APPLICATION OF RANKED POSITIONAL WEIGHT IN DETECTING RESOURCE CONFLICTS IN CONSTRUCTION PROJECT

[1]CHALITA SURINRAT, [2]PORNTHEP ANUSSORNNITISARN, [3]SUDARATANA WONGWERAGIAT

[1,2,3]Kasetsart University. Department of Industrial Engineering
E-mail: minkycrash@gmail.com, fengpta@ku.ac.th

Abstract- Most of construction companies encounter the difficulties of addressing resource conflicts as they usually perform multiple projects at once. The decision support tool is developed on Microsoft Project using Visual Basic Applications (VBA).The extension supports the decision of prioritizing the tasks by applying the concept of Ranked Positional Weight Method (RPW) from assembly line in manufacturing process.The extension facilitates the function of viewing multiple project performance at once with a more user friendly interface and a customisation of report generator. Therefore, the amount of time wasted in trying to generate such reports has been reduced and the project performance can be monitored more closely and accurately. As a result, this leads to less possibilities of cost overrun, delay, and poor quality which are the undesirable outcome for all projects.

Keywords- Construction Industry, Microsoft Project, Multi project management, Ranked Positional Weight, Resource Conflicts

I. INTRODUCTION

At the present, project management has taken a significant role in many different aspects, including the construction industry. The application of project management can be beneficial and useful for all types of project, either in a big or in a small scale. The concept of balancing the triangle constraint which is comprised of cost, time, and quality, has been applied in several contexts. These three constraints are the key for the project management. The purpose of project management is to avoid cost overrun, delay, and unsatisfying quality which occurs in most projects. When applying the concept of project management to the construction project management, the main focus remains the same. However, there are a lot more details involving in the construction industry. There are several tasks within a single project and all projects are unique. As a result, the level of complication and uncertainty is potentially higher than projects in other industries.

The most complication in construction management is the resource which, most of the time, is the cause of conflicts. In a small scale construction business, resource is shared among several projects, especially the human resource which is considered to be quite scarce in terms of quantity. For the reason that in construction project, many skills are required and all of the skills are rarely found in a person. Therefore, the human resource is very difficult to manage.

Apart from human resource conflict, there is also the problems arising from a poor monitoring system. The loss of control in most processes and inability of the project manager to analyse and monitor the project efficiently have decrease the change of a successful project. Even though construction industry prioritise cost as the first rank of concern, time is also valuable. As the saying “time is money”, having a complete project delivered as it has been scheduled is another way to help guarantee the satisfaction of customer. The delay is found as the most common problem in most project. Therefore, to be able to deliver the project on time, every task must be on the same track with the schedule. As construction projects involve a high level of complexities, unexpected problems should always be aware at all time. Due to the number of unexpected problems, the schedule and other little details will always be changing and this makes the construction project so dynamic. In order to make changes in the project, an adequate decision making is highly required. Sufficient information will help enhance the decision as all significant data is gathered and take into consideration.

Since there are so much information available in a project, project manager sometimes might have overlooked some important details that actually contribute to the decision, without it, the decision could possibly be worse than it could have been. Therefore, this is when the complementation of Information technology (IT) has played its part. Technology is known for its supporting functions as it helps to manage project easier. The information system becomes more systematic and more comprehensive when monitor. The process of monitoring a project will take less time to request for an information that is needed for the decision making. The faster and accurate decision is made, the better for the project. If there is an unexpected problem, it is best to solve it as soon as possible so that all process would not have to stop. The project can run smoothly if the decision is made by a professional that understands the project nature well. However, there is a saying says even the best swimmer can drown. It is possible that an experienced project manager can make a bad decision if the information is not there for consideration.

The extension of Microsoft Project is written to serve the purpose of generating the report of multiple project performance. The focus is at the customisation of report. There are two main functions for the customisation. The first one is the presentation of task overallocated resource. When resource conflicts occur, portfolio manager has to make the decision to address this conflict. This particular extension will assist the manager to make the decision more easily and accurately. However, this does not mean the software will solve the entire conflict but the manager himself must analyse and consider the best solution, considering from the important relevant information that the software provides.

