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Effectiveness of Requirement Prioritization Using Analytical Hierarchy Process (AHP) And Planning Game (PG): A Comparative Study

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Abstract— **A requirement may be defined as a demand or need. In software engineering, a requirement is a description of what a system should do. Requirements prioritization plays an important role in the requirement engineering process, particularly, with respect to critical tasks like requirements negotiation and software release planning. Selecting the right set of requirements for a product release largely depends on how successfully the requirement prioritization is done. There are different requirement prioritization techniques available which are some more elaborated than others. This paper takes a closer look at two different techniques of requirement prioritization namely Analytical Hierarchy Process (AHP) and Planning Game (PG) and also shows how these techniques can be compared on various factors.**

Keywords—**Requirement, Requirement Prioritization, Analytical Hierarchy Process (AHP), Planning Game (PG), evaluation & comparison**

I. INTRODUCTION

The ultimate goal of any software organisation is to create systems that meet the stakeholder demands. Since there are usually more requirements than can be implemented, decision makers must face the dilemma of selecting the right set of requirements for their next product release. In order to select the correct set of requirements, the decision makers must understand the relative priorities of the requested requirements. By selecting a subset of the requirements that are valuable for the customers, and can be implemented within budget, organizations can become more successful on the market. Requirements prioritization plays an important role in the requirement engineering process, particularly, with respect to critical tasks like requirements negotiation and software release planning. Selecting the right set of requirements for a product release largely depends on how successfully the requirement candidates are prioritized. There are different requirement prioritization techniques available which are some more elaborated than others**.** As Wiegers puts it: "Prioritization means balancing the business benefit of each requirement against its cost and any implications it has for the architectural foundation and future evolution of the product" There are several different techniques to choose from when prioritizing requirements. Some techniques are based on more or less structured sorting algorithms, while others use pair-wise comparisons or numeral assignment

II. BACKGROUND AND RELATED WORK

This paper does not explain how the software requirements will be prioritized mathematically? It has only compared two prioritization techniques. D. Firesmith [1] has worked for prioritization dimensions, prioritization approach, prioritization techniques and processes. In [2] J.Karlsson, C Wohlin , and B.Regnell have evaluated six different methods for prioritization software requirements. In this paper, authors have found that Planning Game (PG) can be the most promising method. In literature we have found some weaknesses of AHP. The limitations of AHP are that it only works because the metrics are all of the same mathematical form known as positive reciprocal metrics. In this paper PG and AHP prioritization techniques are compared on basis of various factors.

III. REQUIREMENT PRIORITIZATION TECHNIQUES

The two techniques compared in this paper are (1) the Analytical Hierarchy Process (AHP) that is based on exhaustive pair-wise comparisons and (2) the Planning Game (PG) that uses a sorting algorithm to partition the requirements. The two techniques are further described below.

A. Analytical Hierarchy Process (AHP)

AHP is a decision-making method that involves comparing all possible pairs of requirements, in order to determine which of the two is of higher priority, and to what extent. If there are *n* requirements to prioritize, the total number of comparisons to perform is *n*(n-1)/2*. This relation results in a dramatically increasing number of comparisons as the number of requirements increases. However, due to redundancy of the pair-wise comparisons, AHP is rather insensitive to judgment errors. Furthermore, AHP includes a *consistency check* where judgment errors can be identified and a *consistency ratio* can be calculated. In AHP, any system structure can be abstracted into a hierarchy that explains the system's components and their functions. Hence, AHP takes the whole system into account during decision-making since it prioritizes the components on each level in the hierarchy. Karlsson *et al.*performed an evaluation of six different prioritization techniques based on pair-wise comparisons, including AHP. The authors

concluded that AHP was the most promising approach because it is based on a ratio scale, is fault tolerant, and includes a consistency check. AHP was the only technique in the evaluation that satisfied all these criteria. Furthermore, it includes a priority distance, i.e. a *ratio scale*, while the other approaches only provided the preferred order. However, because of the rigor of the technique, it was also the most time-consuming one in the investigation. Since the major disadvantage of AHP is the time consumption for large problems, different investigations have been performed in order to decrease the number of comparisons, and thus the time needed.

