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From Efficient to Effective Project Teams

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Abstract:
Purpose and Originality: The purpose of the study is to analyse the throughput of projects in project portfolios that share common resources. The study is focused on demonstrating drawbacks of traditional practices of managing project portfolio, while on the other hand showing sequential improvement steps how to significantly improve project portfolio throughputs. Notably, this study presents the benefits by changing policies and rules on how project tasks are planned, queued, and scheduled in such an environment.
Method: The analysis was carried out using a quantitative approach that involves use of simulator, which was capable of recreating conditions similar to the conditions in a controlled project environment. In the simulation we provided the means to control different policies and rules how project work is managed, especially staggering of project tasks and addressing human behaviour such as Multitasking, Student Syndrome, Parkinson Law, which are necessary for the systematic evaluation. In particular, we looked into the Theory of Constraints applications for project management and how we can apply it in a project portfolio that uses shared resources to increase throughput.
Results: The results shown in this study emphasizes the need for a change of traditional working policies, rules (and measurements), and even a culture within an organization when managing project portfolios with shared resources. The simulations demonstrate that staggering the release of work into the system reduces workload on most critical resources and increases predictability of project deliverables and throughput. Moreover, introducing the Theory of Constraints methodology in project portfolio, also addressing human behaviour additionally improved the performance of the portfolio – system.
Society: We strongly believe that this analysis will help to understand the benefits of managing project portfolios differently, compared to a traditional approach that focuses on a system (organization) and not at an individual level. Moreover, significant increase of the project portfolio throughput is expected and, as a consequence improved competitiveness of organizations on the market.
Limitations / further research: We suggest further research using Theory of Constraints tools and applications in Agile / Dev(Sec)Ops environment.

Keywords: managing project portfolio, project management, theory of constraints, critical chain project management, team performance.

1 Introduction

Organizations consider project management to be the competitive advantage of the future. In recent years, IT projects have proven to have a significant impact on improving the business processes and better customer services, thus enabling organizations to become more competitive in the global market. However, there is significant space for improvement. The

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Standish Group Chaos Study report (Standish Group, 2015) defined that project success is limited to the triple constraint, which has been the standard for the Project Management Institute for a number of years - schedule, budget, and scope. Using the triple constraint, the Standish Group evaluated projects as *successful*, *challenged*, or *failed*. Successful means that the project met all three of the triple constraints: schedule, budget, and scope; challenged that the project would have met two out of three constraints (e.g., delivered on-time and on-budget but not with the desired scope); and failed means that project was abandoned before it was completed, or completed but not used.

The results of this study, shown in Table 1 shows that in 2015 only 29% of software development projects were completed on-time, on-budget, and on-scope. Moreover, 19% of projects have been abandoned before they were completed, and 52% of the projects spent more budget, scope or time compared to their original evaluation.

Table 1. Standish Group Chaos Study revealing success rate of IT projects from 2011 to 2015

	2011	2012	2013	2014	2015
Successful	29%	27%	31%	28%	29%
Challenged	49%	56%	50%	55%	52%
Failed	22%	17%	19%	17%	19%

To deal with this situation, we have examined several approaches how projects are traditionally managed. As the primary improvement approach in this paper, we will use the methodology that was introduced by Eliyahu M. Goldratt (Goldratt, 2018), called the Theory of Constraints (TOC). TOC assumes that any system or organization can be seen as a network of interdependent elements or processes. These systems are analogous to chains or chain nets. Similar to a chain, the throughput of the system is limited by the weakest link - the constraint. This means that only improvements, which are made on constraint (weakest link), will result in significant improvements in a system. On the other hand, any improvements in all other places of the system will result in higher costs (i.e., investment) without any or very slight detectable improvement result. In order to address this, TOC enables organizations to find (few) constraints, exploit them, and subordinate other parts of the organization to that constraint to obtain the most of the existing system. To achieve this, TOC changes management mindset from optimization of individual organization units or departments to system-wide approach by focusing on a throughput of a system (local efficiency vs global efficiency). TOC's key processes are focused on removing barriers that prevent each part of the system from working together as an integrated whole.

2 Theoretical framework

In this chapter, we will describe the main topics, from the project execution point of view, that affect the performance and effectiveness of project teams, thus throughput of project(s). Additionally, we will show effects of unappropriated management of Work-In-Progress (WIP) and devastating effect of focusing on efficiency of resources instead of focusing on effectiveness of the system. Moreover, we will also demonstrate negative consequences of human behaviour and Murphy's Law (i.e., "Anything that can go wrong will go wrong)" in traditionally managed project portfolios with shared resources. Robinson & Richards (2010, p. 3) shows examples of human behaviour such as student effect and Parkinson's law. Student effect addresses a situation when there is more than suffient time to complete a task, but employees (aka human resources) let time pass before any serious effort is put into its completion (i.e., "Why do it today, if you can leave it for tomorrow"). On the other hand, Parkinson's law addresses situation where human resources usually take as much time as it is defined to complete a task, regardless of whether they finish it early (i.e., work expands the time that is available for a task). In the end, we propose TOC application for managing projects, called Critical Chain Project Management (CCPM) that was described by Millhiser & Szmerekovsky (2008).

WIP refers to a component of a company's inventory that is partially completed. In IT environment, this means unfinished tasks. Ronen & Pass (2007, p. 147) stress that the main evils of high WIP are reduced performance of the organization, long response times, reduction of throughput, high operating expenses, diminished quality, diminished response to market and technology changes, and so forth. As we can see from Figure 1, WIP in a system plays an important role in project(s) throughput. The goal is to have the right amount of WIP.

