International Journal of
Science and Engineering Investigations vol. 2, issue 19, August 2013
ISSN: 2251-8843

Modeling Agility Evaluation in Critical Chain Project management (Approach of Dynamic Systems)

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Abstract- Since 1997 Critical Chain as a superior alternative to PERT/CPM for managing projects in multi project environments. The aim of Modeling Agility Evaluation in Critical Chain Project management is to maximize the system efficiency by finding an optimal planning for a better cooperation among various processes. In recent years many algorithms proposed to solve this problem, and most of them are based on heuristic methods. Several vendors have incorporated his ideas into software packages for industry use. In spite of using such systems companies commonly struggle with managing multiple projects and completing them on-time. In This paper extends Goldratt's model by proposing dynamic system's model that we found useful for managing projects at a local company.

Keywords- *Critical Chain, Project Management, Dynamic Systems*

I. Introduction

In today's competitive environment, delivery time between customer-supplier relationships has assumed a high level of significance that is non-negotiable. There is a growing trend among firms to rate their suppliers on several factors with on-time delivery being the most important.

Purchase decisions by many firms are no longer based on a supplier's relationship with its customers but rather its performance on timely delivery.

Steyn [2002] states that majority of all projects are managed in multi-project environment which makes it very challenging to complete then on time. In the last decade, Goldratt's Critical Chain methodology (CC) has evolved as a new technique to solve all project management problems Elihu [1997].

Since its codification in popular software applications, Critical Chain methodology has been widely embraced by project management professionals. Steyn [2002] considers Critical Chain methodology to be the new paradigm for project management which represents the longest chain of activity and resource dependent events. It removes contingency reserves from each activity and aggregates those provisions as Critical Chain Project Buffer (CCPB) at the end of the critical chain. Buffer penetration of CCPB simply implies its consumption when a critical chain task exceeds its given duration or when no work is done on that task.

In the last few years, several researchers (Trietsch 2005; Herroelen et al. 2002; Cohen 2004; Raz et al. 2003) have cast doubts on the merits of Critical Chain methodology for project management. They express much reservation in calling Critical Chain as "radically new" and endorse its lack of superiority when compared with other algorithmic methods for managing projects. On the other hand, Critical Chain's list of proponents include several researchers such

As Tukel [2006], Newbold [1998], Simpson and Lynch [1999], Homer [1998], Leach [1999], and Rand [2000].

They claim Critical Chain to be a "new and revolutionary" approach that not only reduces delivery time significantly but also significantly increases ability to meet schedule and budget commitments. In spite of such diverse opinion on the merits of Critical Chain among researchers, it continues to be widely used in industry for managing multiple projects. Clearly, any real world application of Critical Chain for managing projects requires use of commercial software packages such as Concerto. Hoel and Taylor [1999], Evans [2000], mention that a control mechanism, Called Buffer Management, lies at the heart of critical chain methodology. Under Critical Chain, project managers typically divide project buffer into three time zones each with its own set of managerial actions. If buffer penetration is restricted to the first or "Green" zone, which is farthest from the deadline, then managers need not take any action. In the second or "yellow" zone, managers formulate recovery plans in consultation with task owners and resource managers. In the third or "red" zone, managers implement corrective actions.

Commercial software packages support this simple and green-yellow-red color coded graphic of overall buffer usage. In this paper, we examine a limitation of Critical Chain methodology for project management that we experienced at a local company. In our view, Critical Chain's 1-dimensional focus on buffer penetration using color codes represents just half the picture. We propose a 2-dimensional model that considers both percent buffer penetration and percent job complete as more effective in managing projects. The paper also presents a new metric, Buffer Show Index, for managing project performance proactively in a multi-project environment. We provide an application of this model in the context of a real world case scenario.

II. Problem (The Case Company) Description

Esfahan Steel Company (ESC) is one of the largest manufacturers of sheet metal stamping dies. At any given time, ESC has an average of 70 unique jobs with a total of nearly 400 dies to produce. Currently, each die within each job has an average lead time of 32-34 weeks. This multi-project environment constitutes a very complex system of managing projects. Job scheduling has been a major issue at ESC for quite some time. Management commonly uses a "shoot-from-the-hip approach" for job scheduling. The company felt a need for a system that could not only monitor job progress, but also handle multiple projects simultaneously. After much deliberation, the company decided in favor of implementing Goldratt's Critical Chain model using a commercial project management software package called Concerto.

III. Project Management by Buffer Penetration

As Globerson [2000], Herroelen [2001], Lawrence [2010], Capers [2004], Concerto incorporates Goldratt's Critical Chain concepts for project management. It uses Microsoft Project as the front end, a web client, and a three-module icon menu. Once a manager builds the network for a project, Concerto determines the critical chain for that network. It adds a buffer at the end as well as determines all tasks that feed into the chain. These are used so that non-critical chains will not affect the Critical Chain. The firm calls these intermediate buffers the Critical Chain Feeder Buffers (CCFB), and the buffer that is added at the end of the project the Critical Chain Project Buffer (CCPB). Now that the network is in the system and buffers added, the project is ready to be managed by its buffer.

