A Critical Look at Critical Chain Project Management

Article *in* IEEE Engineering Management Review · February 2004

DOI: 10.1109/EMR.2004.25048 · Source: IEEE Xplore

Dov Dvir
Western Galilee College

A CRITICAL LOOK AT CRITICAL CHAIN PROJECT MANAGEMENT

TZVI RAZ, Faculty of Management, Tel Aviv University, Ramat Aviv 69978, Israel

ROBERT BARNES, Consultant, The iE3 Group Ltd, 162 Chelsea View Drive, Birkenhead, Auckland, New Zealand

DOV DVIR, School of Management, Ben Gurion University of the Negev, P.O.Box 653, Beer Sheva 84105, Israel

ABSTRACT

Critical Chain Project Management (CCPM) has emerged in the last few years as a novel approach for managing projects. In this paper the authors analyze the principles of CCPM, starting with a review of its key elements: reduction of duration estimates; buffer calculations; task completion notification; progress measurement; and priority setting. The authors continue with a CCPM critical analysis using evidence in the research literature and in practice. The points addressed include duration estimation practices, project network structure, stability of the critical chain, resource productivity under multi-tasking, and the project's organizational and operational environment. The place that CCPM occupies in the broader project management context and the costs associated with its adoption are also considered. The authors' conclusion is that although CCPM has a number of valuable concepts, it does not provide a complete solution to project management needs, and that organizations should be very careful about the exclusion of conventional project management techniques.

Keywords: scheduling; critical chain

Vol. 34, No. 4, 24-32, ISSN 8756-9728/03

Introduction

Critical Chain Project Management (CCPM), which was developed and publicized by Dr. Eliyahu M. Goldratt (1997) in his book Critical Chain, is a novel approach for managing projects. Goldratt is well known in the operations management community as the inventor of the Theory of Constraints (TOC). TOC is a tool for managing repetitive production systems based on the principle that every system has a constraint, and system performance can only be improved by enhancing the performance of the constraining resource. CCPM is an extension of TOC designed specifically for project environments. In the original book, as well as in the writings of its proponents, e.g., Newbold (1998), Simpson and Lynch (1999), Homer (1998), and Leach (1999), CCPM is presented as an alternative to the classical methods for project planning and control, such as those contained in the management and engineering textbooks and those in professional standards, such as PMI's *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*.

The publication of Goldratt's book generated some controversy in the project management community (Globerson, 2000). CCPM proponents claim it is a totally new, revolutionary way of thinking that can lead to superior performance in terms of reducing delivery time and increasing the ability to meet schedule and budget commitments. Others dismiss this as hype, arguing that experienced project managers have known the principles behind CCPM for decades, and CCPM's uniqueness is in the terminology rather than in its substance.

In addition to departing from the commonly accepted practice of project management, CCPM application requires the use of specialized software currently offered by a small number of vendors that are not necessarily the market leaders. As a result, any organization considering CCPM adoption as a way for improving project performance faces significant costs, both in economic terms and in changes to its culture and work procedures. Consequently, a careful evaluation and assessment of CCPM and its potential to bring about significant and sustainable performance improvements is in order.

The purpose of this paper is to provide some guidance to organizations considering CCPM as an addition or a substitute to their current project management practices. The paper is organized as follows. The authors begin with a brief overview of CCPM and a discussion of its key concepts and techniques. This is followed by a critical examination of the assumptions behind CCPM that considers relevant results from the published research literature and from the authors' own consulting practices. Next, the authors examine the place CCPM occupies in the *PMBOK® Guide* and conclude with an assessment of the benefits and limitations of CCPM.

An Overview of the CCPM Method

CCPM's starting point is a list of tasks along with their duration estimates and dependencies. The first step consists of developing an initial schedule for project tasks. This is done while taking into account the dependencies among the tasks (as reflected in the project network) and the availability of resources. Because at least some of the resources have limited availability, the resulting schedule is likely to be longer than the schedule obtained with the basic Critical Path Method algorithm, as critical activities are delayed while waiting for the resources they require.

At this point, CCPM identifies the critical chain as the set of tasks that results in the longest path to project completion after resource leveling. The critical chain yields the expected project completion date. Resources required by the tasks on the critical chain are defined as critical resources. So far, CCPM is the same as conventional project management except for the terminology "critical chain", which would otherwise be called the "leveled critical path". The next step in CCPM planning consists of recalculating the project schedule based on shortened task duration estimates. The rationale for shortening the original duration estimates is as follows:

- All tasks in the project are subject to some degree of uncertainty;
- When asked to provide an estimate of the duration, the task owner adds a safety margin in order to be almost certain of completing the task on time. This means that, in general, task durations are overestimated;
- In most cases, the task will not require the entire amount of safety margin and should be completed sooner than scheduled;
- Because the safety margin is internal to the task, if it is not needed, it is wasted. The resources for the next task are not available until the scheduled time. Therefore, when it becomes obvious that the buffer is unnecessary, the task owner will use the buffer time anyway, because there is little incentive to finish early. On the other hand, any delays in the completion of tasks on the critical chain propagate to the successor tasks. Thus, gains are lost, delays are passed on in full, and the project is likely to finish late even if, on average, there are enough buffers hidden in the tasks.

