PMHRA-PM (Prescriptive Modeling for Human Resources Allocation to Project Implementation)

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Abstract
Human resources play a vital role in the success of a project, and often the resource allocation for the project is a critical area wherein the organizations fail to have optimal use of resources. In this manuscript, the objective is to explore the scope for developing a prescriptive model wherein among the available resources for a project, an optimal combination of resources is chosen for the project. An effective model of Likert scoring approach, wherein the resources are ranked based on certain features that impact the work breakdown schedule tasks are developed into a framework. The system works on the basis of weighted average depending on the context and circumstances of the project, and the respective tasks. The system proposed is highly flexible and the ones that can be customized to the project requirements across industrial verticals. The experimental analysis of the model refers to the ease and effectiveness with which the solution can be implemented for ideal ways of choosing the resources for project environment.

Keywords: Human resource, prescriptive modeling, WBS, Assessment scores

Introduction
Project developments in the software domain is having vital role in developing contemporary range of application systems, which transform the way businesses are carrying out in the e-business scenario. One of the critical challenges faced in the project development is effective project management, that can help the teams in taking decisive actions towards streamlining the project conditions, and accordingly develop contemporary solutions[1].

Project management as a domain is widespread and there are distinct set of project management solutions and protocols that are imperative in the process. Some of the critical aspects that impact the project conditions are the timelines, efforts, and right kind of resources available for execution of the project[2]. Statistically, among the successful projects or the failure for projects, one of the critical impact factors is the realistic project schedules, and effective usage of the resources available for the project requirements.

Profoundly the project developments across the domains have the issue of pragmatic schedule planning, and how the organizations are able to leverage on the competency and efficiency of the individuals towards in delivering the task requirements. In simple terms, across the team working over a project, there are people with diverse skill sets, effectiveness and efficiency levels being part of the project scenario[3].

Based on the critical reasons ascertained, ensuring optimal efficiency in the team performance and having balanced approach in the process stand critical for the project failures or successes. Numerous project management practices, risk mitigation systems, and project tracking solutions are available in the public domain, and organizations already adapt to such solutions. However, one of the key areas wherein the gap is imperative is how the organizations are
failing to understand the human behavior and operational efficiency conditions into account, whilst planning the resource scheduling[4].

In this manuscript, a contemporary model of prescriptive modeling in terms of choosing the best team composition towards attaining the expected or planned project schedule. The objective of the model is to estimate the team competency, skill set conditions, efficiency, and effectiveness with which the resource can execute the tasks be ascertained and used to identify the teams that can be highly resourceful for a chosen project.

Problem Statement
In a case scenario of project, wherein ten resources are expected to work and deliver a project within ten days times, the work-breakdown schedules are usually planned on the manhours required for executing each of the task, and accordingly the finish date and the task precedence factors etc. are planned. However, the critical challenge is about the performance ability of all the ten resources being part of the task. For instance, if one of the key resources among the ten are not in right mindset while on duty or facing any kind of mental stress, it shall seriously affect the performance of the resource, and the ripple effects are evident on the task completion[5][6][7].

If the same sequence is applied to multiple resources on multiple timeframes, it is bound to impact the project outcomes. There are scores of fundamental and advanced project tracking tools that define the project schedule variance from the estimated time, calculate the revised finished date etc. While such quantification and analysis are value addition, the root cause problem needs addressal[8][9][6]. For instance, the issue in terms of considering the mental and physical fitness of the individual team members, the load factors on the team resources, and their personal competency to execute the project[9][2][10]. Accordingly, a dynamic prediction in terms of applying the problem solver to optimize the efficiency of the resources and have best possible team composition available for work should be the outcome[11][7][2].

Hence it is important for a successful project to have right kind of team composition in the best possible conditions and have dynamic or periodic assessment of the resource effectiveness and efficiency for the project[3][8][6]. More specifically, in the case of the long-term projects, periodic analysis of the resource effectiveness to the project conditions can help in more effective outcome from the process, reduce the risk of project delays[12][4][8]. Manual efforts towards such detailed analysis of the conditions could be daunting and additional cost for the project management[13][14][15]. Thus, developing a predictive modelling approach which can identify the best possible project team conditions can help in mitigating the risks of selecting in-effective team composition.

