MANAGEMENT THROUGH NETWORK SYSTEMS

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Introduction

The network systems used in planning, scheduling and control of complex, inter—related and inter—dependent project activities and of the resources (time, money, manpower, equipment etc.) mark a break—through in the art and science of project management. The accelerated pace of to—day's development programmes, combined with the uncertainties associated with them have rendered the conventional procedures ineffective and stimulated the development of these systems now used by engineers, indus—trialists and business executives. The availability of high speed digital computers and techniques of statistics and probability has further enhanced the applicability of these techniques to practical problems. These systems are known by a wide variety of abbreviated names, but the two most popular are Critical Path Method (CPM) and Programme Evaluation and Review Technique (PERT) and are considered as standard.

Origin and Development

The CPM was evolved by the Integrated Engineering Control Group of E.I. du—pont de Nemours & Co. and two men : Morgan Walker of du—pont and James Kelly Jr. of Remington Rand—Univac U.S.A. in the middle of 1958. The first application was made in planning the erection of a new chemical facility of du—pont costing $ 10,000,000 and reportedly saved a million dollars in cost.

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At about the same time a similar system called PERT was developed by the U.S. Navy working with the consultants Booz, Allen and Hamilton. This was applied to the construction of the Polaris Missile Project and was instrumental in its timely completion.

Before the advent of these systems, complex projects were managed through the conventional bar chart or some variation of the same. This traditional system has several drawbacks. There is a lack of uniformity and detail in the bar chart and it is not immediately apparent how the jobs are related to each other. It is not possible to identfy the key jobs easily. The times are integral in this approach and the bar chart is quickly rendered out−of−date once some of the jobs lapse behind schedule.

On the other hand, the network systems provide a graphic plan of the project showing inter−relationships at a glance; the key jobs are easily identified and alternatives can be readily evaluated. It is possible to optimize time against cost and to level and allocate resources. The revisions and updating are easily effected and a probabilistic study of the project duration can be made.

CPM Network and Planning Phase

The Critical Path Method is applied in three distinct phases: planning, scheduling and controlling. The planning phase deals with the work breakdown structure and drawing of the arrow diagram. In the scheduling phase time durations are considered and project completion time evaluated. The controlling phase concerns with updating and revisions as also with studies of alternatives while revising the plan of work.

Before construction of the arrow diagram the work breakdown structure is prepared. The work is broken down into smaller units and their inter-relationships are established. The detail to which project break-up is made depends upon the nature of the project and the fineness of control desired. The relationships or dependencies are then established. The questions asked are: What activity needs to precede this activity? What activity must immediately follow this activity? What activity can continue alongside with this activity? The answers to these questions provide the necessary information to set up dependency relationships. A great deal of thinking and proper understanding of the jobs are necessary in order to fix these relationships. This in itself, is a great benefit of the system.

The popular form of the critical path is the arrow diagram in which each arrow represents one activity, and the relation of one activity with the other is indicated by the relation of one arrow to the other. Each node or circle (meeting point of arrows) thus represents an event and the logic of the network is that : each activity is represented by a line whose length has no significance but which has an arrow representing the progress of time, and the start of all activities leaving a node depends on the completion of all entering the node. Computations for start and finish times and project duration can be made using computer programmes for the arrow diagram of the system.

Scheduling Phase

In this phase the time estimates for duration of activities are made and entered in the network. It is then possible, through

simple arithmetic computations, to find the shortest time in which the project is capable of completion. When this is done it is found that one or more chain of events through the network determine this time as they form the longest path through it from start to finish. Such a path is known as 'Critical Path' and the activities that lie over this path are known as critical activities. The duration of the project is controlled by these activities. These activities have the same earliest and latest start times, and thus have no built-in margin of reserve through which these could be delayed. This reserve is called 'Float', and exists in non-critical activities. The critical path, thus, lies along the activities with zero float.