II. LITERATURE REVIEW

A. Project Management

According to Project Management Institute, project management can be defined as "an organizational approach to the management of ongoing operations" in which it applies the combination of knowledge, skills, tools, and technique to execute a certain project in order to fulfill the need or expectation of a certain group of people. This certain group of people can be clients or stakeholders.

When managing a project, there are three main constraints that must be concerned at all times. These constraints are scope – what needs to be done and the specifications, time – how much time available to complete the project, and cost – how much money or resources available for such project. They are also known as the 'Project Management Triangle'. As seen in figure below, the scope, cost, and time are interdependent. That is, the impact is unavoidable for the rest of constraints when one of them has been altered or re-planned. For instance, a smaller budget most likely to cause a longer length of time to finish and the specification might have to be reduced. Similarly, these conditions can also be applied to the case of shorter duration and more specifications.

In order to measure the success of a certain project, there are three major criteria must be taken to consideration which are the deadline, the budget, and the satisfaction of clients. These criteria are considered to be equally significant. However, sometimes the prioritization can occur, depending on the situation. In simple words, the client might want to give priority to one of the three which can be the deadline, the scope, or the cost. This is entirely up to them if they have a fixed amount of a certain thing. For example, if the budget is fixed, the project manager have to reorganize and rebalance the project-management triangle. This is to make sure that time and scope are adjusted accordingly to the fixed budget.

All in all, the project that is overdue or over budget is not necessary always be a fail project. Rather, a successful project is judged from an ability to reach an agreed requirements between the project manager and the client, under the circumstance of different clients prioritizing these criteria differently.

The interview demonstrates that task complexity is one of the most important factors in project requirements. "In projects with high task complexity, coordination is a key challenge…". The project manager needs to make sure that the tasks are identified and scheduled, the resources are correctly allocated, the critical path is determined and the progress is monitored in order to accomplish the project objectives by taking time, budget, and design quality as the primary responsibility.

Due to the difference in client needs, cost-time-scope constraints, and the complexities occurred in each task, the project manager has to encounter several unexpected problems. Therefore, a fast decision making, an efficient resources allocation, and a clear focus is what the manager needs to achieve.

In order to be successful in making decisions when encounter unexpected challenges, a good project management process is required as it would lead to an effective and efficient decision making. There are five process groups according to PMI. They are 1) initiating process, 2) planning process, 3) executing process, 4) controlling process, and 5) closing process. If the project management is competent and well managed, there would be sufficient information to make a certain decision in the best way possible. The more information there is, the better decision can be made as there would be more alternatives available and less room for uncertainty or mistakes.

B. Construction Management

In construction industry, project management is very popular among project managers and stakeholders as it makes the management more systematic. Construction project is difficult to manage as there are many detailed tasks which need to be accomplished within a certain time limit. Moreover, each task is consisted of its unique conditions, complexity and uncertainty which also contribute to the overall project complexity. A high level of complexity and uncertainty often put the project at risk and has become the cause of loss within the industry.

The nature of operation in this industry is a project-based operation and there would be a project manager in charge of each project. Realistically, construction companies would usually handle several projects at the same time. That is, there are many ongoing projects operating simultaneously or can also be called the multi-project management. Managing a single project is already complicated but not as much as the multi-project management. The difficulty in managing multiple projects in construction industry is

the fact that each project is already full of details. All project is unique, in this case could be the uniqueness in size, budget, scope, or time duration. There are different types of constructions such as a house, a condominium or a factory which means it could involve from small to large scale constructions and such difference occurs in time, cost, and also quality. It is quite challenging to manage a project that costs a few million and the one that costs up to hundred millions simultaneously. This example also applies to the range in time duration and quality.

One thing that most project managers find really problematic about multi-project management in construction industry is the resource management. "Resources consist of materials, equipment, and labours". Resource management for a single project is simple as all available resource is allocated directly to a certain ongoing project. As the number of projects increase, the more complex it gets to manage and allocate effectively. "Because there are multiple ongoing projects all the time therefore it is typical for the overlapping time in different projects to occur". Conflict frequently occurs when many different ongoing projects need the same resource at the same time. This is when an efficient resource management and adequate allocation is required.

