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Reallocating Resources in Systems Development Projects

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Abstract

Systems development projects are time constrained. Project managers use a variety of tools to track project development, including traditional PERT/CPM charts and Gantt charts, to insure timely delivery of program code. Resource reallocation between project activities, through the identification of slack resources, is a common solution when faced with project delays or demands for earlier-than-expected delivery dates. This paper describes a network analysis methodology for reallocating resources along the critical path of a project that offers benefits not available through PERT/CPM analysis.

Keywords: PERT/CPM, Gantt charts, project resource reallocation

Introduction

Completing a systems development project before its scheduled delivery date requires that existing resources be reallocated or additional resources be expended (e.g., hiring more programmers). Reallocation is often less costly and is therefore the more desirable alternative. Although a critical path, the longest path through the various dependent and simultaneous tasks to project completion, implies no slack time between activities, reallocation is frequently made along that path because the activities on it often contain buffer or safety margin time included in their duration to account for unexpected problems or delays (Raz, Barnes, and Dvir, 2003). Accurately determining the activities that should be included on the critical path is an issue itself (Winter, 2004). Unfortunately, proposed network or mathematical solution procedures for different problem types may not always work with real-world problems (VanHoucke and DeMeulemeester, 2003). Nevertheless, project scheduling is a critical issue because schedule overruns have been identified as a serious contributor to project failures (O'Brien, 2004).

This research deals with the important issue of project scheduling by addressing the shortcomings of some popular, path-based techniques for project resource reallocation. Other studies have similarly suggested modifications to path-based techniques (Zhao and Tseng, 2003). It proposes a methodology that combines multiple project management techniques to obtain a more efficient resource reallocation. The paper provides a brief review of traditional project management techniques, explains the proposed methodology, and compares traditional techniques with the proposed methodology.

Traditional Project Management Techniques

Information technology (IT) projects are often administered or managed jointly, combining individuals who have business-area knowledge with technical managers (Ulfelder, 2004). Project managers, who may have PMI certification (www.pmi.org), use a variety of charting and mathematical techniques to keep projects on time and within budget, including: work breakdown structures, Gantt charts, PERT/CPM analysis (Chapman and Ward, 2003; Taylor, 1998), and critical chain project management (Raz, Barnes, and Dvir, 2003). There are a number of economical desktop tools available to managers that can produce these project management diagrams (Von Roenn, 2003).

Gantt charts list activities vertically and time horizontally; although nearly 100 years old, they are still used frequently (Hamilton, Holland, and Ohara, 1999). One problem with Gantt charts is that they do not directly show the connectivity between activities in a project. PERT/CPM originated in the 1950's to assist in the management of large projects by focusing on minimization of time and cost respectively. Though a mature technique, PERT/CPM is still explained in the practitioner literature (O'Brien, 2004), academic literature (Chapman and Ward, 2003; Zhao and Tseng, 2003), and it still appears in analysis and design and project management textbooks (Gido and Clements, 1999). PERT/CPM analysis shows the production path but loses the time dimension. The methodology proposed in this paper is a time-dimensioned PERT/CPM analysis that obtains the best of both approaches, and adds information not obtainable otherwise.

The SNAPP Methodology

In PERT/CPM the earliest time is the soonest an event can occur, given that all preceding activities are complete. The difference between earliest time, a left to right process in the PERT/CPM diagram, and latest time (the latest an event can begin without delaying the entire project), a right to left process, is called slack time or float. Float is sometimes defined synonymously with slack, but often it takes on other meanings (Harrison, 1985). "Slack is extra time available between activities; total float is 'slack' time for the entire project while free float is related to non-critical activities" (Kliem and Ludin, 1998). "Unfortunately, three types of float are in general use, namely, total, free, and independent float, and very few people completely understand the meaning of any of these" (Harrison, 1985). Although this confusion in terminology was identified in the mid-1980s, there are few concepts as ill-defined as float. Alternatively, the critical chain project management technique moves "buffer" time within individual tasks to the end of a project schedule, to explicitly account for that time (Raz, Barnes, and Dvir, 2003).

Systematic Network Analysis of Production Paths (SNAPP) is a time-dimensioned PERT/CPM analysis. It defines a segment as any portion of the production path that is either a part of the critical path or begins and ends with events on the critical path but has no other critical event on it. A segment either lies on the critical path or touches it at the beginning and at the end but at no other point. Similarly, a sub-segment is any portion of a non-critical segment. The segment excess time is the amount of time a series of activities on a non-critical segment can be delayed without delaying the project. Segment excess time is the difference between the sum of activity times for any non-critical segment and the sum of activity times on the critical path segment that has the same beginning and ending events. Some segments will have sub-segments that are constrained; we refer to these as limited sub-segments. A traditional PERT/CPM problem is presented in Table 1. The PERT/CPM Chart (Figure 1, Appendix) incorporates earliest time, latest time, and slack time into the solution.

