Duration Control System for Construction Project Using PERT

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Abstract

*The **Program Evaluation and Review Technique** (PERT) has been widely used as a tool for project management. In PERT analysis, the activity time distribution is assumed to be a beta distribution, and the mean and variance of the activity time are estimated. These support the **critical path** and the **probability** of the whole project. With the information of mean and variance of critical path, which is assumed as **normally distributed**, the probability of completion of a project with specified dates can compute. To establish a PERT Cost, one first develops a framework for gathering cost data for each activity. Using the **Optimum Time- Cost Estimate** Concept of **Resource Allocation Supplement method of Cost Estimation**, one can find the minimum cost for specific completion dates. The system in this paper gives the expected duration, critical path, probability and time-cost estimates of the whole project using the application of Bridge Construction.*

1. Introduction

Project Management tools are primarily aimed at improving the decision making related to coordinating a large number of different activities, especially such that are not routine operations. Construction project is very much dependent on scheduling techniques. The reason for this is the need to coordinate a number of activities in projects that imply engaging considerable human, financial and technical resources.

A precondition for applying project management techniques is to have a correct determination of activities, goals, costs and priorities, as well as of resources required to complete the project, and determine the proper sequence of the activities. A role is played by network diagrams, which can facilitate problem understanding and problem solving to a significant degree. After that, it is necessary to assess the duration of each activity and then associated costs. On the basis of such data the critical path is identified and the mean duration of the whole project is determined. Project managers have to pay particular attention to such activities on the critical path. And then, the estimate of total costs is made.

Many uncertainties are associated with these activities. The variance is a descriptive measure of the uncertainty associated with an activity time distribution. For estimating the probability of reaching this expected schedule date, we again turn to a relatively simple two-step statistical technique for computing a probability factor using normal distribution.

PERT Cost is simply an extension of the PERT Time technique. Information provided by PERT Cost helps the manager find the spots currently creating cost problems With it, the manager works directly on the more critical problems, prevents cost overruns, anticipates potential problem areas in time to act and identifies those activities from which (or to which) he can divert resources to the more critical program phases. Resource Allocation Procedure which determines the lowest cost allocation of resources among individual project activities to meet the specified project completion dates.

The main objective of PERT is to facilitate decision making and to reduce both the time and cost required to complete a project. The model presented in this paper uses PERT method as a quantitative support for determining critical activities, as well as for estimating project duration and costs.

2. Related Work

The related works of Beta PERT Distribution for Construction project Duration are mostly project management section. Project Management - Critical Path Method (CPM) and PERT with Process Model demonstrates how simulation with process model can remove the needless restrictions [9]. The one is the Application of PERT/CPM to the Care of Pulmonary Lobectomy Patients. CPM and PERT have been used as a framework to establish a framework for open-heart surgery patient to improve patients length of stay, cost and quality of care [10]. A Multi-valued DAG model and an Optimal PERT-like Algorithm for the Distribution of Application on Heterogeneous Computing Systems have to be statically distributed and execute on the heterogeneous servers of a multi-user system on a wide area, heterogeneous network [7]. Project Completion Time in Dynamic PERT Networks with Generating Projects is another related works. This approach is to transform PERT network into a stochastic network and then to obtain the project completion time distribution by constructing a proper continuous time Markov chain [1].

3. Theory Background

PERT, the Program Evaluation and Review Technique is a network-based aid for planning and scheduling the many interrelated tasks in a large and complex project. PERT was developed in by US Navy in the 1950s'. Large projects require a series of activities, some of which are sequentially activities and others that can be performed in parallel with other activities. These series and parallel tasks can be modeled by PERT.

PERT planning involves the following steps:

1. Identify the specific activities and milestones.
2. Determine the proper sequence of the activities.
3. Construct a network diagram.
4. Estimate the time required for each activity.
5. Determine the critical path.
6. Update the PERT chart as the project progresses.

The project managers need to identify activities sequence with predecessor and successor tasks and determine dependencies within these activities. Constructing a network diagram can easy to change from the sequence of activities and times by software packages.

3.1 Estimating the time required for each activity

PERT belongs to the group of stochastic methods. Within this method, each activity is given three time estimates. They are Optimistic, Pessimistic and Most Likely Time.

Optimistic Time (**a**): the minimum time period in which the activity can be accomplished.