In a small scale construction business, the materials and equipment are not really complicate to manage as it can be hired or purchased when needed. However, for the labours, it is almost impossible to request more labours on the spot as the skilled labours are highly wanted in this industry. It can be said that resource management, especially the human resource, is the most problematic point for the multi-project management.

Patanakul and Milosevic point out that it is crucial to understand the interdependencies and interactions between projects which is the focus of multiple projects management as well as how to manage an individual project. That is, project manager must be able to manage individual project as well as looking at the whole picture, trying to reduce conflicts as all projects are interdependent from using the same resource pool. Despite the complexities and difficulties of requiring and allocating resources from the central pool, there is still advantage about it. Resource pool, looking from human resource management perspective, is full of skilled project managers and staffs. Skilled and experienced labours can be considered as a valuable asset of the business. The expertise can be rotated to several projects which would facilitate some difficult processes or share knowledge and experience to other members. As it is said good things become even more valuable when it is shared. The more expertise have been rotated, the more skill they improve as all projects are different and it definitely helps to multiply and spread the skills to the rest of the labours more or less. In construction industry, the most concerned factor is the cost. The cost has been used to set as a baseline to determine how successful the project is. It is done by comparing the planned cost and the actual spending and how much spending has been put to accomplish a certain task.

C. Ranked Positional Weight (RPW)

Ranked Positional Weight, developed by Helgeson and Brinie is one of the best-known heuristics for assembly line balancing in manufacturing industry. Chow points out that each assembly line may consist of one or more operations with different processing time, which varying by complexity of each operation. Thus, the manager makes an effort to determine the level of complexity at each operation by using ranked Positional Weight Method. Reikek and Delchambre declare that the strategy of this method is to firstly assign tasks that have longest chains of succeeding tasks. The length of the chain is known as positional weight. The weight of an operation is defined as the processing time of the operation itself plus the sum of the processing time of all succeeding operations Then, the tasks are ranked by their positional weight in descending order. Stockton and Wainwright states "the ranked positional weight technique does not guarantee optimality."

Tam and Dissanayake applied the ranked positional weight method to the construction industry for the reason that the resemblance between construction process on site and assembly line manufacturing is very close. When conflicts in "resource-constraint allocation" occur, the method of RPW would be applied. This is to make sure that the importance of all tasks is being ranked, regarding its severity that would eventually contribute to the overall project delay.

III. METHODS

The author implements RPW method to Microsoft Project's extension and develops the code. The algorithm of the procedure of RPW has been altered due to the limitation of VBA. The algorithm can be divided into three sub-procedure as follow:

Sub-procedure 1: Aiming to get all successor'sid

1) Start getting direct successor id from first task to the last in ascending order (Microsoft Projects can only retrieve direct successors)
2) Store the direct successor id into notes of each task
3) Start looking for all successor id from the last activity and run up to the first in descending order
4) Identify the predecessor id of each task
5) Record successor id of that task into the note of identified predecessor

The procedure in step 4 - 5 can be illustrated as following:

Let, Task 5, 6, and 7 are the successors of Task 4

(Result from step 1 and 2). And, Task 2 and 3 are the predecessors of Task 4. Therefore, add task 5, 6 and 7 into the note of Task 2 and 3

Sub-procedure 2: Aiming to delete duplicate successor's id

As a result from sub-procedure 1, there might be some duplicated successor id in the notes of each task. For example, Task 4 (successors are Task 5, 7, and 8) and Task 6 (successors are Task 7 and 8) are the direct successor of Task 3. Then, successor id of Task 3 can be arranged as 5, 7, 8, 7, 8. It can be seen that successor's id 7 and 8 is duplicated. Hence, they should be deleted.

1) Convert data type in Notes field of each task from Integer to String (no specific format, can be anything for instance, number with decimal point, or normal text or combined.
2) Split the String of successor's id into Array of String ("An array is a set of values that are logically related to each other"
3) Create Dictionary object, "A Dictionary object is the equivalent of a PERL associative array. Items can be any form of data, and are stored in the array. Each item is associated with a unique key. The key is used to retrieve an individual item and is usually an integer or a string, but can be anything except an array."))
4) Put data from each index in Array of String into dictionary. In simple word, if compares to a regular dictionary, vocabulary represents key and meaning represents value. Similar to the fact that there is no duplicated vocabulary in a dictionary, the duplicated successor id would be automatically ignored. That is, only the unique successor id will be stored.
5) Assign the value of each key equals to 1. (In this case, the value can be any number because it is irrelevant information to calculate the positional weight.)
6) Put the successor's id in dictionary back into notes of each task

