

Simulation Approach to Estimate the Activity's Expected Running time

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Abstract

Activity time is the elapsed time required for an activity. Estimating is an inexact art, so we expect that our initial duration estimates have some error in them. What we would really like to know is how much this error is going to affect our estimate of the total project duration. Fortunately, with a few assumptions and very little extra work we can make some judgments about the likely amount of variation in the total project time. Estimating activity times is probably one of the project Evaluation and Review Technique's (PERT) most critical features. The concept of three times estimating are used (Optimistic Time, Most Likely Time, and Pessimistic Time). However, the best estimate of the time period (Most Likely Time) in which the activity can be accomplished was provided by experience. In this paper we attempt to optimize the expected running time estimates and the most accurate estimates of the activity performance time using simulation. New method was proposed for this purpose and some details was explained about this method. The result show that the simulation is necessary to optimize time as well as it's flexibility.

الخلاصة

وقت الفعاليات هو الوقت المستغرق لانجاز الفعالية. تعد عملية التخمين عملية غير دقيقة، وقد تقود إلى أخطاء تؤثر على التخمين لفترة المشروع بصورة كاملة. تعد مسألة تخمين وقت الفعالية من الأمور الحرجة. ويتم استخدام مبدأ الأوقات الثلاث للتخمين (وقت التفاؤل، وقت الاغلبية، ووقت التشاؤم). على أية حال فان تخمين وقت الاغلبية يتم بواسطة التجربة. في هذا البحث نحاول الحصول على تخمين دقيق لوقت أداء الفعاليات باستخدام المحاكاة. تم اقتراح طريقة جديدة لهذا الغرض وتم توضيح تفاصيلها داخل البحث. وأوضحت النتائج إن استخدام المحاكاة ضروري للحصول على الوقت الأمثل بالإضافة إلى مرونتها.

1. Introduction

The Program (or Project) Evaluation and Review Technique, commonly abbreviated PERT, is a model for project management designed to analyze and represent the tasks involved in completing a given project. It is commonly used in conjunction with the shortest and critical path method or CPM. It is a method to analyze the involved tasks in completing a given project, especially the time needed to complete each task, and identifying the minimum time needed to complete the total project. Historically, PERT was developed primarily to simplify the planning and scheduling of large and complex projects. It was developed for the U.S. Navy Special Projects Office to support the U.S. Navy's Polaris nuclear submarine project, [Malcolm, D. G et al., 1959]. It was able to incorporate uncertainty by making it possible to schedule a project while not knowing precisely the details and durations of all the activities. It is more of an event-oriented technique rather than start- and completion-oriented, and is used more in projects where time, rather than cost, is the major factor. It is applied to very large-scale, one-time, complex, non-routine infrastructure and Research and Development projects [Winter Olympics official report, 2010]. This paper focuses on simulation to estimate the best activity performance time. Rest of the paper is organized as follows. section 2 present definition of PERT with some details. In section 3 our proposed method is described

in detail step by step . Section 4 demonstrated the experimental results. Finally conclusions are provided in section 5.

2. Definition of PERT

Like all new techniques, PERT is the subject of animated discussion in business management and industry fields, where the public service and its applications are a topical issue. Some people regard it as an ideal solution to all planning problems, and the remedy against inopportune decisions, while others are less categorical. These conflicting attitudes often arise out of a faulty definition of PERT.

PERT is an instrument of management designed to define and coordinate what has to be done to achieve the objective set within the time fixed. It is therefore a decision-making tool. The method integrates a considerable number of statistical data it brings out the uncertainties attached to the accomplishment of any specific task and shows, thanks to the technique of simulation, the possibilities of adjustments to meet the time requirements or to economize resources; it is based on strict mathematical principles, while not demanding from its users any particularly advanced scientific training. [Jacques Hallak,1970]

PERT is based on the theory of graphics it is expressed in graphic diagrams in the form of a network of arrows resulting from the analysis of a program. These diagrams support the elements used to establish the calculations. It follows from this definition that, in order to introduce the general principles on which the PERT method is based, it is necessary to consider (i) the program analysis phase and (ii) the phase of constructing the network. [Jacques Hallak,1970]

2.1 Program analysis

Analysis consists essentially in specifying the precise objectives of the program and breaking them down into successive stages, increasingly detailed, until the breakdown shows all the phases of advancement. The task therefore is to define a general objective of the program and subdivide it into partial objectives or successive phases of advancement.

