# CPM/PERT

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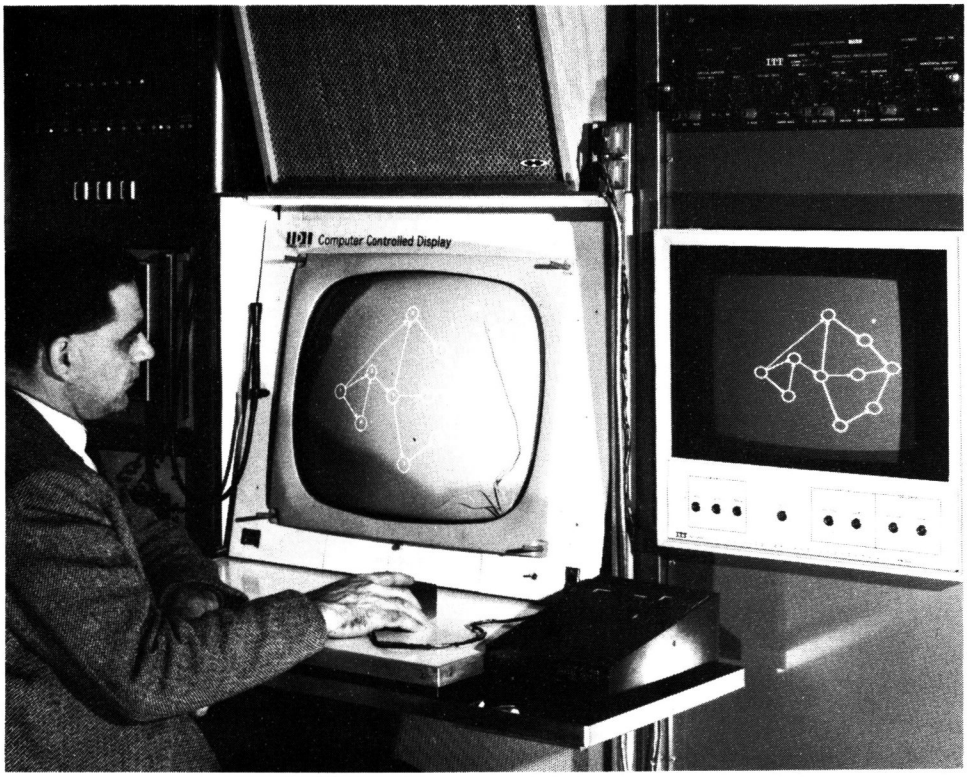


This paper describes a study of the application of interactive computer graphics techniques to the field of planning with CPM and PERT methods. The computer-controlled cathode ray tube display is a convenient communication medium between the planner and the computer; especially since the planner normally uses a graphical representation of the project being planned or controlled.

The study has proceeded in two phases. The first phase involved implementing a system for network drawing, critical path calculations, and a limited ability to handle resources and cost information on a medium size, dedicated computer, a SEL 840A, with a conventional refreshed display. The second phase is now in progress and is being done on a time sharing system with a remote display. The computer is a 360/67 operating under TSS and the terminal is a Tektronix T-4002 storage tube display unit.

The two implementation methods are very different in their capabilities and each has a number of advantages and disadvantages, some foreseen and some not, which have become apparent during the work.

Network planning is an obvious choice for the application of interactive graphics because the work is conceived and communicated to others in graphical terms and because the field of applications is very wide. CPM is normally associated with construction and industrial maintenance and PERT with large defense projects but the techniques have been applied in many other areas: academic program planning, resources systems analysis, informations systems, sociological studies, social and welfare programs are examples.

There are three phases normally associated with these methods: planning, resource allocation, and control. Not all phases are always applied, but all require decisions which are difficult to program on the machine. The planner must make the decisions in problem definition, investigation of alternatives, and network updating or revision based on real performance. Hence, the justification for operation in an interactive mode with a machine capable of remembering the rules and doing a large bookkeeping chore.

The programs written for the SEL 840A computer allowed network construction and modification primarily within the limits of the planning phase. Limits on the size of network and the number of resources associated with a task (activity) were imposed by the amount of available memory and the simple data structure chosen. Much of the use assessment is based on the experience with one example. The main conclusions are briefly summarized as follows:

1. The large number of lines and alphanumerics required for network planning can impose severe demands on a conventional, refreshed display.

2. Off-line preparation of data for large networks is probably desirable but data input at the graphics console allows reaction by the machine in response to problem syntax errors.

3. Several control devices may be active without causing undue confusion provided they are used consistently.

4. Data for network planning problems can easily exceed the memory capacity of a medium size dedicated computer unless segmentation of the project is done, e.g., by using fragnets.

5. Only a portion of a network can be displayed at one time. The ability to change the area displayed (the window on the overall plan) continuously and to change it rapidly by large displacements is very desirable and is an advantage of a conventional display operated from a dedicated computer.

A graphics console operating as a terminal connected to a large time-shared computer via a low data rate communications link is a very different environment from that provided by a dedicated machine. The first step has been made using a terminal with a direct-view storage tube (DVST) and with no processing assistance local to the terminal. The advantages of a DVST are:

1. A flicker-free picture with nearly unlimited capacity to display alphanumeric and vector data.

2. While the DVST is not really portable, it is partly so and the system allows access to the same information at any location with telephone service.

3. The display routines need not be as efficient nor the electronics as fast.

4. A very large data storage capacity is available in the time-shared computer system.

5. Equipment costs are lower.

Disadvantages of the DVST include:

1. With a low data rate, picture generation is slow.

2. The ability to select and identify a part of a displayed picture is limited. There is no selective erase. Selection and identification with a conventional display are easier. Refreshing a selected portion less often to cause blinking provides a simple, effective identification method not possible on a DVST.

3. The light output from a DVST is low; it is necessary to darken the room near the terminal.

First experience in using the DVST has been good although the waiting periods between input/output time slices can be much more tedious than the effect of the low data rate itself (10 characters per second). Very little programming for network analysis specifically has been done to the present time as emphasis is being placed on the generation of service routines for terminal input/output and file handling which can be used in common by general drawing, data display, and flow-charting programs and others of a similar nature. The plotting facilities associated with the 360/67 installation will be used for hand copy.

The operation of a mini-computer with the DVST is being considered as a means of achieving faster response. This machine should have a capacity to allow local generation and modification of all the data for a picture frame and the ability to exchange data with the large computer under computer as well as keyboard control.

Other, and perhaps more economical and useful methods of implementing graphics and interactive assistance to the planner are becoming attractive. Lower cost secondary memory devices such as fixed-head disc units and cassette tape recorders may place small dedicated processors in a more competitive position for tasks now done on large machines.

In conclusion, the advantages of interactive graphics for network planning include:

1. Excellent problem visibility

2. Step-by-step control of problem solution

3. Ease of making modifications

4. Communication among planners and between the user and machine is in the same form - the network itself

5. Ease of use and little learning time required

6. Knowledge of programming of data formatting is not necessary.