Sub-procedure 3: Aiming to calculate positional weight (duration of a task plus duration of all of its successor)

1) Split successor's id in notes of each task into Array
2) Retrieve duration of each task and put into Number 1 (Number 1 is a built-in field with empty data in Microsoft Project)
3) Retrieve duration of successor in each task shown in notes and add to existing value of Number 1. Then, divides by 60 x 8 to get a unit in day(s).

IV. EXPERIMENT

As the resources of the company are share in a resource pool. This research demonstrates two situations of the resource conflicts that have different causes. Firstly, the most common situation that project manager is going to confront is resources overallocated that occur when new projects or new activities are added or the changes in schedule where the conflicts mostly occurred in planning phase. Secondly, resource conflicts from the delay of projects.

A. Resource over-allocation in managing multiple projects caused by adding new activities and new projects

Assuming that the company has two ongoing projects namely Mc Charter, and Maeklong Resort. Later on, Lenso Wheels project has been added. In this case, each project manager is individually responsible for one project. So the portfolio manager is the one who looks after all projects. The resources are share for all project as a resource pool. In Microsoft Project, there are 3 resource types, which are "work", "material", and "cost". The resource type "work" refers to human resource. In this company, the human resources can be segregated into 14 unique expertise. All human resources has different specialties and cannot be replaced by one another. This expertise can be divided into 4 groups based on their roles and responsibilities, consisting of skilled labor, general worker, management, and subcontractor.

Project Mc Charter starts at April 1, 2014 and ends at January 26, 2015 with the duration of 300 days. While project Maeklong Resort starts at May 1, 2014 and ends at January 15, 2015 with the duration of 260 days. And Project Lenso starts at July 16, 2014 and ends at April 11, 2015 with the duration of 270 days. Each project has different sub-task. Mc Charter and Lenso Wheels projects are the warehouse construction, so the sub-task for each project is quite similar. For Mc Charter, the work can be divided into 4 phases including structural, architectural, sanitary, and exterior work. And for Lenso Wheels, the work can be divided into 5 phases, including preparation work, piling footing, office structural work, warehouse structural work, and architectural work. Apart from these two projects, Maeklong Resort has only 2 phases, which are structural and architectural work.

Usually, the project manager identifies the resource conflicts by looking at the Resource Sheet and Resource Usage. As a result, the conflicts are easy to recognize as they are shown in red with the exclamation mark in front. it can be seen that there is resource conflict for plasterer. Furthermore, if the manager wants to know which task such conflicts occur, it would be easier and faster to use the extension the author has developed.

Thus, the extension will be used to detect the conflicts by generating the report named "Task with overallocated resources" that presents the resource conflicts and to sum up the information that is relevant

to the decision making regarding such conflicts. According to the information given in the report, the manager would be able to make more precise decision in timely manner, in order to avoid delays and cost overruns.

	A	B	C	D	E	F	G	H
1	Resource	Over-allocat	Project	Task	RPW	Critical	Total Slac	Free Slac
24	Plasterer	TRUE	Mc Charter	Floor Finishing	20	FALSE	0 d	0 d
25	Plasterer	TRUE	Mc Charter	Fence & Road	55	FALSE	86 d	0 d
26	Plasterer	TRUE	Lenso Wheels	Brick Wall & Finishing	210	FALSE	15 d	0 d
27	Plasterer	TRUE	Lenso Wheels	Floor Finishing	110	TRUE	0 d	0 d

I	J	K	L	M	N	O
%Complete	Detail	Start	Finish	Resources	Max Units	Cumulative Units
100	Current	22/11/2014	11/12/2014	Plasterer[10],Worker[5]	50	40
40	Current	22/11/2014	31/12/2014	Worker[10],Plasterer[50]	50	-10
50	Current	23/11/2014	6/1/2015	Plasterer[30],Worker[10]	50	-40
0	Future	6/2/2015	25/2/2015	Plasterer[15],Worker[10]	50	-55

Fig. 1Resource conflicts detected from "Tasks with Overallocated Resources" report using Microsoft Project's extension

Report in Fig. 1, indicates that plasterer has conflicts in Task floor finishing and fence & road in Mc Charter project, and in Task brick wall & finishing and floor finishing in Lenso Wheels project. Project manager also perceive the information associated with the overallocated tasks such as start and finish date of such task, all resource name and quantity that has been used for each task, percent complete, free slack and total slack.

