Requirements Negotiation: Making System Stakeholders’ Multiple-Views One

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Abstract: The requirements engineering activities within a software project are known to be critical to the successful production of a correctly functioning system. This is particularly so when considering the varying views of multiple stakeholders. One promising approach for improving the outcome is to introduce formal negotiation. Clearly, making the set of requirements more closely represent all the stakeholders’ perspectives and perceptions, underpins a sound basis for project estimation, improved system quality and a reduction of the resources necessary. However, such benefits are mere speculation if it is not possible to provide empirical evidence. This paper presents a framework to provide empirical evidence on the effectiveness of formal negotiation to identify and to resolve conflicts between stakeholders. In particular, it is valuable in the allocation of priorities for a particular requirement and in the decision on its inclusion or exclusion. This is particularly useful in evolutionary and incremental paradigms such as the Agile methods. Also, it is necessary when time and resources are constrained — a condition in most software projects. Whereas this outcome is hardly surprising, it does validate the fundamental purpose of negotiation.

Key words: Requirements engineering, system requirements, negotiation.

1. Introduction

The biggest challenge in software development is to define the right thing to develop. ‘Right’ in terms of requirements is somewhat subjective but the set of requirements must describe the stakeholders’ needs to ease their business processes and must be feasible in order to be realized within time, cost and technology constraints. The requirements statement is the basis for every project, defining what the stakeholders need and also what the system must do in order to satisfy that need. Further, errors in requirements are the most numerous in the software lifecycle and also the most expensive and time-consuming to correct [1]. The context in which requirements are elicited is usually a human activity, and the problem owners are people. It is seldom technical problems which inhibit productivity and quality [2, 3]. Instead the vast majority of requirements problems are related to human interactions, process and communications. One of the main problems during requirements elicitation is communication and understanding among the stakeholders. This involves conflicts, scope boundary and erroneous interpretation. The argument is supported by Zowghi [3] who believed that requirements elicitation is inherently imprecise as a result of multiple variable factors, a vast array of options and decisions, and communication.

Dorfman [4] determined that benefits of good requirements include agreement among all the stakeholders on the job to be done and the acceptance criteria for the delivered system, a sound basis for resources estimation, improved system qualities and the achievement of goals with minimum resources. Theoretically, negotiation effort is able to resolve conflicts among multiple stakeholders through the different approaches to dealing with conflicts such as competing, accommodating, collaborating, avoiding or
compromising [5]. Competing involves an emphasis on winning one’s own concerns at the expense of another, often leading to win-lose situations. Whilst accommodating involves trying to satisfy the other’s concerns without attention to one’s concerns, this can mean that one stakeholder is self-sacrificing and yielding to the other. Collaborating focuses on satisfying the concerns of all parties to find solutions that try to satisfy the concerns of all. The emphasis is on finding ‘win-win’ situations. Avoidance of conflict could be a result of indifference, denial or apathy while compromising involves concessions to find a satisfactory middle ground. These five different orientations are defined by Grunbacher [5] and are based on organizational psychology [6]. According to this model a stakeholder’s orientation has two dimensions: the focus on satisfying their own concerns and the emphasis on satisfying the concerns of others.

This research emphasizes the win-win situation and therefore adopts a collaborative strategy in which the system’s stakeholders work together to reach a group objective rather than compete against each other.

2. Aims

One of the benefits of negotiation is to achieve a mutual agreement among multiple stakeholders who have different roles and responsibilities. It is a great challenge to bring together every individual of the key stakeholders each of whom has a different perspective and perception. A mutual agreement will benefit the system to be developed and the organization as a whole. Therefore, this paper aims to show:

- Resolution of conflict between key stakeholders in the meaning and objective of particular requirements.
- Resolution of conflict between key stakeholders in the priority to be allocated to particular requirements.

