HUMAN RESOURCES ALLOCATION SYSTEM: A CASE OF SIGNAL AND TRAIN CONTROL SYSTEMS COMPANY

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Abstract: This paper is applying the bin-packing algorithms to reallocate workload under human resource availability and budget provided constraints in a company whose implemented matrix organizational structure divided into functions and projects. The main objectives are to improve and balance hour allocation for each subordinate under a team and to support managers by decreasing administrative task and time for internal resources management. The bin-packing problem of cutting and packing problems is proposed to develop human resources allocation system (HRAS) using VBA based Microsoft Excel. The application contains three functions to allow the user to get the best result. Using this application, the users reduce the administrative hours, the unbalancing of hour allocation of subordinators is improved, and gets the best possible solution and number of new hiring of their team.

Index Terms: Bin-packing, Human resources, Hours allocation, VBA

I. INTRODUCTION

Software projects are one of the most complex scheduling and forecasting projects. Effectively managing scarce resource allocation to multiple projects in order to meet the projects' key milestones within the project timeline is very crucial and should be treated as top priority for every business. [1] A project is a temporary endeavor undertaken to create a unique product, service or result. The project is a non-routine work, start and finish dates are always defined.The case study for this work is based on a company whose products and services are signal and train control systems.

The company implemented matrix organizational structure divided into functions and projects.The current workflow in the case study company starts from Sales function receives a budget and strategic plan direction from top management. Sales representatives seek new opportunities in the market to maintain their key performance indicators (KPIs). When an opportunity becomes an actual bid project, the sales representatives shall present top management an overall customer requirement, and a preliminary product segment shall be determined for the project. After receiving approval from top management, a bid team will be assigned to handle a bid proposal delivery to the customer. After the bid project team won the bidding, the bid team shall hand over the awarded project to the project team. Information handed over includes the project's technical details and the initial budget to execute the project. Required man-hour for the project would also be allocated in the database by project planner. Each team leader will be able to access the database and can generate the report for hour allocation for their subordinates. The case study company has seen a fast growth in the few part years and has planned to take many more opportunities and order intakes in the future. This causes the resources capacity planning of the business to be overloaded and leads to a significant deficiency of resources to support those future projects.

The company is in an engineering business and the majority of direct human resources is under the Engineering department. This work considers the details for each engineering team which are divided into ten teams. The root causes for the lack of human resources could be the following reasons, sales strategy, the project, and the team leader. The report will be generated from the system by each manager. Many manual and time-consuming tasks are taken to develop the raw data from the system. Not only human resources allocation is required but the balancing of each human resource workload is also important. However, considering the current allocation of resources between engineering teams and in each team by calculating actual hour (for January to September 2017) and forecasted hour allocation (since October 2017 onwards) divided by number of team member, shown that there is still unbalanced human resources hour allocation.

Human resources allocation is the responsibility of each manager, however, the task is really complex and takes time. The manager must develop a plan to manage their subordinates to deliver a project within its time frame and budget. Therefore, the human resources allocation and management system is an important tool required to support managers for efficient human resources allocation improvement. The program does not only support the manager to

reduce the administrative task but also improve the balancing of workload for the team. Moreover, the program would show the efficiency rate for each subordinate in the team, this could enable the manager to assign the suitable task for each subordinate.

II. A TYPOLOGY OF CUTTING AND PACKING PROBLEMS

[2] The cutting and packing problems have many names such as cutting stock and trim loss problems, bin packing, and knapsack problems, or even memory allocation and multi-processor scheduling problems. The logical structure for cutting and packing problems can be determined into two groups of basic data in a one- or more-dimensional space of real numbers. The cutting or packing process patterns being the geometric combination of small items assigned to the large object. [3] Cutting and packing problems are categorized into four criteria. Criterion 1 is dimensionality of geometric dimensions there are one, two, three or larger number (n). Criterion 2 is the kind of assignment of small items to large objects contains all large objects shall be used or all small items shall be assigned to a selection of large objects. Criterion 3 represents the assortment of the large object which are one large object, several but identical large objects, and several different large objects. Criterion 4 the assortment of the small items that are few items of different figures, many items of many different figures, many items of relatively few different figures and congruent figures. All main features summarize as the Table 1 as below.