Moreover, it can also identify whether it is a critical task or not. In the real world, the manager could be able to recognize the critical task but if the case that there are more than one critical task needed to be concerned at the same time. How the managers would prioritized those tasks. In most circumstance, they just use their sense, experience, surrounding environment, and project situation as the factors to judge which task is required to get done first. They don't have enough information to substantiate their decision. Occasionally, the uncritical tasks need more attention than the critical one. For the reason that those tasks are very significant, many other tasks can't get start if this task does not finish.

The extension has applied the Ranked Positional Weight (RPW) method to solve this problem. The calculation of RPW will give the value that could make the manager know the total duration of the task itself along with all successor task.

Therefore, if the manager has to choose between two critical tasks, it is recommended that the manager would give the priority to the task with the higher Ranked Positional Weight value. The higher RPW value indicates the higher severity of the damage towards the whole project.

Furthermore, the manager can also choose the dimension of data represented such as sorting by start date or finish date or free slack or total slack, and filtering only critical tasks or delayed tasks or upcoming tasks or delayed tasks or future tasks. The extension also provides the number of days that each task has been delayed. The upcoming tasks can be distinguished from future tasks. Upcoming task is the task, which the project manager can manually filter from all future tasks by looking for tasks that are planned to start with specific time period.

The manager could choose a desired time period and change at any time.

B. Resource over-allocation in managing multiple projects caused by delay of tasks

In this scenario, it is assuming that all the resource conflicts or any other issues in planning phase are solved. After executing in the construction phase for a period of time, some tasks are delayed. In perspective of resource, this may lead to a shortage for the task that use the same resource.

As in resource planning, each task gets different time slot but when the tasks are delayed, it can be overlapping. Only Microsoft Project Server that able to review the availability for resource pool in order to find overallocated or underallocated resources either within a project or across projects.

However, using the Microsoft Project's Extension could help the manager to be aware of those conflicts by generating "Tasks with overallocated resources". It provides an extra information other than Microsoft Project which is "Cumulative Units".

First of all, the author sorts the report in ascending order, sorting by setting resource in column A as the first key, start date as the second key and finish date as the last key. Then, identifies the maximum units for each resource and subtracts from the maximum unit if the resources have been used and the tasks are not one hundred percent complete, and displays in bold text.

V. RESULTS AND DISCUSSION

In this section, the author deliberates the results in accordance with the three main features of the extension which are managing multiple projects, detecting resource conflicts, and monitoring and tracking project performance.

A. Management of Multiple Projects

Refers to the experiment demonstrated, the extension has a user friendly interface for every users as shown in Fig. 2 The extension can be used by people who are not familiar to or don't know that much about Microsoft Project.

It facilitates the users to analyze multiple number of projects simultaneously under just few clicks. As portfolio manager is the one who could gain most benefits from this, they can choose to analyze each project alone or any number of projects or even all the projects operated by the whole company.

