Traditional Critical Path Method versus Critical Chain Project Management: A Comparative View

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Abstract

Critical Chain Project Management (CCPM) provided a tangible progress to the Project Management Body of Knowledge. The Critical Chain Project Management (CCPM) differs from the traditional Critical Path Method (CPM) which includes never changing resource dependencies. CCPM improves the project plan by aggregating uncertainty into buffers at the end of activity paths. In this research, one hundred twenty random projects were generated and analyzed using Microsoft Project software according to the traditional CPM and the CCPM once using the Sum of Squares (SSQ) method and another using the cut and past (C&P) method. CCPM-SSQ method revealed an average savings of 13% and 43% in duration and cost, with a standard deviation of 21 and 11 for duration and cost respectively. While the CCPM-C&P method revealed an average overestimation of about 2% in duration and 43% savings in cost, with a standard deviation of 25 and 11 for duration and cost respectively.

Keywords: Project management; Critical path method; Critical chain method; Scheduling; Theory of constraints

Introduction

Creation of reliable and accurate schedules in project management is the first step towards project success. Using the Critical Path Method (CPM) implies calculating Early Start and Finish dates as well as Late Start and Finish dates by forward and backward analysis of the project network diagram paths. Choosing the relevant resources is usually done after identifying the path. Activity owners add buffers (i.e. safety margin) for each activity in order to overcome the uncertainties [1]. Using CPM, if a resource completes an activity before the planned finish date, the time gain is still not propagated to next activity. That is because the early start date of next activity has been not reached yet. However, delays are propagated which may even change the existing critical path [2]. Critical chain project management (CCPM) is the direct application of the theory of constraints (TOC) to project management developed by Goldratt [3-5] which is a technique related to scheduling analysis for network that considers task dependencies, scarcity of resources, and buffers. CCPM has received much attention recently in project management literature. However, there are still arguments over the advantages and difficulties of the CCPM when compared with the traditional CPM [6-10]. The first buffer sizing method reduces the duration of each activity by 50% and lets the buffer size equal to the summation of half of the reduced duration for each activity. This implies about 25% reduction in project duration. Tukel [10] referred to this as the ‘Cut and Paste Method’ (C&PM). Leach [11] refers to this as the ‘50% of the Chain’ method, and clarifies by stating that one should not count gaps in the chain or path when applying this method. Advantages include, simple to apply method, and it provides a large enough buffer. Disadvantage of this method is not allowing accounting for known variation in the feeding path. The ‘square root of the sum of squares’ method (SSQ) makes buffer size as the square root of the SSQ of the difference between low risk duration and mean duration for each task. It perhaps a duration with a probability greater than 90% of being achieved. Merit of the SSQ method is that it permits to account for known variation in task duration. Demerit is that it could lead to undersized buffers for long chains [10]. CCPM method’s first step is to identify the set of activities that results in critical chains. The resources which are used in the critical chain activities are usually considered as critical resources. Activities that are not included in the critical chain while at the same time converging to critical chain are considered feeders. The following step is to reduce the duration of the activity considering the buffer management. The main focus of CCPM is to eliminate the uncertain delays, task overestimation duration delays, and wasted internal buffers delays [12]. In CCPM, project duration does not change even if all the activity safety margins were eliminated, because of the project buffer [13]. Project buffer protects the project completion on the critical chain path, while feeding buffers protects the critical chain from path merging [14]. Managing the buffer further improve the decision making of project control. In general, using CCPM will further enhance the project schedule, cost, and scope performance. Experience with CCPM projects demonstrates completion with 10% to 50% in cost and duration [15].

Why are Projects Late

In spite of the fact that task durations are often carefully estimated to begin with, the presence of certain behaviors causes them to increase. Four important behaviors make project durations longer than necessary, which are deliberate padding, student syndrome, bad multitasking and Parkinson’s law Woeppe [16], following is a description of each.

Deliberate padding

Deliberate padding happens when after the work has been conservatively estimated several layers of management will increase it even more. Managers feel they must protect their own performance, in many organizations task estimates are not treated as ‘estimates’ but rather as ‘commitments’. People don’t want to be late on commitments, thus, they “pad” their estimates of how long a given task will take.

Student syndrome

Student syndrome is a natural defense mechanism in which the work is put off until the last possible moment. The student syndrome causes longer durations because some of the time needed to complete

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a task is lost when it is started too late or even when it is started "just in
time." Then, according to Murphy’s Law it takes even longer either due
to common cause process variation or special cause process variation.

