4. Planning under Precedence/Duration Constraints: Networking Techniques

The networking techniques we will present in this chapter — CPM, PERT and GERT — allow us to manage essential planning problems: scheduling, cost planning and resource allocation. Also, sticking to disciplined planning is natural and easy, since the representation languages used are variants of activity networks.

CPM (Critical Path Method) was developed at the end of the fifties by Walker of the DuPont Company and Kelley of the Univac Division of Remington Rand Corporation as a tool for programming maintenance activities in DuPont industrial plants.

PERT (Program Evaluation and Review Technique) was developed independently during the same years at the U. S. Navy's Special Projects Office. It grew from planning and scheduling the realization of the Polaris missile. CPM and PERT are rather similar techniques, so that they are often referred to with the common name of CPM-PERT. But we will see that there are good reasons for introducing them separately.

GERT (Graphical Evaluation and Review Technique) was first introduced by Pritsker, in the middle sixties, for planning and analyzing terminal count-down of an Apollo space system.
4. Networking Techniques

4.1 No Choices, No Cycles, Known Durations: CPM

The Critical Path Method offers a technique for the design and control of projects requiring development of large and complex plans.

Activities take place over time, and require resources as they progress. Large projects will hardly meet their objectives without careful planning of times, costs and resources. The CPM method helps whenever project plans can be assumed to be free of choices and cycles, and when the planner is able to estimate the duration of activities.

CPM has found wide acceptance in business and administration environments for the simplicity of its graphical representation language and the direct applicability of its outcome.

The Critical Path Method only applies to plans that are free of choices and cycles because it is based on the activity network representation of plans.

The project is subdivided into a finite set \( S \) of non-overlapping, partially ordered subprojects to be considered primitives within a first project specification. These subprojects will often require further specification. If so, we will call them macro-activities, else activities.

On the basis of \( S \), a project specification, and hence a project plan — or a set of project plans — is worked out. This plan will be expressed in terms of macro-activities and activities, and will mirror the partial ordering of \( S \). In this chapter, we shall only consider plans with no macro-activities.

CPM requires that the considered project plan is represented as an activity network \( N = (E, A, d) \) such that the elements of \( A \) represent the elements of \( S \) — that is, the initial subprojects. We shall apply the denomination activity both to the elements of \( S \) and of \( A \). The partial ordering among the planned activities will give the precedence relation of the network.

Not every partial ordering of activities can be directly expressed by means of an activity network. Sometimes, dummy activities will be necessary in order to represent the plan activity ordering fully.

CPM requires that duration of planned activities to be estimated by means of a real number. This number will give the value of function \( d \) for the activity.