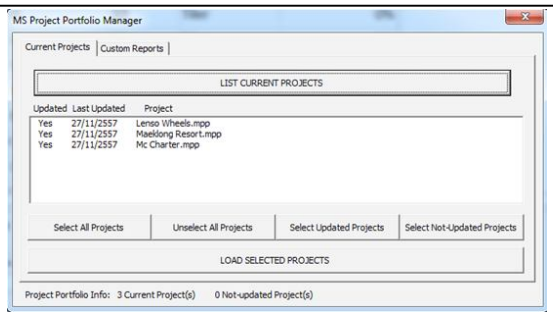


Fig. 2(a)Microsoft Project's Extension user interface

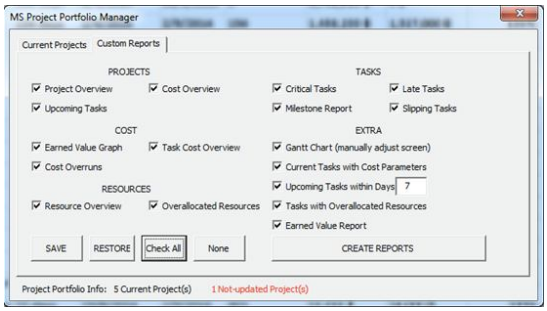


Fig. 2(b)Microsoft Project's Extension user interface

The extension also provides the structural file management system to keep all files in the same place. Furthermore, the user better upload the folder to any cloud service, such as Dropbox, One Drive, Google Drive or Box, for a more convenient use. Project manager at each construction site can update the progress and easily upload to the cloud service. So this is convenient to portfolio manager, they could be more confident that the file they are viewing is the latest one.

B. Resource Conflicts Detection

Initially, the author will compare the results between resources levelling in Microsoft Project and manually handle conflicts by using information in "Tasks with overallocated resources" report, generating from Microsoft Project's extension.

Fig. 3 illustrates the report generated from the first scenario where resource conflicts in managing multiple projects are caused by adding new projects. Firstly, the author categorizes the task by their status. In this case, fence & road task in Mc Charter and brick wall & finishing task in Lenso Wheels project are the current task, and floor finishing task is the future task. If we look at the start date of both current tasks, we can see that they are very close. We also see that both tasks are non-critical task.

	A	B	C	D	E	F	G	H
1	Resour	Over-allocat	Project	Task	RPW	Critic	Total Slac	Free Slac
25	Plasterer	TRUE	Mc Charter	Fence & Road	55	FALSE	86 d	0 d
26	Plasterer	TRUE	Lenso Wheels	Brick Wall & Finishing	210	FALSE	15 d	0 d
27	Plasterer	TRUE	Lenso Wheels	Floor Finishing	110	TRUE	0 d	0 d

I	J	K	L	M	N	O
%Complete	Detail	Start	Finish	Resources	Max Unit	Cumulative Units
40	Current	22/11/2014	31/12/2014	Worker[10],Plasterer[50]	50	-10
50	Current	23/11/2014	6/1/2015	Plasterer[30],Worker[10]	50	-40
0	Future	6/2/2015	25/2/2015	Plasterer[15],Worker[10]	50	-55

Fig. 3Partial "Tasks with overallocated resources" report to detect resource conflicts

Thus, we rather consider the ranked positional weight (RPW) as it is the indicator for level of significance of each task. We could recognize that brick wall & finishing task has the highest positional weight of 210. Floor finishing task and fence & road task have a positional weight of 110 and 55, respectively. Moreover, considering slack time could help us affirm that our decision will have less effects to the company.

From the above analysis, we can conclude that brick wall & finishing task in Lenso Wheels project is the first priority. We should allocate 30 plasters for that task and the possible earliest start date is November 23, 2014. Then, we are required to shift any other task so that the time slot from Nov 23, 2014 to Jan 6, 2015 would be available.

Whether floor finishing task in Lenso Wheels has second highest RPW value and it is also critical, its earliest start date is February 2, 2015, which is almost a month later than the finish date of brick wall & finishing task. We rather allocate the plasterer to fence & road task in Mc Charter first. Thus, we allocate 50 plasterers to floor finishing task. In this case, we will shift the entire task start date so the new start date of this task will become January 7, 2015 and finish at February 15, 2015. Finally, the only task left is floor finishing. We allocate 15 plasterer from February 16, 2015 to March 7, 2015 for floor finishing task in Lenso Wheels project. The report generates after solving all the conflicts can be seen in Fig. 4.