3. Negotiation Model

The model introduced in this paper is emphasizing ‘win-win’ situation to adopt a collaborative strategy. The collaborative strategy is usually understood as a consensus based negotiation in order to achieve an agreement among multiple stakeholders. Hence, the agreement achieved represents the key stakeholders’ perspective and perception [7] and it is a reasonable expectation that a decision based on a combination of thoughts would be of a higher quality than any individual decision. Consensus based negotiation refers to an agreement by the key stakeholders which leads to acceptance of consensual decisions. The stakeholders feel that their perspectives and ideas are acknowledged, respect is shown for all persons involved in the decision making process, use is made of the collective knowledge and skills of the group of collaborative environment among the stakeholders is created. Choudhury et al. [2] stated that working in a group provides a wide range of advantages by sharing information, generating ideas, making decisions and reviewing the effects of the decisions. Ideally, the group will reach a better decision than an individual because collective knowledge and expertise of the group is greater than that of any individual [8]. Further, people are more likely to implement and accept decisions they have accepted by consensus [2, 9].

Applying consensus based negotiation, the ideal result is a total agreement. This means all the stakeholders’ representatives who are involved in a negotiation understand the entire concept and achieve

Up to a certain point, there is a positive relationship between the amount of negotiation and increase in agreement level between stakeholders.

Within the context of the experiment, given a certain amount of time, a certain amount of agreement is achieved. However, there exists a point (generally well beyond the amount of negotiation covered in this research) beyond which further effort produces little benefit.

Through the measurement of negotiation effectiveness on achieving an agreement, this paper presents two roles of negotiation which benefit the software project:

- Resolution of conflict between key stakeholders in the meaning and objective of particular requirements.
- Resolution of conflict between key stakeholders in the priority to be allocated to particular requirements.
an agreement on all the negotiated requirements (either to proceed or to drop or to have the same priority level). In addition, the agreement achieved out of a negotiation session depends on the person’s effort being devoted to negotiation. Thus, even though this research applied consensus based negotiation, there is a possibility that the total agreement is not achieved due to the time constraints. Even though total agreement is not achieved, an effort to narrow the disagreement gap is of benefit to the software project.

Illustration in Fig. 1 is the role of negotiation which improves the agreement between multiple stakeholders during the requirements elicitation process. The figure illustrates an ideal model of negotiation activities and their outputs. The oval notations represent activities undertaken during the negotiation and the rectangle notations represent the inputs and outputs of the activities. The first two activities assign preference score and compare preference score are to identify conflicts. The conflicts are detected systematically based on the different values assigned to the requirements by multiple stakeholders. Based on the conflicted requirements, negotiation effort starts with sharing and defining glossary and sharing perspectives, views and expectations of requirements. These activities provide common meaning to keywords and develop team learning. These two outputs represent the tacit knowledge which is revealed through the negotiation effort. After the stakeholders share the same understanding of the terms used and the requirements statements, they assess the feasibility and justify the requirements needs. These two activities establish an awareness of project constraints and reveal the importance and relevance of the requirements respectively. This knowledge helps the stakeholders to prioritize the requirements. The prioritization helps to reduce the uncertainty in which things needing attention are highlighted. All the information gathered and knowledge revealed assists the stakeholders to achieve an agreement. The final output is a list of feasible and mutually satisfactory requirements.

4. The Experiment

This section describes the experimental design and identifies the participants involved in the experiment. Also, this section defines the experimental process.

The experiment detects conflicts by identifying the stakeholders’ perspective on individual requirement. Negotiation is applied to produce a consensus on a list of requirements which will be developed for the current release of the software system. The amount of requirements which will be in the list is restricted to the resources available for the software project. Basically, the stakeholders need to consider not only the requirements they think are important, but also what other stakeholders claimed as important and may be crucial to the system. The exercise is not about a good negotiator winning a battle but it is about identifying a set of requirements which represents the stakeholders’ needs that can be translated into a reliable and a workable system. This exercise is deployed with an assumption that all the stakeholders have positive motivation and that they work together towards developing a good system. This assumption is tested by a questionnaire during the post-mortem session immediately after the experiment. The questionnaire is designed to test the above assumption and to gather feedback from the participants in order to know how far the experiment meets the objectives.

