Sequential Decisions Under Uncertainty in the R&D Project Selection Problem

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Abstract— **In most cases, the R&D project selection problem is concerned with how to evaluate and identify the best subset of projects under some resource constraints. In this paper, we consider the sequential decision problem of optimally sequencing a set of projects which must be undertaken sequentially over time. We derive the optimal ordering strategy for two special cases, 1) a series system of tasks in which the selection process is terminated as soon as one of the tasks is failed and 2) a parallel system of alternatives in which the selection process continues until any of the alternatives is completed successfully. We further consider the precedence restriction in a series system of tasks which specifies that, for some technological or budgetary constraints, a certain task must be undertaken before another. In a parallel system of alternatives, we also investigate the availability condition under which a certain alternative will not be available if not selected within a certain period of time.**

I. Introduction

SINCE the late 1950's and early 1960's, numerous mathematical models intended for use in selecting the R&D projects have been proposed. These include a ranking procedure, scoring or rating methods, decision analysis, and optimization methods such as linear programming, integer programming, dynamic programming, goal programming, multiobjective methods, Analytic Hierarchy Process (AHP), and so forth. Excellent survey and review papers on the R&D project selection problem can be found in Weber, Werners, and Zimmermann [33], Steele [30], Souder and Mandakovic [29], Booker and Bryson [6], Liberatore and Titus [21], Winkofsky, Mason, and Souder [35], and Atkinson and Bobis [3].

Most of the works in the R&D project selection are focused on evaluating and identifying the best *subset* of projects among several proposed ones under some resource constraints. In some cases, however, the *sequence* of performing a set of tasks must be determined if only one task can be undertaken at a time. Consider, for example, a R&D project which is composed of several tasks as shown in Fig. 1(a). The tasks are performed sequentially over time and, to complete the R&D project successfully, each of the tasks must be completed successfully one at a time. If any of the tasks is unsuccessful, no remaining tasks need to be initiated and the R&D project is considered a failure. Such a sequential selection problem is called as a *series system of tasks*. Intuitively, performing a high-risk, low-cost task first might be an optimal strategy to minimize the expected total cost.

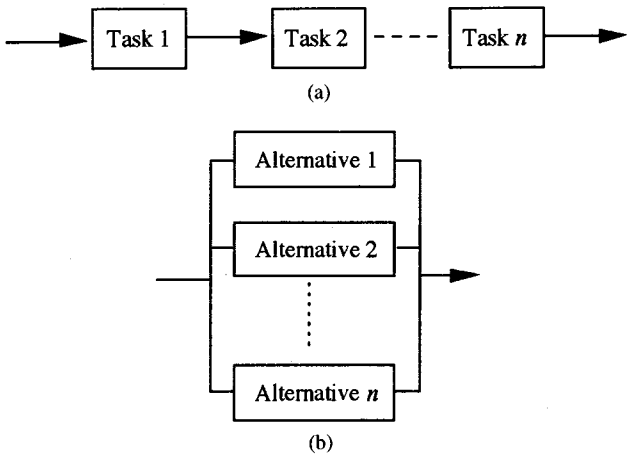

Fig. 1. The series and the parallel system. (a) A series system of n tasks. (b) A parallel system of n alternatives.

Consider another example shown in Fig. 1(b), in which several different alternative methods are available for selection in completing a R&D project (Abernathy and Rosenbroom [1]). If an alternative fails when attempted, another will be undertaken. The decision process continues until one of the alternatives is completed successfully. Such a sequential decision problem is considered as a *parallel system of alternatives*. In such a case, a low-risk, low-cost alternative must be undertaken first to minimize the expected total cost.

In this paper, we discuss the R&D project selection problem which involves the sequential decisions over time, assuming that only one task or alternative can be undertaken at a time. Such a sequential decision problem is different from most existing R&D project selection models in a sense that, in the sequential decision problem considered, we are concerned with determining the optimal *sequence* of tasks or alternatives, rather than selecting the best *subset* of projects as in most existing R&D project selection models.

The sequential selection problems considered in this paper are special cases of the k-out-of-n type system, in which a system is functioning if any k out of n sub-systems are functioning (Ben-Dov [5]). The R&D project selection problem involving several tasks as in the first example is regarded as a *series* system where k is n, while the second example with several alternatives is considered as a *parallel* system where k is 1. In particular, we consider in this paper the optimal

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