

Project and Production Management
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Lecture - 20
Project Completion and Review

Today we are going to talk about the last phase in the life cycle of a project namely the stage of project completion and we will also talk about review and future directions in this area of project management. Now let us try to briefly recapitulate the various stages in the life cycle of a project and see what kinds of decisions and what kinds of problems manifest themselves in the various stages. If we look at the project life cycle we notice that the first important stage of the project life cycle was one of project selection and in this stage of project selection we were concerned with the problems associated with new project identification and then appraisal of the prospective projects and finally a selection of one appropriate project for purposes of implementation. After the stage of project selection, we encounter the next stage of project planning and in most of this course we have been talking about tools and techniques for project management.

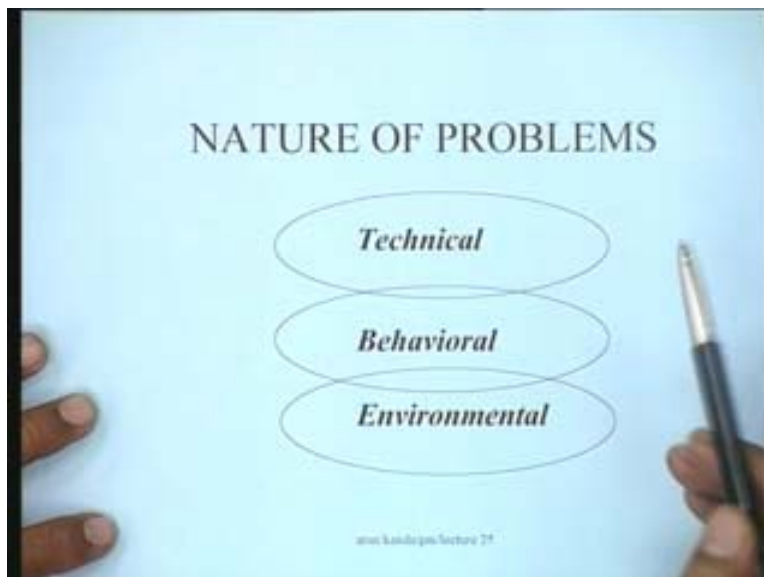
Essentially project planning involves determining the project scope and doing the basic scheduling computations, talking about time and cost tradeoffs in projects and finally looking at resource considerations in projects. After you have developed the project network, developed the project schedule and taken care of the resource problem and the crashing aspects in a project you come to stage where you have to implement the project and implementation is basically of the plan that was arrived at in the second phase of the project life cycle. In the implementation phase we were concerned with project monitoring and control and specifically we looked at the technique of PERT cost which was a very effective device to monitor project progress and give us information pertaining to both the time and the cost overruns in a project. Then finally once the project is implemented comes the stage of completion and the stage of project completion is actually the stage where the project staff has to wind up.

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The project is complete; it has to be handed over to the user. There are a number of behavioral, sometimes technical, sometimes accounting problems which crop up at the stage of completion and moreover completion is also the stage where you try to consolidate your learnings from the project and final report writing and things of this nature. It's an important stage. The entire project team has essentially gathered together to accomplish a certain task. After passing through these various phases this is now time for the project team to say good bye and wind up all the activities and may be embark on their next mission. Let us briefly see the kinds of problems that are encountered during the various phases of the life cycle.

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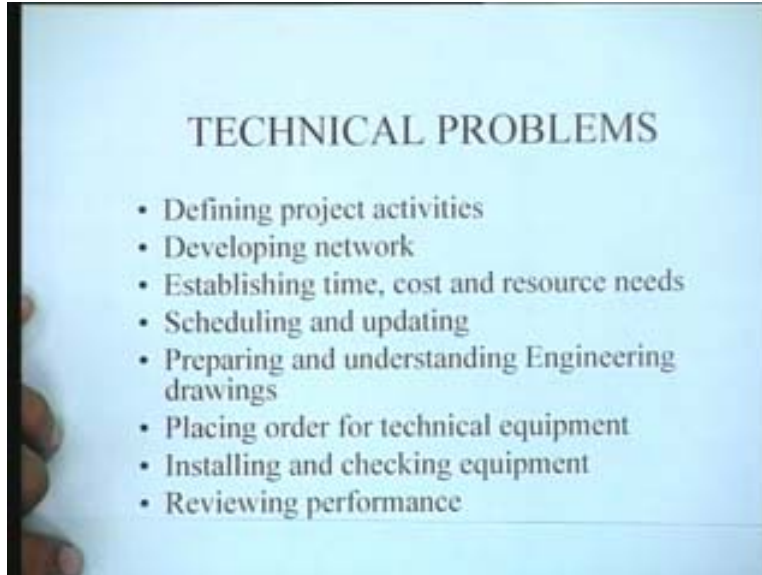


Projects have a technical component and therefore many of the problems arising in projects are technically oriented. They could be technological problems. They could be problems pertaining to the acquiring of the right kind of instruments, acquiring the right kind of equipment, trying to set up this equipment and making it work. These kinds of problems typically would be technical problems. Apart from that central to this is the fact there are a large number of behavioral problems in a project because projects are managed by teams of people. Therefore there are invariably issues of conflict, invariably issues of interpersonal communications and issues pertaining to motivation of the entire team which are again very important problems and then the third major class of problems that a project encounters is the environmental problems; problems which come not from the project staff but from the outside environment, from the economy, from government legislation and so on and so forth.

Let us try to see, during the course of the project, what kinds of problems are being handled at different stages. If you look at the technical problems in a project typically one of the major problems which is encountered right at the stage when you start to initiate a project is defining the project activities; what all has to be done and this is essentially a technical problem because only specialists in that area would identify exactly what is to be done for the success of that particular project. Developing the network is again a technical problem where you have to identify not only the activities but the precedence relationships among the activities and based on this information you can develop a network and the project network was a basic tool that was used for purposes of planning, subsequently implementing the plan and it also provided a common agenda for all the members because it showed them very clearly their share of work in the overall project.

Establishing time, cost and resource needs is again typically a technical problem. Scheduling and updating; developing a project schedule and subsequently whenever there is a review based on the updated information, to update the schedule is again essentially a technical problem. Preparing and understanding engineering drawings again is generally a technical problem because to read a drawing and to make sense out of it is essentially an engineer's job. Placing order for technical equipment is again one of the major technical problems that one has during a project because you have to order a large variety of equipments. Either you have to order it yourself or you have to get it ordered through your sub contractors and so on but then having a thorough knowledge of what kind of equipment is being ordered and what are the capabilities again is a technical problem. Installing and checking equipment at various stages of the life cycle again is an instance of a technical problem which you encounter in projects.

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Reviewing the performance of the project is also essentially a technical activity which essentially involves finding out as per plan what you are supposed to do and subsequently when the activities are done, to be able to find out how much of it has been done which is the key element in project monitoring and control. These activities are also essentially technical activities

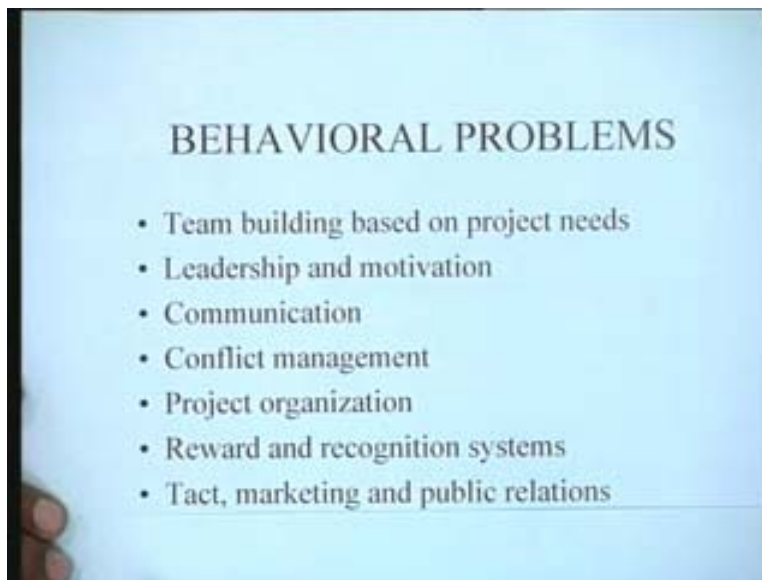
Apart from the technical problem, the second major category of problems which you encounter in a project or what we term as behavioral problems or human problems, problems of handling human beings. In this category the first problem is team building based on project needs. A team has to be built and this particular team has to be built taking into consideration whatever is required by the project in terms of what activities are to be accomplished. You got to pick up the right people from either within your organization or from outside and bring them together to operate as a team and whenever people from diverse backgrounds come and try to settle down in a team there are always human problems of adjustment and making an effective team have to look after this particular project.