CCPM states that original duration estimates are such that the likelihood of completion is 95%, and they should be reduced to the point where the likelihood of completion is 50%. The difference between the project duration based on new estimates and the original project duration is called the project buffer and should be displayed on the project Gantt chart as a separate task. Figure 1 illustrates the relationships between the original schedule and the CCPM schedule based on the shortened task durations.

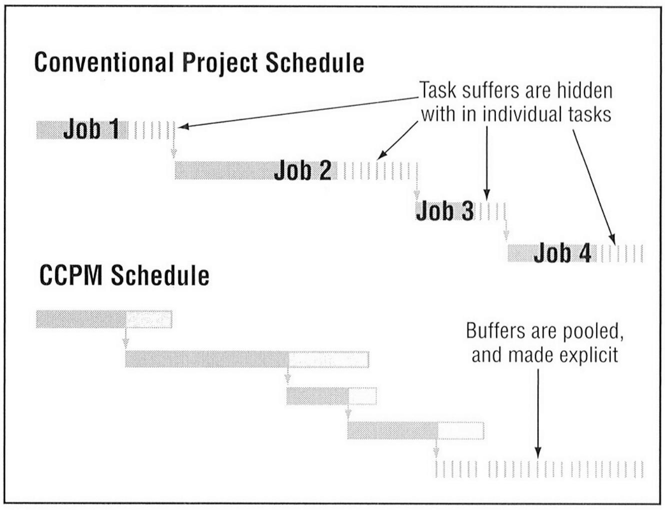


Figure 1. Conventional Schedule and CCPM Schedule With Time Buffers Shown Explicitly

The buffers, which were previously hidden in each task, have been made explicit and pooled. This pooled buffer is called the project buffer. Note that by calculating the project buffer, the total duration of the project did not increase. Under CCPM, the project buffer is considered part of the project and, as such, must be scheduled and assigned resources. A Gantt chart showing the project buffer serves to communicate the inherent uncertainty in the project as opposed to a conventional Gantt chart that presents a spurious air of certainty.

It is improbable that all the critical chain tasks will exceed their 50% likelihood duration estimates. Under the assumption of statistical independence, about half the tasks will exceed the 50% mark, while the other half will be completed at less than 50%. By pooling together the safety margins of the individual tasks, the protection against uncertainty is improved, so CCPM suggests that the combined project buffer can be less than the sum of the safety margins of the individual tasks. This argument is supported by statistical theory that states that the standard deviation of the sum of a number of mutually independent random variables (in this case, the actual durations of the tasks on the path) is less than the sum of the individual standard deviations. Although the assumption of statistical independence of task durations is questionable, this justifies reducing the overall duration of the project. In practice, it may be easier to gain task owners' acceptance of pooling their individual task buffers if the total is not reduced.

The same process of making safety margins explicit and pooling them can be applied to noncritical paths. As before, the safety margin in each task is identified, taken out, and pooled at the end of the path. Because this buffer is placed where the path feeds back into the critical chain path, it is called a feeding buffer. Figure 2 shows a simple project network where the feeding buffer has been identified. Note that noncritical paths still can have slack, as well as a buffer.

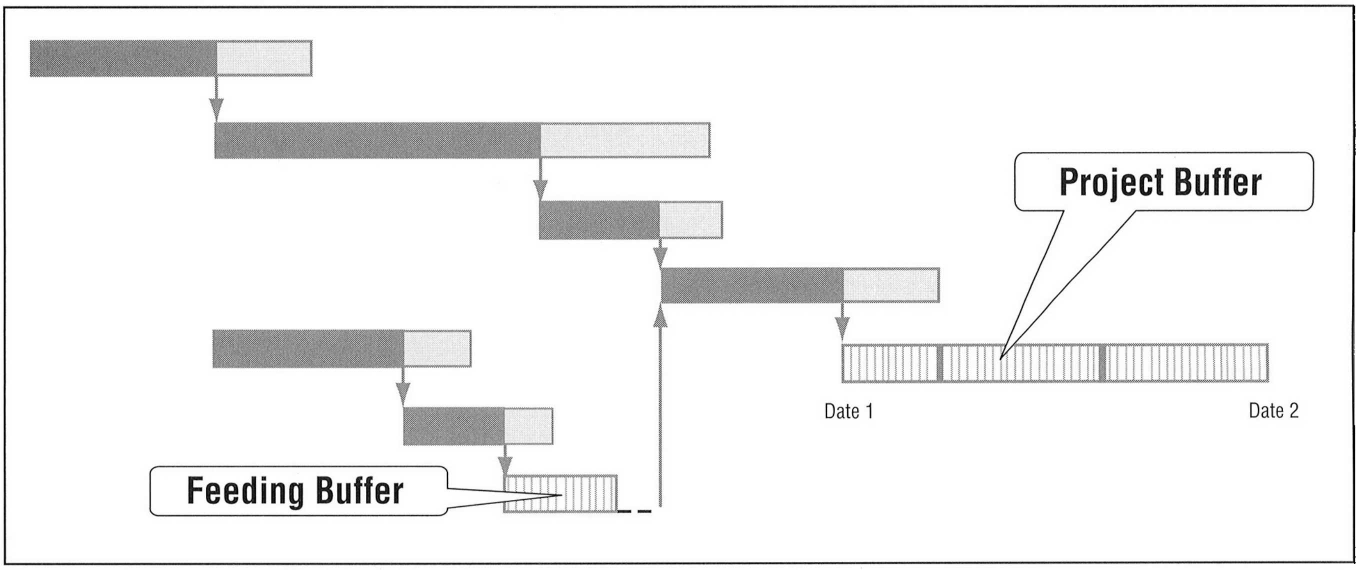


Figure 2. Project Network With Feeding Buffer

According to CCPM, a feeding buffer represents the extent of the critical chain's protection against the uncertainty in the feeding noncritical chain, and its size may be adjusted as desired. Once the size of the feeding buffer has been determined, if there is still some slack on the feeding chain, CCPM prescribes that the task be scheduled as late as possible. This is justified on the basis that it reduces waste of time and work in process on the noncritical tasks while preserving the desired degree of protection of the critical chain.