Most Likely Time (**m**): the best estimate of the time period in which the activity can be accomplished.

Pessimistic Time (**b**): the time required if everything went wrong, excluding major catastrophes. For a

In Beta Distribution, an estimate of expected duration is using the formula:

$$\mu = \frac{1}{6}(a + 4m + b)$$

It forms the basis for estimating the **expected duration** of each activity performance time.

3.2 Determining the Critical Path

In order to determine the whole project duration from the starting date to the end date and possible activity slack times, and to identify the activities in the critical path, the following values need to be determined for each activity:

- the earliest start time (*ES*)
- the earliest finish time (*EF*)
- the latest starting time (*LS*)
- the latest finishing time (*LF*)

3.2.1 Critical Path Algorithm

Three Steps to decide the critical path are:

Step1: Forward pass: Determine ES and EF for each task

Earliest occurrence of initial tasks, ES= 0;

Once ES is determined, EF=ES + Expected duration;

ES (for all task) = max {EF (for all tasks with its' predecessors)}

TE = max {EF (for all final tasks)};

Step2: Backward pass: Determine LS and LF for each task

Earliest occurrence of initial tasks, LF = TE;

Once LS is determined, LS = LF - Expected duration;

LF (for all task) = min {LS (for all tasks with its' successors)}

At least one initial task must have LS = 0, none may be negative.

Step3: Calculate the activity slack (AS) time

AS= LS - ES (or)

AS = LF - EF

A critical path is a path of activities from the START node to the FINISH node, with AS = 0

3.3 Calculating the Probability Factors

To help us measure the degree of uncertainty we turn to a term called **variance.** A large variance indicates great uncertainty; a small variance indicates a more accurate estimate. The symbol for variance is σ^2. To calculate the variance for each activity completion time, if three standard deviation times were selected for the optimistic and pessimistic times, then there are six standard deviations between them, so the variance is defined by:

$$\sigma^2 = \frac{1}{36}(b - a)^2$$

For estimating the probability of reaching this expected date values, we again turn to a relatively simple **two-step** statistical technique for computing a **probability factor using normal distribution**, i.e., the probability of meeting a scheduled date. With the whole duration (T_E) from PERT algorithm, the variance of the critical path duration is obtained by adding variances of activities on the critical path, which is assumed as normally distributed, we can compute the probability of completion of a project by a specific date (Ts) from the following steps:

Step1: Find Z value, where Z is known as standard normal distribution with mean and variance using the formula:

$$Z = \frac{T_S - T_E}{\sqrt{\sum \sigma_{T_E}^2}}$$

Step2: In the second step, the task is to convert the Z value into a probability value (**PR**) using normal distribution and get the probability of specified dates from the **Values of Table of the Standard Normal Distribution Function**.

3.4 PERT Cost System

The activity cost estimates are developed on a sound philosophical and working basis consistent with the manager's information needs. Presently activity cost estimates may take optimum time-cost curves used in conjunction with the Resource Allocation Procedure supplement. The intention of this approach is to optimize project time and costs by using optimum estimated activity costs. It assumes the existence of a direct relationship between time and costs for each network activity. This supplement method is also based on the concept that activities are subject to time-cost trade-offs. The Resource Allocation supplement method of cost estimation is described a series of procedures:

Step1: Construct network of activities in which you are interested.

Step2: Obtain alternative time-cost estimates for each activity.

Step3: Select the lowest cost activity for each activity.

Step4: Calculate critical path by the using of critical path algorithm and compare with directed completion date.

Step5: Adjust critical path to meet directed completion date at lowest possible costs.

The cost and time expenditures for each activity are estimated for only two conditions: normal and crash. The normal point is the minimum activity cost and corresponding time; whereas the crash point is the minimum time in which the activity can be performed and the related cost. As shown in Figure1, a linear function is assumed to exist between these two points.

With these normal and crash (times and costs) data, acceleration cost per day or week or month (slope_ m) can compute and calculated as:

$$m = \frac{\text{crash cost - normal cost}}{\text{normal time - crash time}}$$

These m values can select the lowest cost for each activity in the whole project. By decreasing one day or week or month of the critical activity, the slope value of this activity would be added to the total cost of the project. The costs of further reductions in completion times could be increased.