**Bad multitasking**

Bad multitasking occurs when an individual is working on more
than one task at the same time. Multitasking is divided into two
categories which are, good and bad. Good multitasking is moving more
than one task together in a smooth way. Bad multitasking is working
on a single task before it is finished so as to start another.

**Parkinson’s Law**

Parkinson’s Law states that "the amount of work rises to fill the
time available to complete it'.

**Objective**

This paper aims at comparing the traditional CPM against CCPM
Goldratt, [4] once using SSQ and other using C&PM techniques in
terms of duration and cost performance.

This will be done by applying the different methods to the one
hundred twenty project networks with the different number of activities
in each project and different interconnections with resources.

**Methodology**

To achieve the research objectives, one hundred and twenty
combinations of randomly generated project networks were studied
and evaluated once using the traditional CPM and another using
CCPM with SSQ and C&PM methods. The project networks comprised
of activities ranging from seven up to four hundred fifty activities
with four different combinations of resources for each. The resources
ranged from two to thirty types [17-20]. The networks were tested
once without mixed the resources and another with mixed resources.
Microsoft Project (MS Project) Software© (2007) have been customized
to accept CCPM networks in addition to traditional scheduling, and
was used to schedule and evaluate the one hundred twenty generated
networks. Table 2 shows the duration, cost, and percent of savings in
both duration and cost for each tested network using the traditional
CPM, CCPM with the C&PM and SSQ methods [21]. To demonstrate
the procedure followed for the one hundred and twenty networks
throughout this research, the first case is explained. Figure 1 depicts
the Precedence network diagram (PDM) for the first sample project
network of the thirty project networks. Next, the resources are loaded
and leveled; Figure 2 depicts the Gantt chart after loading resources
and leveling for the first case with seven activities and two resources
using traditional CPM, while Figures 3 and 4 depicts scheduling using
CCPM using the SSQ and C&PM methods respectively (Figures 1-4).

Table 1 shows the output analysis for the first case with a savings of
about 25% in duration and 50% in cost. Summary results for the one
hundred twenty cases are shown in Table 2.

**Analysis**

The one hundred twenty sample projects are analyzed using MS
Project using CPM and the two CCPM methods with added feature to
accommodate for the CCPM criteria. The CCPM-SSQ method revealed
an average savings of 12.72% and 43.08% savings in duration and cost
respectively, with a standard deviation of 20.99 and 11.05 for duration
and cost respectively. Figures 5 and 6 depict those changes against the
traditional CPM method.
Table 1: Analysis results of CPM and CCPM method.

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Number of Activities</th>
<th>Number of Resources</th>
<th>CPM Duration (Days)</th>
<th>CPM Cost (JD)</th>
<th>Change in Duration</th>
<th>Change in Cost (JD)*</th>
<th>CCPM Duration (Days)</th>
<th>CCPM Cost (JD)</th>
<th>Change in Duration</th>
<th>Change in Cost (JD)*</th>
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<td>1</td>
<td>7</td>
<td>2</td>
<td>22</td>
<td>2448</td>
<td>16.61</td>
<td>24.5</td>
<td>1224</td>
<td>50</td>
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<td>25.0</td>
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<td></td>
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<td>19</td>
<td>3200</td>
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<td>1600</td>
<td>50</td>
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<td>4</td>
<td>42</td>
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<td>3160</td>
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<td>3184</td>
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<td>23.13</td>
<td>1880</td>
<td>40.96</td>
<td>11.00</td>
<td>26.67</td>
</tr>
</tbody>
</table>