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In the further sections of this report, the emphasis is on the related work referring to how the project resources selection optimization is explored in the earlier studies. Followed by, a narrative in terms of detailing the proposed model, materials, and the process flow are discussed. In section -4, the experimental study of the model is detailed, followed by conclusion discussed in section 5.

Related Work
Numerous research studies have focused on the subject of project management practices. Some studies have explored the qualitative solutions like the project implementation frameworks, tools and techniques for resource optimization, software requirements management etc. Some of the comprehensive literature studies refer to the conditions wherein the companies are failing to have pragmatic project schedules, or ineffective resource management and other such complications. Some of the key studies pertaining to human resource management for projects discussed in the literature are summarized in this section, which highlights the importance for the efforts similar to the proposed model in this manuscript.

One of the critical challenges discussed as issue in the project management is the effective identification of the human resources for the project. Some of the common issues observed are about how the resources considered or
allocated for the project turns out to be non-resourceful. It could be related to interim stress or challenges faced by the resource or due to lack of competency issues etc[16][17][10]. In a survey conducted by a study, the emphasis was on overlapping of tasks from a single project or multiple project handling as a critical reason why the resources fail to deliver in a project scenario.

Also, the issue of non-pragmatic schedules is highlighted as critical concern, wherein the project teams are using the automated project management tools to simply assign the resources to the project. However, the delivery elements like the effectiveness and efficacy with which the work is carried out is often ignored. Some of the human resource related studies indicated balanced score card approach, mapping the resources for the key result areas as some of the mainstream solutions to be adapted in the project environment[18][12][9].

From the dimensions of analytics being adapted in the project environment, many of the studies point to the application of project management tools or business intelligence tools adapted for executing the project conditions. Few of the studies appropriately highlighted the problem in terms of how such solutions are being limited to quantitative representation, but do not consider the contextual application and circumstances while assigning the resources to the project[7][19][20].

Studies that focused on machine learning models of improving the SRS requirements automation and project handling leads importance to the accuracy of the project scheduling and ensuring there is right kind of selection process that defines applying the project resources to the conditions. Random selection of project teams to a project environment can be challenging, and it could be affecting the process significantly[13][14][15].

In summary of the requirements discussed in the literature, it is evident that with the changing trends of project conditions and environment, it is essential for the teams to focus on correlated developments that can help in aligning the resources to the project effectively in a strategic alignment.

Model Narrative: PMHRA-PM (Prescriptive Modeling for Human Resources Allocation to Project Implementation), wherein the model is ideated on the concept of understanding the relative strength of each of the resources available for the project, and accordingly choose the optimal possible resource combination to delivery optimal results[21][22].

Table 1: Process adapted in the system

| Steps  | Process Description |
|--------|---------------------|
| Step-1 | Using conventional approach or any standard approach, the WBS tasks for the project are assessed, for time duration, resource requirements etc, and accordingly the project chart is developed. |
| Step-2 | Based on the WBS, for each of the WBS, the resource requirement is charted as a list of competencies required. |
| Step-3 | From the internal or external resources available with the project team, the resource allocation for the WBS shall be completed using the steps 4-10 as a loop for each resource. |
| Step-4 | Self-Assessment score of the resources on a Likert Scale (1-10, wherein 1 is low and 10 is high) is captured into a table, for all the key features or metrics chosen |
| Step-5 | Project Manager or Competent Authority assessment for a specific resource on a Likert Scale (1-10, wherein 1 is low and 10 is high) is captured into a table, for all the key features or metrics chosen |
| Step-6 | Depending on the project conditions, the weighted average proposition for the project is decided |
| Step-7 | According to the weighted average detailing, the weighted average scores for both self-assessment and PM Assessment scores are estimated. |
Step-8 For the estimated weighted average scores from both the sources, a mean value score is decided

Step-9 The resource ratings for the specific WBS is sorted based on the descending order of the scores

Step-10 Resources who top the ranking chart with higher mean scores shall be chosen for the tasks.