TABLE 1. ACTIVITIES LAYOUT

Activity	Description	Expected Time
AB	Remodel current facilities	8
AD	Evaluate manpower requirements	2
AE	Design new applications	8
AG	Design modifications to existing applications	5
BC	Install LAN & new computers	5
CH	Test new hardware & compatibility	5
DE	Hire new programmers	2
EF	Code new applications	7
FI	Test new applications	7
GC	Application compatibility & selection	6
GE	Link existing & new applications	1
GH	Modify existing applications	7
HI	Test modified applications	3
IJ	Revise existing applications	2
IL	Revise new applications	4
JK	Parallel Run existing/new applications	4
JN	Revise & update documentation	5
KP	Implement modified applications	2
LM	Re-test new applications	3
MN	Prepare documentation	2

NP	Implement new applications	2

PERT/CPM diagrams have the advantage over Gantt charts of showing the relationship between activities, while Gantt charts have the advantage of showing the time dimension and the overlap of activities. Merging the time dimension of a Gantt chart into a PERT/CPM diagram provides an analysis that is richer than using each independently, or in combination. To accomplish this merger the PERT/CPM diagram is drawn with time on the horizontal scale. The activities listed in Table 1 are used to illustrate SNAPP procedures.

In the SNAPP diagram (Figure 2, Appendix), distance on the horizontal scale indicates the time required to complete an activity. Four activities start at the beginning of the project: AB, AG, AE, and AD. Each event designating the completion of these activities (events B, G, E, and D) is drawn such that the time required to complete the activity is represented by the horizontal distance between the events. For example, the AB activity takes eight weeks, which dictates that event B be located on the vertical line measuring eight units from event A, as will event E, because the duration of the AE activity is eight weeks. Event G will be located on the five-week line and D on the two-week line. Events subsequent to these are located on the diagram in a similar manner. For example, event E will also be located on the line two weeks from D (four weeks from A) and one week from event G (six weeks from A). This process results in multiple representations for some events, but clearly an event can only occur once. As in PERT/CPM, the rightmost representation is the earliest time for an event. However, by not having a time dimension, PERT/CPM does not show the multiple representations, and thus looses valuable information. SNAPP labels these shorter segments as independent segments and uses a dotted line connector to connect the multiple representations. As will be seen shortly, these dotted connectors can be used for many purposes.

The Critical Path and Segment Excess Times

In a SNAPP diagram, the path without dotted lines is the critical path (AEFILMNP in Figure 2, Appendix). Segment excess times are computed once the critical path is determined. The segment excess time for any segment that has only one dotted line is the horizontal length of that line. For example, the AGE segment has two weeks of segment excess time. Similarly, ADE requires four units of connection time yielding a segment excess time of four weeks and ABCHI has a segment excess time of one week. On the right-hand side of event I, the IJN segment has a segment excess time of four weeks while the IJKP segment has a segment excess time of three weeks. For any segment that contains multiple dotted lines, the excess times are summed. For example, in the AGHI segment there are six weeks between events G and H and one week between events H and I. Thus, AGHI has a segment excess time of seven weeks. Similarly, AGCHI has a segment excess time of three weeks.

Segments often contain sub-segments that are common with other segments, which may impose limitations on that sub-segment because the different segments can have varying segment excess times. For example, the AG sub-segment is common to the AGE, AGCHI, and AGHI segments. AGE has a segment excess time of two weeks, AGCHI has a segment excess time of three weeks, and AGHI has a segment excess time of seven weeks. Thus the AG sub-segment of the AGCHI and AGHI segments is limited to two weeks, because if this sub-segment consumes more than two weeks of segment excess time then the critical path must change. This limitation is easy to verify because if AGE is longer than eight weeks it would replace AE as part of the critical path. The limited sub-segment excess time is computed similarly for other sub-segments. For any sub-segment, simply list all segments that contain that sub-segment and the limited sub-segment excess time will be the smallest segment excess time. Limited sub-segment excess times are the smallest of the segment excess times for any longer segment.

Highlighting Similar Activities

Activity GH (Table 1) is similar to activity EF in that both involve programmer time. Given this task similarity, these activities involve resources that might be transferable from one activity to another, by shifting programmers between the activities. Under PERT/CPM analysis, neither the slack time of two weeks for event G nor the one week slack for event H suggests the opportunity to shift substantial resources from GH to EF. In contrast, SNAPP highlights this potential resource reallocation. The overlap of these two activities further suggests the potential for resource transfer or reallocation, which may not be possible without such overlap. For example, if one programming activity is scheduled to be completed before the start of another, shifting resources may not be possible. This potential resource reallocation becomes clear in the SNAPP analysis.