The third type of buffer used by CCPM is called a resource buffer, which is a virtual task inserted prior to critical chain tasks that require critical resources. Its purpose is to issue a signal to the critical resource that a critical chain task to which they are assigned is due to start shortly. According to CCPM, this wake-up call will cause the critical resource to wrap up any noncritical work and be ready to start work on the critical chain task as soon as its predecessors are completed. The resource buffer does not actually consume any resource, and it adds neither time nor cost to the project.

- At this point, CCPM has created a new project schedule, which consists of the original tasks with reduced durations and various types of buffers: the project buffer, the feeding buffer and the resource buffer.
- For project plan execution, CCPM prescribes the following principles:
- Resources working on critical chain tasks are expected to work continuously on a single task at a time. They do not work on several tasks in parallel or suspend their critical tasks to do other work;
- Resources are to complete the task assigned as soon as possible, regardless of scheduled dates;
- If the task is completed ahead of schedule, work on its successor is to begin immediately. If the task successor utilizes a critical resource for which a resource buffer has been defined, advance warning is provided to that resource at the point in time where the resource buffer begins;
- If the task is completed past its planned completion date, as shown on the CCPM schedule, this is no reason for immediate concern, as the buffer will absorb the delay.

As progress is reported, the CCPM schedule is recalculated, keeping the final due date of the project constant by adjusting buffer sizes. Project control focuses on consumption of the buffer. Out of proportion buffer consumption is a clear indication for implementing corrective actions, such as reassignment of resources to the tasks on the chains leading to the buffer in question. In this manner, the extent of buffer utilization serves to monitor the likelihood of project completion by its committed due date.

CCPM also provides some guidelines for managing multiple projects sharing a common pool of resources. While scheduling the various projects, CCPM suggests that we first identify the resource whose availability constrains the system (the "drum," according to TOC terminology) and then schedule the projects around it. During execution, if a given resource is required to work simultaneously on several tasks, CCPM prescribes that priority should be given to the task of the one project that is in the greatest risk of missing its committed date, as measured by the remaining fraction of project buffer. Of course, working concurrently on tasks that belong to different projects is not allowed.

CCPM Critique

In this part of the paper the authors consider the main elements of CCPM and analyze them in terms of the validity of the underlying assumptions and the availability of supporting empirical evidence.

Task Duration and Safety Margins

CCPM assumes that all task owners overestimate task duration by a certain safety factor, and that the duration of the actual execution of each task will expand to fill the time allotted. In other words, actual task duration is a self-fulfilling prophecy. These two assumptions are plausible, but CCPM theorists fail to provide any supporting scientific evidence. In fact, a recent study of task duration estimation in software development by Hill, Thomas, and Allen (2000) provides some contradictory results. The study analyzed estimated and actual durations of more than 500 tasks carried out by the information systems development department of a major international financial organization. Only in 8% of the tasks was the actual duration equal to the estimated duration, while in about 60% of the tasks the actual duration was less than the estimated duration. These findings, in effect, contradict the assumption that task owners use up all allocated time. Further, in 32% of the tasks, the actual duration exceeded the estimate, indicating that the safety factor, if it existed at all, was certainly not sufficient for the 95% confidence level.

However, let us leave aside the contradictory evidence and proceed under CCPM assumptions. There are still two important issues that CCPM does not address satisfactorily. The first issue is how does the project manager determine the safety factor that the task owner presumably built into the duration estimate. The only way for obtaining the correct answer is to have another method for estimating task durations that provides an accurate estimate and to subtract that estimate from the one provided by the task owner. Of course, if such a method is available, it should have been used in the first place, and the issue remains. CCPM suggests reducing the estimates by a certain percentage, typically 33%. Such an approach is problematic, not only due to the need to justify the percentage reduction chosen, but also due to the fact that not all people overestimate by the same amount. There are bound to be variations based on personality, job experience, nature of the task, workload, or other reasons.

Even if project managers are willing to accept that there is an appropriate formula to reduce duration estimates provided by task owners, the second issue still remains: Will they agree to shorten their duration estimates and merge their individual safety factors into the project and feeding buffers? Imposing shortened duration estimates on task owners will reduce their commitment to the estimates. In addition, the knowledge that their estimates will be reduced is likely to encourage task owners to add larger margins so they still have the safety margin they prefer after the correction,. At any rate, the behavioral aspects of identifying the precise amount of safety margin and taking it away from the task owner are dealt with only superficially by CCPM literature and still require empirical support.

Use of Buffers in Planning and Control

The various types of buffers play a key role in CCPM theory. In principle, the size of the project buffer should reflect the amount of protection required against the uncertainty of the sum of the durations of the tasks on the critical chain, while the sizes of the feeding buffers should reflect the amount of protection appropriate for the feeding chains. In order to contribute to the reduction in the overall project duration, the size of the buffer has to be less than the sum of the safety margins extracted from the tasks on the corresponding chain. However, CCPM does not provide any scientific or objective basis for determining the buffer size. This raises several problems.