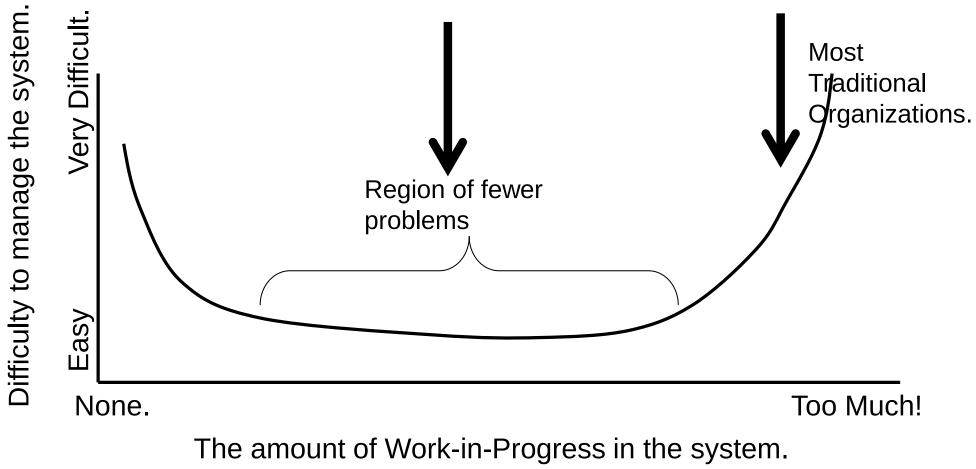


Figure 1. Bathtub approach by Holt, et al, 2014, EM 530 Lecture materials, Washington State University

When organizations are facing low throughput of projects, Aljaž (2014, p. 2) recommends reducing WIP by freezing or canceling at least 20% of already approved project activities. This provides an opportunity that resources can prioritize remaining tasks (projects) and to begin completing them. As throughput will start to improve, there will be less unproductive work needed – e.g., such as writing reports why some project activities are late. This way we gain additional available time of resources to work on project tasks. The first positive effects we will see in a short amount of time, typically in a few months.

Moreover, resource utilization has deep impact of the performance of the organization. In order to understand this impact, Kingman's formula (1961, p. 902) gives an approximation of the waiting time of the parts for a single process based on its utilization and variance. This equation (or more precisely approximation) shows two factors that influence delivery time and queue length. One important factor is utilization. The higher the utilization is, the longer is the queue. Eventually, the queue will approach to infinity as utilization approaches 100.

In order to understand the impact of resource utilization, we have used an example of five interdependent human resources that work in a process. All of them are utilized at 90%, which means that every task will take approximately 90/10= 9 x longer than initially planned. A simple task of one workday by every resource with 90% utilization (may) at the end take 9 days x 5 = 45 days, as shown in Figure 2.

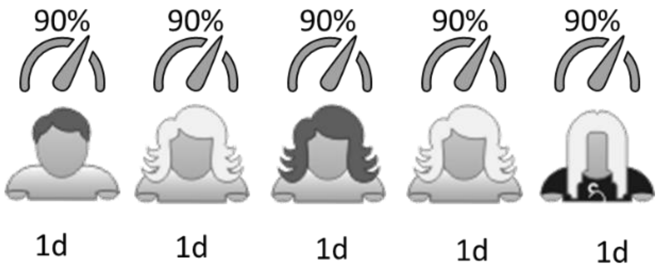


Figure 2. Resource utilization example following the Kingmann's Formula

The next improvements are focusing on the reduction of multitasking. Russ & Crews (2014, p. 139) defines multitasking as activity when human resources try to perform two or more tasks simultaneously, switching from one task to another, or perform two or more tasks in rapid succession. Simple exercise, shown in Figure 3, gives a good indication on throughput in a multitask environment – the question being should we execute as shown in the first row or second row?

M U L T I T A S K	1 2 3 4 5 6 7 8 9
Or	
M 1 U 2 L 3 T 4 I 5 T 6 A 7 S 8 K 9	

Figure 3. Effect of multitasking. Available from: http://bit.do/ePmau.

Russ & Crews (2014, p. 151) research study showed at the individual level that up to 30% of (working) time could be wasted while switching between tasks. If we extrapolate these results to the organization level, the results are even higher as described in their research study. The main negative effects are related to unsynchronized priorities by human resources working on those tasks and high WIP for managers who are managing them – i.e., lack of management focus. Unsynchronized priorities show that human resources or teams instead of working together on the same streams in tandem to complete it, each person or team is focused on different streams, and these streams (usually) do not overlap. Also, managers are flooded with too many active streams and projects at the same time that need support, thus providing non-optimal support for human resources / teams that need their support and proactivity.

As such, we will follow the guideless described by Holt et al. (2014) and stagger projects by project portfolio priority. Clearly, top-ranked will have all available resources and will be able to move quite quickly. Other lower-ranked projects throughput will be accordingly to resource conflicts between all approved projects. If there are fewer resource conflicts, the throughput of the projects will increase, even doubled if there are no conflicts. This will work until the number of projects will saturate the system, having more and more resource conflicts between projects, thus resulting in decline throughput of projects. By adding additional projects in a system, it will even more drastically reduce throughput until resource conflicts will be so high that the project throughput will almost stop, and human resources will suffer from this chaotic environment (remember utilization issue and Kingman's formula).

As a way forward to improve throughput of the project portfolio, we will first introduce a policy, which will approve the new project / tasks based on highest business / customer value and availability / utilization of critical resources. In organizations where cost accounting is the primary tool for approving projects, there is a need to do detailed estimations of needed work to get the most detailed estimates and the most detailed associated costs. Due to the complexity of this activity, this is usually completed by the most experienced and critical resource. However, Agile Upgrade (2019) indicates that estimates are almost always wrong. Therefore, our most experienced and critical resources spend a lot of effort and time on unproductive work. Aljaž (2014, p.3) demonstrated that using simplified task estimation and associated cost calculations increase the availability of critical resources and additionally improve throughput of the system. Therefore, we will need to change policy on how estimates are conducted and used, including associated project approval process, if needed. We will use simplified solution for workload estimates that will increase availability of critical resources. Usman et al. (2017 p. 643) showed different approaches to how estimations could be conducted in Agile software development environment.