5113 Concerto software monitors and prioritizes multiple projects by categorizing them into color coded - green, yellow, and red – zones based on their buffer penetration. The Green zone represents CCPB penetration from 0-33%. It is associated with the fact that the project is moving smoothly and does not require any additional concern. As the project moves through the system and uses buffer, it will undoubtedly reach the yellow zone. The Yellow zone represents CCPB penetration from 34-66%. It is associated with "Caution" and the fact that the project now deserves some attention and management needs to formulate recovery plans. The Red zone represents CCPB penetration of 67-100% and is commonly associated with the project being in trouble of missing its due date. At ESC we found this color coded one dimensional focus on buffer penetration to distort reality easily. The actual colors chosen create a subconscious correlation among workers that often becomes misleading. Red color level is always associated with "danger" or "project in trouble" mindset. What if a project came into a department categorized as red but already 90% complete.

Is there any necessity for the task manager to panic for missing the due date? In weekly meetings to review project status, oftentimes, spreadsheet forms showing colors, CCPB

Penetration levels, and project due dates are used to determine the level of action to be taken. Several projects end up receiving too much or too little attention in contradiction to their actual need. We found this anomaly to be a result of upper management's over reliance on color levels and buffer penetration and not having an accurate assessment of a project's current level of completion.

IV. THE PROPOSED MODEL

We propose that color code based 1-dimensional focus of commercial Project Management software's on buffer penetration alone for managing projects does not help in their timely delivery. It is to be noted that red is not always bad and at some point all projects would enter the red level. All the stake holders - management, task managers, and employees - must be sensitized against this psychological correlation of red being always bad. We propose that a 2-dimensional graphical model that considers both percent buffer penetration and percentage Critical Chain job complete (henceforth referred to as just "percent job complete") as more effective in representing the reality of multi-project environment. The model also helps to minimize the psychological correlations associated with the color levels. Figure 1 shows the proposed 2-dimensional model. Series 1 line in the figure with a 45-degree slope shows the theoretical rate at which the buffer should be consumed i.e. at 50% job complete, the project should have 50% buffer penetration. Figure 1 also shows that all projects would eventually go into red in order to finish.

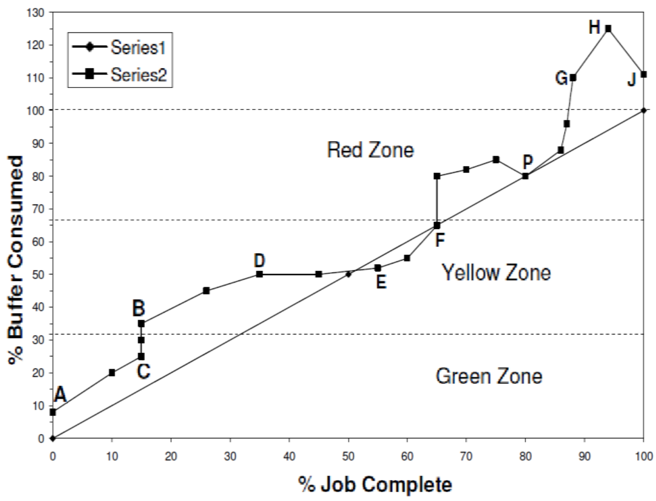

Figure 1. Project tracking graph

In the proposed 2-dimensional model, to know the current status of a particular project, one only needs to know the latest coordinate points, (X, Y) representing % job complete and % buffer penetrated respectively. Points (X, Y) are given by :(X, Y) = (% job complete, % Buffer Penetration) where X =

(Original number of days – Remaining duration of project)/ (Original number of days) *100

Original number of days = Finish Date – Start Date

Remaining duration of project = Project end milestone – Today's date 5114 and Y = (Buffer consumed/Original scheduled project buffer)* 100 Once X and Y values have been calculated, the relationship when paired gives more valuable information on project progress.

For any given project, its progress can be mapped on this 2-dimensional plot after collecting X and Y data points weekly. These points can now be connected and the project's weekly performance compared against the theoretical or 45-degree buffer show rate line. A steeper (greater than 45-degree) or a flatter (less than 45-degree) slope of the project progress line between any two weeks would indicate buffer consumption at a higher or lower rate respectively than the corresponding theoretical value. A flatter slope would have the desired effect of saving or recovering back the buffer. The weekly progress on a project can now be seen visually on the 2-dimensional plot. In a multi-project environment, the 2-dimensional plot can become too cluttered if all projects are mapped on to the same graph. To see and compare multiple projects at a time, we propose the use of a new metric, Buffer Show Index (BSI) in a tabular format. Thus, we define the metric, Buffer Show Index as:

$$(BSI) = \left(\frac{\text{change in \% buffer consumed}}{\text{change in \% job completed}}\right) = \left(\frac{Ycurrent - Yprevious}{Xcurrent - Xprevious}\right) \quad (1)$$

Ideally the Buffer Show Index should be less than or equal to 1. Any value greater than 1 would imply consumption of more than allotted buffer. Thus, this new metric would provide a better comparison of project status in a multi-project environment.