**Presumptions for the Model:** Preliminary presumption for the model is that the resources being considered for the task are fundamentally available for the project task, and only then the scope is being assessed. When the resources are filtered based on the mean scores, and the tasks assigned for a project, the other resources in the list could be considered for subsequent task in the WBS of the project or use the resource base for the other projects.

**Material and Methods**

**Features:** There are metrics upon which the key aspects pertaining to an individual resource fitment to the project is assessed. Focusing on the project dynamics, it is of paramount importance that the resource competency, skillset, effectiveness, and efficiency are assessed for the specific WBS. For instance, in the context of project requirements, though an individual resource can be profound in designing or strategizing the project tasks, the same resource may not be so effective in ground level implementation of the strategy, and some other resource could be strong in such implementation. Thus, there is need for the organizations to take such factors into account, while choosing the resources for the specific tasks.

**Competency:** In the context of the proposed model, the competency factor assessed in the conditions are pertaining to how the specific resource has adequate knowledge, skillset, and experience in terms of completing the project. Thus, for the project scenario, the requisite skillset and the resource competence are to be aligned, and hence, the resource shall be scored on the fitment for the project using the Likert scoring.

**Efficiency and Effectiveness:** Efficiency refers to the ability of a resource to accomplish the task with minimal efforts and least wastage of resources. Effectiveness refers to the degree to which the resource is successful in terms of producing the desired outcome as a result in the process. In the context of project management, both the efficiency and effectiveness with which the project tasks are executed improves the overall quality of the project. Hence, it is of paramount importance that while the resources assessed for the tasks, such practices are effectively monitored.

Some of the other self-explanatory metrics considered in the process are

- Teamwork Capability
- Availability
- Domain Expertise

**Weighted Average:** The context of weighted average refers to how each of the features are considered significant for the given process, and when the project related tasks are individually assessed, the weightage could change for each of the competency or skillset requirements from the resources. For instance, for a testing task in the project development scenario, the competency or knowledge of coding the programming language is not of high importance, whereas for the task of developing the interface, programming knowledge is essential. Thus, the weighted average model helps in giving priority for each of the feature considered for the process.

**Algorithm Flow**

Let “P” be the Project to which the resources are to be allocated

“R” be the resources, and the resources are identified as “R1, R2……Rn”

“T” be the task to which the resources are to be engaged.

The following steps are integral to the resource allocation process.

Stage-1

Resource Requirements Identification.
For the Project, “P”

{ List all the tasks “t” integral to the project.
Thus,

P = (Pt1, Pt2…. Ptn)
For each of the Ptn…. The resource requirements are listed

Hence, the model can be considered as

Ptn = Ra, Rx, Ry…. (a, x, y, represents the skillsets or designated profile essential)

} 

Stage-2

{ Estimate the weighted average for each of the resource Rn on the following feature metrics using the following steps.
The weightage “Y” shall be apportioned by the project committee team, wherein on a scale of 10, the weightage for each of the metric is defined in the process.

| Feature/Attribute | Scoring (A) Rating scale of (1-10) | Assigned Weight (B) | Weighted Value (WV=(A*B)) |
|-------------------|------------------------------------|---------------------|---------------------------|
| Competency        | X1                                 | Y1                  | Z1                        |
| Effectiveness     | X2                                 | Y2                  | Z2                        |
| Efficiency        | X3                                 | Y3                  | Z3                        |
| Teamwork          | X4                                 | Y4                  | Z4                        |
| Availability      | X5                                 | Y5                  | Z5                        |
| Total             | X=Sum (X1:X5)                      | Y= Sum (Y1:Y5)      | Z= Sum (Z1:Z5)            |

Self-Assessed Weighted Average Value SAWA = \(\frac{Z}{Y}\)

Thus, the outcome stands the self-assessment weighted average value SAWA.

| Feature/Attribute | Scoring (A) Rating scale of (1-10) | Assigned Weight (B) | Weighted Value (WV=(A*B)) |
|-------------------|------------------------------------|---------------------|---------------------------|
| Impact on WBS     | X1                                 | Y1                  | Z1                        |
| Cost Variance     | X2                                 | Y2                  | Z2                        |
| Schedule Variance | X3                                 | Y3                  | Z3                        |
| Competency        | X4                                 | Y4                  | Z4                        |
| Other Resources   | X5                                 | Y5                  | Z5                        |
| Total             | X=Sum (X1:X5)                      | Y= Sum (Y1:Y5)      | Z= Sum (Z1:Z5)            |

Authority Assessed Weighted Average Value AAWA = \(\frac{Z}{Y}\)

Mean Score Estimation

For Resource the mean score “S” stands as = \(((AAWA + SAWA)/2)\)

Stage-3

Rank the Resources R list on the basis of descending order values of “S” rank for the respective profile.