Ronen & Pass (2007, p. 85) describe powerful and robust TOC solutions that are intended to manage the flow of work through a (development) process rather than managing the capacity of resources is called Drum-Buffer-Rope (DBR). It is designed to protect against general cause variation that cannot be removed from the system and specific special cause variation (e.g., Murphy). As basis for its work, it uses the first three steps out of five focusing steps defined by TOC, which is to (1) identify the system constraint, (2) decide how to exploit the system constraint, and (3) subordinate everything else to the above decisions. The basic principle of DBR is shown in Figure 4.

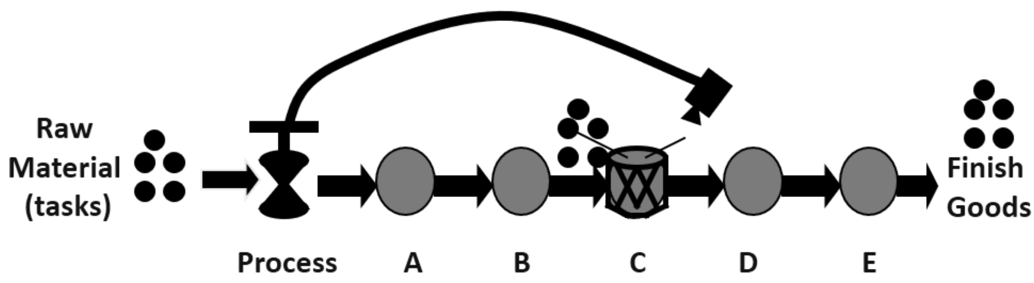
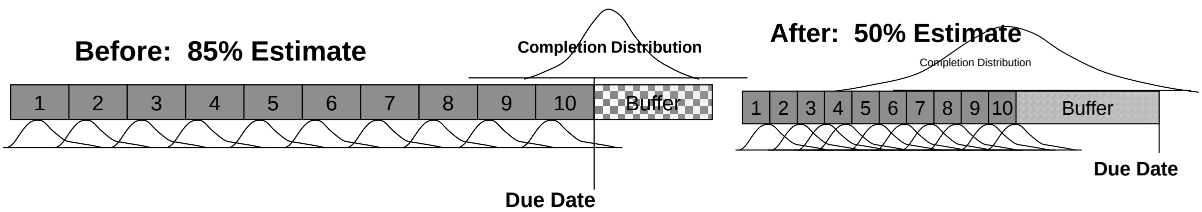


Figure 4. Basic principles of Drum Buffer Rope (DBR) by Holt, et all, 2014, EM 530 Lecture materials, Washington State University

As we can see, resource C is the weakest link – the constraint of the system. Therefore, we need to control the pace of new tasks based on the pace that resource C can handle. Moreover, resource C has also a buffer to protect itself against variability and a Murphy of execution done on the first two resources, resource A and resource B, respectively.

With the DBR approach, we can identify that some of the resources will be part of the time idle, due to the *rope* process of the DBR – not releasing more tasks as the constraint (i.e., Drum) is able to handle. That approach is contradictory to a well established work policy, where human resources need to work, for example, 8 hours per day, 40h per week – if there is no work available, managers are required to find it. Change of organization working policy, associated measurements, and cultural changes need to be addressed in order to fully throttle throughput that can be achieved using the DBR approach.

In order to address management of project portfolio with shared resources, Millhiser (2008, p. 1) showed the DBR-like approach for project management and called it the Critical Chain Project Management (CCPM). It should be noted that CCPM is not only project management methodology but also protects against Murphy and addresses human resources behavior such as student effect and Parkinson's law. Moreover, CCPM does not change the logic of the project tasks, it just reduces duration of task for 50% and returning 50% of removed task duration (safety) to the strategic place in project – project buffer (i.e., variation of task execution can be better managed on central place as on individual tasks).



Before CCPM scheduling After CCPM scheduling

Figure 5. Example of CCPM scheduling by Holt, et all, 2014, EM 530 Lecture materials, Washington State University

Figure 5 shows that each project has its own tasks buffer (safety) and all tasks are estimated with an 85% confidence level. Adding additional protection at the end of the project (buffer) to protect due date will not produce the desired results – remember student syndrome and Parkinson's law. With 50% reduction of task duration and returning 50% of removed safety in the project buffer results in 25% reduction of project duration. Figure 6 shows an example of a project plan before and after CCPM scheduling using cc-(M)Pulse tool (Spherical Angle, 2005).

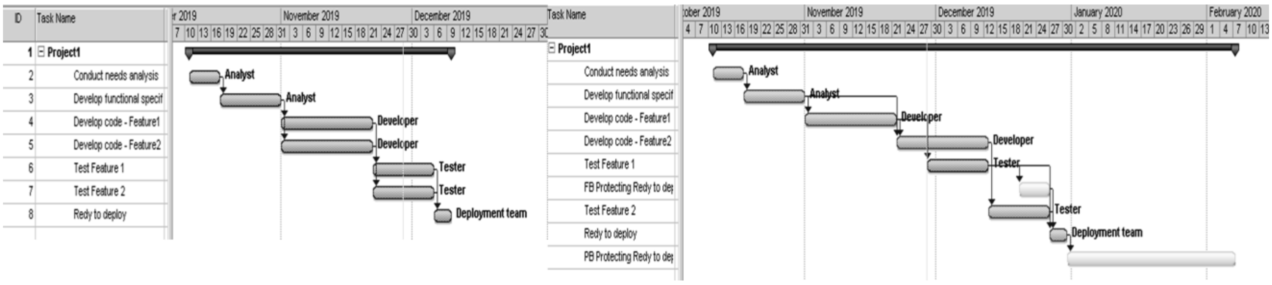


Figure 6. Simple project before and after applying CCPM scheduling

When we introduce CCPM for managing project portfolio, we also need to modify certain working policies, rules, measurements, and culture within organizations. Primarily, we need to change company policy that resources are not any more accountable for their estimates. This is in contradiction with traditional management practice where we *hold resources accountable* for their estimates.

