Negotiation-Collaboration in Formal Technical Reviews

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Abstract: This paper discusses the negotiation-collaboration process: a binomial process mixing collaboration, negotiation and argumentation. We applied the negotiation-collaboration process to Formal Technical Reviews, commonly adopted to verify the functional specification of software. We developed a groupware tool demonstrating the dynamic of the negotiation-collaboration process in Formal Technical Reviews. And we provide results from an experiment with the tool in a software engineering firm. The obtained results demonstrate the negotiation-collaboration process promotes bigger participation in FTR.

Keywords: Formal Technical Reviews, Negotiation, Software Quality Assurance

1. Introduction

Formal Technical Reviews (FTR) are recommended software quality assurance activities in software engineering [1]. A FTR is a collaborative endeavor involving designers, developers and testers. It serves fundamentally to verify, at various points in the product development lifecycle, if the product is being engineered with quality and coherency with the specification, i.e. the product supplies the right solution to the requirements specified by the client.

In spite of having a common goal, the participants in a FTR often develop conflicting perspectives, interpretations and positions regarding the product quality. This type of conflict justifies the negotiation-collaboration process: a process aiming to integrate conflict management in collaboration. We thus have, on the one hand, the FTR activity that has to be fulfilled by a group of persons and, on the other hand, the negotiation-collaboration process necessary to accomplish the FTR activity with success.

Groupware may simultaneously support the FTR activity and the negotiation-collaboration process. Unfortunately, resolving conflicts and getting to consensus is a complex problem. One major intricacy is dealing with the main assumptions behind

conflict resolution: (1) the interlocutors have diverse profiles, interests, viewpoints and strategies that should be respected and often promoted to reach quality results; (2) in this context, reaching consensus requires a collective cognitive effort, understanding the different positions and seeking creative consensus solutions; (3) while also taking into consideration that the process should be as fast and affective as possible.

Many approaches to FTR emphasize collaboration to the detriment of negotiation, for instance adopting a strict focus on shared information. This strategy naturally seeks to enforce consensus. Such an approach may however fail, either because the conflicts may remain dormant, just to arise later in the product lifecycle; or the conflicts may escalate to unacceptable levels, making it more difficult if not impossible to accomplish the intended goals. It is therefore necessary to develop an integrated and balanced view of collaboration and negotiation.

The problem discussed in this paper concerns the lack of negotiation-collaboration balance observed in the current groupware tools [2]. The research described in this paper tries to supplant this lack of balance by integrating models of collaboration, argumentation and negotiation. This research guided the development of a groupware tool supporting FTR in the software engineering Functional Specification phase.

The paper is organized in six sections. In Section 2 we present the theoretical foundations that guide FTR. In Section 3 we describe how the negotiation-collaboration process occurs during FTR and delineate its major requirements. Section 4 describes the developed prototype. Section 5 describes an experiment carried out with the prototype. And in Section 6 we present some conclusions from this research.

2. Theoretical Foundations

Fagan [3] developed the FTR technique while working for IBM. A FTR is defined as an activity practiced in groups, based on formal procedures and designated roles, aiming to discover defects in documents and code. FTR is an activity belonging to the more general software verification and validation process and, even more broadly, integrated in the software quality assurance process [4].

The International Software Testing Qualifications Board provides a general vision of the FTR process organized in several phases [5]. The several phases are described as follows:

- Planning: select the team, allocate functions, define input and output criteria, and select the products to be revised;
- Kick-off: distribute documents, explain the objectives, processes and documents to the participants, and check the input criteria;
- Individual preparation: work done by each participant before the review meeting, taking notes of the potential defects, questions and comments;
- Review meeting: analysis of the work submitted for review, identification and discussion of defects, and decision about the acceptance or not of the product;
- Re-work: addressing the defects found in the review meeting (carried out by the authors);

- Accompaniment: inquiring if the defects were forwarded, obtaining project metrics and checking the output criteria.

Also in accordance with the ISTQB [5], the roles and responsibilities involved in the FTR process include:

- Manager: who assumes responsibility and takes the final decisions during the review, allocates time and determines if the revision's objectives were achieved;
- Moderator: who leads the review, including planning and accompanying the re-work. If necessary, the moderator mediates conflicts. The moderator is responsible for the success of the review meeting;
- Author: the person who submits the document/product for review;
- Reviewers: the persons, having technical and/or business knowledge, who identify, analyze and describe the defects found in the document/product under review;
- Secretary: the person that documents what happened in the meeting, registering the reviewed items and defects found.

With a small differentiation of roles, Pressman [1] indicates the review must have the participation of the review leader, several reviewers and the producer. The producer and author have identical roles, i.e., they deliver the reviewed product. However, the manager and moderator roles are substituted by the more focused role of review leader; and the secretary task is simply carried out by one of the reviewers designated by the leader.