	A	B	C	D	E	F	G	H
1	Resour	Overallocated	Project	Task	RPW	Critic	Total Slac	Free Slac
16	Plasterer	FALSE	Lenso Wheels	Brick Wall & Finishing	210	FALSE	25 d	0 d
17	**Plasterer**	**FALSE**	**Mc Charter**	**Fence & Road**	**55**	**FALSE**	**50 d**	**0 d**
18	**Plasterer**	**FALSE**	**Lenso Wheels**	**Floor Finishing**	**110**	**TRUE**	**0 d**	**0 d**

I	J	K	L	M	N	O
%Complete	Detail	Start	Finish	Resources	Max Unit	Cumulative Units
50	Current	23/11/2014	6/1/2015	Plasterer[30],Worker[10]	50	20
40	**Future**	**7/1/2015**	**15/2/2015**	**Worker[10],Plasterer[50]**	**50**	**-30**
0	**Future**	**16/2/2015**	**7/3/2015**	**Plasterer[15],Worker[10]**	**50**	**-45**

Fig. 4Task with overallocated resources partial report after solving the conflicts manually

On the other hand, the author uses the same scenario and solves the conflict by using resource levelling in Microsoft Project. In this case, assuming that the task cannot be split, it will shift the task to the next available date. As a result in **Error! Reference source not found.**, Microsoft project allocates the plasterer to brick wall & finishing task first, then prefer floor finishing than fence & road activity.

	A	B	C	D	E	F	G	H
1	Resour	Overallocated	Project	Task	RPW	Critic	Total Slac	Free Slac
16	Plasterer	FALSE	Lenso Wheels	Brick Wall & Finishing	210	FALSE	25 d	0 d
17	Plasterer	FALSE	Lenso Wheels	Floor Finishing	110	FALSE	10 d	0 d
18	**Plasterer**	**FALSE**	**Mc Charter**	**Fence & Road**	**55**	**TRUE**	**0 d**	**0 d**

H	I	J	K	L	M	N	O
Free Slac	%Complete	Detail	Start	Finish	Resources	Max Unit	Cumulative Units
0 d	50	Current	23/11/2014	6/1/2015	Plasterer[30],Worker[10]	50	20
0 d	0	Future	6/2/2015	25/2/2015	Plasterer[15],Worker[10]	50	5
0 d	**0**	**Future**	**26/2/2015**	**6/4/2015**	**Worker[10],Plasterer[50]**	**50**	**-45**

Fig. 4 Task with overallocated resources partial report after solving the conflicts by auto resource levelling in Microsoft Project

In conclusion represents, the manager solves the resource conflicts by considering several factors including RPW, free slack, total slack, critical task, start and finish date. In this case, using information generated from the extension will cause less delays than resource leveling in Microsoft Project, the result is shown in Table 1.

	Mc Charter	Maeklong Resort	Lenso Wheels	Total
Old finish	26/01/15	15/01/15	11/04/15	
Extension - New finish	02/03/15	15/01/15	21/04/15	
Delayed (days)	35	0	10	**45**
MSP - New finish	21/04/15	15/01/15	11/04/15	
Delayed (days)	85	0	0	**85**

Table. 1Comparing solutions solved by Microsoft Project and data from extension.

In Microsoft Project, the alerts for overallocated resources would show only if the resources are assigned to the tasks simultaneously for more than their maximum capacity. Hence, if any tasks are delayed, it means that the resource would continue occupying the following time slots. In reality, the resources are not available whether they were assigned to different time slots.

CONCLUSION

The tool is developed for the purpose of detecting resource conflicts, tracking and monitoring, and managing multiple projects. We demonstrate 2 scenarios for resource conflicts. The first one is the conflict that occur in planning phase when new task or new projects are added. The second scenario is occurred from project delay in construction phase, given that the conflict in planning phase is solved. The extension could help the project manager to detect resource conflicts faster and more accurate. The results show that Ranked Positional Weight is the factor that should be most concerned proven from the comparison between the extension and the leveling resource in Microsoft Project. The result from extension specifies the delay at 45 days while Microsoft Project specifies at 85 days which can be conclude that the manual scheduling is more efficient than the auto leveling by Microsoft Project. However, Ranked Positional Weight is not guarantee for the optimum solutions or minimum delays.

Additionally, for multiple project management, the project manager can manage and analyse overall performance of several projects at once which will reduce time from the usual report generation from Microsoft Project.

VI. RECOMMENDATION

From this research, the further study of Ranked Positional Weight (RPW) is recommended as it can be applied in other parameters to calculate its effectiveness. Other technique that can also be used to address the resource conflict can be linear programming. Though, material and equipment are considered to be unlimited resource, cost should be more concern.

Additionally, the extension might be applied to Construction Company with larger-scale or any other industry to affirm that the extension could help the company to detect conflicts earlier and make an accurate decision.