Additionally, buffers that are part of CCPM scheduling approach represent cumulative safety of project tasks. Resources that are working on project tasks need to accept and understand that buffer is available for anyone on any project task. As soon as project team accepts this approach and the trust is established, the throughput of project portfolio will increase significantly – providing clear working priorities and focus.

3 Method

In the paper we are using a quantitative approach that involves the use of simulation technologies (simulator), complemented with other testing methods such as analysis of international literature, observations, and personal experience. Reasons to use simulation technology resides in a fact that it is challenging to analyze the same project with different parameters and approaches, as we are not able to provide the same project conditions even if the scope is the same. There are too many excuses and reasons for differences, too much variability in task execution and every issue is different.

It is much better to use a simulator to analyze one or more projects many times with different parameters and monitor the results. The analysis we carried out using in simulation environment, which was capable of recreating conditions similar to the conditions in a controlled project environment. The simulation environment represents a managed environment that will provide the means to control the separate parameters, such as Multitasking, Student Syndrome, Parkinson's Law, which are necessary for the systematic evaluation of their influence on project execution with different approaches.

For the evaluation, we used the PmSim simulation tool (Elyakim, 1998), as shown in Figure 7, that is used in Project management academic and research work at Washington State University ETM program. It enables comparative analysis of the results collected in this study. The simulated environment consists of three identical projects with the same resources. For each resource, initial task duration is defined as 22 days, with skewed distribution and confidence level at 90%, as recommended by Holt et al. (2014).

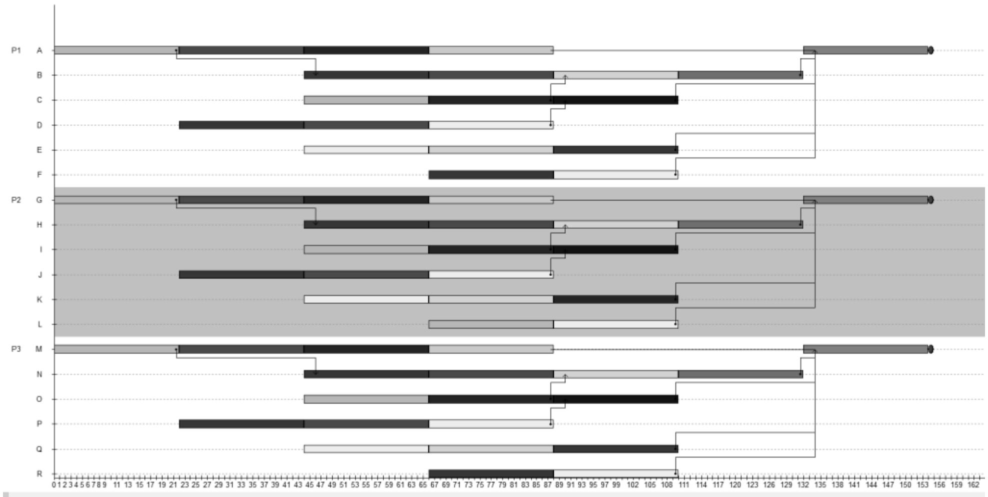


Figure 7. Project portfolio environment with three projects in simulation environment

The initial analysis we carried out with a more complex configuration environment that included additional projects and more resources. However, we found that increasing the number of projects and resources does not give any additional information about the throughput of the project portfolio environment that would justify the increased complexity and the scale of the simulation.

For each simulation iteration, we have completed 1,000 simulations of Project portfolio environment with three projects, which provides us with a sufficiently stable network condition for the analysis. We used the skewed distribution to simulate the behavior of the task execution by each resource in a project. The skewed distribution was used because of its similarity with the actual distribution of task execution, and because it is also often used in the literature as indicated in Holt, et al., (2014), which makes it easier to compare results.

4 Results and Discussion

Figure 8 provides an example of a project portfolio with three projects that share the same resources (*NB.* Each resource is marked with different color). All three projects were approved for execution on the same day. Planned duration of all projects was 154 working days. We can see that the planned finished duration of all projects is unrealistic. This is immediately visible on the first simulation days, as the first resource would not be able to work on three projects simultaneously. As simulation is continuing, multitasking, student syndrome, and Parkinson's law comes into effect and results in a situation that no one from (top) management in a company would accept – the finished date of projects would be too long.