Stage-4

Selection of the top set of resources as required for the project conditions from the available pool.
In instances of any future requirement wherein the selected resource is unable to continue for the task, the next ranking resource in the prescriptive list shall be chosen for the role.
Results and Discussion
The aforementioned project model is assessed over the project requirements of a web-applications development environment, wherein three of the WBS tasks integral to completing the project successfully are considered.

For the chosen WBS tasks, the task WBS-id are classified as WBS 23, WBS 13, and WBS 15, and the resources integral to the project are available as eighteen resources. Thus, for each of the project tasks WBS, the resource requirements essential are estimated based on the optimal utilization conditions.

WBS-23: Four Resources
WBS-13: Three Resources
WBS-15: Eight Resources

Contextually, the resource competence required for each of the tasks is similar and no cross-cultural competency factor is considered in the experimental study. In the case of cross functional competency, among the existing resources, the top rank from each competency segment could be used for the process.

Assessment for WBS-23

Using the computation of the self-assessment score, and project authority assessment score, following computations for the project are handled in terms of weightage considered for various conditions.

Weighted Average

| Competence | Effectiveness | Efficiency | Availability | Teamwork | Weighted Score (X) | Weightage (Y) | SAWA-Z |
|-------------|---------------|------------|--------------|----------|--------------------|---------------|--------|
| R1          | 22            | 16         | 19           | 11       | 18                 | 86            | 28     | 3.07   |
| R11         | 25            | 14         | 19           | 22       | 21                 | 101           | 28     | 3.61   |
| R12         | 11            | 11         | 15           | 15       | 17                 | 69            | 28     | 2.46   |
| R4          | 22            | 22         | 23           | 15       | 20                 | 102           | 28     | 3.64   |
| R5          | 12            | 18         | 13           | 25       | 15                 | 83            | 28     | 2.96   |
| R6          | 12            | 25         | 19           | 13       | 21                 | 90            | 28     | 3.21   |
| R8          | 19            | 18         | 25           | 16       | 20                 | 98            | 28     | 3.50   |
Table 5: Project Authority Assessment Analysis

| Resource | Competency | Effectiveness | Efficiency | Availability | Teamwork | Weighted Score (X) | weightage (Y) | PAWA-Z |
|----------|------------|---------------|------------|--------------|----------|--------------------|---------------|--------|
| R1       | 14         | 17            | 23         | 16           | 22       | 92                 | 28            | 3.29   |
| R11      | 19         | 23            | 22         | 12           | 16       | 92                 | 28            | 3.29   |
| R12      | 17         | 11            | 15         | 24           | 20       | 87                 | 28            | 3.11   |
| R4       | 15         | 19            | 15         | 14           | 13       | 76                 | 28            | 2.71   |
| R5       | 21         | 17            | 17         | 25           | 11       | 91                 | 28            | 3.25   |
| R6       | 17         | 13            | 24         | 17           | 21       | 92                 | 28            | 3.29   |
| R8       | 19         | 14            | 11         | 24           | 14       | 82                 | 28            | 2.93   |

Table 6: Mean Score Estimation of WBS-23

| Resource | Mean Score Rating |
|----------|-------------------|
| R1       | 3.18              |
| R11      | 3.45              |
| R12      | 2.79              |
| R4       | 3.18              |
| R5       | 3.11              |
| R6       | 3.25              |
| R8       | 3.21              |

Table 7: Descending Value Ranking Process

| Resource | Mean Score Rating |
|----------|-------------------|
| R11      | 3.45              |
| R6       | 3.25              |
| R8       | 3.21              |
| R1       | 3.18              |
| R4       | 3.18              |
| R5       | 3.11              |
| R12      | 2.79              |

For the task WBS23, four resources are essential to complete the project as per the actual WBS plan. Thus, based on the mean score ratings, the four resources chosen for the project are R11, R5, R8 and R1 are chosen for the project. However, for furtherance in terms of schedule allocation, the other optimization models like can be used for scheduling the tasks for weekly schedules.

