UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PROJECT MANAGEMENT: A SIMULATION APPROACH

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Management) with Honours.

by

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……

(Associate Professor Dr. Mohamed Khaled bin Omar)

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ABSTRACT

Project schedule development with CPM (Critical Path Method) or PERT (Program Evaluation and Review Technique) are the two most common project scheduling tools being used by project management practitioners. The development of computer in the mid-1980s encouraged the use of project management by making CPM/PERT easily available as part of integrated software packages. CPM/PERT is not without problem. The deterministic nature of CPM model does not account for uncertainty. Although PERT is able to deal with uncertainty in activity times by using the three point estimate, but the estimate of activity times are somewhat subjective and rely solely on judgment. On the other hand, simulation is a powerful approach for investigation some scenarios that a management may take, unfortunately, it is not widely used yet in project management. Thus, this research is to investigate how simulation can be used to enhance management decisions associated with activities time duration and the estimation of the probability that an activity is in fact a critical activity that deserves the project management practitioner's attention. It defines the related advantages and disadvantages, found in the literature and will be illustrated through a real life complex project.

ABSTRAK

Pembangunan jadual projek dengan menggunakan “CPM” (Critical Path Method) atau PERT (Program Evaluation and Review Technique) adalah dua alat penjadualan projek yang paling umum digunakan oleh pengamal pengurusan projek. Perkembangan komputer pada pertengahan 1980-an telah menggalakkan penggunaan pengurusan projek dengan membuat “CPM/PERT” mudah didapati sebagai sebahagian daripada pakej perisian bersepadu. “CPM/PERT” bukanlah tanpa masalah. Sifat deterministik model “CPM” tidak mempertimbangkan ketidakpastian. Meskipun “PERT” mampu menghadapi ketidakpastian dalam masa aktiviti dengan menggunakan anggaran tiga titik, tapi anggaran masa aktiviti kali ini agak subjektif dan hanya bergantung kepada penilaian. Akan tetapi, simulasi adalah pendekatan yang kuat untuk penyiasatan sesetengah senario oleh pihak pengurusa, malangnya, simulasi tidak banyak digunakan dalam pengurusan projek. Oleh itu, kajian ini adalah untuk menyiasat bagaimana simulasi boleh digunakan untuk meningkatkan keputusan pengurusan berkaitan dengan masa aktiviti dan anggaran kebarangkalian bahawa suatu aktiviti pada kenyataannya merupakan aktiviti penting yang patut pengamal pengurusan projek patut beri perhatian. Ini dapat menerangkan kelebihan dan kelemahan, yang dijumpai dalam sastera dan akan digambarkan melalui suatu projek kehidupan nyata yang kompleks.

DEDICATION

This research is dedicated to someone I value more than anything else.

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LIST OF ABBREVIATIONS

CPM	-	Critical Path Method
MCS	-	Monte Carlo Simulation
PERT	-	Program Evaluation and Review Technique
R&D	-	Research and Development
USA	-	United States of America

CHAPTER 1
INTRODUCTION

This chapter will first address project management and then simulation since together they represent the theme of the project. The problem statements, objective and scope of the research will be based on the theme derived from both project management and simulation.

1.1 Overview

Project management could be defined as managing resources to achieve the project objectives within a specific time frame, cost and performance. On the hand, simulation comprises of “any technique of statistical sampling used to approximate solutions that imitating the real life system in this case the author is referring to project network time.

1.1.1 Background of Project Management

There is a broad category of Operations Management problems having to do with the management of *project type* operations. Such operations are typically illustrated by the example of some large-scale, one-time activity such as the design and production of a new prototype machine, the construction of a new facility, or the design and manufacturing of a new system to serve a specific or general propose. Project-type activities are in and of themselves nothing new; indeed, they represent one of the oldest types of production activities known to man. However, it is comparatively very recently that this type of activity has been recognized as an operation

management problem of great significant. This recognition came about primarily as a result of post-war II emphasis in the USA on the design and production of very large-scale system in the aerospace industry. Such system typically involved the development and manufacturing of extremely complicated and expensive products in relatively small numbers. Because of the enormous costs involved in these development programs and the national importance assigned them, entirely new management procedures were needed for their effective control. Such procedures were developed around 1958; since then they have been applied to an amazingly wide variety of activities including building and road construction, equipment management, and machinery manufacture and maintenance, research and development management, health-care activities (even to the planning of surgical operations), marketing and financial-area program management, and other types of activity to numerous to list.

1.1.1.1 Characteristics of Project Planning/Scheduling Problems

The special characteristics of this type of problems arise both from (1) the typical complexity of the activity undertaken, wherein customer design and performance of multiplicity of tasks on a non-repetitive nature maybe involved, and (2) the fact that "projects" typically have a specific beginning and end point. In such situations the planning of sequence of processes required becomes of extreme importance since operations performed not in proper sequence can lead to extra costs and delays in overall project. One can note, compared with the set of all modern production management techniques, the development of the production plan in advanced of actual project execution, in the form of a network of required operations, probably yields the greatest net improvement over older traditional management methods simply because the operation of the plan in network from requires planning, questioning , and preparing. What operations are required? How long will they take? How will they be performed? What equipment is required? What kind of labor skills? Which operations can go on simultaneously? If management can produce answers to such questions, it has the basic information required to perform the project activities effectively.