REFERENCES

[1] Project Management Institute. 1996. A Guide to the Project Management Body of Knowledge (PMBOK Guide). 1 ed. Project Management Institute, Pennsylvania.

[2] DeMarco, A. 2008. Estimating is not just about cost, it is about respecting the Project Management Triangle. Price Systems. Available Source: http://www.pricesystems.com/ blog/tabid/458/postid/36/estimating-is-not-just-about-cost-it -is-about-respecting-the-project-management-triangle-1.asp x, October 28, 2014.

[3] JNC Solutions. n.d.. IT Project Management. Available Source: http://www.jncsolutions.com/index.php/component/content/ article/53-slides/123-it-project-management.html, October 15, 2014.

[4] Patanakul, P. and D. Milosevic. 2006. Assigning new product projects to multiple-project managers: What market leaders do. Journal of High Technology Management Research 17 (1): 53-69.

[5] DeMeyer, A., C.H. Loch and M.T. Pich. 2001. Uncertainty and Project Management: Beyond the Critical Path Mentality. 22.

[6] Caniëls, M.C.J. and R.J.J.M. Bakens. 2012. The effects of Project Management Information Systems on decision making in a multi project environment. International Journal of Project Management 30 (2): 162-175.

[7] Zoho. 2014. Construction and Manufacturing. Available Source: https://www.zoho.com/ projects/ construction-project-management.html, October 18, 2014.

[8] Mota, C.M.d.M., A.T. de Almeida and L.H. Alencar. 2009. A multiple criteria decision model for assigning priorities to activities in project management. International Journal of Project Management 27 (2): 175-181.

[9] Howell, R.A. 1968. Multiproject Control. Harward Business Review 46 (2): 63-70.

[10] Hendrickson, C. and Tung Au. 2008. Project Management for Construction: Fundamental Concepts for Owners, Engineersm Architects and Builders. 2.2 ed. Carnegie Mellon University, Pittsburgh.

[11] Patanakul, P. and D. Milosevic. 2008. A competency model for effectiveness in managing multiple projects. The Journal of High Technology Management Research 18 (2): 118-131.

[12] Zika-Viktorsson, A., P. Sundstrom and M. Engwall. 2006. Project overload: An exploratory study of work and management. International Journal of Project Management 24 (5): 385-394.

[13] Quinn, L and D Stockton. 1995. Genetic Algorithms for Assembly Line Balancing, pp. 257-261. In D Stockton and C Wainwright, comps. Advances in Manufacturing Technology IX: Proceedings of the Eleventh National Conference on Manufacturing Research. Taylor & Francis Ltd., London.

[14] Chow, W.M. 1990. Assembly Line Design: Methodology and Applications. Marcel Dekker, Inc., New York.

[15] Rekiek, B. and A. Delchambre. 2006. Assembly Line Design: The Balancing of Mixed-Model Hybrid Assembly Lines with Genetic Algorithms. Springer, London.

[16] Mahapatra, P.B. 2010. Operations Management: a Quantitative Approach. PHI Learning Pvt. Ltd., New Delhi.

[17] Panneerselvam, R. 2012. Production and Operations Management. 3rd ed. PHI Learning Pvt. Ltd., New Delhi.

[18] Nof, S.Y., W.E. Wilhelm and H.J. Warnecke. 1997. Industrial Assembly. 1 ed. Chapman & Hall, London.

[19] Tam, P.W.M. and P.B.G. Dissanayake. 1998. Construction Project Scheduling by Ranked Positional Weight Method. Canandian Journal of Civil Engineering 25 (3): 424-436.

[20] Ng, S.T., D.X.M. Zheng and J.Z. Xie. 2013. Allocation of construction resources through a pull-driven approach. Construction Innovation 13 (1): 77-97.

[21] Microsoft Developer Network. n.d.a. Arrays in Visual Basic. Available Source: http://msdn.microsoft.com/ en-us/library/ wak0wfyt.aspx, October 19, 2014.

[22] Microsoft Developer Network. n.d.b. Dictionary Object. Available Source: http://msdn.microsoft.com/en-us/library/ x4k5wbx4(v=vs.84).aspx, October 19, 2014.

★★★