In brief, program analysis means answering the following questions:

- (i) What is the objective and what is the starting point towards achieving it?
- (ii) What are the major intermediate events to be achieved in order to carry out the program?
- (iii) What activities are necessary to achieve these events?

Analysis therefore helps to define the key points of the program, that is to say, its origin, its objective, its events and the activities to be carried out. [Jacques Hallak,1970].

2.2 The construction of the network

As we have seen, PERT is based on a network of arrows prepared by using the results of the analysis. The principle of constructing a network is very simple, It uses the properties of vectors. It may be recalled that a vector is a segment of a continuous line having a beginning, an end, a direction and a value (often measured by the length of the vector). In the PERT method, the vector represents an activity, its beginning the predecessor event, its end the successor event and its value both time and cost. [Jacques Hallak,1970]

2.3 Estimates the Activity Performance Time

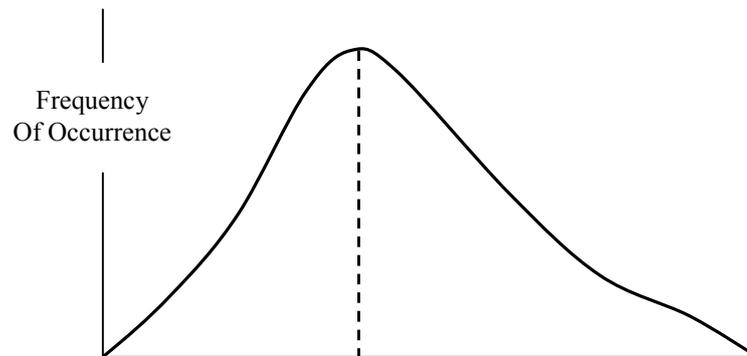
One of the PERT planning steps is estimate the time required for each activity. In our paper we used this step to Estimate activity times . Activity time is the elapsed time required for an activity. It's probably one of PERT's most critical features. All

three times estimates assume a static level of resource use. [John W. Chinneck, 2009] [Miller, Robert W, 1963]

The estimates should be as good as possible because PERT results depend directly on them. The most familiar with the operation and requirements of each activity should submit the three time estimates. These should meet the following criteria:

1. Optimistic Time -- the minimum time period in which the activity can be accomplished, i.e., the time it would take to complete if everything proceeded better than expected, (labeled a) .
2. Most Likely Time -- the best estimate of the time period (having the highest probability) in which the activity can be accomplished, i.e., the estimate submitted if one (only) had been requested , (labeled m) .
3. Pessimistic Time -- the maximum time period it would take to accomplish the activity, i.e., the time required if everything went wrong, excluding major catastrophes, (labeled b) .

It is acceptable to state these estimates in days, weeks, or months as long as the measure is used consistently. Once made, activity time estimates are firm and should not be changed without a change in the nature and scope of the activity or in the level of resources allocated to it. The following time relationships must be adhered to: $a \leq m \leq b$. When an estimator makes three time estimates for performing an activity, he/she implies the existence of a distribution of possible activity times which may approximate that shown in Figure (1) , where (a) is the optimistic time, (m) the most likely time and (b) is the pessimistic time, and (t_e) for each distribution, the statistical mean or average value of the three time estimates. More simply, t_e is defined as the average time an activity would require when it repeated many times. [John W. Chinneck, 2009] [Miller, Robert W, 1963] [Richard J. Hopeman,1965]



The relative values (positions) of a, m, and b on each distribution, of course, depends on the estimator's judgment and calculations. Once established, their relative positions on the distribution affect the value or the position of t_e . In fact, once the numerical values of a, m, and b are known, it is relatively easy to determine t_e .

