Broken Critical Chains

Introduction

Every Project Manager is aware of the significance of Critical Paths and Critical Path Analysis. A slip on the Critical Path will cause a slip over the entire Project. However, how about if the Critical Path tasks are completed early? In theory the Project should come in early. In practice, this does not happen too often. If we were doing things right we should see as many Projects come in early as come in late (all things being equal). Of course we do not! This paper explores some of the work done by Eli Goldratt on the topic of Critical Chain and by Lawrence Leach on Critical Chain Project Management.

Here are some of our reasons (excuses) for Projects failing to deliver on time and within budget.

1. Lack of User Inputs 12.8%
2. Incomplete Requirements & Specifications 12.3%
3. Changing Requirements & Specifications 11.8%
4. Lack of Executive Support 7.5%
5. Technology Incompetence 7.0%
6. Lack of Resources 6.4%
7. Unrealistic Expectations 5.9%
8. Unclear Objectives 5.3%
9. Unrealistic Time Frames 4.3%
10. New Technology 3.7%

Other 23.0%

Luckily I have a host of these statistics to show how our projects fail and that it is not really our fault. After all, we are not responsible for many of the above reasons. And yet, in the face of this acknowledgement of impotence we continue with our planning process unchanged, bolting in larger and larger amounts of contingency or planning to more and more detail in an attempt to reduce the unknowns. And still our Projects fail and Murphy triumphs again!

Estimation

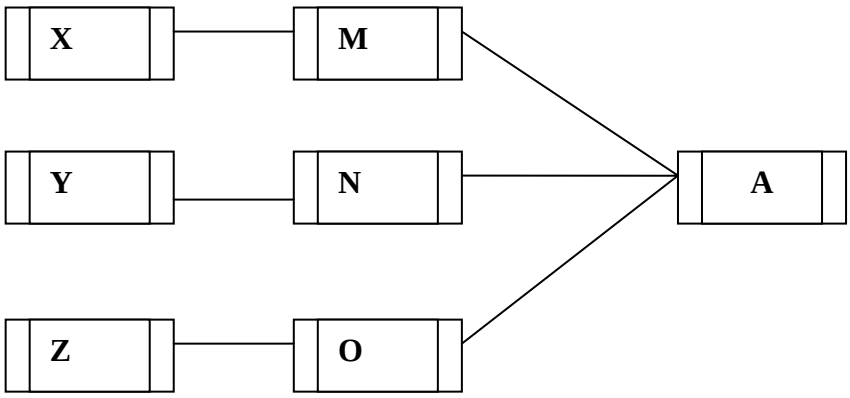
Let's examine some of the basics of Project Management and Estimation.

In the IT world Estimation is still a black art. Until we really are able to build systems mainly from reusable components each project will have a large unknown element which we will have to "guesstimate". This is an uncomfortable fact that underlies much of the detailed work on Project Planning. In many cases, we do not know how we are actually going to do what we need to do!
So Estimation, which is critical to the Planning process, is a high risk business. The standard method of dealing with uncertainty in estimation leads to the addition of

Contingency, or "padding" as it is more popularly known. But, surely, if we were getting our estimates (padded or otherwise) right, we should see as many project tasks come in early as come in late? This does not seem to happen and here we have our old friend, Parkinson's Law, coming in to play. It is basic human nature to want to do one's best. If a task is completed early, then it will be polished and honed ad infinitum or at least until its delivery date. There is little motivation for early delivery for there is little benefit and some risk to those concerned. The risk comes from the fear that the product will not be "good enough" or the deliverer will be accused of overestimation. The result is that tasks which slip, slip, and those which finish early, tend to finish on-time. This is a two-edged sword for the Project Manager. Part of the problem here, and a clue to the answer, is that the management and ownership of the task-level contingency (padding) rests with those responsible for performing the task.