Assessment for WBS-13

In lines with the computation process defined above for WBS-23, the resource computation is carried out for the task WBS-13 and the following stands significant rating for the resources available in the team with requisite competence.
Table 8: Mean Score Estimation of WBS-13

| Resource | Mean Score Rating |
|----------|------------------|
| R13      | 3.920            |
| R15      | 3.870            |
| R6       | 3.230            |
| R18      | 3.160            |
| R4       | 2.890            |
| R17      | 2.876            |

Thus, for the three top resources available for the project, the right resources fit as per the prescriptive assessment are R13, R15, and R6 in a sequential order.

WBS-15 Assessment

Based on eleven resources who are resourceful for the process, the estimation of the right resource for the tasks are assessed. And the following are the resulting outcome.

Table 9: Mean Score Estimation of WBS-15

| Resource | Mean Score Rating |
|----------|------------------|
| R6       | 3.67             |
| R10      | 3.45             |
| R1       | 3.43             |
| R9       | 3.25             |
| R17      | 3.25             |
| R7       | 3.21             |
| R3       | 3.18             |
| R4       | 3.18             |
| R18      | 3.11             |
| R2       | 2.97             |
| R16      | 2.79             |

Based on the assessment of the tasks and the rating system, the resources in combination for all the tasks in the process are mentioned below.

Resource Gantt: The table below represents how the project comprising eighteen resources, when random selection of three tasks (WBS23, WBS15, WBS13) when assessed for the right resources, has the following computation.

Table 10: Assessment of resources of the three tasks

| Resource | WBS-23 | WBS-15 | WBS-13 | Total Tasks |
|----------|--------|--------|--------|-------------|
| R1       | 1      | 1      | 2      |             |
| R2       |        |        | 0      |             |
| R3       |        | 1      | 1      |             |
| R4       |        | 1      | 1      |             |
| R5       | 1      |        | 1      |             |
| R6       |        | 1      | 1      |             |
The graph below indicates potential ways in which the model refers to resource allocation for various tasks. The resources indicating no-colored bars in the graph represents how they are not suitable for the task, based on the prescription pattern adapted.

Among the resources, two specific resources R1 and R8 are potential for working on two different tasks WBS-13 and WBS-23. However, if there is any clash or overlap of schedules for resources, the next best alternative resource can be chosen to fill the requirement.

Fig 1: Resource allocation for various tasks
The proposed model refers to the visual representation wherein a simple dashboard as depicted above can be developed that refers to the potential schedules for each of the resource available in the project environment. From the graph it is evident that while 12 of the 18 resources with the organization is currently suitable for allocation to one or the other task, the other 6 resources are not suitable for chosen tasks, and the resources could be used for other requirements any.

**Conclusion**

One of the critical challenges in the project environment leading to project delays is non-pragmatic conditions in terms of choosing the resources for the project. It can be resourceful to understand the current work dynamics of a resource, and accordingly identify if the specific resource who can be more optimal for the process. A simple linear model of weighted average assessment pattern combined with mean score of peer evaluation pattern proposed in the model can help the project teams identify the potential teams for the work.

However, in lines of discussing the pattern for assessment, in this manuscript model, self-assessment score and project authority assessment score is adapted. Whereas, depending on the project requirements, the assessment stakeholders in the model can be altered, to suit the organizational requirements. Experimental study of the prescriptive model proposed in the study refers to potential ways in which the best possible selection of the resources for the project tasks could be attained is discussed in effective ways. Also, in a simple dashboard view, the engagement of resources for various tasks of the project too can be reviewed. For future requirements, the proposed solution can be applied on a machine learning approach to have predictive outcome for each of the project requirement.

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