The expected time for each activity can be approximated using the following weighted average Formula: [John W. Chinneck, 2009] [Miller, Robert W, 1963] [Richard J. Hopeman,1965]

$$Expected\ time = (Optimistic + 4 * Most\ likely + Pessimistic) / 6 \quad \dots\dots (1)$$

$$The\ variance\ of\ each\ activity\ duration\ in\ this\ model\ is\ [(b-a)/6]. \quad \dots\dots (2)$$

2.4 Advantages of PERT

PERT is useful because it provides the following information: [Miller, Robert W, 1963]

1. Expected project completion time .

2. Probability of completion before a specified date .
3. The critical path activities that directly impact the completion time .
4. The activities that have slack time and that can be lend resources to critical path activities .
5. Activity start and end date.

Nowadays PERT techniques are routinely used in any large project such as software development, building construction, etc. Supporting software such as Microsoft Project, among others, is readily available. It may seem odd that PERT appears in a book on optimization, but it is frequently necessary to optimize time and resource constrained systems, and the basic ideas of PERT help to organize such an optimization. [John W. Chinneck, 2009]

3. Proposed method to estimate the expected running time

After finding out the minimum running time and the maximum running time the min running time is regarded as the optimistic time (labeled a), while max running time is the pessimistic running time (labeled b) and find the most likely running time (labeled m). We then use probabilistic PERT equation for the activity time estimates (equation 1) which fit to beta distribution to calculate the expected running time, the equation is : $Expected\ running\ time\ (t_e) = (a + 4*m + b) / 6$
 To take the train acceleration and deceleration in our account we add 7% of Expected running time to the Expected running time. If stop time in source and destination stations for any segment is zero we don't need add this value The details of proposed method was described in the following developed algorithm.

Algorithm (1) Expected Running time with beta distribution

Inputs: Optimistic Time (Minimum Running time) (labeled a) , Pessimistic Time (Maximum running time)(labeled b), Stop time (Dwell time) (St)

Output: Expected running time (labeled te).

Begin Of Algorithm

- Call most likely running time (m) procedure

$$m = \text{most_likely_time}(a, b) .$$

-Find the value of Expected running time .

$$t_e = (a + 4*m + b)/6 .$$

- Add 0.07 Of value of running time to running time

If St for source and destination stations $\neq 0$ then

$$t_e = t_e + 0.07 * t_e$$

else

If St for source OR destination stations $\neq 0$ then

$$t_e = t_e + 0.035 * t_e$$

End if

End if

End Of Algorithm

3.1 Proposed Method to Predict Most Likely Value

To find out this value, we have used the idea of simulation by generating a number of random figures(R) by using RND() function which generates random numbers that are uniformly between (1 and 0), then the use of the random varieties equation ($X=a+(b-a)*r$) to generate random varieties followed by finding out the most frequent value (mode) and regarding it as the most likely. The details of proposed method was described in the following developed algorithm.

Algorithm (2) Most Likely Value

Inputs: Optimistic Time (labeled a) , Pessimistic Time (labeled b).

Output: Most Likely Value (labeled m).

Begin Of Algorithm

-Divide the interval [a,b] to n subintervals(such as n=10) and .

- Set Counter K=1.

-While termination criterion not reached (such as $k \leq 10000$)

Begin While

-Generate random number (R) in this interval [0-1] by Rnd() function .

-Find the value of random varieties that uniformly distributed .

$$X = a + (b-a)*R$$

-Increment the counter of subinterval that X belongs to it .

(Each subinterval has Counter and when we found X in the range of an subinterval then we increment the subinterval's counter)

End While

-Find most frequently interval .

-Find average of this interval, consider it (m).

End Of Algorithm

4. Experimental Results

The proposed method used in railway optimization , we use it to find the expected running time. After finding out the minimum running time (labeled a) and the maximum running time (labeled b). Usually the minimum and maximum running times were given by the designers depending on the specifications, while the most likely times required to be estimated .The min running time is regarded as the optimistic time, while max running time is the pessimistic running time and most likely running time which is estimated by using our suggested method regarded as m . We then use equation (1) which fit to beta distribution to calculate the expected running time, the equation is :

$$\text{Expected running time} = (a + 4m + b) / 6$$

Our case study is Baghdad – Karbala railway line, this line is one of the Iraqi future planned internal railway lines network .Figure (2) shows the Baghdad-Karbala line route and Table (1) shows the minimum, maximum, most likely and expected running times for each track segment in our case study line .