4.1 The Participants as the Experimental Unit

The participants for the experiment describe in this paper were third year students enrolled in Software Requirements and Project Management (CITS3220) unit in The University of Western Australia. Based on the curriculum structure at this point after three years of study, the students already have considerably good foundation and significant theoretical background on software engineering. Moreover, focusing on software requirements in the current semester, they were aware of the importance and complexity of the requirements elicitation process especially when it involved multiple stakeholders.
There were thirty participants randomly allocated into seven groups. Five groups were formed by four participants and the remaining two groups had five participants each. Every participant is assigned a role to play as a stakeholder of the Academic Unit Registration System. They were student, lecturer, and administrator and finance department staff. Group 1 and Group 7 consist of five participants each and
decided to have two lecturer’s role and two student’s role respectively. The remaining groups have one participant playing one role in the experiment.

4.2 Experimental Protocol

The entire experiment took approximately an hour with 30 minutes allocated for negotiation. The remaining 30 minutes were for the instruction session, pre-negotiation and post-mortem session. The pre-negotiation was for assessing individual preferences for each requirement according to roles and this process systematically identified the conflicts. The conflicts were detected based on the value of each requirement assigned by individual stakeholder. It is a conflict whenever the values differ from each other.

The exercise begins with the pre-negotiation where the stakeholders individually identify their preference values to all the requirements. The preference value is based on the scale 0 to 4 as indicated in Table 1. This effort is meant to capture the individual preference from each participant. The difference in values indicated by different stakeholders shows the existence of requirements conflict in terms of stakeholders’ preferences. The conflict is the basis of requirements resolution as only conflicted requirements are negotiated to achieve an agreement. The negotiation activity promotes group decision by consensus and achieves mutual understanding among the group members on the same requirements. Therefore, negotiation was deployed at this point to identify the most desired and the most important requirements to be developed. Suggestions and examples of ways to achieve group decision were given in advance. During the negotiation process, once agreement was achieved on a specific requirement, the stakeholders recorded the agreed value of the said requirement in the preference value sheet. This indicated the status of the requirements, which would be either included to be in the list or dropped, and portrayed the priority of the requirements. It was noted that there was a possibility of requirements remaining undecided due to the time constraints or due to a highly conflicted set of requirements. Therefore, for the undecided requirements, individual preference values were required.

When the experiment was done, a post-mortem was executed to gather feedback from the participants in order to know how far the exercise met the objectives. The feedback was in a form of statements to be scaled by the participants and two short questions. This feedback showed if negotiation is beneficial from the participants’ point of view.

5. Measurement of Stakeholders’ Agreement Level

This section explains the method and the metrics used to measure the stakeholders’ agreement level.

The measurement of the stakeholders’ agreement level is based on the value assigned to every requirement which is 0 to 4 by an individual stakeholder. The value is assigned twice; before and after the negotiation respectively. This is done to capture the difference in the value assigned to the requirements by multiple stakeholders. The difference, if it exists, portrays the changes in stakeholders’ perspective towards the requirements following a negotiation process. The resulting distance between two sets of values is measured to discover the improvement of the agreement level through negotiation. Out of the experiment, two sets of preference values containing fifteen requirements each are obtained from seven groups. The results obtained after the negotiation process show if negotiation is able to achieve an agreement. An agreement demonstrates negotiation is able to resolve conflicts among the

| Table 1 The preference value scale. |
|---|---|
| Scale | Meaning |
| 4 | Must have this |
| 3 | Should have this if at all possible |
| 2 | Could have this if it does not affect anything else |
| 1 | Will not have this time but would like in the future |
| 0 | Must never have this |
stakeholders and able to collectively prioritize the requirements (the results are presented in section 6).