Another often-fond characteristic of project management problems is the focus on resource scheduling. The development of project plan in the form of network operations indicates the particular sequence and timing of activities required to complete the project in minimum time usually called “critical path schedule”. This plan show which operations can be delayed somewhat without delaying the overall project and, perhaps more importantly, it can show the pattern over time of the resource levels needed to achieve the indicated plan. Since the amounts of individual resource are typically limited in quantities, the question of most effective resource utilization is extreme importance. This focus of resource management is one which continues during project execution, and because of the typically large number of activities going on simultaneously the associated information flow and control problem is also complex. As a result, another characteristic of project planning/ scheduling activities is the utilization of computer-based system-both for developing the schedule operations in advance and for developing updated schedules and providing important information for management control during project execution.

1.1.1.2 Network Based Planning/Scheduling Techniques

In general, large scale projects are complex and involve large number of components activities that must be timed-phased according to specific precedence requirements, and details considerable financial efforts. The main concern in managing such project is how to schedule the components activities in order to achieve a certain goal: to complete the project by a specified deadline, or minimize the cost of meeting the target date, or to minimize the total project completion time.

The classes of techniques used for analyzing, planning, and scheduling large-scale projects have an important feature in common: all of them are based on representation of the project as a network of activities. Therefore, they are often referred to as network analysis, network planning, and network planning and scheduling. The most widely used names, however, are the acronyms PERT and CPM, which stand for two techniques that evolved in the late 1990’s.

PERT (Program Evaluation and Review Technique) was developed in 1957-1958 by research team set up by the Navy Special Project Office, the Booz Allen, and Hamilton consulting firm, and the Missiles System Division of Lockheed Aircraft companying order to efficiently plan and produce the Polaris missile system. On the other hand, CPM (Critical Path Method) is a development independent of PERT. It was the result of a joint effort of the DuPont Company and Remington Rand Univac Division, originally aimed at a better planning in controlling the overhaul and maintenance of chemical plants. The project was started in 1957 and the CPM method was released in 1959.

From the point of view of the network representation and activity scheduling, there is no essential difference between PERT and CPM. This is why today, more often than not, the two names are used interchangeably. However, as originally developed, they bore the mark of environments from which they stemmed.

Thus, as outgrowth of an R&D undertaking, PERT had to cope with uncertainties that accompany R&D activities. Hence, the PERT regards the total project duration as a random variable, and performs probabilistic calculations in order to characterize it. CPM was developed in the context of a project which consisted, in general, of routine operations whose durations were more or less well established. Therefore, CPM is basically deterministic. But a major concern of the originators of CPM was to reduce the total time during which the facility had to be shut down for overhaul, because plant downtime meant lost production capacity. Starting from the idea that some activities may be shortened if additional resources were allocated to them, CPM was associated with a time-cost tradeoff feature by which an optimal balance was sought between the duration and the cost of the project.

1.1.2 Simulation

Simulation is an analytical method that imitating or mimics a real-life system. It can either be a static simulation which imitating a system without involving the passage of time or dynamic simulation which is imitating a real-life system as it progress

with time. Simulation can also be divided into physical simulation or a computer based simulation. In this thesis, the term simulation is referring to the dynamic simulation by using computer software. In other word, simulation in this thesis is defined as a computer based simulation imitating a system as it progress through time. Simulation model can be classified into continuous model and discrete model. In a continuous model, the status of some components in the system is continuously changing with respect to time; an example would be the level of water flowing out from a tank which is changing continuously over time. Contradictory, in discrete model, change occurs only at separated points in time. Between the points, the system did not change with respect to the number of entities in the system. However, it is possible to have both of these elements in a combined system which is known as mixed continuous-discrete system.

Simulation is a crucial problem-solving methodology for the solution to problems especially when other analyses are too mathematically complex or too difficult to reproduce. It can be used to describe and analyze the behavior of a system, testing different scenarios that might occur in the system without interrupting or disturbing the actual system. In addition, simulation also allows experimentation in compressed time, reducing the analytic requirements needed by the practitioner, and reducing the cost involved. However, simulation has its drawback which it cannot give accurate result if the input data are inaccurate. Therefore, more time should be used on the planning and the understanding of the system rather than the programming of the simulation code. Besides, simulation by itself does not provide the optimal solution in solving problems. It is actually providing all the possible and potential solutions to the practitioner and it is up to the practitioner on what to be done or change in the actual system.