V. MODEL APPLICATION

Table 1 shows weekly progress for a typical project at ESC. Each data point (X, Y) reading was 5115 taken weekly for the duration of the project. Figure 1 shows the corresponding weekly project progress graphically as Series 2. By visually looking at Point A which shows buffer penetration without any progress, a project manager may try to proactively find the bottlenecks that caused the particular project to start behind schedule in order to avoid similar mishaps in future.

TABLE I. WEEKLY PROGRESSION FOR A TYPICAL PROJECT AT ESC

Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
% Buffer Penetration	8	20	25	30	35	50	55	50	45	55	65	80	82	85	80	88	96	110	125	111
% Job Complete	0	10	15	15	15	26	35	45	55	60	65	65	70	75	80	86	87	88	94	100

The vertical line segment BC represents a scenario where no work is being completed but the buffer is still being penetrated. Even though it is below the red level, it can alert the management to proactively find the assignable cause for the project sitting idle and take corrective action.Segment DE represents very efficient task completion where job completion rate is higher than the buffer consumption rate with nothing to worry. Segment EF shows an interesting outcome.Even though it shows the desired effect of being to the right of the theoretical line, yet its slope being greater than 45 should signal alarm to investigate further. A cursory look at point P (80,80), even though in the red level may signal the manager not to panic since the project is on track. Segment GH illustrates how uncertainty can hit right at the end of a project when it can be most devastating. As shown, it resulted in the project to be shipped late even though just 4 weeks prior it was right on track at the point (80, 80). Point J represents a scenario where % buffer consumed can exceed 100%.

Previously at ESC, during weekly meetings only buffer penetration was discussed, and necessary action was taken on projects as needed. Often times, the % job complete were never discussed since it was assumed that all in attendance knew the status. Now the work team is better positioned to initiate early discussions when the % job complete and % buffer consumed are found to be far apart.

In weekly meetings, ideally, each project should be reviewed by its graph analysis. However, at ESC which typically has over 75 different projects implemented at any given time, the weekly document can become too large. Therefore, to quickly compare the performance of multiple projects a simple table containing the proposed buffer show index may better suit the weekly meeting format.

Table 2 shows how the Buffer Show Index values are used to onitor multiple projects at ESC by using actual data on 18 projects. The report in Table 2 provides a quick snapshot on the status of multiple projects to the management. It is intended to focus a manager's attention to projects that truly need corrective actions. For example, Table 2 shows that for project numbers 1936 and 1941, the BSI values are "infinite" implying consumption of buffer without any work being completed. Such projects need immediate management attention to determine assignable causes for project idleness.

5116 Similarly, for project numbers 1954 and 1955, the BSI values are significantly greater than 1, implying buffer consumption rate to be significantly greater than the job completion rate. These projects are also prime candidates for management attention. For projects with BSI values equal or closer to 1 buffer consumption and job completion occur at almost the same rate.

One may conclude that the progress of these projects is on track for the time being and no intervention is needed. The table also shows BSI values of less than 1 for a few projects implying buffer consumption occurring at a rate lower than that for job completion. Such projects do not need immediate management attention. The negative BSI values represent a gain in buffer time during the course of job completion. Thus, BSI metric can prove to be an effective tool to proactively manage multiple projects before it gets too late.

TABLE II. MANAGING MULTIPLE PROJECTS USING BUFFER SHOW INDEX

Project Number	%Job Completed 1/14/06	%Buffer Consumed 1/14/06	%Job Completed 1/21/06	%Buffer Consumed 1/21/06	Changein %Job Completed	Changein %Buffer Consumed	Buffer Burn Index (BBI)
1616	51	220	52	213	1	-7	-7.0
1935	50	95	52	94	2	-1	-0.5
1936	58	125	58	142	0	17	Infinite
1937	55	84	57	84	2	0	0.0
1938	42	0	44	0	2	0	0.0
1939	47	47	55	55	8	8	1.0
1940	53	53	59	60	6	7	1.2
1941	48	100	48	107	0	7	Infinite
1952	43	90	58	101	15	11	0.7
1953	43	55	47	56	4	1	0.3
1954	47	58	50	69	3	11	3.7
1955	47	89	48	99	1	10	10.0
1956	40	109	49	99	9	-10	-1.1
1957	44	38	52	43	8	5	0.6
1961	41	67	53	77	12	10	0.8
1962	32	76	50	75	18	-1	-0.1
1995	11	2	16	0	5	-2	-0.4
1997	5	6	11	13	6	7	1.2

VI. CONCLUSION

In spite of codification and wide acceptance of Critical Chain methodology for project management, companies continue to face challenges in its implementation under multi-project environments. It is expected that by using the two dimensional model, based on % job complete and % buffer consumed, managers will have a more accurate picture of each project's reality (status). As each project progresses, the history can be recorded in graphical form and simultaneously compared to the theoretical show rate. From this graphical representation the users (management) will be able to identify the trends and steep sloped tasks that would require additional review.

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