First, the feeding chain concept is based on the assumption that the project network consists of several paths that start in parallel and proceed to merge into each other, eventually leading to the final product of the project, as shown in Figure 3.

This network structure is applicable to projects that consist of construction, assembly, and integration tasks, which are common in manufacturing environments. But many

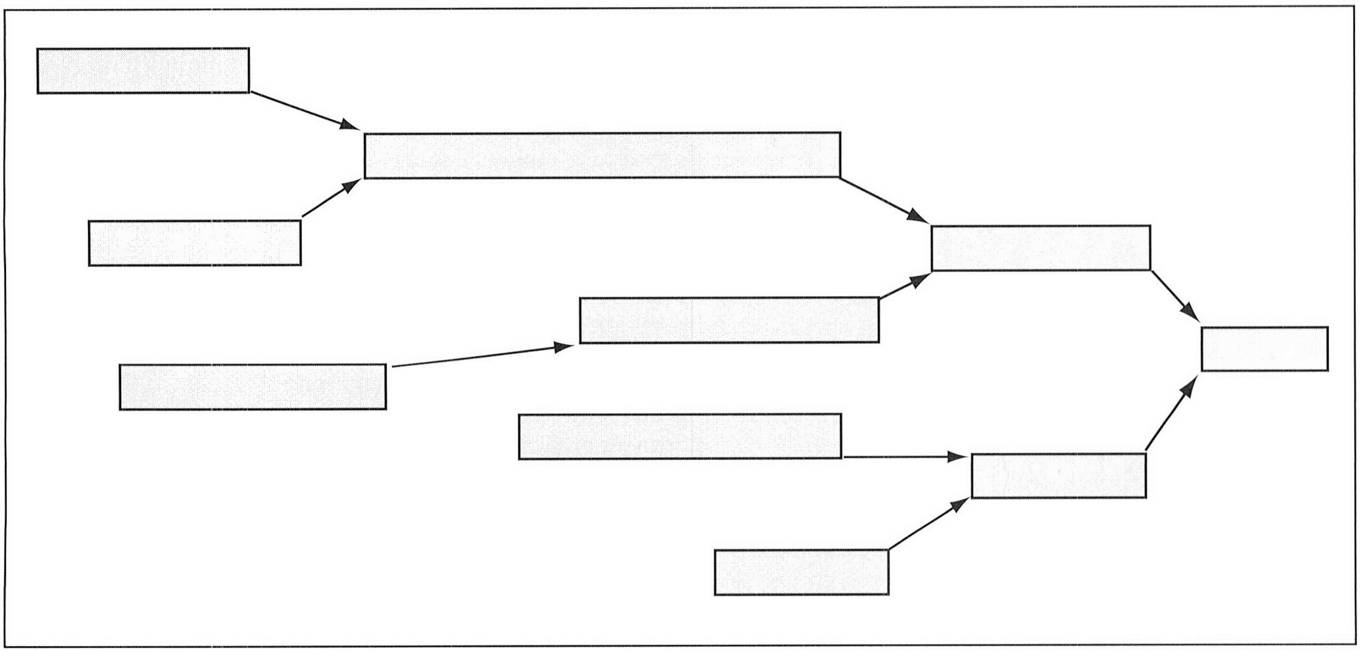


Figure 3. Typical Project Network According to CCPM

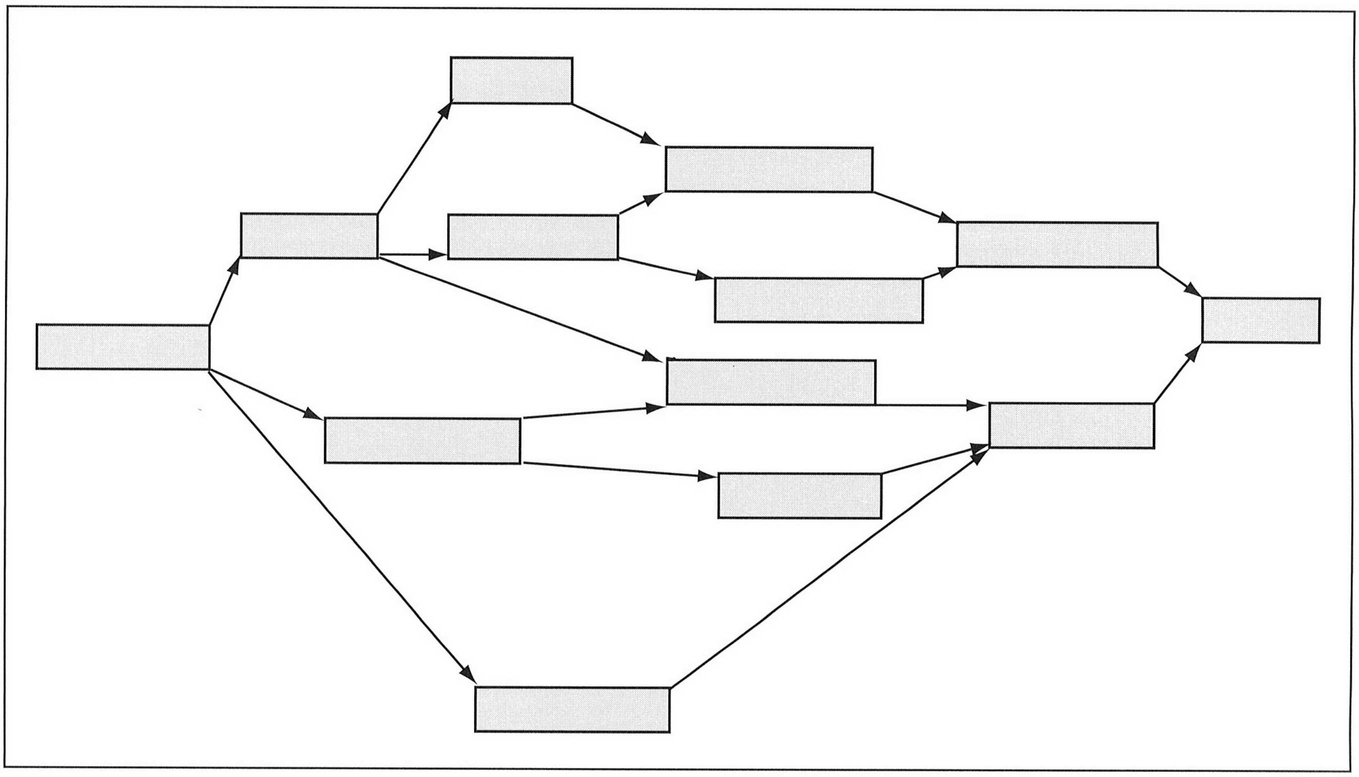


Figure 4. General Case of a Project Network

projects begin with a small core of central activities, i.e., design and analysis, which split into parallel tracks that merge at various intermediate review points before producing the various project deliverables. This leads to more complex network flows where a given task may have both predecessors and successors from several chains (Figure 4). In such cases, it is not clear how much of a feeding buffer should be allotted to each merging task.

Schonberger (1981) has shown that projects will always be late—relative to the deterministic critical path. The amount of delay is contingent on the time variability of activities and the amount of parallel paths in the network. In that respect, the critical chain is no different from the critical path, especially in nonarborescent networks.

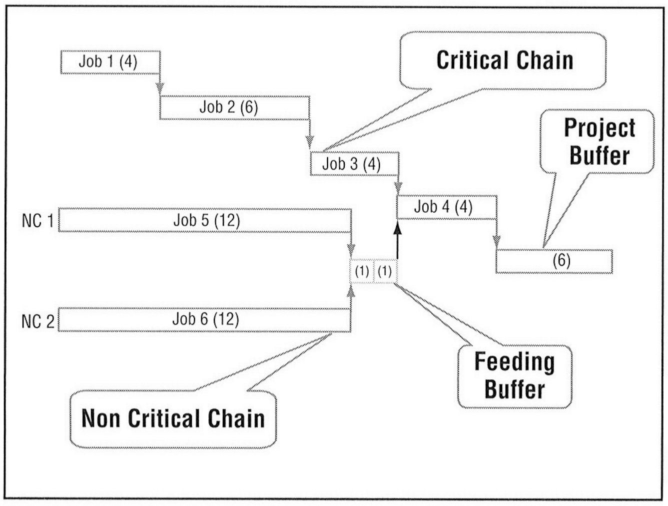


Figure 5. The Effect of the Time Variability on Project Duration

Figure 5 provides an example of such a network. In addition to the critical chain that consists of activities 1 through 4, there are three more activities: Job 5 and job 6 run parallel to each other and feed into job 7, which in turn feeds into the critical chain at the beginning of job 4. For the sake of the example, let us assume that the durations (after reductions of up to 33% as recommended by CCPM) are 12, 12, and 1 time unit for jobs 5, 6, and 7, respectively.