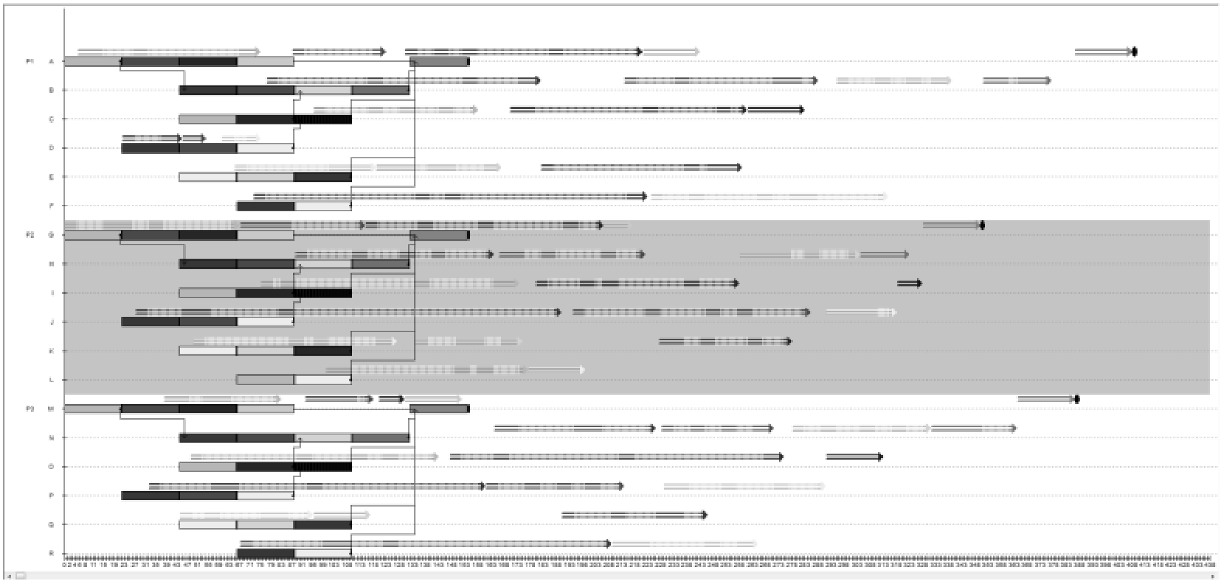


Figure 8: Results of project portfolio execution

This devastating effect is visible in Figure 8, where none of projects would be completed in planned duration. Moreover, expected duration to complete project has increased from 154 to 421 days, with 90% probability – almost 3 times longer than planned, as shown in Distribution of project completion time and probability to be finished on planned Figure 9.

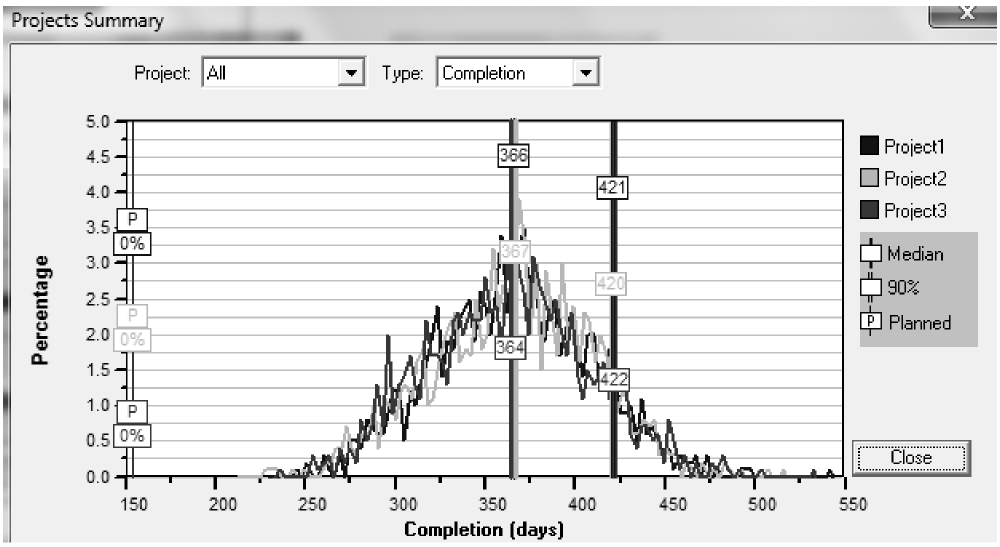


Figure 9. Distribution of project completion time and probability to be finished on planned duration

To improve the situation, we will use the first step of the five focusing steps of TOC – identify system constraints. In our simulation model, we can identify resource that is a system constraint at the project portfolio level. Next, following the second step out of the five focusing steps, we will need to decide how to exploit systems constraint – constraint resource needs to have clear task priorities on which the person needs to focus on. As result, we will improve its effectiveness by reducing time wasted on multitasking, especially jumping from one project to the other. We should gain at least 20% of throughput, as described in previous section. Finally, following the third step out of the five focusing steps, we need to subordinate all other resources to this decision. This is called staggering, as shown in Figure 10.