Antunes et al. [2] adopted a different perspective over the roles and responsibilities involved in the FTR process. They discussed the different attitudes the participants may assume during a FTR, identifying two stereotyped attitudes: highly collaborative and highly conflicting. Of course these extreme attitudes may be detrimental to the quality of the FTR process, one because it may lead to groupthink [6, 7] and the other because it may lead to a failed task. Interestingly, dealing with conflict has been considered a way to avoid groupthink [8] and collaboration is also a viable way to overcome conflict. Therefore, the two extreme attitudes, as well as all the other possible attitudes in between, should be reconciled. Ramires et al. [9] developed a groupware tool implementing the Software Quality Function Deployment (SQFD) [10] technique to study the integration of collaboration and conflict. The tool integrates argumentation and negotiation support with SQFD.

The research described in this paper extends the previous works on collaboration and conflict integration in two different streams. The first stream concerns developing the negotiation-collaboration process as a generalization of the previous SQFD process, integrating aspects of collaboration, negotiation and argumentation. The second stream considers developing a groupware tool supporting FTR.

Regarding the negotiation-collaboration process, its theoretical foundations may be found on the confluence of three different views over group work and decision-making:

- Collaboration - Where the fundamental assumption is that a group of people communicate, coordinate activities, share a workspace and construct shared awareness, including awareness of who are the group members, what are they doing, and where are they located in the workspace [11].

- Negotiation - Considering there are several conflicting parts that must bargain to reach a mutually satisfactory outcome. Bargaining will thus involve communication, offers and counteroffers, the definition of a settlement space, and search for mutually beneficial agreements [12, 13].
- Argumentation-based negotiation - Complementing the negotiation view with the perspective that communication is fundamental to justify the own negotiation stance and persuade the other parts to change their stance [14].

3. The Negotiation-Collaboration Process

A problem statement triggers the negotiation-collaboration process. In our case study, the problem statement concerns the approval or rejection of a specification document or piece of code. After being triggered, the process evolves according to three phases:

- **Presentation of proposals**: Several proposals to resolve the problem may be presented by the participants;
- **Argumentation-based negotiation**: The participants have to reach a consensual position about each proposal. Communication is necessary to confront the individual positions, for and against the proposals, and provide arguments to substantiate the adopted positions;
- **Decision**: Having obtained a consensual set of positions, a decision must be made. This step involves analyzing the implications of the adopted positions and the subsequent steps necessary to put them into practice.

Notice that argumentation and negotiation are entangled. It should also be considered the presentation of proposals may be done during the argumentation-based negotiation.

3.1. Data model

The data model of the negotiation-collaboration process is organized around the following elements: proposals, scores, positions, arguments, results and decisions. A proposal may be regarded as an action-statement that must be analyzed and discussed by the group. Figure 1 depicts this model.

The participants in the process should individually score every proposal. We currently support three scores: accept, reject and accept with restrictions. The occurrence of different scores for a proposal indicates there are divergent positions about the proposal. The positions are thus inferred automatically from the scores. In order to enforce argumentation, the reject and accept with restrictions scores should necessarily be complemented with arguments.

The goal of the negotiation-collaboration process is not necessarily to obtain consensual scores for every proposal. Several rules may be defined by the organization regarding what results should be drawn from the individual scores. The following rules may be considered: majority voting, where the result corresponds to the score selected by the majority of the participants; consensus, i.e. there is only a result if it corresponds to the score selected by all participants; and moderated, where the moderator should decide the result based on the participants' scores.

After obtaining a result for each proposal, the whole collection of results should be subject to a final verdict and lead to a decision. Again, several organizational rules may be adopted to obtain the final verdict. We adopted the following rules to deal with FTR: (1) general acceptance, only if there are no reject solutions; (2) general reject, if there is at least one reject solution; (3) postpone, if there is at most a predefined number of accepts with restrictions; and (4) general acceptance otherwise.
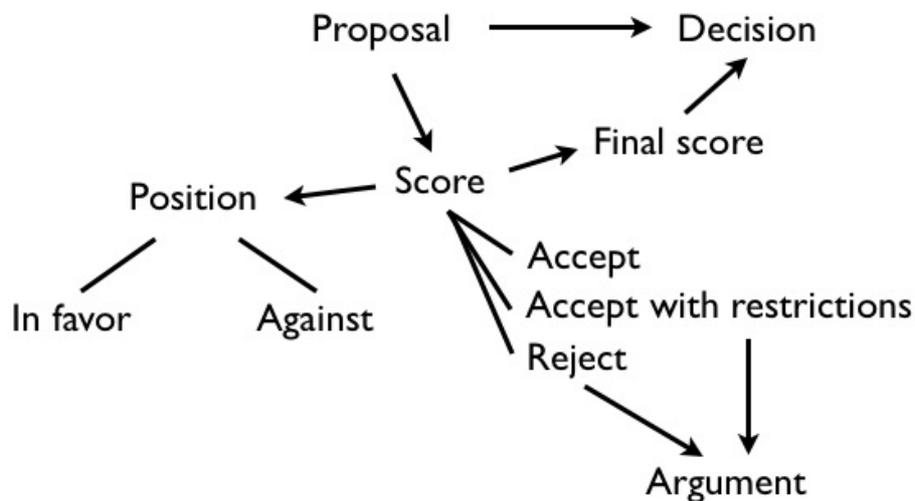
Fig. 1. Data model of the negotiation-collaboration process