Leadership and motivation is another important factor because the project leader or the project manager has to lead his team and there are various styles of leadership as we have seen and to motivate the people so that the people are always enthusiastic and not indifferent to their individual assignments in the project. Communication also is a very important aspect. It has to be done at all stages of the project. Conflict management is another major problem and as we had seen during our discussion that the source of conflict varies with the priorities of the schedules, or the times and the cost or interpersonal conflicts and by and large throughout the project you have conflicts though the source of the conflict at different stages could be different. This again is a behavioral problem and how to manage conflict properly? Having the right kind of project organization for a project; do we have a matrix organization or do we have some other

type of organization which will be able to give us the kind of flexibility that is required in project management and at the same time it would allow people to stay within their functional departments and grow normally or naturally. This again therefore is extremely important to have the right kind of project organization.

Looking at the reward and recognition systems is again very important because this is something that governs how enthusiastic people can become if you have a right reward system and recognition scheme in operation where you reward the people. Rewards need not always be monetary rewards. If every week you put up a notice saying that such and such gentleman in this entire project earned the maximum number of points for whatever reason or how it is that itself would be quite enough recognition for the person and developing reward and recognition systems are instances of appropriate behavioral issues which you have to take care of.

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Another thing that you tend to learn in a project is how to be tactful, how to get work done from people doing your marketing. Marketing not only of your project, not only of your products but marketing of the individual itself in terms of whatever is being done and whether you are good on public relations. These are some of the behavioral problems which you invariably encounter when you are trying to handle a project.

Let us now talk about the third category of problems namely the environmental problems which you could be facing in a project. We call them environmental in the sense that the source of the technical problems and the behavioral problems is generally the project objective itself or the project team itself whereas these are problems which are there by virtue of the project team operating in an environment and number of issues can come up. For instance the project manager ought to be aware of the market trends, how things are going on in the market specifically with regard to any major competitors that might be there on the scene because it is becoming more and more competitive in the global

economy nowadays. An awareness of who your major competitors are, what are their strengths and limitations and how exactly can you carve a niche for yourself in this particular arena. These are therefore very important considerations for the project manager, being aware of what kinds of facilities other competitors are able to offer. Then awareness also refers to the kinds of vendors which are available for doing the various jobs and supplying the various kinds of items that you would need. This kind of awareness is also needed because it's only on the basis of this awareness that you will be able to pick up the most competitive vendor and be able to do your project within the time and cost targets that you have set for yourself.

Another thing which happens while a project is going on is that there are fluctuations in prices. There are fluctuations in supplies and lead times for different items. If the project manager and his team members are aware of these then if you know that there is going to be an impending shortage of this particular raw material for the project during the summer months, the arrangements should be made in advance to procure that material at time when the prices are reasonable. These characteristics of which material that's seasonal, which are not, who are the major suppliers and how are they affected during this particular duration of the project, these information would be very valuable and project activities require inputs of man power and other resources, other resources being capital, equipment and so on. We must ensure the timely availability of all these resources. This has to be ensured in fact by a good project leader.

Another thing that can take place is Government regulations and changes. There could be on the part of the government new legislation, new kinds of rules and regulations which might affect your working. For instance if you are setting up a car factory with certain kinds of requirements may be in view of the stringent environmental laws that are being propagated you cannot insulate yourself from that kind of requirement. You have to make sure that your production system is actually designed to take care of all the regulations at least on environmental pollution and things of that kind. So there could be changes in government legislation from time to time. There could be new legislations. You should be aware of what the legislation is with regard to your products and another thing is that the project manager should keep track of any new technology which is emerging in a particular area. The rate at which new technologies are being developed today is faster now than what it has been in the past and therefore there is a supply of new materials from new vendors, new people coming up in the scene all along and therefore if you have to make use of these, if you have to be at the forefront of technology you must be aware of these changes and you must be in a position to take advantage of any new technologies that are likely to emerge.

This would be for instance true in the case of something like computer software. You might be doing certain kind of reports manually, various things. May be there is a new software which can do this kind of thing for you very easily. So even an awareness of what kinds of computer software are available in your area could be very necessary and the same could be true with regard to availability of new equipment.

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Newer, faster computers with faster processing speeds and higher memories are currently being produced from one day to the other and so the rate of obsolescence is very high in such systems. You should be aware of all those kinds of changes and try to take maximum advantage of the new developments in that particular field. Having got an idea of the project life cycle and the various problems which are associated with it at different stages and these three problems of behavioral, technical and the environmental problems are almost present in all the stages. Let us try to see when we come to the completion of the project what kinds of major activities are involved and what are the implications as far as the project manager is concerned?

Let's try to identify the major activities of project completion and see how exactly we go about looking at the various problems? In many informal projects there might be no formal report writing. One of the main activities that should take place is this accounting and report writing. In most big projects report writing and submission of the report might be mandatory and at the end of the project you might be required to submit a report to the client that this, this, this is what has happened. These are the features of the project. This is how it has been installed, these are the layouts. So a complete project completion report might be mandatory. This kind of report is very useful even if it's not a mandatory requirement. It's always good to document the whole process so that your successors can refer to that document and they don't have to reinvent the wheel or they don't make the same kind of mistakes that you have been making in that particular project. It will be like forewarning the person as to the kinds of difficulty. This accounting and report writing looks at taking stock of the performance, time and cost of a project. This would mean essentially that you would know that you have originally planned that the project would be over let us say in 18 months. You probably took 21 months. You would have information in this report on both the target and the actual accomplishment and a similar statement about cost.

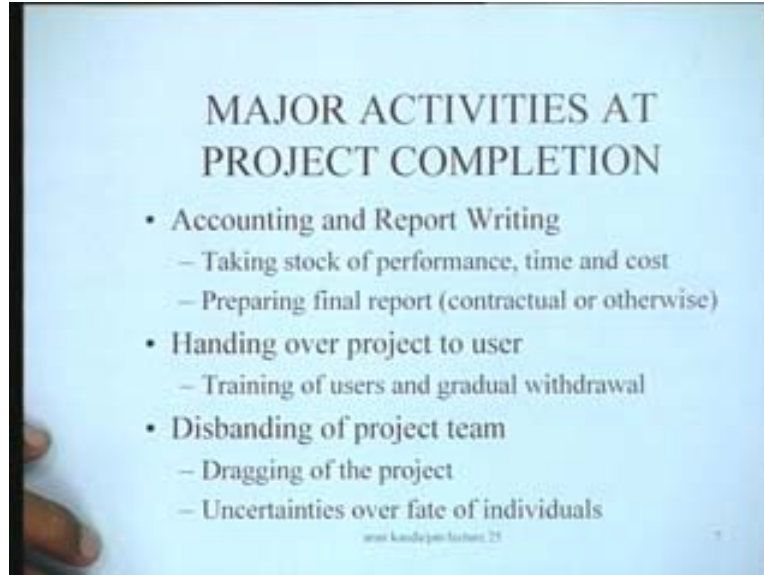
You might have imagined that the project is going to be in over 1.5 million rupees but it might have taken 1.6 or 1.7 as the case may be. That's one of the purposes of doing this report writing at the project completion. As I indicated to you before the final report could be either contractual or otherwise but it's always good to prepare a final report. All activities concerned with accounting and report writing are confined to this phase of project completion. You will be doing your major projects. The final activity which is generally done after you have done your experimentation or you have done your project and so on is the writing of the thesis. The writing of the thesis is basically this stage of project completion. We all know that a project is essentially the effort which is made by a project team to accomplish an objective. It is a temporary collection of people to accomplish that objective. Once that objective has been accomplished the team members will go away and they will go away after handing over the project to the user.

For instance if your project is to set up a refinery as long as the refinery is not set up the project staff will be there doing this job but at the time when that refinery is complete this refinery has to be handed over to the regular production people. There has to be in this regard a kind of a gradual process of handing over and taking over and what is really required is the training of users and a gradual withdrawal of the work force. During the project completion stage there would be instances when the project staff is involved with training the production department, telling them or acquainting them with the various features of the equipment before they finally withdraw. This training of users and gradual withdrawal is again a very necessary part of project completion and finally after you have handed over the project to the user the project team has to be disbanded and different people have to go back to their respective places wherever they are from.