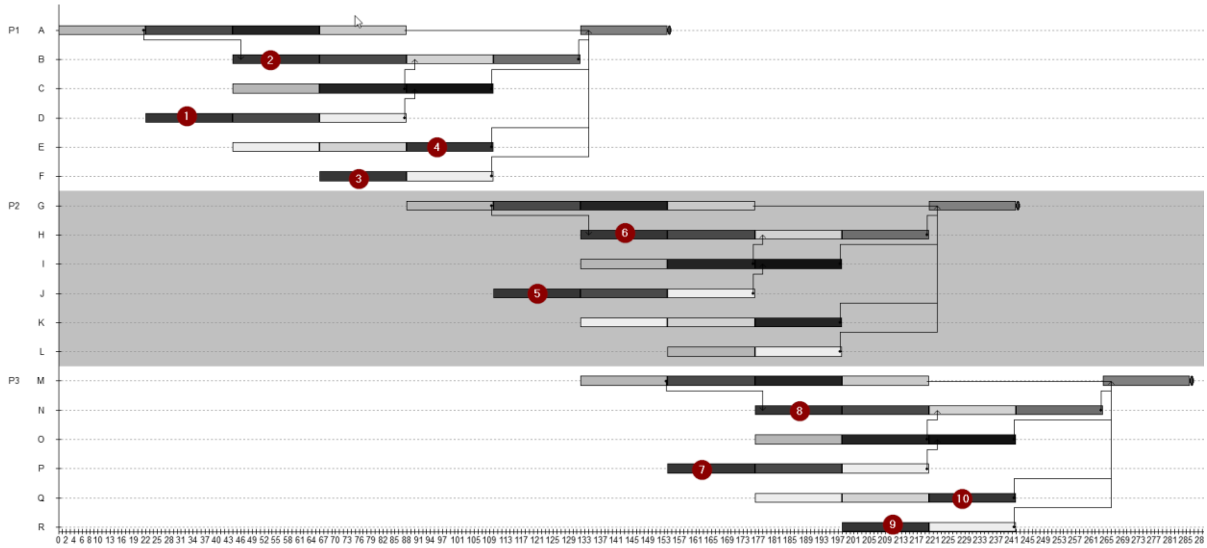


Figure 10. Planned project portfolio with staggering & task priorities for critical resource

With staggering on the project portfolio, as shown in Figure 11, we have project portfolio execution slightly improved.

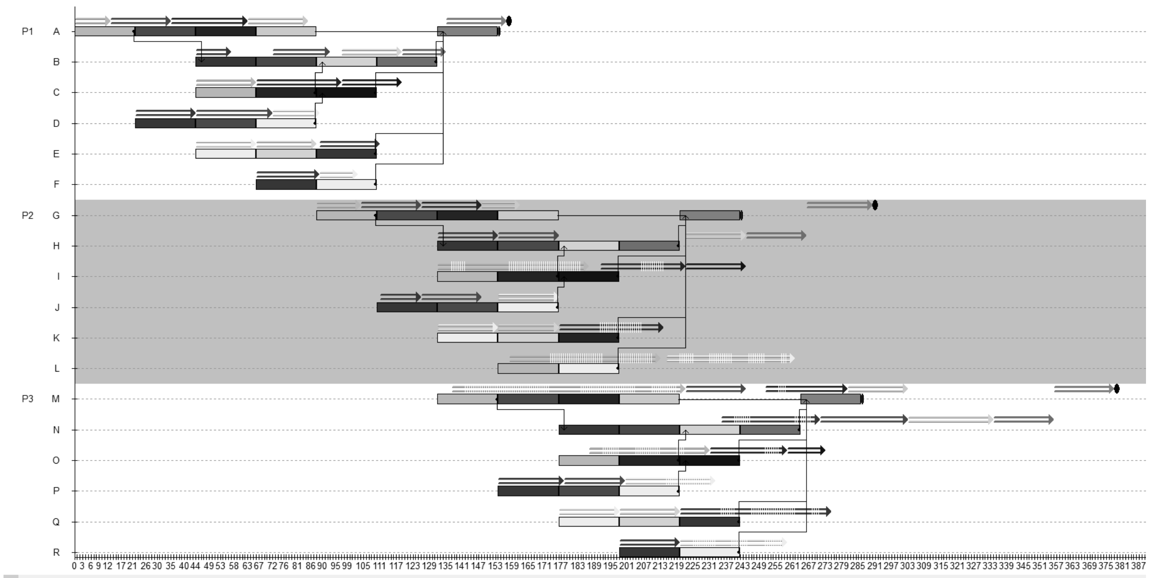


Figure 11. Results of project portfolio execution with staggering

Moreover, Figure 12 shows that the first project has increased the probability to 24% that it would be finished at the predicted duration; realistically it would take about 201 days - almost

30% longer than planned. The remaining two projects face negative effects of Project 1, having quite a bit of multitasking due to prolongation of the first project tasks and unclear working priorities, thus predicting its finish in 310 days and 378 days, respectively.

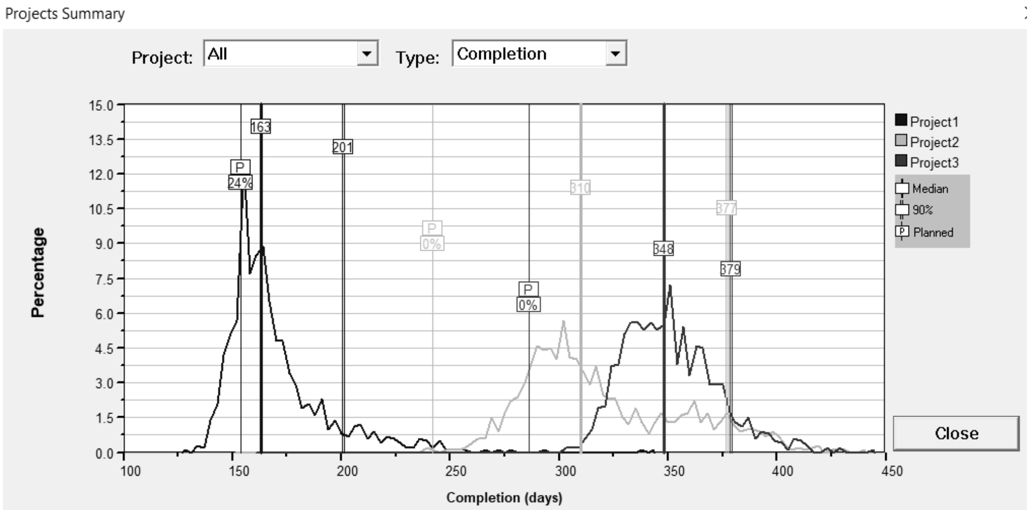


Figure 12. Distribution of project completion time and probability to be on defined time with staggering

As we have identified above, only with staggering based on constraint resource, would not provide the desired results. We need to address interdependency of tasks between projects, which are executed by constraint resources.