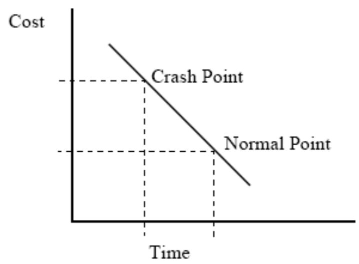

Figure 1. Linear Time-Cost Relationship

4. System Implementation

The implementation of the overall structure of system design is showed in Figure3.

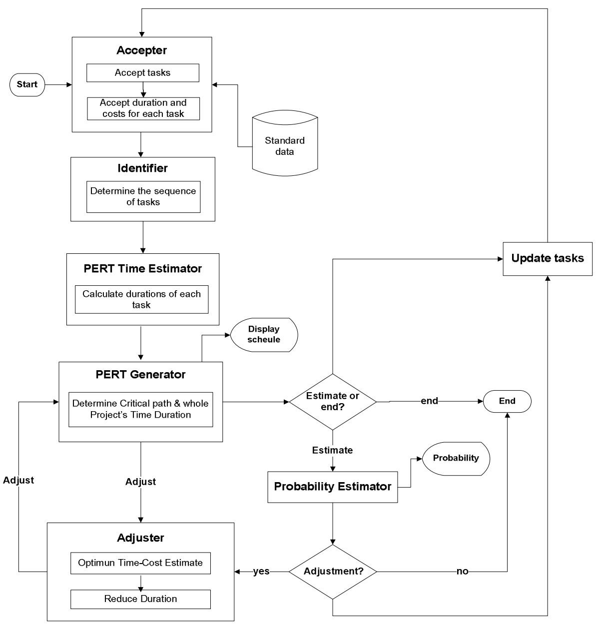

Figure 2. Data Flow Diagram

PERT system generates the critical path, critical activities and the expected duration of the whole project from the start node to the end node. Reducing the whole duration to user schedule date can change the activities' times and can increase the total costs. The original time schedule was resulted in Figure 3 by the using of the activities times and costs for the 10ft*22ft Reinforced Concrete Bridge Project. The whole project completion time was 46 days. The new time- schedule was showed in Figure 4 by the reducing of whole duration to 43 days. Tasks A, G and D were reduced one day from their activities' times. The total cost could be increased to (420500) Kyats.

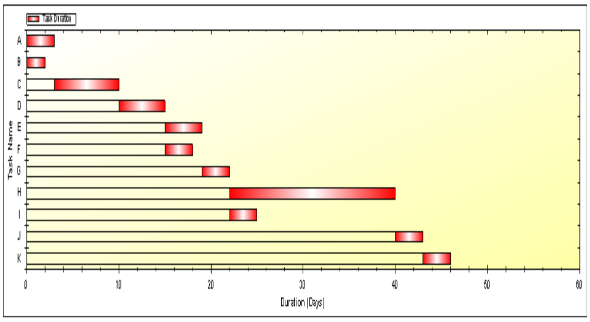

Figure 3. Original Time Schedule

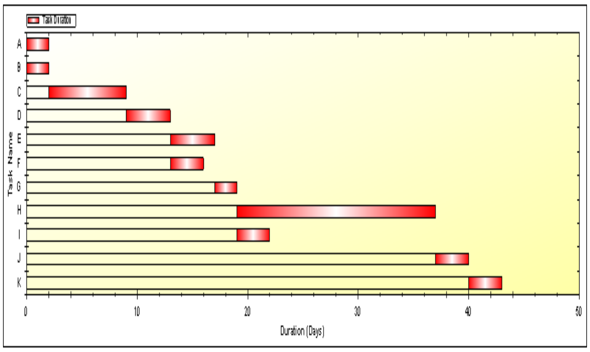

Figure 4. New Time Schedule

6. Conclusion

The estimates of the mean project duration and its total costs belong to the most important activities in managing a construction project. Their importance is especially prominent in project planning and contracting. In such situations a correct estimate of project duration and costs enables managers to minimize possible losses. It is developed to compute the distribution function of completion time for complex bridge construction project with a PERT network. The result will give expected time for each activities, critical path, critical tasks, expected whole duration, probabilities and time/cost background control. This model is implemented by using Microsoft ASP .Net (C#) and Microsoft SQL Server.

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