Disbanding of the project team sometimes might not be all that easy because people have stayed may be for 2 years, 3 years together and they might have their own reasons to continue for a longer period of time; may be there could be personal reasons, there could be family reasons. Somebody is posted in Delhi. He would like for instance that his children should complete the 11th class or the 12th class examinations before they go back. Somebody else might have some other reasons. May be his wife has got an employment in some nearby place. Therefore he would not like to go back to that. These are instances of personal and nevertheless these could be very pressing reasons. What may happen in such situations is that people because they are unwilling to go back might start dragging the project. I mean the completion which might have been over in 1 month they might drag it to the next 6 months or 9 months doing things rather slowly and dragging it on so that they can accomplish their hidden objectives.

This is again one of the problems that have to be sorted out at the time of doing this and finally there are uncertainties over the fate of individuals. A person who comes and participates in a project is not sure that after going back to his parent organization where exactly he would go in the next project. If somebody is posted at Panipat for this refinery he doesn't know that if he comes back he might have to go to Barauni or he might have to go to somewhere else and there are these kinds of uncertainties associated over the fate of individuals and these can also become therefore barriers in successful project completion because people would not like to finish up everything.

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There would be people who are probably over enthusiastic to finish up and go back. What we are trying to say is that in looking at the disbanding of the project theme there would be both types of problems. There could be over enthusiastic people who are very keen to finish up and go home. So they will not even hand over the things properly to the user and would be in a hurry to catch their next train to the home town. That is also not desirable and at the same time, the other extreme when people tend to drag the projects for ulterior motives. This also is not desirable in that sense and these are practical problems which one faces when you are looking at the completion of the project and looking at this entire activity. As far as the uncertainties over fate of individuals is concerned to some extent the matrix organization tries to remove a part of the uncertainty because if you are coming from a matrix organization the individual knows exactly that this is the place I have to go back. It is like going back home and then when they are sending to the next mission; it's like that. So he keeps coming home and then he is sent back on a new project. Once he completes that he comes back home and then goes on for a new project and something like this. In that sense the matrix organization structure at least provides him a place where he can go and he knows that he has to go back there. It is very much like the cycle of life and death for individuals. We come here to accomplish some project, whatever that project may be. You have your goals for that project. You do that project and then go back. We don't know where we go back but we go back to our respective places in the matrix organization and may be the Hindus believe that you have a new birth where you come to do a newer, better project, better product. In that sense this matrix organization is like the theory of karma. You come and do your project. After you finish your project go back to your parent organization and then you will be picked up by the parent for the next project and you will accomplish that. Part of the uncertainty can be taken care of in this regard.

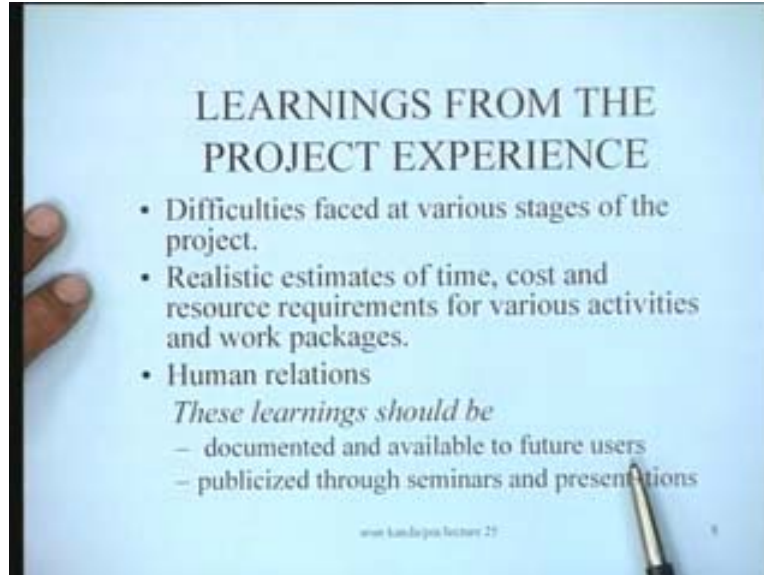
What are the typical learnings from a project experience? Each project will be unique and therefore it would offer unique learnings. You will learn something new on a project

because as I said every project is unique. Even if you are doing the same project I mean if you are setting up a flyover in one place as compared to setting up a flyover in another place the project would have similar activities but no two projects are ever identical because the surroundings would be different. The problems and the soil test might show you different kind of results. You might have to design a different kind of structure and then implementation agencies would be different. There would be different kinds of problems. But what are the kinds of learnings that you get from a project experience? The first thing that I think comes out very well is that you tend to understand what are the difficulties faced at the different stages of the project once you have gone through the experience and this is a tremendous learning in itself. You know what kinds of problems are likely to take place in the project selection phase? You know what kinds of problems you are likely to encounter in the project planning stage? No matter what the project is, you have grown wiser by your experience and you can even anticipate the kinds of problems that you might encounter at different stages. You know these difficulties and you know you will face them.

Another thing that comes out from the project is you obtained realistic estimates of time, cost and resource requirements for various activities and work packages in the project. After all the entire project planning exercise is based on estimates of time and cost and resource requirements and you base the whole planning and the subsequent implementation on these estimates. But it's only after the project is complete that you know how much time you actually took. What was the actual cost for something that you might have planned and therefore this will give you some experience of realistic estimates of time so that in future when you are doing similar projects or handling similar kinds of activities you can benefit from this particular estimation. Your estimates in future can become more and more refined and the third major lesson that you learn and this is a lesson that you keep learning all along in your life time is the lesson in human relations.

How to get along with people? Because in a project you deal with different kinds of people right from your boss to may be labourers who are working on the site and each person has ego. How to get rid of that ego or how to accommodate that ego is a major problem. You would have learnt some lessons in human relations and all these learnings that you have had should be documented and should be available to future users as I said.

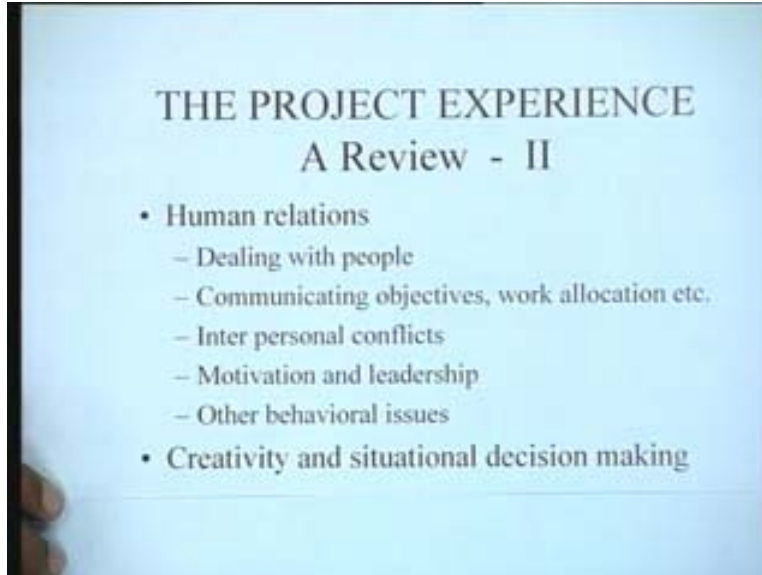
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That is how you perpetuate the experience and these learnings could be publicized through seminars and presentations. For instance you look at a company like Engineers India limited which is a project consultancy organization. When a project manager comes back after completing a project, let's say doing the Panipat refinery when he comes back to his department he should make a presentation; half an hour presentation or 1 hour presentation to all his colleagues, to all the staff including the managing director on what the experiences were like. What were the difficulties that he faced and this presentation will help others to imbibe some of those learnings.