Controlling Phase

In order to complete the project within the scheduled time, it is essential to maintain the critical activities progressing according to schedule. A delay in the completion of any of the critical activities would result in delaying completion of the project as a whole. Therefore, the identification of the critical activities helps management to devote greater attention to these activities, thus ensuring their completion according to the schedule. However, some of these activities are still delayed due to unanticipated reasons, and this necessitates a revision of the original schedule with revised time durations. It may also be possible to adhere to the original completion date by reducing durations of some of the critical activities. This reduction in duration is called 'Crashing'. A number of alternatives

are usually studied to optimize the cost before the final decision is taken.

Project Cost Vs. Project Time

When a decision is to be taken to shorten the completion time of some activities, it becomes necessary to examine the cost-time relationships of the activities completing for crashing. Any shortening of completion time may result in increasing the cost, and in order to keep this additional cost minimum, decision to crash must be taken in favour of the activity involving minimum cost per unit of time shortened. In this way activities can be crashed progressively in the order of their crashing costs.

The shortening of the critical path in this manner reduces the total completion time for the project, but increases the cost. Depending upon the extent of crashing, there are different project durations and for each duration there is a different cost. A cost-time relationship can thus be evolved, and this curve helps in deciding the completion time that should be adopted.

Resource Allocation

The initial network schedule is based on normal rates of carrying out the various operations which result in minimum cost. There is little consideration given to availability of resources, such as labour, materials, equipment etc. In reality the resources are nearly always limited, and it is necessary to modify the schedule in line with available resources. This may be done by delaying

the non-critical activities to the extent of their floats, and diverting their resources to the critical activities. If this can be done, the resulting schedule will take no longer than the one made without regard to resources.

If this cannot be done, and it happens in most of the cases that utilization of floats is either not possible or not enough then it becomes necessary to examine the plan of work afresh with a view to re-orient the activities on the network or to reschedule them on the basis of a different rate of working. A working plan is gradually evolved which will meet the prescribed limitation of resources. To handle some sophisticated resource allocation problems some computer programmes are now available.

PERT Network

While in the critical path method the activity durations are known with certainty, in PERT these have a degree of uncertainty associated with them. Therefore, the proper use of PERT network is made in situations where the time estimates cannot be done with exactness, such as R and D or Defense and Space projects. In the planning phase the two networks, viz., CPM and PERT are identical. It is only in the scheduling and controlling phases that the two systems differ.

In PERT the duration of an activity and its certainty are expressed as the expected time of the activity and the variance of the expected time. These are derived from the three-time

estimates of the activity, viz., the most likely time, the optimistic time and the pessimistic time. The three times are the estimates of the most likely, the shortest and the longest times that might occur for an activity. It is assumed that these three time estimates are part of a Beta frequency distribution from which the mean or expected time, and variance are derived.

With the expected times of each activity, it is possible to determine the critical path through the network in just the same way as in the case of CPM. The sum of all the expected activity times along the critical path gives the total duration of the project. The sum of variances of the activities along the critical path gives the variance of the total project duration, and from this the standard deviation can be computed. With the help of this value of the standard deviation and the value of the total project. duration as found from the critical path, the probability of meeting a scheduled project date can be found, considering the project duration as normally distributed. In a similar way, the chance of being at a particular stage of the project by a given time can be assessed through the use of the PERT technique.

The uncertainties of the future make it impossible to forecast the precise time at which an event will occur. However, the PERT technique provides a way to the manager to know the expected times, as well as a procedure for calculating the probability of any deviation from these expectations. Low values of the probabilities indicate infeasible schedules. High values indicate the opposite i.e.,

the probability that the schedule will be met. Managers can, thus, review a given schedule in the light of probabilities calculated through PERT. If a schedule is found infeasible as a result of low value of probability of meeting the comptetion date, then resources must be increased or activities rearranged on the network.

Conclusions

Planning, scheduling and controlling of industrial projects using network analysis results in better understanding of the complexities of the work, and helps management by exception. The managers can devote their attention to jobs which are crucial for completion of the entire project within the scheduled period without being burdened to attend to unimportant activities. The use of network based systems. however, depends greatly upon authenticity of data for successful implementation. Sophisticated use of these systems necessitates availability of digital computers, but in most of the cases the non-computer approach is quite effective.