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Method | Duration (days) | % Change in Duration | Cost (JD)* | % Change in Cost |
-------|-----------------|----------------------|------------|-----------------|
CPM    | 22.00           | -                    | 2448       | -               |
CCPM-SSQ | 16.61         | 24.5                 | 1224       | 50              |
CCPM-C&PM | 16.50         | 25.0                 | 1224       | 50              |
<table>
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<tr>
<th>Time</th>
<th>Mode</th>
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<th>Value 2</th>
<th>Value 3</th>
<th>Value 4</th>
<th>Value 5</th>
<th>Value 6</th>
<th>Value 7</th>
<th>Value 8</th>
<th>Value 9</th>
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<td>645.8</td>
<td>-0.96</td>
<td>133748</td>
<td>21.92</td>
<td>739.63</td>
<td>-21.35</td>
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<td>21.92</td>
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<td>657</td>
<td>149595</td>
<td>715.63</td>
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<td>15(mix)</td>
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<td>224560</td>
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<td>36.88</td>
<td>812.13</td>
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<td>10.93</td>
<td>129136</td>
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<td>50.00</td>
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<td>127388</td>
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<td>1140853</td>
<td>2080.94</td>
<td>0.71</td>
<td>570441</td>
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**Note:** The table details are not fully transcribed as they seem to be incomplete.
Table 2: Microsoft Project Sample Results.

<table>
<thead>
<tr>
<th>Project Network</th>
<th>% Change in Duration</th>
<th>% Change in Cost</th>
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<tr>
<td>25</td>
<td></td>
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</tr>
<tr>
<td>365 12</td>
<td>891 792576 633.12</td>
<td>28.94 396288</td>
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<tr>
<td>365 12(mix)</td>
<td>660 622692 614.11</td>
<td>06.95 311346</td>
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<td>365 30</td>
<td>648 621340 612.45</td>
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<tr>
<td>365 30(mix)</td>
<td>837 803596 628.41</td>
<td>24.92 401798</td>
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<td>365 20</td>
<td>1775.67 945374 1183.81</td>
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<tr>
<td>385 30</td>
<td>927.5 632662 782.7</td>
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</tr>
<tr>
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<td>-09.49 487602</td>
</tr>
<tr>
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<td>-02.15 511626</td>
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<tr>
<td>400 30</td>
<td>1370 841826 631.64</td>
<td>53.90 441549</td>
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<td>400 30(mix)</td>
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<td>-07.32 422569</td>
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<td>-08.51 466294</td>
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</table>

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Figure 5: Changes in duration using CCPM-SSQ method.

Figure 6: Changes in cost using CCPM-SSQ method.

Figure 7: Changes in duration using CCPM-C&PM method.

Figure 8: Changes in cost using CCPM-C&PM method.
Using the CCPM-C&PM method revealed an average overestimation of 2% in duration and 43% savings in cost, with a standard deviation of 24.69 and 11.05 for duration and cost respectively. Figures 7 and 8 depict those changes against the traditional CPM method.

In both CCPM methods there was an obvious average savings in cost of about 43%, as for the duration SSQ method resulted in an average savings of about 13% while the C&PM method resulted in an overestimation of about 2%.

**Discussion and Conclusions**

The traditional CPM technique faces a number of problems such as bad multitasking, Parkinson’s Law, student’s syndrome and deliberate padding [22-24]. CCPM provides a substantial step in continuous improvement to the project management body of knowledge; however, more research is still required in this direction.

CCPM focus for the whole project, the “Buffers” provide focus and obvious decision for the Project Manager. The essential changes introduced by CCPM relative to the current CPM practices are development of the critical chain using both activity logic and resource constraints, reduction of activity estimated duration and costs in some cases, using buffer management as the primary tool for project management and control.

In this research CCPM technique reduced the duration for some projects, while in others it gave an overestimation in duration. For the projects that CCPM was effective in reducing their durations, there was no particular trend for percentage of reduction, the points are scattered randomly. Looking at the two buffer sizing methods, it appears that each method has its own advantage and disadvantage [25]. A reduction in duration for some projects was obtained using SSQ method while an overestimation occurred using the C&PM method. As for the “time” performance, CCPM-SSQ method changed the project’s duration from an overestimation of 47% to a saving of 50%, with an average savings of about 13% and a standard deviation of about 25%, which is consistent to a certain level with the literature that SSQ method provides a reduction in duration between 10% to 50%. For the CCPM-C&PM method, the project’s duration changed from an overestimation of 93% to a saving of 84%, with an average overestimation of 2% and a standard deviation of about 25%. Hence, this method resulted in longer project duration than CPM. As for the “cost” performance and looking at the data, we can conclude that CCPM was always an effective approach to reduce the cost for projects. The reduction in cost was the same for both CCPM methods; this can be explained by that the two methods have the same resource leveling. The percentage of savings in cost ranged from 10% to 54% with average savings of 43% and a standard deviation of 11%, which is consistent with the literature which states that the reduction in cost falls between 10% to 50%.

**References**