Table 1 Categorization criteria, main types, and coding scheme

Categorization criteria	Main types	Coding scheme
Dimensionality	one-dimensional	1
	two-dimensional	2
	three-dimensional	3
	N-dimension with N>3	N
Kind of assignment	all objects and a selection of items	B
	a selection of objects and all items	V
Assortment of large object	one object	O
	identical figure	I
	different figures	D
Assortment of small items	few items (of different figures)	F
	many items of many different figures	M
	many items of relatively few different (non-congruent) figures	R
	congruent figure	C

1. Structure of Cutting and Packing Problems.

[2] Wascher et al. (2007) Cutting and packing problem have two set of elements that are a set of large object or input, and a set of small items or output which are defined in one, two, three or larger number (n) of geometric dimensions. All items are grouping to subset and assigned to the object under the conditions that all items lie entirely within the object and the items do not overlap. The result of this solution can be some or all large objects and some or small items.Sub-problems can be selection problem regarding the large objects, selection problem regarding the small items, grouping problem regarding the selected small items, allocation problem regarding the assignment of subsets of items to the object, and layout problem regarding the arrangement of the small items on each of the selected large objects with respect to the geometric conditions.

2. Bin Packing Classification.

[4] NP-hard problems have a wide range of variations such as storage software optimization, optimization of logistics networks, semiconductor chip design and manufacturer cost and financial stock decisions.Bins and items dimensions can be 1D, 2 D or 3D. Binpacking problems have 2 types of the problem depending on algorithm can see all items beforehand which is off-line, or items come in the process time by time which is online, see the summary of variations in Table 2.

Table 2Phenomenology of cutting and packing problems

Classification Criteria	Set of Types
Item/Bin Dimension	1D, 2D, and 3D
Vector	1D and multiple D
Items Visibility	on-line / off-line
Number of Bin Types	single sized, variable sized

3. Basic, intermediate and refined problem types.

[3] Problem types of cutting and packing problems contain the combination of two criteria that are a type of assignment and assortment of small items. Type of assignment has two basic situations as shown in Figure 1, output (value) maximization and input (value) minimization. Output maximization is a set of small items shall be assigned to a given set of large objects. For input minimization is a set of large objects is sufficient to accommodate all small items.

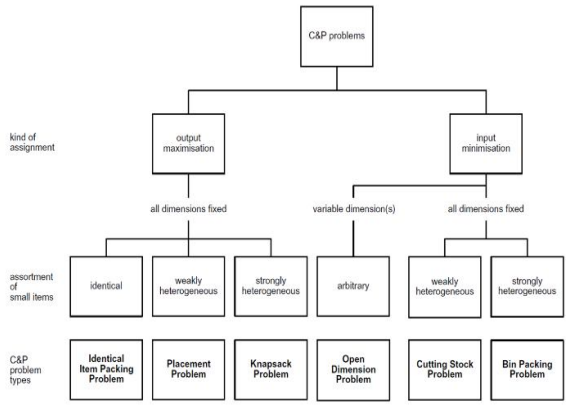

Figure 1: Basic Problem types

4. Heuristics and Optimization Decision.

[4] Bin assignment and bin allocation are the decision for the variable sized bin packing. Bin assignment determines the existing bins to assign the item while bin allocation determines the new type of bin when the item cannot fit with the existing bins. Bin assignment contains four types that are best fit, first fit, next fit and worst fit and bin allocation contain two types that are best fit and expect fit. The different

characters of each type are defined in Table 3 and Table 4 as below.

Table 3Bin assignment

Best Fit Keep bins open until filled with the fit item.	**First Fit** Fill item into the first fit bin.
Next Fit Close the existing bins if the current item cannot fit into the existing bins.	**Worst Fit** Fill item into the most room of the existing bins.

Table 4Bin allocation

Best Fit Open the best fit space of bin with at least space wasted	**Expect Fit** Smaller items can be packed into larger bins that were allocated earlier.

III. TOOLS AND METHODS

1. Tools
   1.1 System
   - Processor Intel® Core™ i5-4310M CPU @ 2.70GHz
   - Installed memory (RAM) 4.00 GB
   - System type 64-bit Operation System

   1.2 Windows 7 Enterprise Service Pack 1
   1.3 Visual Basic for Applications (VBA), the programming language in Excel 2010

2. Methods

2.1 Study and collect case study's raw data to understand the information from the case study.

2.2Study and classify the data. The data has been grouped and classified for the next step.

2.3 Define the problem and objective for the work to dig down into the root cause and gain more idea about the problem of the case study.

2.4Study the related theory and literature review to understand problem type and get ideas about problem's solution.

2.5Design flowchart for the program

2.6Design input and output information for the program

2.7Create the program by Excel add-in VBA (Visual Basic for Applications)

2.8Test the output from program in item 6

2.9Demonstrate the program with the actual data

2.10Analyze the outcome of the program and conclude

2.11Program launch to managers and collect the result to compare efficiency between human resources management manually versus program

2.12Document the program manual

IV. RESULTS AND DISCUSSION

1. Type of budget hours under the project.

Budget hours, which allocated in each project that generated from the case study's system, are separated into two types. First, hour that allocated under the specific human resources in the specific period called "Staffed". Second, hour that allocated under the specific engineering team in the specific period, which there is no human resource name assigned called "Unstaffed".