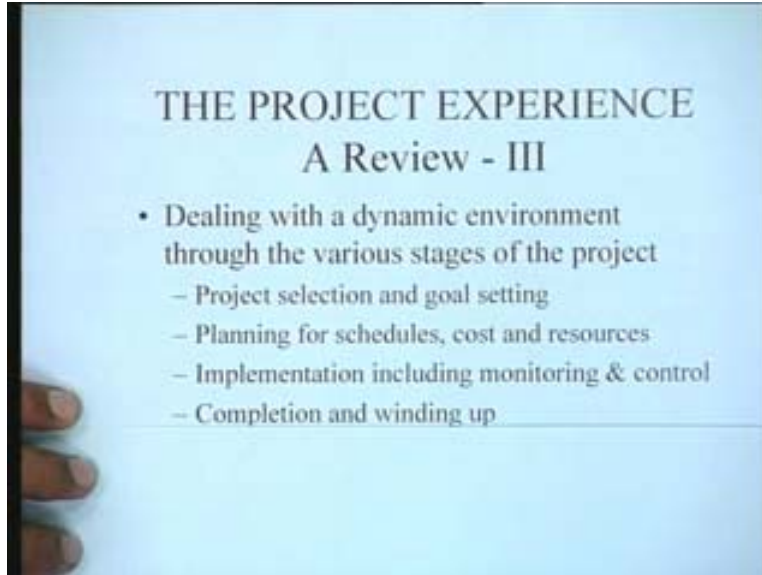
What is the experience of a project? Let's try to review the things that you probably get out of a project. What is the project experience? You learn how to work as a team. That's an important thing. You get technical exposure through consultants, suppliers, vendors and subcontractors. By talking to different people you get this kind of exposure and also by talking to clients because these are the various categories of people with whom you come in contact and then it's a training in human relations. That's another thing that we emphasize and when we are talking about human relations what is the kind of experience? What have you learnt primarily? You have learnt dealing with people; how to deal with different people? You have learnt how to communicate your objectives? How to communicate the work allocation to different people, breaking down a work and making different individuals responsible for different parts of work. So communicating all this to people this is **what you will come**. You will become aware of inter personal conflicts. You understand the aspects of motivation and leadership which are very important and you understand a variety of other behavioral issues which are connected with human relations and one thing that comes out as learning from the experience is aspects of creativity and situational decision making.

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Everything cannot be anticipated and planned for in a project and a project manager depending upon how the situation arises should have this capability of doing creative thinking and coming up with solutions on the spot, spur of the moment. This is required much more in project managers than for instance in production managers who are doing routine jobs. Depending upon the situation you make the right kind of decisions and do it quickly and be creative and encourage creativity in your people. This is another thing which comes up with people. Then you learn about dealing with a dynamic environment through the various stages of the project because the project environment keeps on changing as you are going from project selection to project planning to project implementation to project completion. You learn how to operate in this dynamic environment right at the stage of project selection where you are doing goal setting. Then you are planning for schedules, costs and resources. Then you are implementing including monitoring and control and finally you are doing completion and winding up of the project.

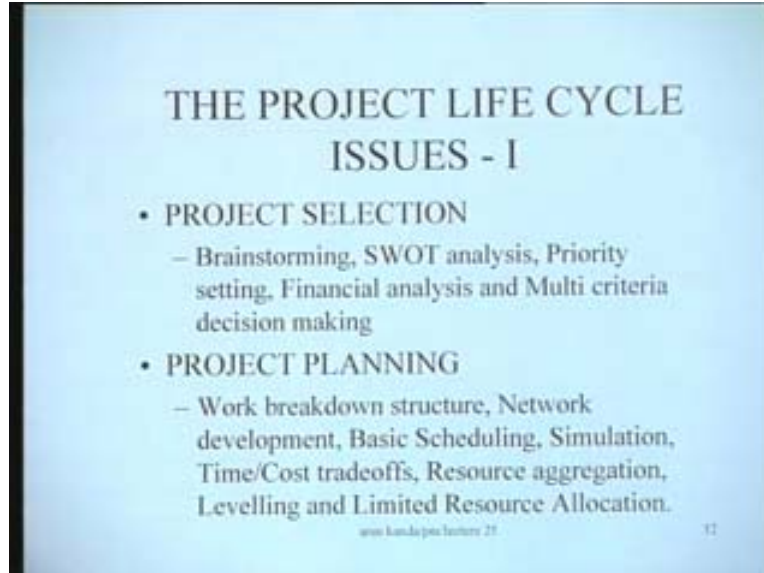
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You learn to become as it was a master of all trades or at least a jack of all trades if not a master of all trades. You have a variety of things that you have learnt during this particular project.

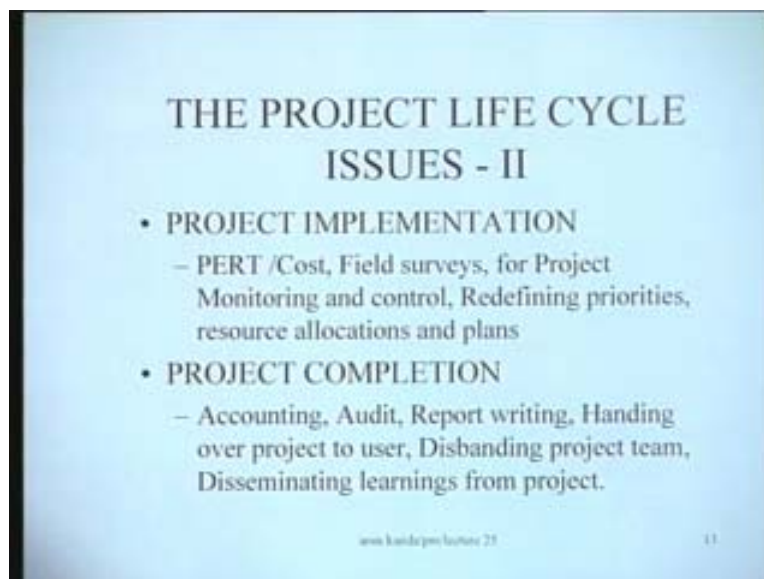
Now let's try to see what kind of issues and what kinds of techniques to be used in the different stages of the lifecycle. In the stage of project selection what are the kinds of issues and how do we handle them? We have to resort to brainstorming. We use a strength weakness opportunity threat analysis. We do priority setting. We have to do a financial analysis and multi criteria decision making. So you are basically dealing with these issues and you have a variety of tools to deal with these kinds of issues. During the project planning stage after having defined the project scope you are doing a work breakdown structure. You are doing network development, you are doing basic scheduling, you might be doing simulation, you could be doing time/cost tradeoffs and you could be doing resource aggregation, leveling and limited resource allocation. These are the kinds of activities that would occupy you during the phase of project planning.

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Then at the stage of project implementation what do we do? In the stage of project implementation our basic tool is PERT/cost. We might be doing field surveys, for project monitoring and control and all these things would be done. We might have to redefine our priorities. We might have to do new resource allocations and make new plans. These are the kinds of activities that you would be doing when you are doing project implementation. At the stage of project completion what are we doing? Now we are looking at accounting, audit, report writing, handing over project to user, disbanding project team and disseminating the learnings from the project whatever the learnings are, we are trying to do that.

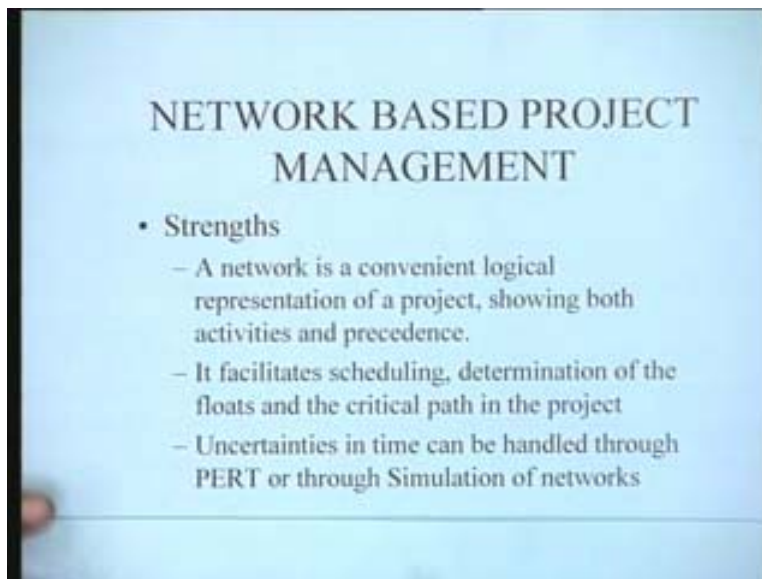
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During all these stages we are using different tools. You need financial management and financial criteria tools in the project selection phase but then after that you are basically working on a project network and doing basic scheduling and other things right along. In fact you will find that the project network is the one basic tool which you are using almost consistently throughout in the various stages of the project life cycle. We will discuss some of the strengths and limitations of the project network based methodology and we will try to then see what kinds of modifications and extensions in the future are in store in the area of project management.