ANOVA assumes continuous and normally distributed data rather than deviate values. The ANOVA test is robust and provides a useful measure of the size of difference between the stakeholders’ priorities. Analysis of variance or ANOVA is applied as a basis to measure the difference in individual requirement and the difference in a set of requirements by an individual group due to the negotiation process. The purpose of analysis of variance is to test the differences in means for statistical significance. This is accomplished by analyzing the variance; that is by partitioning the total variance into the component that is due to true random error and the components that are due to differences between means. These latter variance components are then tested for statistical significance and, if significant, we reject the null hypothesis of no differences between means, and accept the alternative hypothesis that the means are different from each other.

In this paper, a two-way analysis of variance without replication is applied. The parameters are the value indicated by the multiple stakeholders before and after the negotiation. As for the values indicated for each requirement, the variance shows the improvement in individual requirement. The variance initially shows the degree of disagreement among the multiple stakeholders. Through the negotiation process, whenever the variance is 0, agreement is achieved. In summary, the higher the variance, the bigger the disagreement gap between the stakeholders and the closer the variance to 0 the better the agreement level achieved through negotiation. Stated in Eq. (1) is the variance formula which shows the improvement in an individual requirement.

\[ \sigma^2 = \frac{\sum(X - \overline{X})^2}{N} \]  

In addition, ANOVA provides analysis needed for the calculation of interclass correlation coefficient or ICC. ICC is applied to measure the difference in agreement level for a set of requirements by multiple stakeholders. Correlation coefficient was discovered to be suitable to assess agreement between quantitative measures as good agreement is only obtained when the pairs of readings closely follow the line of equality [10]. Each of the fifteen requirements is rated independently by the stakeholders who belong to the same group. The ICC is estimated as in Eq. (2):

\[ ICC = \frac{RMS - EMS}{RMS + (k-1)EMS + k(SMS - EMS)/n} \]  

Where RMS is requirement mean square, EMS is error mean square, SMS is stakeholder mean square, \( n \) is the total number of requirements being measured and \( k \) is the number of the stakeholders. For example, if fifteen requirements are rated by four stakeholders, \( n \) is 60. The result from the experiment is illustrated in section 6.

6. Results and Discussion

This section presents the results and the analysis obtained from the experiment.

Table 2 shows the variance for every requirement from each group before and after the negotiation. Value 0 signifies agreement is achieved for the specific requirement and the farther the value from 0, the higher the disagreement is. At the bottom of the table, the difference represents the total improvement achieved through negotiation effort for all the fifteen requirements. The result shows that substantial improvement in agreement achieved through negotiation for each group.

Meanwhile, Table 3 presents the same values in a way to show the difference between before and after the negotiation in variance for individual requirements. The average of variance achieved by all groups for every requirement is also presented. Table 3 (A) represents variance before negotiation and Table 3 (B) represents variance after the negotiation. The average value shows average level of agreement achieved for each requirement through negotiation. Every requirement represents customers’ needs and usually multiple customers have different needs and priorities towards the systems to be developed. The differences
are essentially based on the customers’ roles and responsibilities to fulfill a business process. Even worse, conflicts are inevitable when the requirements elicitation process involved other stakeholders, other than the system owner. The involvement of other stakeholders such as the end user and the administrator is to consider a broader view to ensure the usefulness and the feasibility of the system to be developed.
Through negotiation, mutual understanding is developed and the key stakeholders are able to make informed decision which leads to mutual agreement. The results in Table 3 support the obvious fact that negotiation improves the agreement level for every single requirement. Even though not all requirements achieved consensus, the variance before and after the negotiation shows substantial improvement is achieved.

Table 3 also shows the ability of negotiation to prioritize the requirements. This is shown by the improvement in variance presents in Table 3, before and after negotiation respectively. When the variance for the particular requirement is more than 0, it shows that two or more of the key stakeholders have different priority value for the requirement. After a negotiation, the variance value in all the requirements for G1, G4 and G5 turn to 0, which shows the groups manage to collectively prioritize the requirements for all fifteen requirements. As for G2, G3, G6 and G7, the variance value shows a significance movement towards 0 after negotiation with narrowing of the gap of the requirements priority allocation by the key stakeholders. This shows that not only negotiation effectively resolves conflicts between the key stakeholders but at the same time it is able to collectively prioritize the requirements. This effort assists in group decision making as to which requirement is important and to proceed with the development. This is especially important in evolutionary and incremental software life-cycle.