Scheduling with PERT Charts

For a moment let's back away from this interesting issue and look at our Project Planning. We are all familiar with Pert Charts, Gantt Charts and the like. Below is a simple example showing three parallel task streams which are predecessors of Task A and Task A cannot begin before all of the three streams have completed.



If the PM has done a good job and each of the paths feeding into A have a probability of 90% completing on time, then what is the probability of A starting on time?
The answer is approximately 73%. Try the calculation with 6 streams at the same probability. The result is about 53%, so roughly evens. Given the amount of planning which goes into a real project, this simple calculation is a shocking result. Of course a real project is much more complicated than this example and then the probability of later tasks starting on time must be approaching a very low number indeed. I am hesitant to say "zero", but perhaps it is? It would explain a lot.

So here is our situation. We do not benefit from tasks completing early because of "polishing time" (Parkinson's) and our planning basis is extremely tenuous due to tight

coupling and sensitivity to out-of-control events (Murphy's). Critical Chain Scheduling breaks this deadly embrace.

Critical Chain Scheduling

I hope that the discussion above has whetted your appetite for more detail, and I can supply it partly here and by referring you to the work of Eliyahu Goldratt and the Theory of Constraints and Critical Chain Scheduling. Unlike many Management Theories, this one has some solid theoretical basis and some practical techniques for adoption. Rather than step through the theory leading to Goldratt's conclusions I will present the proposed steps and discussions as we go along. Interested readers are referred to the references at the end of this article.

So far we have identified the mathematics of scheduling, indicating that task starts are extremely likely to slip, and also that early-completion of tasks is relatively unknown due to the Parkinson's Law effect. We of course will not be forgetting Murphy's Law and the never-ending fun that he provides.

Critical Chain Management focuses on the following:

1) Identification of Project Constraints.
2) Exploitation of Constraint
3) Subordination of all everything else to (2)

1. Identification of Project Constraints.

A Critical Chain is essentially the Critical Path but it also takes into account the resources used by the Critical Path. Currently, pure Critical Path typically ignores resources and allocates Risk within each task. We have shown that mathematically, it is unsafe to simply focus on the Critical Path due to the uncontrolled dependencies and Parkinson's Law effects.

2. Exploitation of Constraint

The Constraint in a project is the longest path to delivery. The key then is to protect all elements of this chain from unplanned deviation. The methods are:

1) Risk Aggregation
The removal of padding from each task and the allocation of a padding pool, the Project Buffer – see later

2) Buffering of Critical Path from "feeding" paths
Providing buffers to the task-chains feeding in to the Critical Chain, so as to isolate it from unplanned variations.

3) No multi-tasking of resources.
Encourages timely completion, finishes tasks earlier so that they can be handed on.

3. Subordination of everything else to (2) above

This is basically the idea that if the Critical Chain is taken care of (that is, monitored and managed) then, in general, the rest of the project will take of itself. The reason this works is because of the use of the Risk Aggregation from (2.1) above and is explained more fully below.

Critical Chain Management in Practice

As ever, the best Management Practices take into account the people being managed, and this is no exception. There needs to be a culture in place which does not unfairly apportion blame. If the culture is unduly aggressive in this respect then the padding around task estimates tends to become greater.

Estimations are requested and provided in terms of 90% probability of completion and 50% probability of completion, by the given date. For the latter case, we should expect as many over-runs as under-runs as the project progresses. With this many over-runs it is obviously important to have a positive culture in the organisation or else there will still be over-padding to protect the guilty from attack. Aggressive scheduling really only becomes possible with the proper motivation and checks in place to so as to ensure professional behaviour.

Scheduling is performed on the basis of the 50% figures. The total of the differences between the 50% and 90% estimates over all tasks is aggregated and allocated to the **Project Buffer**. However, the total allocation to the Project Buffer may be less than the total of the differences. The % difference is based on Risk and can be as low as 50%, depending on the judgement of the Project Manager. Here is an immediate benefit. We have exposed the total risk (padding) and been able to reduce it. Moreover the risk contingency is a public visible amount able to be managed and monitored by the PM!