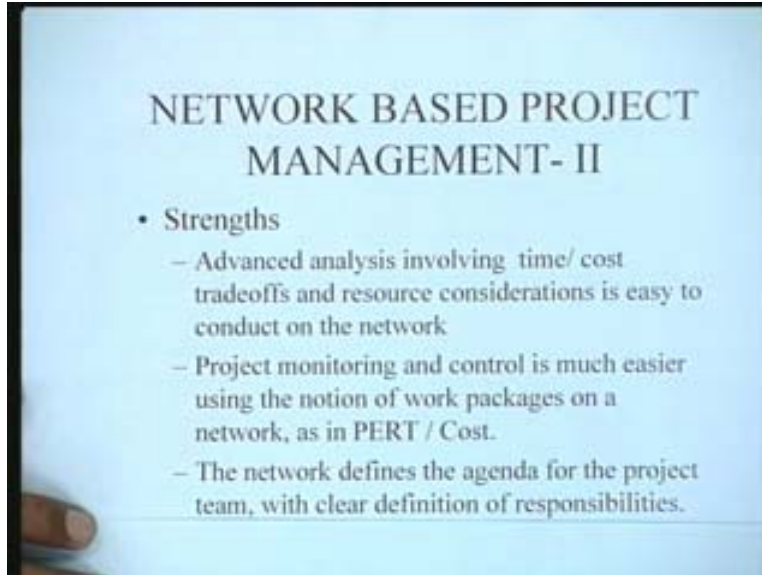
Some of the major strengths of network based project management that is using a network what is the basic advantage? A network is a convenient logical representation of a project which shows both the activities and their precedence because the project is a collection of inter dependent activities and the project network is a vehicle which shows both the activities as well as the precedences. In that sense we had seen that it is much superior to just bar chart or something else. The network facilitates scheduling, determination of the floats and the critical path in the project. All exercises can be done on this and uncertainties in time could be handled through PERT or simulation of networks again.

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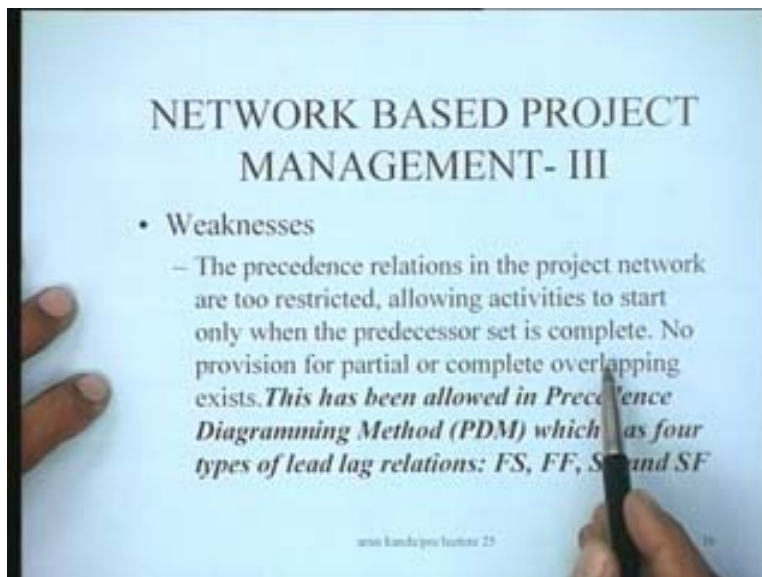
These are some of the major strengths that we have of the project as far as the representation and scheduling and capabilities are involved. It has many other strengths. For instance advanced analysis using time/cost tradeoffs and resource considerations is easy to conduct on the network. We have seen that there are a large number of procedures and well defined algorithms which we can employ for doing this. Project monitoring and control is much easier using the notion of work packages on a network as in PERT/cost. This is another strength of the project network and perhaps the fact that the network defines the agenda for the project team with clear definition of responsibilities is one of the most important advantages of the network.

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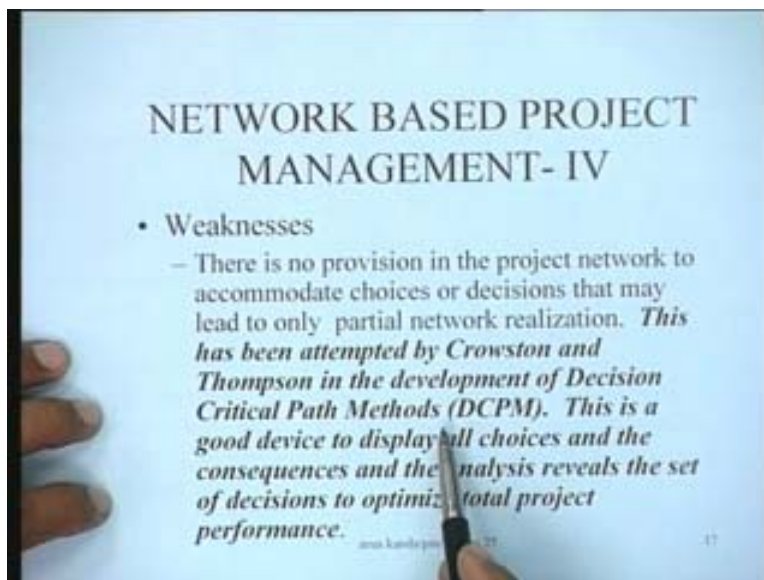
We have seen that the network sort of unites the team. It gives everyone an agenda. It tells everyone what you have to do, whose responsibility is which activity or which activities and I see my role in the project as compared to the role of all others. In that sense it's a common agenda. It provides a kind of unifying basis for all the team members to come together but the network based project management has certain weaknesses and the weakness is that the precedence relationships in the project network are too restricted allowing activities to start only when the predecessor set is complete.

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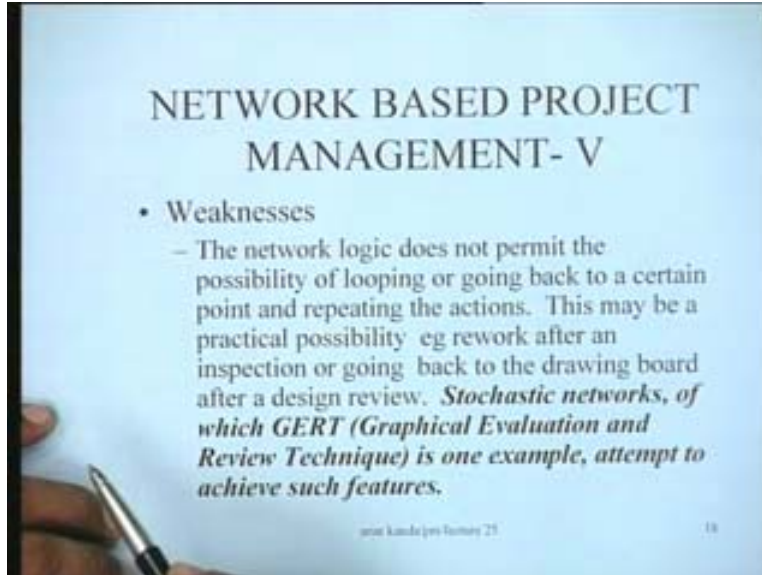
No provision for partial or complete overlapping exists. We say that an activity can start only when its predecessors are complete. We are always talking of complete precedence. This has been allowed in precedence diagramming methods which we have already seen, PDM which has 4 types of lead lag relationships; finish to start, finish to finish, start to start and start to finish. If you have these kinds of lead lag relationships what we have is we have basically a mechanism to expand the precedence relationships from a simple finish to start lag to including all these 4 types of lags. Another major weakness in the network models is that there is no provision in the project network to accommodate choices or decisions that may lead to only partial network realization. This has been attempted by Crowston and Thompson in the development of decision critical path methods or decision networks.

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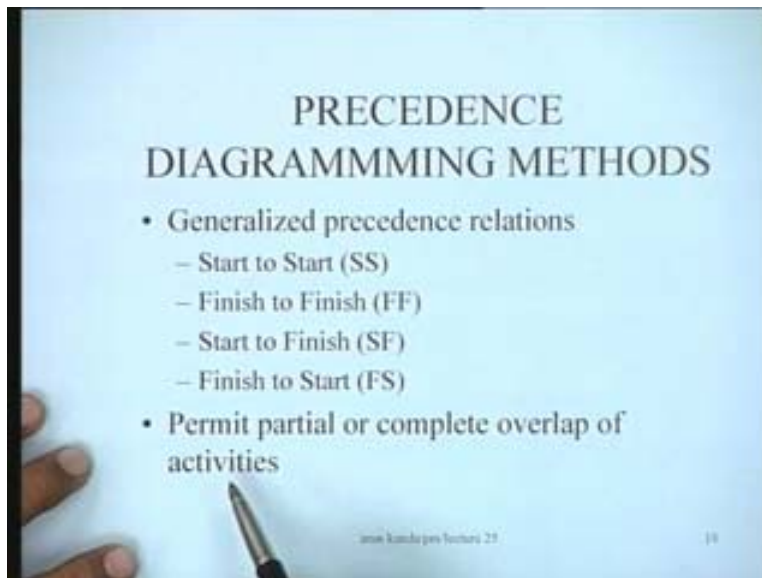
This is a good device to display all choices and the consequences and the analysis reveals the set of decisions to optimize total project performance because in the conventional network methodology we are taking only a unique way of doing a task. But there could be alternative decisions, you could employ alternative contractors to do the same activity and these individual contractors might have different capabilities. So they would be able to handle everything on their own. How do we take care of that? The network based project management has another major weakness which is the network logic does not permit the possibility of looping or going back to a certain point and repeating the actions. Cycles are not permitted in a project network. In fact we have consistency checks to make sure that there are no cycles. But this may be a practical possibility such as rework after an inspection or going back to the drawing board after a design review. Stochastic networks of which GERT is an example attempt to achieve such features.