As the next improvement step, we will use a well-proven solution of TOC related to project management – CCPM, as described in the previous section. We will reduce project tasks by 50%, and we will return 50% of this reduction (safety) as a buffer. The results are better than in the previous example, the first project is predicted to be completed in 117 days, the second project in 165 days, and the third project in 219 days with a 90% probability, as shown in Figure 13.

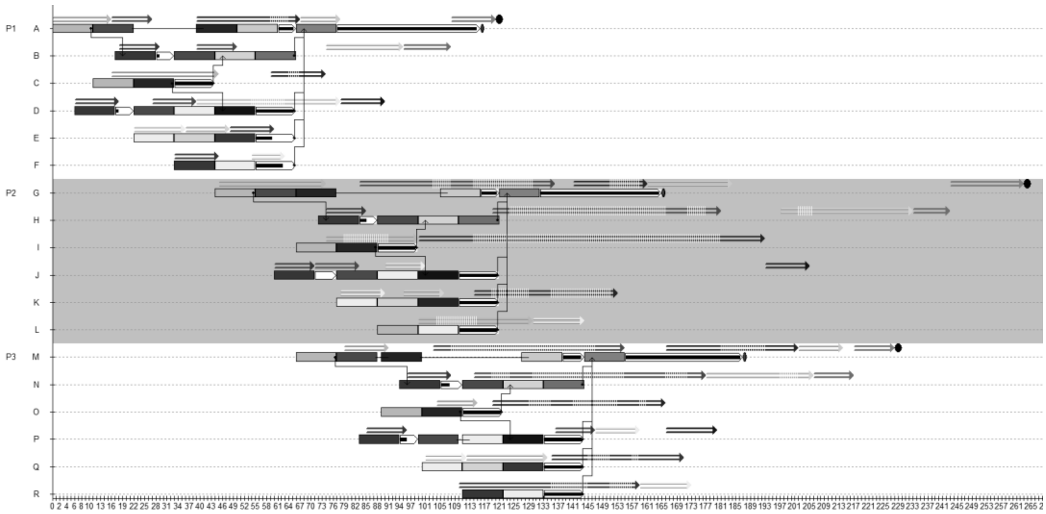


Figure 13. Results of project portfolio execution using CCPM

On the other hand, as shown in Figure 14, the initial estimation of project durations (project end date) was not satisfactory. The first project would be finished by the planned date with an 83% probability, the second project with a 34% probability, and the third project with only a 25% probability, respectively.

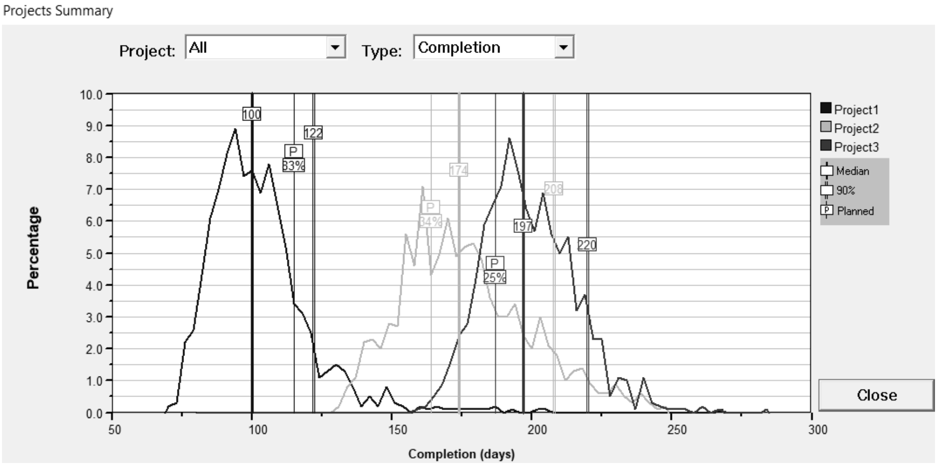


Figure 14. Distribution of project completion time using CCPM

An analysis of Figure 13 shows that approach is not taking account variability and uncertainty of task execution of constraint resources within a project and especially between projects. We need to recall that all task duration is reduced by 50%, and in the case of constraint resource, any deviation of the above-planned task duration has direct impact on the subsequent tasks done by constraint resource, within a project or on task on another project. This gives us good indication that we need to add buffer (safety) at constraint resource, called drum buffer, on a portfolio level. Figure 15 shows a modified project portfolio plan, where we place the drum buffer in place. We placed the drum buffer after the last task in a project which the constraint resource was assigned and before the individual's first task on the subsequent project.

Figure 15. Results of project portfolio execution using CCPM, with 100% drum buffer

In our example, we have an estimated 100% drum buffer, as proposed by Holt et al, 2014) to protect against variability of task execution and Murphy, as shown in Figure 16. These results with additional improvement on project portfolio throughput – the first project completed in 115 days, second in 202 days, and the third project completed in 254 days. Moreover, initial estimation of the project durations (project end-date) is now significantly improved. In particular, the first project would be finished by the planned date with a 90% probability, the second with an 83% probability, and the third with a 70% probability, respectively.