Thus, the feeding buffer has a length of 1 time unit, as shown in Figure 5. In order to examine whether the feeding buffer is adequate and effective, the authors follow the same method used by Schonberger (1981). Assuming a variability of +/- 3 units for each of the two longer activities, job 5 and job 6, calculate the expected length of time required for the two to complete. Because the two run parallel, the amount of time required for both to complete is the maximum of the actual durations of each of the two. There are seven possible duration values for each activity—a total of 49 combinations. Table 1 shows the combinations in a matrix, with the cells containing the maximum value. The average across the entire matrix is 13.14. Adding to this the duration of job 7, which is 1 time unit (and ignoring its own variability), the authors come up with the result that the variability of the noncritical chain exceeds its feeding buffer. In effect, this causes the noncritical chain to become critical. More parallel chains will increase the estimated duration even further.

A second issue pertains to the validity and stability of the schedule that serves as the basis for determining the buffers. According to CCPM, the critical chain and associated buffers are identified from a schedule obtained with a resource-leveling algorithm. The mathematical problem of scheduling the project tasks under resource constraints is known to be very difficult to solve optimally. In fact, this problem belongs to the class of problems for which it has been shown that there are no efficient algorithms for finding the optimal solution for large projects. A comparison of three exact approaches for solving the constrained resource project scheduling problem and their limitations can be found in Patterson (1984). Consequently, resource-leveling algorithms use heuristic rules to generate solutions that are hoped to be close to the optimum (Wiest, 1967).