Discussion

SNAPP provides a mathematically simple and logically intuitive methodology for analyzing resource reallocation decisions as part of project management activities. The brief description in this paper explains how SNAPP is superior to former methodologies for identifying reallocation opportunities. Adding the time dimension to the more conventional PERT/CPM analysis adds to the value of those diagrams. SNAPP should be easy to apply for practitioners who are familiar with PERT/CPM charts because SNAPP output is so similar to what those practitioners have viewed in the past.

The concepts of SNAPP are particularly applicable to large construction projects, new product development, and any number of other projects that have interrelated (i.e., time dependent) sequences of activities. One objective of this research stream is to generate interest in adding the time dimension to traditional PERT/CPM analysis, and thus to the software that supports PERT/CPM.

The issue of resource reallocation is especially critical given the current environment for software project development. Developers are under severe pressures to meet business-driven deadlines for development projects in order to respond to pressures from trading partners and key competitors. SNAPP provides a practical means of directly addressing an important component or software project management – reallocations. Resource reallocations are made necessary by changing business conditions, unplanned delays (e.g., non-delivery of a component by a vendor or problems trouble-shooting an algorithm), and the unfortunate presence of scope creep (i.e., the emergence of new requirements during development).

Contribution

The previous illustration enables us to now contrast SNAPP and PERT/CPM. The PERT/CPM solution (two weeks slack time for activity G and one week for activity H) does not direct attention to the GH activity for possible resource reallocation as clearly as the SNAPP solution (seven weeks for the AGHI segment). Even if two weeks of excess time are used by activity AG (thus making GE critical too), five weeks of excess time remain for activity GH. Activity GH should be one of the first activities examined for potential resource reallocation because of the extra time to complete it. Therefore, identifying this opportunity for resource reallocation is one of the primary contributions of the SNAPP methodology.

Furthermore, solutions that compute total float consistent with segment excess time do not include the graphical analysis that identifies the overlap. Graphical analysis is an important method for identifying project problems (Steele and Huber, 2004). The SNAPP analysis is more informative than PERT/CPM and is more useful than using PERT/CPM in combination with Gantt charts. SNAPP provides a unique methodology for analysis because it adds a visual time dimension to PERT/CPM diagrams. This improvement in graphing techniques is a second contribution of SNAPP.

A third contribution of this methodology is that it addresses the ill-defined term "float." The SNAPP methodology replaces a poorly defined term, float, with a more meaningful concept "segment excess time." Thus, the SNAPP methodology attempts to clarify a generally misused term by developing a more intuitive variable.

Limitations and Future Research

The major limitation of SNAPP is that it is a proposed methodology, and therefore not computerized. Project management includes a number of computing-intensive tasks, such as, the development of project schedules and maintenance of charts (e.g., PERT/CPM and Gantt charts). SNAPP cannot be considered for adoption until it becomes an automated process and is integrated into commonly used project management tools. Until the time dimension of SNAPP is incorporated into PERT/CPM analysis, it will be limited to relatively small projects. Once programmed, SNAPP should prove beneficial to a wider variety of more difficult projects that require more frequent resource reallocation decisions.

One future direction for SNAPP is to identify sponsorship so that it can be converted to an automated tool for testing in areas such as construction and software development. It is possible that SNAPP could aid in software development once the procedure is automated into a software package itself.

Conclusion

One advantage of the SNAPP methodology is that the excess time available for resource reallocation, and the overlap of similar activities, are both shown in one graphical analysis. Slack time under traditional PERT/CPM analysis obscures the opportunity for resource reallocation while SNAPP highlights it. Even calculating total float to be equivalent to segment excess time does not include the overlap shown by the SNAPP analysis; separate Gantt charts must be used to accomplish this part of the analysis. A second advantage of SNAPP is the ease of calculation. In contrast to PERT/CPM which moves from left to right (for earliest time) and then right to left (for latest time), all calculations in SNAPP proceed from left to right. This simplification makes the procedure more intuitive to novices, and easier to convey to those not familiar with network analysis.

Resource reallocation decisions are significant when planning and managing a systems development project. In most cases completing the project in a minimum amount of time is desirable, and in some cases it becomes necessary to shorten the expected project completion time. If developers have to complete a project in less time than the initial estimates, they must find activities that can be completed in less time, and identify activities from which resources can be transferred. Otherwise, additional resources are required. SNAPP can be a valuable tool for making such reallocation decisions. This paper explains a modification to a widely used methodology that can be value to project managers who regularly make resource reallocation decisions.