2. Design and development of the application.

Because the raw data from the case study are exported to Excel spreadsheet format, the application is coded and developed under VBA based Excel application. There are 3 modes in the program. The first mode is automatic mode. In this mode, the bin-packing algorithms are coded, and the data shall be reallocated to develop the balanced workload of each employee and give the expected number of new hiring for the selected team. The second mode is semi-automatic mode that allows the user to select the project priority. Human resources under the selected team shall be reallocated in the selected top-priority projects first, after that the rest of the resources shall be reallocated in the bin-packing algorithms. The third mode is manual mode. In this mode, the program shall generate the graphs and reports based on the selected raw data without human resources reallocation. Thesummary flowchart of HRAS is showing in Figure 2.

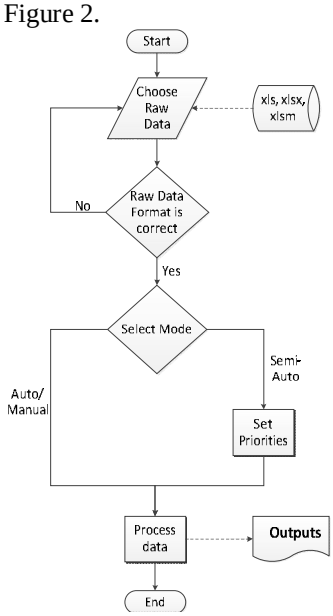

Figure 2: Flowchart of Human Resources Allocation System (HRAS)

3. Implementation of the programming.

When open the program via Excel program, a user is required to choose the raw data in Figure 3 (1). Then the program shall check the format of the selected input file and show the file name in Figure 3 (2). Next, the user is required to select one of the three modes in the program, which are automatic, semi-automatic, and manual as in Figure 3 (3). For the automatic and manual modes, the program will allow the user to select the desire team, Figure 3 (4), however, for semi-automatic, the project prioritize

mode will be required, Figure 3 (5). Last, the function "show me the total processing time", Figure 3 (6), when the user checks on the box, the program shall show the total processing time after the report is generated, this section is not mandatory. Finally, when the user clicks start button in Figure 3 (7), the program shall process the data under the selected mode and provide the outputs to the user.

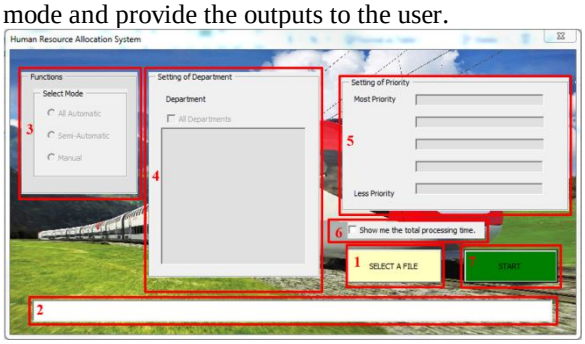

Figure 3: User Interface of Human Resources Allocation System (HRAS)

4. Computational results.

The results were performed based on the raw data as of February 2018 of the case study considered the raw data of the case study with ten engineering team. The raw data period is started from January 2017 to December 2019. The program modes are separated into three modes and applied the different rules as follows.

4.1All automatic mode

All automatic mode applied bin-packing algorithms to allocate the current human resources and budget hours per project which considered the rest capacity of each human resources compared with the Full-Time Equivalent value of each month. The budget hours were allocated into the rest of capacity of each human resource without editing the previous hours allocation from the raw data.

The outputs of all automatic mode selection in case of all departments function was selected areOverall capacity graph, see Figure 4, all departments indirect hour booking graph, Overall efficiency graph, all departments efficiency graphs, Details of overall number of new hiring required, see Figure 5.

The outputs of all automatic mode selection in case of specific team was selected areOverall capacity graph, Selected team capacity graph, Selected team indirect hour booking graph showing details of each human resources, Overall efficiency graph, see Figure 6, Selected team efficiency graph, Details of number of new hiring for the selected team required.

4.2Semi-automatic mode

Semi-automatic mode applied bin-packing algorithms to allocate the current human resources and budget hours per project which considered the rest capacity of each human resources compared with the Full-Time Equivalent value of each month. However, the program will enable Setting of Priority function to allow the user to be able to prioritize the project which included the budget hour for the selected team. The budget hours were allocated into the full capacity of each human resource by the priority of the project selection. The rest human resources were allocated hour under bin packing algorithms by the rest budget from the selected and the rest project in the list. The list of outputs of semi-automatic mode selection in case of all departments function was selected and in case of specific team was selected are generated as same as all automatic mode.