		Duration of Job 5						
		99	110	111	112	113	114	115
Duration of Job 6	99	99	110	111	112	113	114	115
	110	110	110	111	112	113	114	115
	111	111	111	111	112	113	114	115
	112	112	112	112	112	113	114	115
	113	113	113	113	113	113	114	115
	114	114	114	114	114	114	114	115
	115	115	115	115	115	115	115	115

Table 1. Joint Duration of Parallel Activities Job 5 and Job 6

CCPM theory does not prescribe a specific resource-leveling algorithm out of the numerous algorithms that have been published in the operations research literature and vary in terms of average distance from the optimum. Thus, it is hard to assess how good is the schedule upon which the buffers are based. Project networks are not arborescent, and because determination of the appropriate buffer size has to take into account the variability of activity durations and the number of parallel paths in the network of the network, simulation studies are required, as Schonberger (1981) suggests.

In addition, the critical chain itself may change for several reasons. Hoel and Taylor (1999) show that if the overall uncertainty on a given feeding chain is such that the project planner defines a feeding buffer greater than the free slack of the feeding chain, that chain becomes part of the critical chain. Further, during project execution, the critical chain may change as a result of changes in resource availability or in buffer utilization. Changes in the set of tasks that constitute the critical chain are likely to affect the meaning of the buffers of various types, bringing us to the third issue, which is related to the use of buffers for project control.

According to CCPM, schedule control is based on monitoring the extent of buffer penetration, which is defined as the amount of time running from the original start date of the buffer on the critical chain or one of the feeding chains, as appropriate, to the projected end date of the last task on the corresponding chain. The projected dates are based on estimates of the "duration left" for the tasks. The estimation of how much work remains to be done is also subjected to inflation by safety margins—the very same problem CCPM attempted to solve by using buffers. However, let us assume that buffer penetration data is indeed valid and accurate and can be trusted to serve as an indication of the likelihood that the task chain will be completed by the end date of the buffer. CCPM prescribes that, in case of contention for limited resources, priority should be given to the task belonging to the chain with the highest buffer penetration rate. The rationale for this rule is clear: Chains of tasks where a higher percentage of their buffers have been used are at a higher risk of missing their committed dates and, consequently, ought to be given higher priority in resource allocation decisions. However, this consideration is not the only one and may not be the most relevant one. For example, we may prefer to give priority to tasks that belong to a project with very high penalties for missing deadlines, or to those that have a key strategic impact, regardless of the amount of remaining buffer.

A final point regarding time buffers deserves attention. Buffers of various types are shown on the project schedule and Gantt chart as special types of activities. Because there is one feeding buffer at the end of each chain of tasks in the project network (if we assume that typically a chain consists of eight to ten tasks in series before each merging point and take into account resource buffers as well), buffers add at least 10% to 15% to the number of items on the Gantt chart. These additional items, which have to be interpreted differently from the others, add clutter to the schedule and increase the potential for confusion.

Overall, although feeding and project buffers have some intuitive appeal, one ought to be aware of the limitations in their validity and usefulness as the main decision-making criterion in project control.

Resource Utilization

CCPM is against assigning more than one task to be carried out concurrently by a given resource. The organization could reduce the extent of multitasking without switching to CCPM, but it is not clear at all that eliminating multitasking is actually a good idea. In fact, a study of 64 high technology firms carried out by McCollum and Sherman (1991) presents some evidence to the contrary. The researchers examined the effectiveness of matrix organizations and found that there was a relationship between the number of projects to which research and development personnel were assigned and key performance indicators of the firm. Specifically, they found that for two of the most important measures of performance—return on investment (ROI) and rate of sales growth—assignment to two projects seems to be optimal, while up to three may not be problematic.

Resource buffers are a unique feature of CCPM. They are fictitious tasks that provide advance notice to the critical resources that the prerequisites for assigned tasks are about to be completed and that they should complete whatever they are doing and become ready to start working on their tasks shortly. Further, they are asked to complete assigned tasks as soon as possible in order to allow successor tasks to start as soon as possible. This method of coordination among project team members seems to us rather chaotic and requires a great deal of unscheduled communication. It may not be feasible at all if some of the resources are outside contractors who may not have the flexibility to drop their ongoing jobs and invest their full attention on their assigned project task. There is value in alerting resources to important (critical chain activities) early-start opportunities, and CCPM is correct to point out that managing to complete tasks on time is not the same as managing to complete the project on time. However, it is the authors' opinion that this is a supplement, rather than a substitute, for the traditional way of publicizing a schedule to which all task owners have committed. The schedule's integrity still needs to be maintained through an effective change management process.

Overall, the authors fail to see any advantage that this approach gives to the traditional way of publicizing a schedule to which all task owners have committed, and to maintaining its integrity through an effective change management process.

Multi-Project Management

CCPM deals with a multi-project environment by staggering the projects around the constraining resource (the "drum" in TOC terminology). In principle, at any given point in time there could be several constraining resources, each leading to a different schedule. Further, at different points in time we could have different constraining resources, so that there could be conflicting schedules. The premise that there is a single drum is based on a steady state view of the work mix in the organization and is applicable to manufacturing and operations environments. In most project environments there is no steady state and, consequently, the authors doubt the applicability of the solution obtained with CCPM.