As for the entire set of requirements, Fig. 2 shows the result of the agreement level based on the data retrieved from the experiment. Initially, the ICC values are very low for all the groups with the lowest ICC score being -0.11. However, the level of agreement improved substantially towards an achievement of total agreement after the negotiation effort. In addition, three groups achieved total consensus. Even though not all groups achieved total consensus, the graph shows a substantial improvement with two groups needing less than 0.1 to achieve it. Therefore, the result shows that the negotiation is effective to improve the level of agreement among the stakeholders during requirements elicitation process.

Note that the results from this experiment do not show whether the stakeholders are good negotiators or not. There are many other factors which influence the success of negotiation. One example is that the agreement level is influenced by the time devoted to negotiate. Cultural background and different experience also influence the success of negotiation. This is, however, beyond the boundary of this research.

The improvement in the agreement level will make a significant difference on the project outcome as the agreement represents all the stakeholders’ perspective and perceptions, reveals tacit knowledge, underlies a sound basis for resource estimation, improves system quality and minimizes the resources involved [3-5, 7, 11-16].

Through the agreement achieved, the measureable benefits obtained during the experiment are the ability of negotiation to resolve conflicts and the ability of negotiation to collectively prioritize the requirements. As discussed above, Fig. 2 demonstrates the improvement of agreement level achieved through negotiation. The figure also shows the negotiation
capability to resolve the conflicts in order to achieve an agreement. Through the experiment of seven groups negotiating fifteen requirements each, an average of fifteen requirements had been in conflict before negotiation and an average of twelve requirements were subsequently solved by negotiation. Based on the experiments’ results, 80% of conflicts were resolved through negotiation. Not only did these experiments demonstrate the benefit of negotiation but they also quantified the movement towards consensus following a limited amount of negotiation.

6.1 The Feedback

The result in the previous section confirmed the aims of this paper. This sub-section further describes the feedback obtained from the participants exercising the experiment. This feedback is gained in a post-mortem session after the experiments were complete.

It is agreed that negotiation is of benefit to the stakeholders, the organization and the software project in particular. Based on the positive feedback from the experiments, the negotiation effort significantly benefited the current project and helped with a long term relationship between the stakeholders. Good negotiation practice will promote this rapport and a positive relationship between the stakeholders.

Through feedback from the participants involved in the experiment conducted in the post-mortem session, Fig. 3 shows the feedbacks in a scale of strongly agree, fairly agree, agree, disagree and strongly disagree. There are five items to be scaled and they represent the benefit of negotiations applied. The items are:

- Increase the feeling of happiness and belonging to the group (ideas acknowledged to allow dynamic cooperation);
- Understand project constraints and adapt to change;
- Fostering team learning and reveal shared interest;
- Dealing with uncertainty and finding solution;
- Promote rapport and positive relationship.

The graph shows that the majority of the participants voted “agree” to all the items mentioned with a number of them voted “fairly agree” and “strongly agree”. Only small proportions voted “disagree” and “strongly disagree”. Hence, according to this feedback, it is agreed that negotiation effort is beneficial to the stakeholders and the organization as a whole.

7. Conclusions

In any requirements elicitation process, conflicts are inevitable if a number of stakeholders are involved. Even though the initial goal for all is identical, to design and to develop a good and meaningful system, the different backgrounds, experiences, concerns, responsibilities, and priorities of stakeholders may lead to conflicts. Therefore negotiation is beneficial to play a vital role to resolve conflicts between stakeholders. There might be cases where total agreement is not achieved, but the experiment discussed in this paper suggests that the agreement level is improved significantly through negotiation. In addition, the agreement achieved also demonstrates the role of negotiation to resolve conflicts and to collectively prioritize the requirements.

References