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Appendix

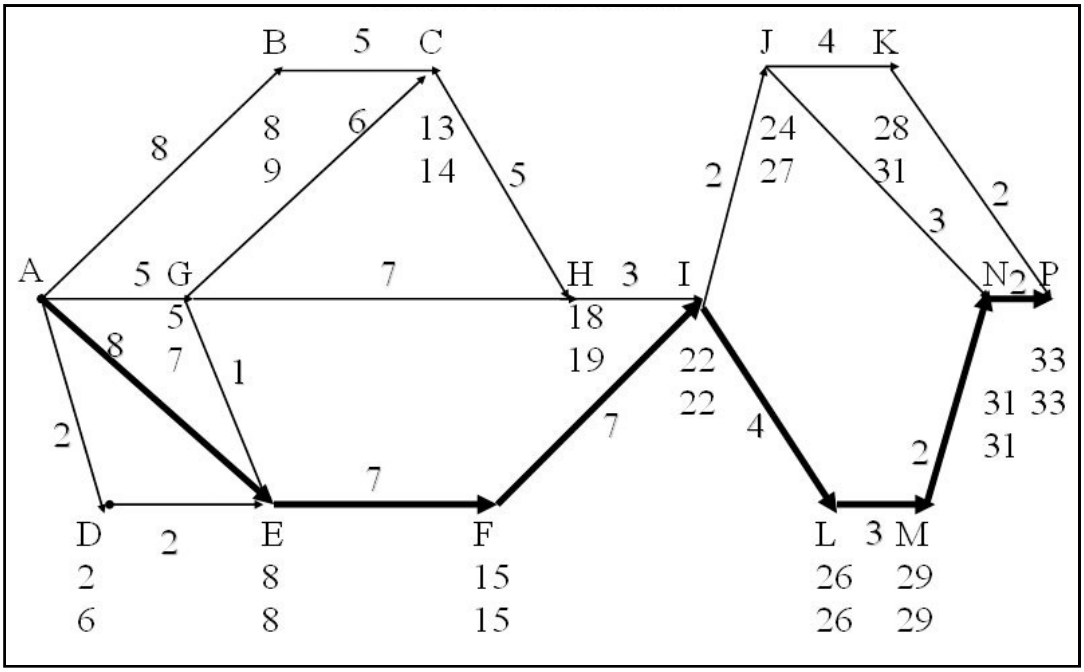

Figure 1. PERT/CPM Solution

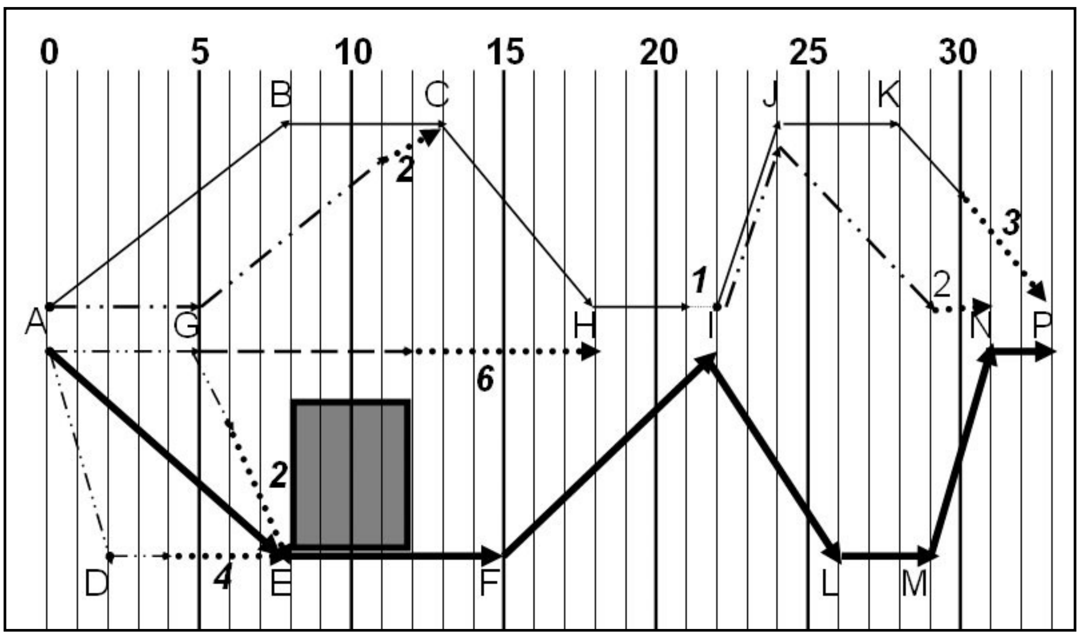

Figure 2. SNAPP Solution