1.2 Problem Statement

PERT/CPM has been a common tool in solving the project scheduling problems. Although PERT and CPM were often treated as the same, but it is wrong to have that perception. The distinctive characteristic of both PERT and CPM were that CPM is used when the activity durations are deterministic while PERT is used when the

activity durations are probabilistic. CPM was developed for projects that are routine with minimal uncertainty in the project completion times. For projects that are less routine with more uncertainty inherent in the activity times, the usefulness of the deterministic CPM model is somehow limited. Although PERT is able to deal with uncertainty in activity times by using the three point estimate (optimistic time, most likely time and pessimistic time), the estimate of activity times are somewhat subjective and rely solely on judgment. Therefore, to address these issues on deterministic nature of CPM and subjective three point estimate on PERT, a simulation modeling is introduced to solve the problem mentioned.

1.3 Research Objectives

The ultimate objective of this research work is to achieve the following goals**:**

1. To fully understand the theoretical background of CPM and PERT and their strength and weakness reported in the literature.
2. To fully understand the concept of Monte Carlo approach.
3. To use MS project to develop the network of a real-life complex project.
4. To develop a Monte Carlo Simulation (MCS) model to study the results that have been developed by the MS project in terms of total completion time and determination of the critical activities.
5. Report the findings of this research.

1.4 Research scope

The scope of this project is to answer the following research questions:

1 How accurate/reliable the estimate produced by Ms Project in terms of project completion time?

2 Is there a probability for an activity which is not in the critical path becoming a critical activity and thus changed the original critical path?

3 Can Monte Carlo Simulation approach provides a solution to the problem posed in question one and two above?

1.5 Organization of Report

The author's report will adhere to the following organization structure: Chapter 1 consists of the section Introduction above. It will give a brief overview of what the project is about which includes the problem statements, objectives of the research, and the scope to be covered.

Chapter 2, which is the Literature Review, will contain the definitions and concepts of Project Management, the review of Project Management software and finally a section on literature that describe the prior researches on application of simulation in Project Management.

Chapter 3 explains the research methodology undertaken by the author. It includes the research method used by the author and a research methodology chart is depicted as well.

Chapter 4 will explain the problem description and simulation assumptions of the project. The problem scenarios will be formed in this section.

Chapter 5 will report the findings obtained from the comprehensive simulation study on the project scheduling. The results were reported and discussed in the scenarios formed.

Chapter 6 will be a concluding section for the whole project undertaken by the author.

CHAPTER 2
LITERATURE REVIEW

This chapter is undertaken to carry out a comprehensive literature review with the available resources from the published journals, books, and online database. The author reviews the definition and concepts of project management and related scheduling tools in the beginning of the chapter. This is followed by the review of available project management software in the market. The core section of the literature review here will basically discuss and summarize prior researches done with respect to the title undertaken.

2.1 Project Management

A simple definition for project is any activity having a distinctive one-off objective, specific start and finish date, and a limited resource budget. It is quite different between managing a project and managing an organization as projects make specific things happen at particular times while management, in the traditional sense, has more to do with directing and controlling repeated on going activities. Thus, project management can be defined as planning, organizing, directing and controlling resources to meet a certain, one-time objective by a specific date and within a finite budget (Taha, 1992).

Project management has three principle phases: Planning (including Creation & Scheduling), On-going management (Controlling), and Reporting (Tatnall and Shackleton, 1992). In the first phase, the main aim is to build a chart illustrating start and finish times and the activities relationship. Creation of project includes defining goals and tasks for the project. Scheduling, on the other hand, involves time and

resource scheduling which are estimating duration and assigning resources to each task respectively. In the second phase, on-going management, commences once a project starts. It comprises of monitoring and controlling the progress of each task. For instance, whenever each task is done, information of its actual start and finish times and costs are entered, consequently, the relevant charts are updated, allowing the project manager to reallocate the resources accordingly. In addition, as project progress dynamically, any delays or resource limitations should be resolved quickly by identifying proper course of action to prevent the project from out of control. In the third phase of project management, reporting is to explain and justify the progress of the project. This is normally aided by generating suitable reports to be reviewed by management.

This research only involves the planning phase of project management which is scheduling. Thus, in the succeeding section, the author will review the two commonly used scheduling techniques – CPM and PERT.

2.1.1 Critical Path Method

CPM is one of the project management tools that is most useful in the practice of project management and are applied in managing complex projects. CPM models the activities and events of a project as a network. The time required to complete each activity in the network is estimated through prior experience by project manager. CPM is a deterministic model that ignores variation in the completion time, so only one number is being defined for the activity's time estimate.

The primary goal of a CPM analysis of a project is the determination of the critical path, which determines the minimum completion time of a project. The critical path is known as the longest duration path through the network. The importance of the critical path is that any delay occur in any of the activities lie on it will delay the entire project. Due to its impact on the entire project, critical path analysis is an important aspect of project planning. The critical path can be identified by determining the following four parameters for each activity (Gray and Larson, 2008):