4.3Manual mode

Under manual mode, the list of outputs in case of all departments function was selected and in case of specific team were selected are generated as same as all automatic mode without hour allocation changed.

5. Summary of Human Resources Allocation System survey.

To ensure the performance of HRAS, the application has been demonstrated with all ten engineering managers. The survey has been separated 5 parts to collect the feedback from the managers. The result after using the applicationcould be summarized as follows.

5.1100% of managers are feedback that the average time per session in order to prepare the reports is improved comparing with the manual hour allocation methodology.

5.240% of managers are feedback that the application attributed the better result in quality of the reports comparing with the manual hour allocation methodology.

5.340% of managers are feedback that the application attributed the good result in overall satisfaction of the application.

5.450% of managers are feedback that the application attributed the good result in user interface of the application.

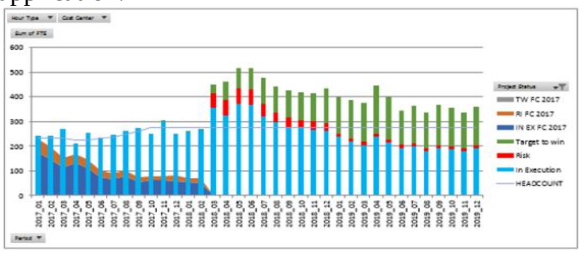

Figure 4: Overall capacity graph

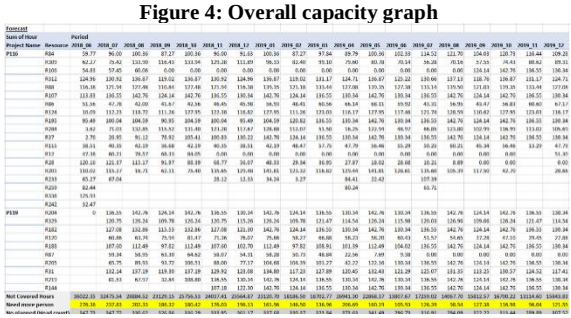

Figure 5: Details of overall number of new hiring required

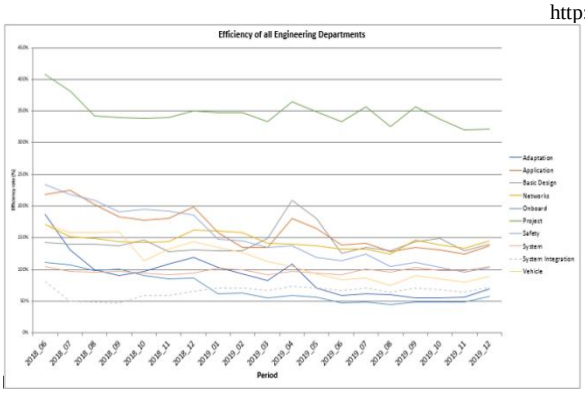

Figure6: Overall efficiency graph

CONCLUSION

The case study company is facing the problem about lacking human resources. Normally, hiring a new employee to the company is required the human resources plan from the managers. The managers often face the difficultly in forecast the human resources plan and this action is required to be done on the regularly basis. In the old fashion, the managers are allocating and planning their subordinators forecast manually using Excel which caused administrative hours to their workload. Bin-packing algorithms have been used as a basis for HRAS development to reallocate forecast hours of human resources. The application was coded by using VBA based Microsoft Excel. This application supports the raw data in the Excel format which common and broadly used by all business and flexibility to revise and update by general users to customize the raw data and the application to achieve the desire result. Implementing the application, the hours balancing of the human resources before using the application has been revised after using the application for 56 percent in overall engineering departments, 27 percent for Adaptation engineer team, 47 percent for Application engineer team, 43 percent for Basic Design team, 45 percent for Networks engineer team, 33 percent for Onboard engineer team, 247 percent for Project engineer team, 51 percent for Safety engineer team, 4 percent for System integration team, and 28 percent for Vehicle engineer team. The optimization of new hours balancing of each human resource is resulting in new hiring number for greater details.In additional, the demonstrator results are showing that the application improved the current manual resources allocation raw data from the case study's company and reduced the administration hours of the users. However, the human resources plan from the manager which applied the application has some deviate number of hours comparing with actual data. This caused by the current human resources are required to support many projects at the same time and cannot work under a few of critical projects which have been listed in the human resources plan from the manager.

FUTURE WORK

HRAS has been developed base on bin-packing algorithms with the aim to make the application simplify, user friendly and reduce the administrative time of resource planning. The other companies could apply this application and use as a basis to further develop their own application that suitable for their raw data, requirements and expectation results.Furthermore, other constraints such as competency or seniority of human resources should be able to consider as additional factors for further development on this application in order to increase accuracy and efficiency of resources planning.

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