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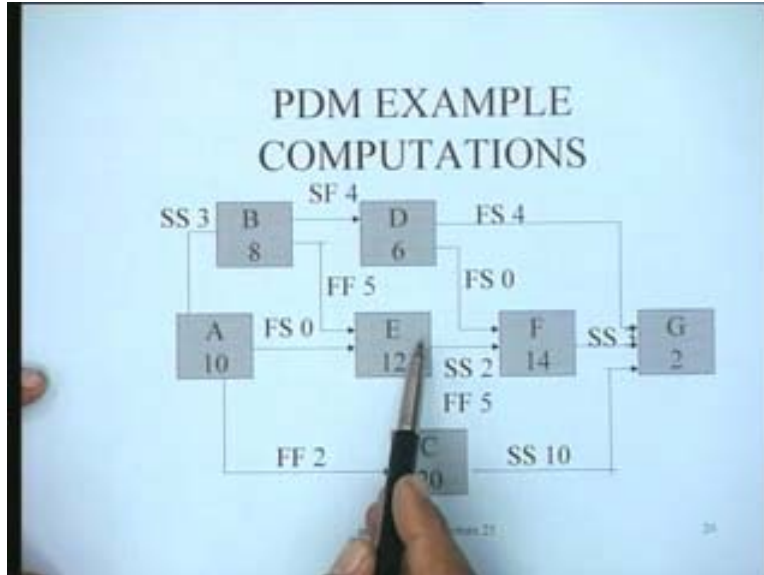
These are the three major weaknesses we can think of. Looking at precedence diagramming methods here we have these 4 types of lags which we are already familiar with and this permits partial or complete overlap of the activities in the project.

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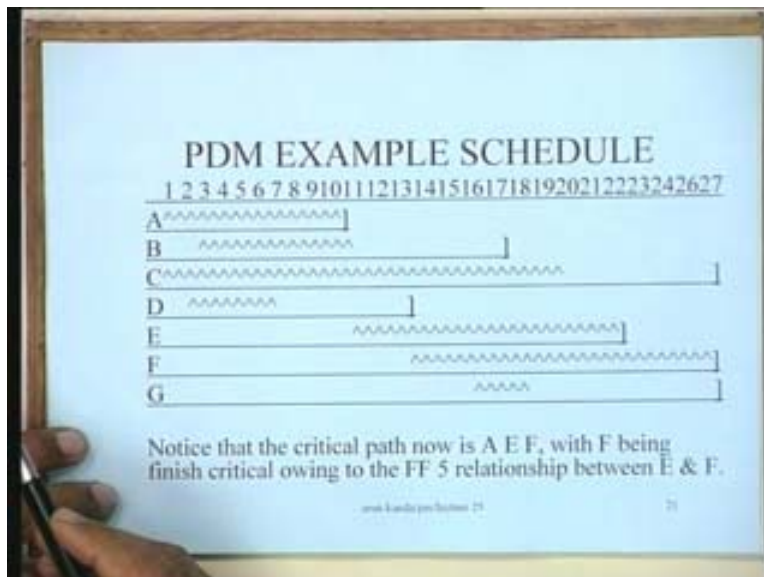
How this is done would be very clear to you if we look at a small example. We look at the example and we see for instance that these are the activities A, B, C, D, E, F and G. What happens is that we are now representing the relationships between the various activities in terms of these 4 types of lags. FS is equal to zero between A and E. FF is equal to 5 between B and E. That means the finish of B constraints the finish of E.

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When you are setting up these kinds for relationships you can do a modified forward pass and take care of the various constraints and develop the whole schedule. For instance for this particular network you find that you have a schedule which looks like this and the interesting thing here is that the critical path now is A E and F; A E and F and these three activities do not actually line up in series as they do in a conventional project network.

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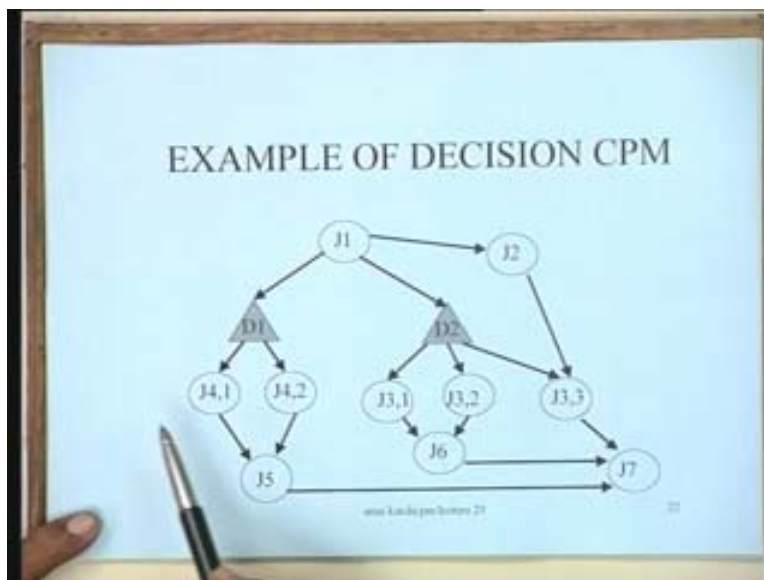


This is because of the expanded precedence relationships that we have and F is now finish critical in the sense it's this duration which is determined due to the FF lag between E and F. Between this and this there is a lag which is a FF lag. By virtue of this we have

these kinds of problems or these kinds of features. This is one of the modifications which has been done to the basic network methodology in terms of expanding the precedence relationships.

Let us now look at an example of decision CPM. In decision CPM what we have is we have a network which consists of 2 kinds of nodes. There are decision nodes and there are the ordinary job nodes like you have in an A-O-N network. What happens is that at this particular stage D1 I can either take the option J4,1 or I can do the option J4,2. Only one of these will be realized. So it could be get work done from contractor A, get work done from contractor B. Similarly here I have the option of taking one decision and there are 3 options.

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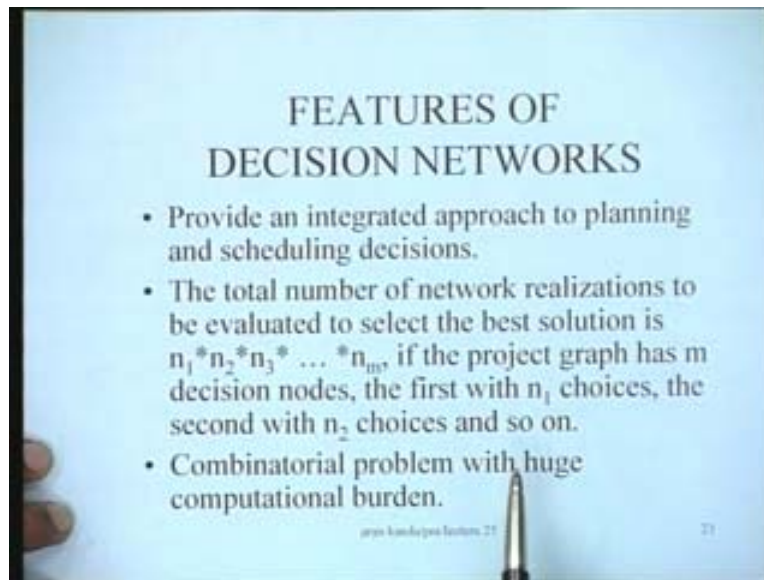


If I take these 2 options then I have to go here and ultimately come here but if I take this option then I don't have to do here. I can just come back here. I have to do job J2 which is a predecessor for J3,3 and then subsequently you have to come here. What you would find is that we have now introduced a situation where the entire network need not be realized depending upon your decisions whereas the conventional project networks are all realized. All jobs are done. What would happen is that we have now been able to combine this question of choice along with scheduling. Some of the features of decision networks are that these provide an integrated approach to planning and scheduling decisions. You are looking at both the aspects together and you are trying to determine a best schedule which will talk about the best decisions overall in the project at all the various stages. That's another thing.

