have no effect on the equivalent one branch network

All the six nodes now coming back to the concept of three input and the two outputs so all those combinations so all the six nodes behave in the same manner if only one branch is received at the input side and only one bunch is emitted at the output side, so whenever you are trying to combine and if there is only one input and one output as stated in this point, so it will mean that the combinations of all the six nodes of the behavior of the six nodes would be exactly the same.

We will see that, as we discuss it will become clear to you. Thus if two branches are in series so now the work can be done in series or parallel if you remember very basic concept of what is the series circuit was a parallel circuit, so obviously they would be, if you consider the precedence diagram for the PERT, CPM based on the fact you have been able to draw the diagram to the maximum details using the GANTT chart concept so there would be some jobs which can run parallel.

So consider we will consider them to be in parallel and then some jobs would basically have a very strict precedence and successor concepts such that one job can only start once the other job has started, or one job can only start once the other job has finished, so in that case you will basically have the concept of the sea of the series so thus so that is what we generally mean by in the concept of series and the parallel concept of the jobs in the network concept.

Thus if two branches are in series and they are being considered then the node type have no effect on the equivalent of one branch on the network so depending on how the work works it will basically be have an implication the reason being that if you remember the initial discussion which we had about the different concepts of three in portion and the two outputs that would make a sense, because in one of the diagram so let the pause here, and I will go back to this detail table once again to refresh our memories.

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| <u>Name</u> | <u>Symbol</u> | <u>Characteristic</u> |
|--------------|---------------|---|
| EXCLUSIVE-OR | ⊞ | The realization of any branch leading into the node causes the node to be realized; however, one and only one of the branches leading into this node can be realized at a given time. |
| INCLUSIVE-OR | ⊃ | The realization of any branch leading into the node causes the node to be realized. The time of realization is the smallest of the completion times of the activities leading into the INCLUSIVE-OR node. |
| AND | ⊄ | The node will be realized only if all the branches leading into the node are realized. The time of realization thus is the largest of the completion times of the activities leading into the AND node. |

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So if you come back to the three inputs so it means that if you read the characteristics that will make you clear, so the first one says which is an exclusive OR that it says that only one and only one of the branches reading to the node can be realized at a given time, so they would only one, so depending on the realization, it will basically depend on which one of is this taken, the second one which is the characteristics which I am going to talk about is on repeat is for the inclusive OR.

It mentions if you did it the time of realization is the smallest of the compression time, which means that you would take the minimum of all the times and proceed accordingly, so the discussion which we had just few minutes back depending on the combinations would obviously mean that either you take the minimum time or the maximum time now the point of maximum time is coming here OR or the realization will be coming here if you read the last characteristics of AND, it stated here.

The time of realization thus is the largest of the completion time of the activities, leading into the AND node. That means all of them combined together would only be achieved and such that the next stage is achievable or into the next stage of the job or the activity is active, so in that case all of them may have to be done in such a way the moment the last switch is put on I am considering the switch as a very simple concept of the jobs and more and once it is completed then only the list of the of the whole project can't start so if you read this characteristics once again for a better understanding will understand what I am basically going or discussing through,

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GERT (discussion of diagram)

- AND node plays a predominant role in the activities up to and including the terminal countdown.
- This is due to the fact that all activities must be performed before lift off
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So this which am saying after the terminal countdown third point after the terminal countdown either possibilities are presented and based on that we proceed.

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GERT (discussion of diagram)

- 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
 - ❖ Unsuccessful orbit after boost phase with orbit correction achieved
- The dotted lines represents the process where it signifies activities that do not contribute to the successful launch

Now, continuing the discussion 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 the boost phase when you are trying to boost the engine of the rocket and then put it into space so if everything is working properly then only the exclusive OR node would be there, and another key would be the unsuccessful orbit after boost phase with orbit correction achieved so in both the cases.

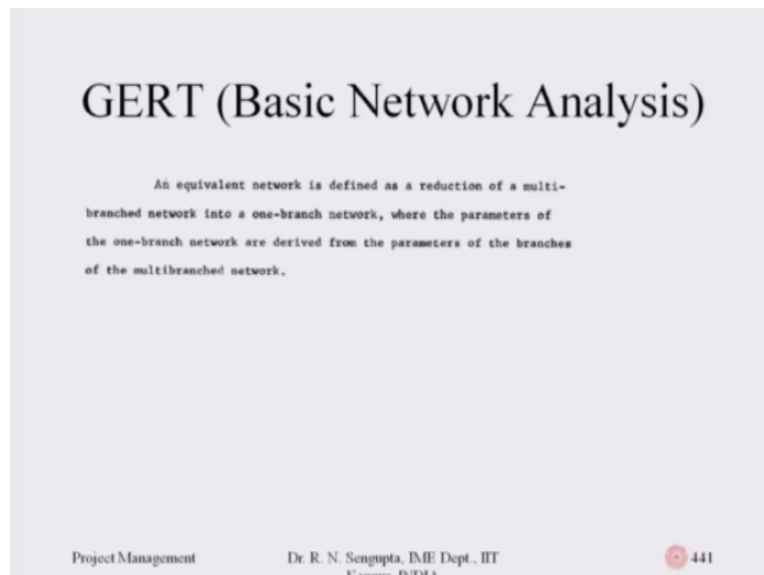
If there is an unsuccessful task or job obviously there would be feedback once the feedback comes you would basically take corrective actions so once the corrective action is taken will consider the work has been solved and then we will proceed to the next phase, so in this both cases the exclusive OR would mean that you are able to take care of whether it goes past the yes phase, yes means everything is correct at one go.

Even if there is some no or some false or some zero implications is there the word falls zero implications of problems I am trying to basically use that interchangeably, so please bear with me so if they do not want obviously it would mean that it would be a feedback basically feeds into and gives us the information for the preceding jobs or activities based on which we take to the action so exclusive OR.

What would be applicable in both the cases and the dotted lines basically represent the process where it signifies activities that do not contribute to the success launched, so they may be some stages or some set of work which would not lead to a successful space so we are trying to basically differentiate that with dotted line so these are basically our nomenclature we are trying to utilize for the arcs in order to make things much better to us.

So for the dotted lines which you mean is basically this one so where I am hovering my finger so this if you see the boost phase is a failure, so obviously it would have no consequence on the successful implication for that those set of jobs or activities, so this is the diagnostic one and the feedback loop which were considered based on which we proceed.

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An equivalent network basic on considering our discussion so we will now basically go into some detail definitions, an equivalent network is defined as a reduction of a multi branched network into a one branch network, where the parameters of the one branch network are derived from the parameters of the branches of the multi branched network, so what we are doing is that we are trying to basically replace the multi branch in whatever complication.

It is with the basically fixed branch, now there I will pause and basically try to go back to one of the concepts which we did discuss when we were considering the decision trees, if you remember I did mention about utility functions and I also did mention about certainty equivalent,

if you remember into certainty equivalent or utility functions we had one important concept was expected value if you go later back to the projects there was net present value or the expected value of the project.

So or the earned value so what it means that you are trying to basically find a one to one implication of the complicated network with a much simple network as the overall feedback loop or overall logic circuit in this GERT concept remains the same which is in somewhere trying to basically draw a one to one correspondence with the concept that whatever complicated utility functions which you have or whatever complicated decision trees you have.

You are trying to replace that with a problem deterministic one such that the expected value of both of them are same considering that the characteristics of the investor or the decision makers you are, so with this I will close this lecture and thank you for the attention and we will continue discussing the GERT in the last three lectures which is the thirty eighth thirty ninth and fortieth with some implications for the practical purposes, thank you very much.