CCPM Scope

Project success and project management success are not necessarily equivalent. For many project managers, success means meeting predefined planning goals stated in terms of schedule, budget and scope commitments. To customers, however, success relates primarily to whether the project contributes to the goals of the organization. The relative importance of the various dimensions of project success was documented by Lipovetsky, Dvir, and Shenhar (1997) in a study of 110 projects in Israel. Their analysis revealed that benefit to the customer was by far the most important dimension, almost twice as important as meeting planning goals. Nevertheless, a sound project management process well executed by a qualified project manager enhances the likelihood of project success in the eyes of the customer.

Like conventional project management, CCPM deals with project management success, rather than project success. Furthermore, CCPM focuses on a single aspect of project management—meeting the schedule goals. The relative importance of this aspect is not universal: A project that exceeded its original schedule by 10%, but still earned ten times its cost in increased profits, would be considered more successful that a project that was completed on time and budget but added little to the customer's business effectiveness.

Within the narrow scope of meeting project schedule objectives, CCPM focuses mainly on the uncertainty inherent in the schedule. Rather than addressing the root cause of duration uncertainty, CCPM accepts it as a given and attempts to overcome it by means of buffer management. In contrast, most project risk management methodologies work at identifying and reducing the sources of uncertainty or by estimation methodologies that work to improve the quality of the duration estimates. Although CCPM does not preclude the application of other, more comprehensive risk management approaches, its limited focus makes it ill suited to serve as the single tool for dealing with project uncertainty. At best, it can help manage the schedule uncertainty that remains after the application of risk analysis and risk mitigation tools.

Further, because CCPM is presented as a revolutionary concept that replaces, rather than complements, current project management knowledge and practices, it is not properly integrated with the accepted body of knowledge and state of the practice. This situation poses a certain dilemma to organizations that are new to project management methodologies and are asked to choose between CCPM and mainstream methodologies, such as those contained in the *PMBOK® Guide*.

CCPM Adoption

An organization that considers the adoption of CCPM as its main project management methodology has to take into account two major sources of cost: software tools and culture change. CCPM implementation requires project personnel to use a software tool that supports the concept of buffer creation and management. Currently, only one of the mainstream mid-size project management software tools is compatible with CCPM and two add-in products are available for the leading tool in the market—one of which requires a specific database server. Thus, the range of software tool options is limited and bound to be relatively expensive.

However, the costs of acquiring, deploying and applying software that supports CCPM are likely to be secondary relative to the costs resulting from the need to change the culture of the organization. CCPM is presented as a methodology that has to be adopted in its entirety, ranging from buffer calculation, personnel assignment, and progress reporting, up to the criteria for determining delivery dates in a multi-project environment. As such, CCPM requires massive education at various levels and functions throughout the organization and may even require experienced project managers to forget some of their conventional knowledge in order to absorb the new methodology. Some of the key points that involve a change in the organizational culture are:

- Giving up ownership of the task duration and relying on the schedule buffers to absorb deviations in individual task performance;
- Replacing the concept of "due date" with "estimated completion date range," as represented by the feeding and project buffers;
- Avoiding multi-tasking.

Clearly, CCPM is a departure from traditional project management and its adoption by any organization will require a concerted effort at all levels.

Concluding Remarks

Project performance is often less an issue of managing the constraints on the schedule and more a function of the personal skills and capabilities of the leaders, such as articulating customer requirements, understanding future needs, enlisting cooperation throughout the organization, etc. CCPM is based on the premise that uncertainty in activity duration is the major factor affecting the ability to complete the project on time. But, there are other relevant mismanagement practices that affect schedule expectations, such as external pressures, internal politics, and distorting estimates to win the project, which should also be addressed.

CCPM leads us to believe that management of projects can be accomplished through the same rational process that works for production management. In order to accomplish this, CCPM adapted the concepts of bottlenecks and material buffers that were developed within the framework of Goldratt's Theory of Constraints, calling them "critical chain" and "time buffers" in the realm of projects. These concepts and other elements of CCPM are not necessarily new. For instance, the impact of resource availability on critical path calculations has been known for quite some time (Raz, 1996). However, the issue of intellectual innovation is not the main one, even though it is emphasized in the CCPM literature. The authors already presented their concerns about the validity of the assumptions and the adequacy of the scope covered. The key question is: Is CCPM indeed superior to the currently accepted project management methodologies?

CCPM seems to hold answers to problems that have challenged project managers for many years, and presentations on it are enthusiastically received. CCPM proponents have claimed some dramatic successes, but from the authors' personal experiences, these appear to be mainly in organizations that started out with weak or nonexistent project management methodologies. However, the authors are not aware of any comparative studies that provide scientific evidence to the effect that organizations that have adopted CCPM perform better than organizations that apply a conventional project management methodology. In addition, CCPM has been out for a short period of time, and it is impossible to assess any sustainable long-term benefits.

Although the bulk of this paper has been devoted to a critical analysis of CCPM, it is important to point out its positive side. First, CCPM is a methodology, and any methodology is better than no methodology at all. Even if CCPM is simplistic and oversold, it is worth studying for its several pieces of good advice. In this respect, CCPM:

- Accounts for duration uncertainty by making buffers explicit, sharing the knowledge of buffer sizes and placement with workers, management, and sponsors;
- Considers resource availability;
- Focuses on the key tasks and resources;
- Constantly monitors the amount of buffer in your schedule;
- Provides advance notice of upcoming work to critical resources;
- Does not split your attention among numerous tasks.