The total number of network realizations to be evaluated to select the best solution is n_1 into n_2 into n_3 and so on up to n_m . If the project graph has m decision nodes the first with n_1 choices, the second with n_2 choices and so on. In that particular example that we were considering what would be the total number of network realizations? We have 2 decision

possibilities here and 3 decision possibilities. So 2 into 3 is 6. You can develop out of this 6 simple A-O-N networks and you can evaluate all these 6 and the one which is the best in terms of either the schedule or the cost would define for you the decisions that you have to take at these places along with the schedule. This is the basic methodology here. However this problem is essentially combinatorial because you have a large number of combinations and generally for practical problems there is a huge computational burden.

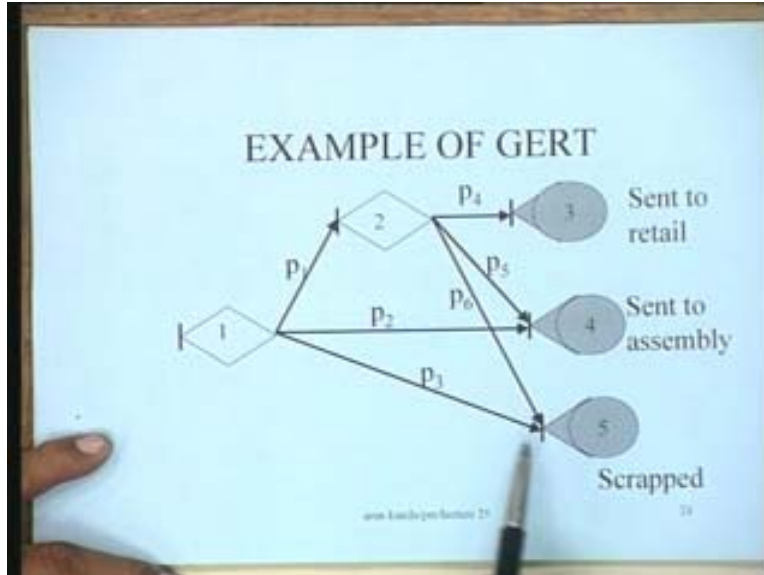
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That's why this technique though developed way back in 1967 has not been very popular but now with faster computers coming on the scene it's quite likely that these kinds of networks could become a possibility.

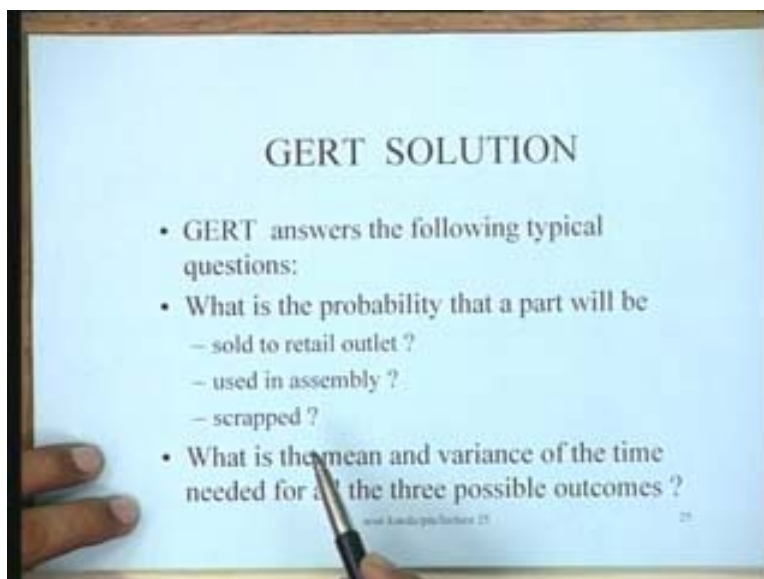
Let's look at the third class of methods. That's GERT; graphical evaluation and review technique. This is an example of a GERT network here. Notice that I have different kinds of nodes, not the conventional nodes. But suppose that there is a part being manufactured that part could be manufactured and there could be 3 possibilities. It can either be scrapped when it's not good or it can be sent to assembly if it's very good or if it's not so good it could go for retail where you will do some rework on it. This is the rework and it could then subsequently also be classified into one of the 3 categories. That means either it's sold outside or it is sent to the assembly of the precision part or it's scrapped. What do you see here? That the part could land up ultimately either here or here or here. There are multiple possible outcomes. In conventional project networks there is only a single unique outcome. You can finish up the part either here or here or here and moreover in a conventional network you go by deterministic arcs. But here we are now taking probabilistic outcomes. p_1 plus p_2 plus p_3 will be equal to 1 showing that this part can either go on this path or it can go to assembly or it can go for scrapping.

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Similarly after doing the rework it can again go to three paths according to certain probability distribution. **This manner of modeling various situations** When there are these kinds of uncertainties whether this activity will be a success or a failure; in all R and D projects. In a missile launch for instance you have this problem of whether it will be a success or a failure and there are probabilities associated with it. You can model this by using GERT methodology. This is a simple example. Similarly you could also be having looping in this. Here you could go back to another possibility. What are the kinds of questions you ask in GERT? GERT answers the following typical questions with regard to that example.

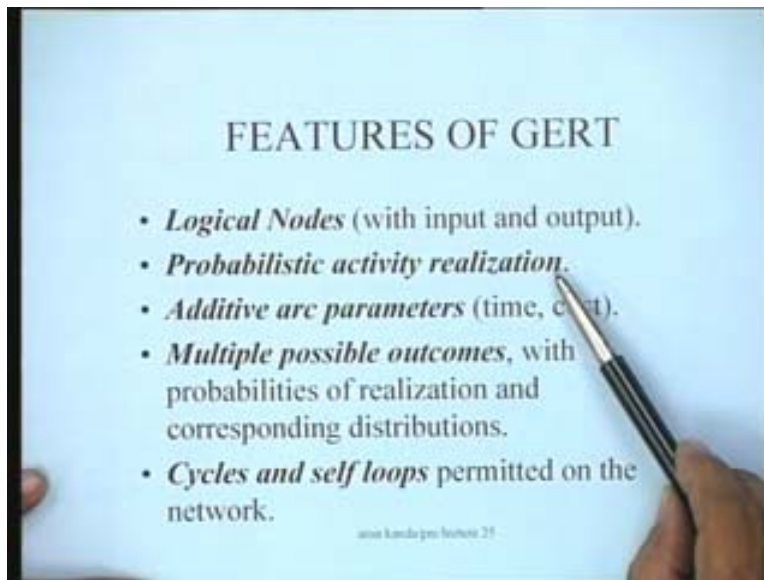
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We are able to work out the probability that a part will be either sold to the retail outlet or it will be used in assembly or it will be scrapped. These probabilities can be worked out. That means you can land up either here or here or here when you work out the probabilities. In conventional networks this probability is 1 always. Then you will always be able to work out the mean and variance of the time needed for all the three possible outcomes. These will be random variables and you can actually work out that solution. We are providing answers to these two basic issues through a GERT analysis. It could be done either analytically or through a GERT simulator but we are trying to answer these two questions.

What are the features of GERT? GERT has logical nodes as opposed to the earlier simple **and** nodes. It has probabilistic activity realization.

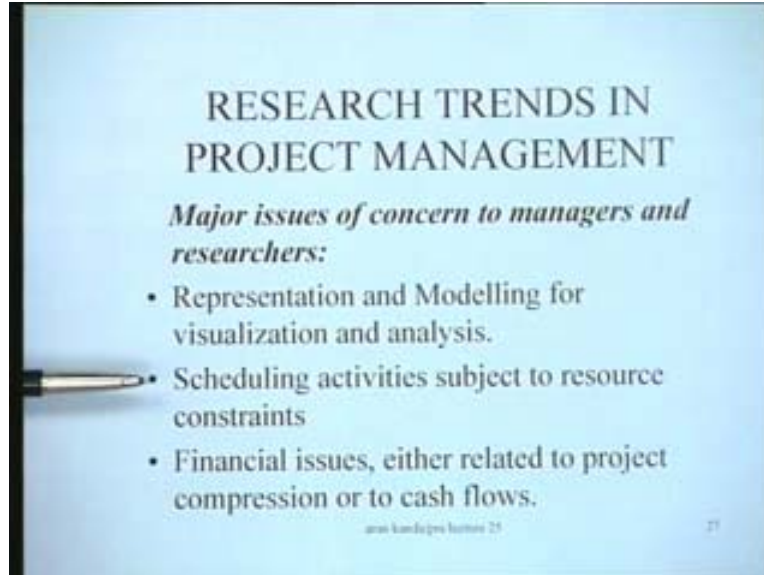
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That means this can happen or this can happen with certain probability. There are additive arc parameters. Both time and cost are additive if you go along a particular path. There are multiple possible outcomes with probabilities of realization and corresponding distributions and there could be cycles and self loops permitted on the network. This gives you an idea of how stochastic networks differ from the conventional project plans in that sense of the term.