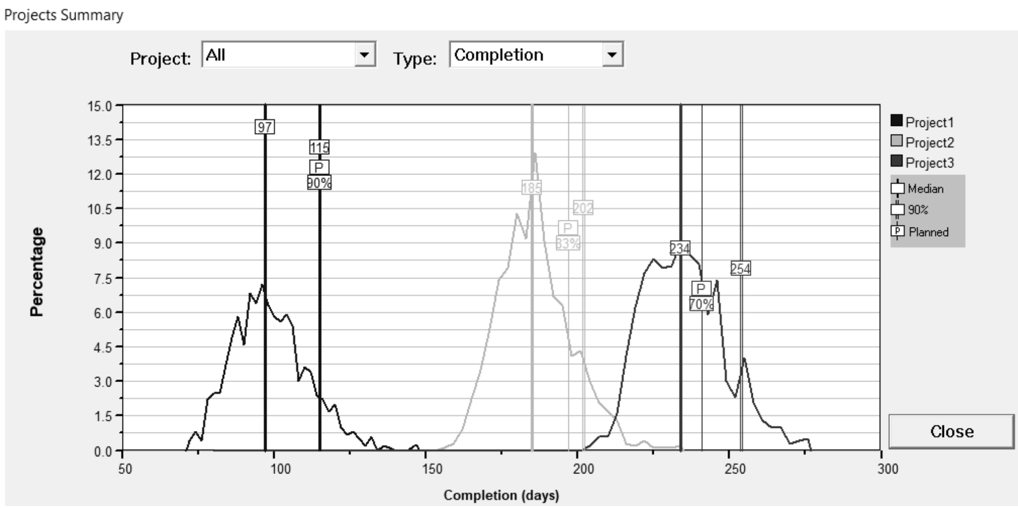


Figure 16. Distribution of project completion time using CCPM, with 100% drum buffer

5 Conclusion

For organizations to remain competitive on the market and react to market changes, they need to deliver its products, solutions, services much faster and more reliable than before, which are usually organized as projects or portfolios of projects. The success of the projects is traditionally measured using a triple constraint – time, budget and scope. As studies have shown, there is considerable room for improvement on how we are managing the projects and especially portfolio of projects. The main question arises – how can we improve management of portfolio of projects in order not to jeopardize time, budget, and scope and to have predictable results and throughput.

This paper presents a common-sense approach supported by the Theory of Constraints (TOC) tools and applications on how to manage portfolio of projects. This approach is, in many cases, contradictory to existing way of managing portfolio of projects with shared resources, where most of the projects flow *as best as they can* throughout the system. Change of existing-working policies, rules (and measurements), and even culture within organization is required. Managing the load towards the (critical) resources and having clear priorities enables increase in the performance of the project portfolio – system, thus leaving behind individual effectiveness. Simulations demonstrate that staggering the release of work into the system reduces workload on most critical resources and increase predictability of project deliverables. Moreover, introducing TOC application for project management, called Critical Chain Project Management (CCPM), in project portfolio additionally improves the throughput of the portfolio – system, without compromising approved duration, scope, and budget.

Finally, in this paper, we have presented that a different way of working could produce meaningful results, especially if addressed correctly – towards a system constraint. It was found that TOC can help to reach this goal to build highly efficient project team, with existing resources and without changes, how project tasks are executed.

In our future work, we will extend the analysis of building effective (project) teams in Agile frameworks and Dev(Sec)Ops methodology for delivering products and services.

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Povzetek:
Od efektivnih do učinkovitih projektnih ekip

Raziskovalno vprašanje (RV): Proučujemo, kako lahko izboljšamo učinkovitost ekip in posameznikov, ki delajo na projektih ter posledično izboljšamo pretok projektov v projektnem portfelju z drugačnim načinom vodenja le-teh.
Namen in izvirnost: Namen študije je analizirati pretok projektov v projektnem portfelju, ki si delijo vire. Študija je osredotočena na prikaz pomanjkljivosti tradicionalnih praks upravljanja projektnega portfelja in prikaz postopnih rešitev za njihovo odpravo. Posebej prikažemo prednosti spremembe politike in pravil planiranja ter odobravanja projektnih nalog, še posebej v okolju portfelja projektov.
Metoda: V študiji je bil uporabljen kvantitativni pristop, ki vključuje uporabo simulacijskih tehnologij (simulatorja) v okolju portfelja projektov. S pomočjo simulatorja smo lahko upravljali različne parametre pravil in politike dela znotraj portfelja. Prav tako smo s simulatorjem sistematično analizirali vpliv človeškega obnašanja pri izvedbi nalog in iskali rešitev s pomočjo Teorije omejitev, s poudarkom na večopravilnosti, študentskem sindromom in Parkinsonovim zakonom.
Rezultati: Rezultati prikazani v tej raziskavi kažejo na potrebo po spremembi tradicionalnih metod vodenja projektov v okolju z deljenimi viri. Še posebej se to nanaša na politiko in pravila dela in celo na spremembe kulture znotraj organizacij. Simulacije prikazujejo, da se izboljša pretok projektov, če začnemo selektivno odobravati in razporejati projekte glede na zasedenost kritičnega vira. S tem zmanjšamo količino njegovih vzporednih aktivnosti, ga razbremenimo in omogočimo njegovo fokusirano delo na najpomembnejših nalogah portfelja projektov. Z vpeljavo metodologije Teorija omejitev smo prikazali še dodatne izboljšave pretoka projektov in zanesljivost dogovorjenih časovnih, finančnih in vsebinskih okvirjev.
Družba: Trdno verjamemo, da bo analiza pomagala razumeti, da imajo tradicionalni pristopi vodenja projektov omejitve in da lahko s spremembo načina vodenja, pravil in meril dela

dosežemo bistveno boljše rezultate. Poudarek dajemo na rezultate sistema in ne na individualni ravni – lokalna učinkovitost naprav globalni učinkovitosti.
Omejitve/nadaljnje raziskovanje: Raziskava se bo v prihodnje osredotočala na uporabo orodij in aplikacij Teorija omejitev v agilnih okoljih s področja informacijske tehnologije.

Ključne besede: upravljanje portfelja projektov, projektno vodenje, teorija omejitev, projektno vodenje s kritično verigo, učinkovitost.