Some CCPM principles do make sense in certain situations and their careful application can improve performance, provided the preconditions and assumptions are fully understood. However, to the question of whether your organization should adopt CCPM as its project management methodology, the authors offer the following qualified answer. If your organization lacks effective project planning and control processes, you run a relatively large number of quite similar projects in a matrix environment, and your main concern is meeting deadlines, CCPM could be beneficial. Otherwise, the authors suggest carefully weighing the limitations of CCPM and its costs against the potential for contributing to the long-term business success of your organization. Perhaps the optimal solution is to incorporate those CCPM principles that are applicable to your environment within a broader conventional project management methodology.

References

Globerson, S. (2000). PMBOK® and the critical chain. *PM Network 14* (5), 63–66.

Goldratt, E.H. (1997). Critical Chain. *Great Barrington,* MA: North River Press.

Hill, J., Thomas, L.C., & Allen, D.E. (2000). Experts' estimates of task durations in software development projects. *International Journal of Project Management, 12* (1), 13–24.

Hoel, K., & Taylor, S.G. (1999). Quantifying buffers for project schedules. *Production and Inventory Management Journal,* 40 (2), 43–47.

Homer, J.L. (1998). Applying the theory of constraints to projects. *Proceedings of the 29th Annual Project Management Institute 1998 Seminars & Symposium. CD-ROM,* Newtown Square, PA: Project Management Institute.

Leach, L. (1999). Critical chain project management improves project performance. *Project Management Journal, 30* (2), 39–51.

Lipovetsky, S., Tishler, A., Dvir, D., & Shenhar, A. (1997). The relative importance of project success dimensions. *R & D Management, 27* (2), 97–106.

McCollum, J.K., & Sherman, J.D. (1991). The effects of matrix organization size and number of project assignments on performance. *IEEE Transactions on Engineering Management, 38* (1), 75–78.

Newbold, R.C. (1998). *Project Management in the Fast Lane.* Boca Raton, FL: The St. Lucie Press.

Patterson, J.H. (1984). A comparison of exact approaches for solving the multiple constrained resource, project scheduling problem. *Management Science, 30* (7), 854–867.

Raz, T., & Marshall, B. (1996). Float calculations in project networks under resource constraints. *International Journal of Project Management, 14* (4), 241–248.

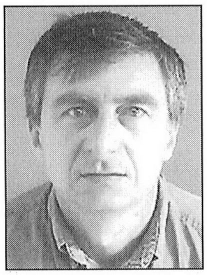
Simpson, W.P., & Lynch, W. (1999) Critical success factors in critical chain project management. *Proceedings of the 30th Annual Project Management Institute 1999 Seminars & Symposium.* CD-ROM, Newtown Square, PA: Project Management Institute.

Schonberger, J.R. (1981). Why projects are "always" late: a rationale based on manual simulation of a PERT/CPM network. *Interfaces,* 11 (5), 66–70.

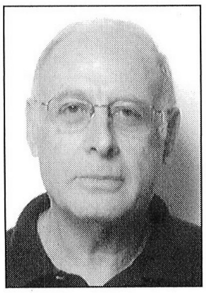
Wiest, J.D. (1964). Some properties of schedules for large projects with limited resources. *Operations Research,* 12, (May–June), 395–418.

Wiest, J.D. (1967). A heuristic model for scheduling large projects with limited resources. *Management Science, 13* (6), B359–B377.

Wiest J.D., & Levy F.K. (1977). *A management guide to PERT/CPM.* Englewood Cliffs, NJ: Prentice-Hall.

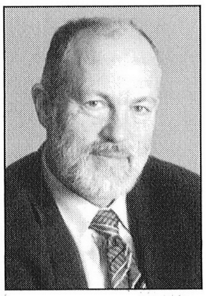


Tzvi Raz holds B.Sc, M.A.Sc and Ph.D degrees in Industrial and Management Engineering. He is a Professor of Technology and Information Systems Management and Assistant Dean at the Leon Recanati Graduate School of Business Administration at Tel Aviv University. Previously, he managed a technology insertion program at an IBM software development laboratory, and was on the Industrial Engineering faculties of the University of Iowa, US and Ben Gurion University, Israel. Dr. Raz has published over 60 research papers in refereed international journals and is on the editorial boards of Computers and Operations Research and the Project Management Journal. In the last five years he has served as consultant to several technology firms in Israel on project and risk management, and has conducted short courses and workshops on these topics in Israel, Europe and South America. Dr. Raz has been certified as a Project Management Professional by the Project Management Institute and was the founding president of the Israel Chapter of the Project Management Institute.



Dov Dvir is a senior lecturer at the Ben-Gurion University in Beer Sheba. Previously he was the head of the Management of Technology (MOT) department at the Holon Center for Technological Education, Israel. He also lectured at the Faculty of Management, The Leon Recanati Graduate School of Business Administration at the Tel Aviv University. He holds a B.Sc. in electrical engineering from the Technion - Israel Institute of Technology, M.Sc. in operations research and an MBA from Tel Aviv University; and a Ph.D. in management (specialization in MOT) from Tel Aviv University.

In his military service as a senior officer in the Israeli Defense Force (IDF) he was a commander of a large Technological Development Center.



Robert Barnes has an MSc and a Diploma of Management from the University of Auckland, and holds PMP certification. He guest-lectures on Information Technology topics at Auckland University's Business School, and is the author of an authoritative textbook on PL/I programming. He is a director of the iE3 Group, and a National Councillor of the New Zealand Computer Society, as well as an active consultant.