Let us now try to summarize some of the research trends in project management. The major issues of concern to managers and researchers these days can be talked of in this particular framework. There are issues of representation and modeling for visualization and analysis. You have more software being developed which can represent project networks better. You can get a better feel for it. Scheduling activities subject to resource constraints is also a major issue of research.

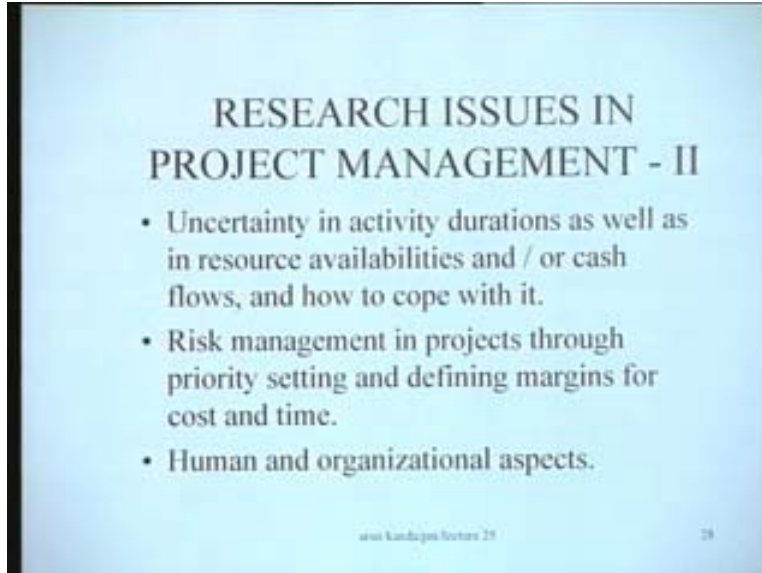
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Financial issues either related to project compression or to cash flows are again some of the major issues for research in project management. Uncertainties in activity duration as well as in resource availability and or cash flows and how to cope with them is again an active research problem in project management. We have seen that PERT deals with activity uncertainty but how to analytically determine the probability density function of the project completion time? Analytically determinate or determinate through simulation. What kinds of procedures are there? What would happen if there are uncertainties in resource availabilities and how to cope with them? These kinds of issues are major issues.

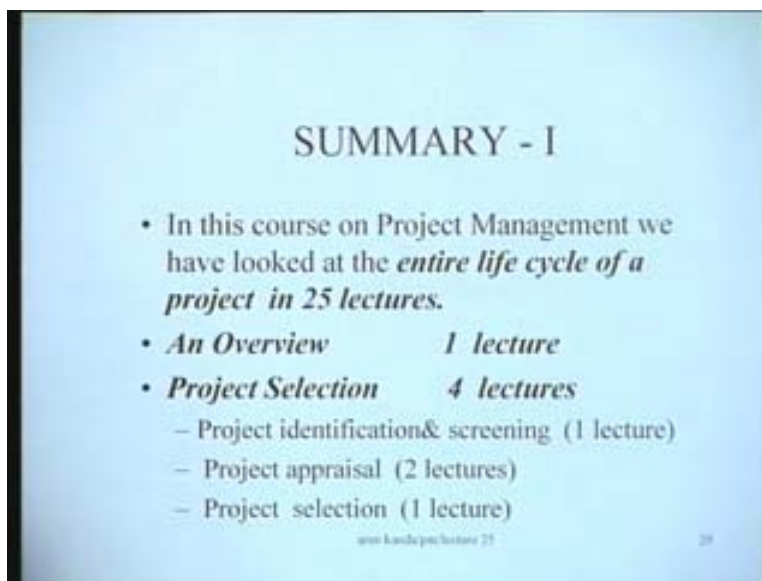
Risk management in projects through priority setting and defining margins for cost and time is again another thing. All projects are risky. There is always some amount of risk involved and since massive capital is involved in such projects therefore procedures have been developed where you assign appropriate priorities to different things and work out. That kind of thing is possible. Human and organizational aspects are other areas where research in project management is being done.

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Finally let us develop a summary of this entire course that we have been trying to do. In this course on project management we have looked at the entire life cycle of a project in 25 lectures and let's try to summarize some of the major results. We did an overview in one lecture and thereafter we talked about project selection in 4 lectures where we talked about issues like project identification and screening, project appraisal and project selection. We talked about some of these major issues in this.

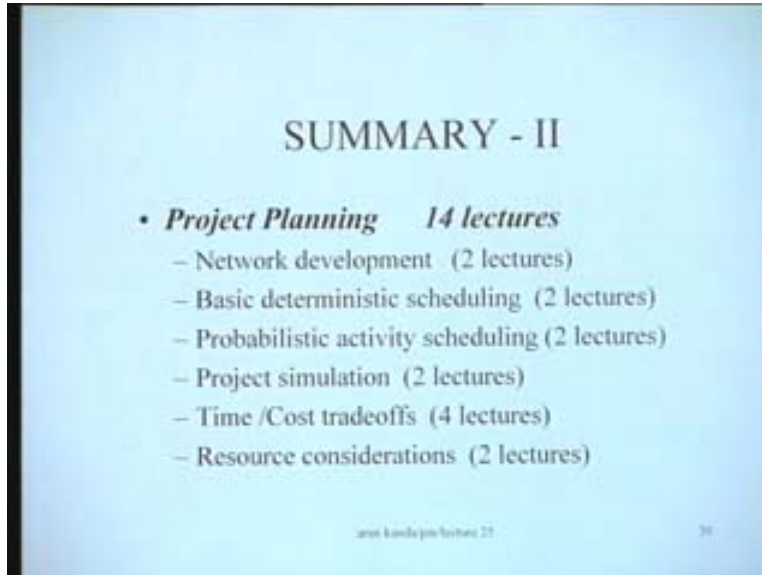
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Then we came to the stage of project planning which was a major chunk of the course. We devoted a total of 14 lectures to this and we talked about issues like network

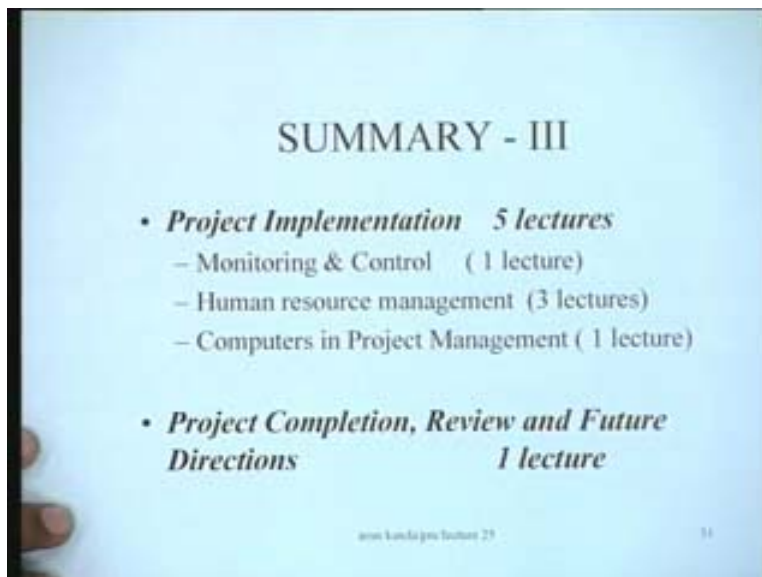
development, basic deterministic scheduling, probabilistic activity scheduling, project simulation, time/cost tradeoffs in projects and resource considerations.

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Finally we came to the stage of implementation. We devoted total of 5 lectures to project implementation. Talked about project monitoring and control, human resource management, computers in project management and finally we devoted the concluding lecture to project completion review and future directions.

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Thank you!