B. Planning Game (PG)

In the last years, there have been an increased use and interest in agile methodologies, such as Extreme Programming (XP). Agile methodologies are based on streamlined processes, attempting to reduce overhead such as unnecessary documentation. The interest and use of agile methodologies have been both from industry and academia. XP is composed of 12 fundamental practices, of which Planning Game (PG) is one. For the purpose of this experiment we have isolated PG despite that the practices likely affect each other. PG is used in planning and deciding what to develop in a XP project. In PG, requirements (written on so called Story Cards) are elicited from the customer. When the requirements have been elicited, they are prioritized by the customer into three different piles: (1) those without which the system will not function, (2) those that are less essential but provide significant business value, and (3) those that would be nice to have [1]. At the same time, the developers estimate the time required to implement each requirement and, furthermore, sort the requirements by risk into three piles: (1) those that they can estimate precisely, (2) those that they can estimate reasonably well, and (3) those that they cannot estimate at all. Based on the time-estimates, or by choosing the cards and then calculating the release date, the customers prioritize the requirements within the piles and then decide which requirements that should be planned for the next release. The result of this easy and straightforward technique is a sorted vector of requirements. This means that the requirements are represented as a ranking on an *ordinal scale* without the possibility to see how much more important one requirement is than another.

IV. PROPOSED WORK

Proposed work compares requirement prioritization based on AHP and PG on the following factors:- Risk calculation, Effort Estimation, Accuracy, Ease of Use, Total Time taken, Scalability, Business value, Resource availability, Total no of comparisons, Consistency ratio, Judgmental errors.

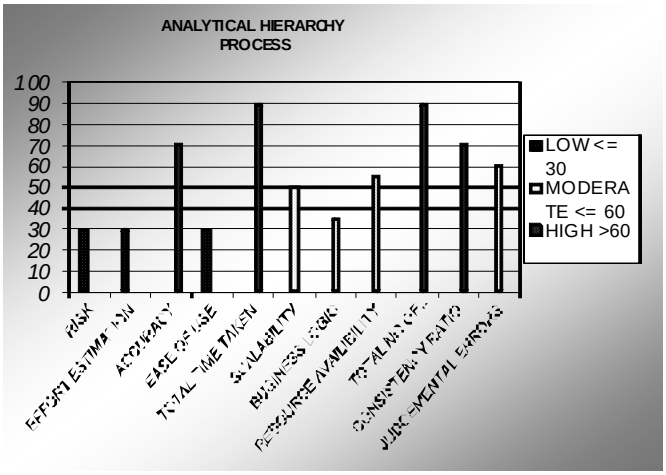

Fig: Following graph represent AHP technique on different factors

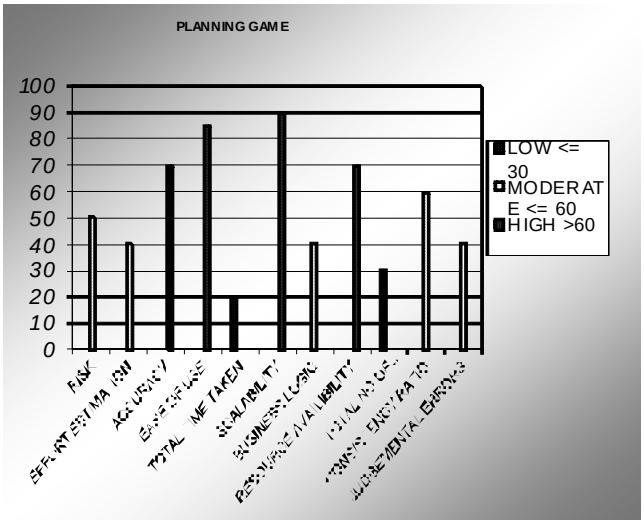

Fig: Following graph represent PG technique on different factors

Table 1: Analysis Table: Techniques versus Factors

Factors	AHP	PG
Risk Calculation	Low	Moderate
Effort estimation	Low	Moderate
Accuracy	High	High
Ease of Use	Low	High
Total Time Taken	High	Low
Scalability	Moderate	High
Business value	Moderate	Moderate
Resource Availability	Moderate	High
Total no of Comparisons	High	Low
Consistency Ratios	High	Moderate
Judgmental errors	Moderate	Moderate

V. EVALUATION

Table above shows the techniques and factors on the basis of which the comparison is done.

A. *Risk Calculation*

Risk calculation is an important factor during requirement prioritization. It may well make sense to prioritize requirements by the risks associated with their implementation. For example, one can attempt to implement those requirements having the highest risk first so as to deal with the resulting problems during development. On the other hand, it may make sense to implement the lowest risk requirements first in order to maximize the amount of the system implemented by ensuring that limited resources are not wasted on trying to implement high risk aspects of the system that may be impossible to successfully implement. Postponing the implementation of high risk requirements can also maximize the time available to research the risks and determine appropriate risk mitigation approaches [1].