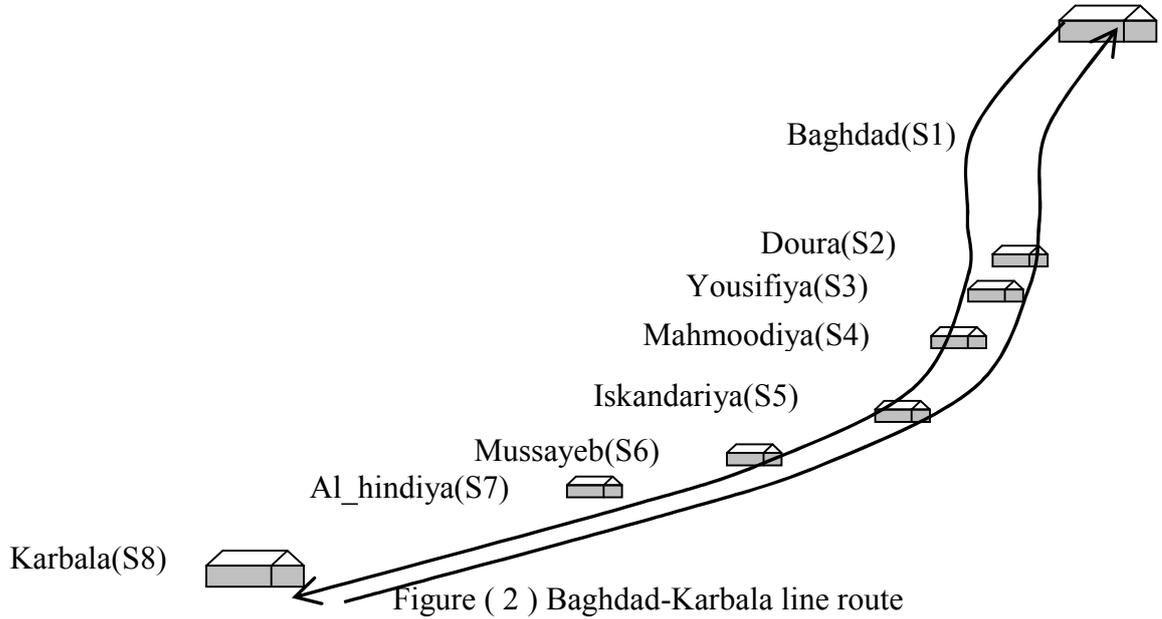


Table (1) Running times for Baghdad – karbala railway line's track

Track Segment	Minimum running time(in min.)	Maximum running time(in min.)	Most likely running time(in min.)	Expected running time(in min.)
S1 --- S2	10.2	14.571	11.77	13.375
S2 --- S3	7.8	11.142	8.98	10.224
S3 --- S4	6.6	9.42	8.77	8.841
S4 --- S5	10.8	15.42	11.03	13.918
S5 --- S6	8.4	12	8.58	10.83
S6 --- S7	5.2	6.5	6.10	6.216
S7 --- S8	7.6	9.5	8.09	8.948

5. Conclusions

New method to predict most likely value was proposed.

In all the available studies the value of the most likely (m) was given as a number, in our study we suggested simulation method to predict it's value in an optimization manner depending on minimum and maximum running times.

The other and good contributions is how to use PERT to build the time tables in railway lines in Iraq.

References

- Malcolm, D. G., J. H. Roseboom, C. E. Clark, W. Fazar (1959) "Application of a Technique for Research and Development Program Evaluation", OPERATIONS RESEARCH Vol. 7, No. 5 .
- Miller, Robert W. (1963) "Schedule, Cost, and Profit Control With PERT: A Comprehensive Guide for Program Management". New York: McGraw-Hill Book Co.
- Jacques Hallak (1970) " PROGRAMME EVALUATION AND REVIEW TECHNIQUE (An initiation to PERT-TIME)", International Institute for Educational Planning ,Paris .
- John W. Chinneck (2009) "Practical Optimization: a Gentle Introduction", Systems and Computer Engineering, Carleton University.
- Richard J. Hopeman.(1965) "The Use of PERT for Planning and Control." Northwest Business Management.
- Winter Olympics official report (1968) p. 49. Accessed 1 November 2010. (English) & (French) .