When introducing Critical Chain there is usually a degree of suspicion and downright fear within the team. One way around this is it actually allocate a Project Buffer such that the total estimated time of the project with Critical Chain is exactly the same as it would be with conventional Critical Path planning. This removes the fear factor. However, because the contingency is in the Project Buffer and not within each task, there is still the pressure on team members to finish on the shorter estimates, and development areas getting into trouble are that more visible with this planning method. The expectation is that this model will bring the project in ahead of the actual estimate because of this visibility. On later projects, based on experience of previous Critical Chain projects, the

actual apportioning of the Project Buffer can be less than 100% thus committing to a more challenging schedule.

In addition to the Project Buffer, there are also buffers inserted in to the plan specifically to protect the Critical Chain. These buffers are known as "Feeding Buffers" and provide isolation of the Critical Chain from Murphy.

SYNERGY

It is always nice when the "2 + 2 makes 5" effect puts in an appearance. It gives the feeling that something is fundamentally correct. Well, with Critical Chain we benefit from the synergy of buffering together with reduced management overhead of the project. The clue here is the Buffers. The state of the Buffers, in terms of their consumption and rate of consumption, combined with the current stage of the project, is a very good indicator of the state of the project. Remember that the buffers have been introduced to isolate the Critical Chain from unwanted variations. The buffers therefore indicate how much of this unwanted variation has occurred, because they are only consumed when estimates have proven to be wrong. For the PM, the traditional detail of multi-task awareness can be reduced to core-task monitoring based on buffer consumption. This integrates well with the Scorecard reporting techniques, where focussed reporting rather than detailed is the order of the day.

Summary and Conclusion

Because of the scope of Critical Chain Scheduling it is hard to isolate just one single benefit. Instead there appear to be a whole raft of them, each of which would encourage its further investigation. Amongst these are:

- An aggressive target duration schedule minimizes impact of "Parkinson's Law."
- Buffers allow resources to focus on work and protect against "Murphy's Law"
- Buffer Management provides focus for schedule management, avoids unnecessary distraction, and allows recovery planning to take place when needed, but well before the project is in trouble

There are a few sensible ground rules for Project Managers wanting to take up this challenge. These are:

- Avoid resource multi-tasking and the extended lead-time which results. Management must take responsibility for protecting resources from competing priorities that drive multi-tasking.

- Account properly for resource contention. Resource dependency is as real as task dependency when determining what is critical for the project.

- Track the consumption and replenishment of buffers. The project team must plan and act to recover when necessary, as dictated by buffer status, but only when necessary, in order to avoid unnecessary distraction of project resources who should be allowed to focus on their work.

It is refreshing to find something as new and interesting as Critical Chain Scheduling. Any active Project Manager should at least be aware of the issues raised by Critical Chain and hopefully have the opportunity to put its principles into place. In the Agile world, where implementation progresses in rather short and speedy "Sprints" or iterations, Critical Chain Analysis would appear to be the ideal scheduling solution. See the deference to the Mike Cohn book, "Agile Estimating and Planning" below.

I shall be addressing this subject within my Project Management training course, where I hope to have a wide-ranging discussion on these issues.

About the Reviewer

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References

Goldratt, Eliyahu M. – Critical Chain, North River Press, Great Barrington, MA.

A.Y.Goldratt Institute – TOC Project ManagementWorkshop, A.Y.Goldratt Institute, New Haven, CT.

Newbold, Robert C. – Project Management in the Fast Lane: Applying the Theory of Constraints, St. Lucie Press, Boca Raton, FL.

Lawrence Leach – Critical Chain Project Management

Fredrick Brooks – The Mythical Man-Month

Peter Senge – The 5th Discipline Fieldbook

Kaplan and Norton – The Balanced Scorecard

Mike Cohn - Agile Estimation and Planning, Prentice-Hall