AHP does not calculate any type of risk whereas risk estimation is moderate in PG. In planning game sorting can be done by risk:

Those that can be estimated precisely
Those that can be estimated reasonably well
Those that cannot be estimated at all

B. *Effort Estimation*

Efforts estimation is the process of predicting the most realistic use of effort required to develop or maintain software Effort estimation is another major issue that has to be address while prioritizing requirements. Effort estimation includes estimation of total effort available and overall required effort for releases. Estimate effort led by the technical leader and architecture team, the development team that must actually implement the requirements creates and records realistic estimates of the effort required to implement each requirement [1].For all releases of software effort estimation is not done in AHP

C. *Accuracy*

Accuracy is the faithful measurement or representation of the truth; correctness and precision. In initial stages of requirement prioritization PG is considered to be a better choice whereas in the later stages AHP is considered more accurate.

D. *Ease of Use*

Based on the no of comparisons in AHP i.e. n*(n-1)/2 it is considered to be tough as compared to PG because it requires only n comparisons for n no of requirements. Hence PG is considered to be easier and more appropriate for requirement prioritization

E. *Total Time Taken*

The total time taken in order to prioritize requirements using AHP is usually high as compared to PG because the no. of comparisons among requirements is far more than in PG [2].

F. *Scalability*

It is important to be able to scale up to atleast that many requirements i.e. the technique should be able to handle a large no of requirements with sufficient ease without too much effort and time overhead. But in AHP if the no of requirements increases then more comparisons are made which results in more time and effort consumption. In PG since only n comparisons are required for n no of requirements so if the no of requirements increases then also it will take less time and effort to scale up as compared to AHP.

G. *Business Value*

Business value is an informal term that includes all forms of value to the organization. An example of a business value is: "Customer Satisfaction." Another example of a value is "Being Ethical and Truthful." Every organization has one or more values, whether they are consciously aware of it or not. Various requirement prioritization techniques consider business values during prioritization process but AHP does not consider such values.

H. *Resource Availability*

Resources refer to the budget, staff and schedule. Resource estimation is one of the crucial factors in requirement prioritization but among AHP and PG,

AHP does not calculate the estimated resource constraints, total resources available and overall resources required for project [3].

I. *Total no of comparison*

In AHP if there are *n* requirements to prioritize, the total number of comparisons to perform is *n (n-1)/2*. This relation results in a dramatically increasing number of comparisons as the number of requirements increases. For 10 requirements we need 10*(10-1)/2=45 comparisons. For 20 requirements we need 20*(19)/2=190 comparisons. For 100 requirements we need 100*(99)/2=4950 comparisons

Therefore AHP will take long time to compare all the requirements. Planning Game takes n comparison for n no of requirements. Hence fewer amounts of comparisons and time is consumed in requirement prioritization.

J. *Consistency ratios*

The consistency ratio (CR) describes the amount of judgment errors that is imposed during the pair-wise comparisons. The CR is described with a value between 0 and 1 and the lower CR value, the higher consistency. Saaty [5] has recommended that CR should be lower than 0.10 in order for the prioritization to be considered trustworthy. The CR limit above is only valid for the scale 1~9. If the time consumption is more the consistency is often influenced so AHP is inconsistent than PG[4,5] .

K. *Judgmental Errors*

It has been shown that AHP is insensitive to judgmental errors due to the redundancy in the pair wise comparisons [4, 5]. This is because the AHP-technique" feels like pouring requirements into a black-box" as one of the subjects stated. It may be difficult to trust something that is not in control.

VI. CONCLUSION

Methods for establishing priorities are of great importance in software development, since the developers' best effort can more easily be focused on the issues which matter most for the success of the system [2]. We have evaluated and characterized two different methods for establishing priorities. In our evaluation we found PG to be the most promising approach as it yields one of the most trustworthy results by taking least time and it also works fine when the number of requirements increases. The investigated techniques are the elaborate Analytical Hierarchy Process (AHP), which is based on pair-wise comparisons and has a ratio scale, and the elementary Planning Game (PG), which is based on pile partitioning and has an ordinal scale. The results reveal that the intuitive and quick PG technique is superior to AHP technique.

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