3.2 Factors affecting the process

Each negotiation-collaboration process, although structured according to the phases previously described, has its own dynamics and depends on a set of factors that interact between themselves, interfering with the process outcomes. We highlight the following contextual factors:

- Level of conflict - As the level of conflict increases, so does the cognitive effort to reach consensus. At the limit, a destructive level of conflict will lead to a failed process. The number of suggested proposals, positions and arguments may serve to measure the level of conflict.
- Number of participants - A large number of participants may also turn it more difficult to reach consensus.
- Status differences - Status differences address the dependence relationships between leaders and subordinates. Groups having significant status differences may be negatively affected by the dependence on people with more power [15]. The balance between the participants' proposals, positions and arguments may serve to measure the effects of status differences.
- Problem involvement - A low involvement with the problem may turn it more difficult to contribute to the process. The number of suggested

proposals, positions and arguments may serve to measure the problem involvement.

- Group expertise - The lack of expertise about the problem under discussion may also affect the process outcomes. This factor may be measured by assessing the quality of the presented arguments.

3.3 Quality criteria for assessing the process

It is fundamental to define quality criteria for assessing the negotiation-collaboration process. However, the selection of criteria is quite challenging. Let us consider, for example, a situation where a decision is immediately reached after a small number of proposals, positions and arguments; and contrast it with another situation in which, after a long argumentation, several proposals were discussed.

We may assume the first case has low quality while the second case has high quality. This assumption may however be misleading. For instance, it may well be the case that the first case has low complexity and relevance, and the adopted solution is not only adequate but also efficient. On the contrary, the second case may correspond to a situation where conflicts may have lead to a suboptimal solution, having the additional cost of spending too much time to finish the process.

When considering negotiation processes, quality has been fundamentally associated with efficiency. For instance, the distance between the agreed solution and the best possible solution that could be obtained by continuing the negotiation process, designated value-left-on-the-table, is commonly used to evaluate the quality of negotiation processes [16]. This approach is however more adequate to bargaining than to negotiation-collaboration, since the former is influenced by the zero-sum game while the later is more influenced by "satisfying" trade-offs [17].

When considering collaboration processes, quality tends to be measured according to a diverse set of variables categorized as efficiency, effectiveness, satisfaction and consensus [18]. This suggests the quality of negotiation-collaboration processes should also be measured according to a combination of criteria, for which we suggest:

- Efficiency - Time to complete the argumentation-based negotiation;
- Depth of analysis - Average number of arguments against and in favor;
- Participation - Number of arguments.

3.4 Principles of negotiation-collaboration

The negotiation-collaboration process should be founded on sound principles. One such principle is transparency: the process and the adopted rules should be clear to all participants. Equality should also be considered, giving the same rights and privileges to all participants. Confidentiality is also necessary to preserve several aspects of the negotiation. For instance, the positions and arguments, and the individual settlement should be kept confidential to avoid personalizing the discussion.

The process should also be impartial, not guiding the participants towards a particular position or participant's profile. And finally, another important principle to ponder is the Win-Win efficiency. This principle is related with the negotiation and considers that the process should promote the maximization of the gains of all parties.

4. Negotiation-Collaboration in FTR

In this paper we assume the first phase of the process (the presentation of proposals) has already been carried out and a series of individual proposals and comments has been produced. We also consider that, before starting the argumentation-based negotiation, the moderator analyzes the data delivered by the individual reviews and polishes a list of proposals that will trigger the argumentation-based negotiation.

This approach avoids managing duplicates, equivocal language and ensures the consistency of contents and format. The moderator turns doubts, problems, comments, alternatives and solution into proposals for assessment by the reviewers during the argumentation-based negotiation.

The proposals are delivered to the reviewers in the beginning of the negotiation phase, but new proposals may be delivered during the negotiation, if necessary. To ensure confidentiality, the proposals are dissociated from the original authors.

The participants are asked to register their respective scores. Each reviewer associates a score to a proposal, reflecting his/her judgment about the proposal (0 => is not an error, 1 => is a light error or 2 => is a serious error). In case the chosen score is a light error or serious error, the reviewer is requested to complement the score with arguments, consisting of small text sentences. The arguments should be linked to the Functional Specification Document. Examples include: "the item cannot be related with the Functional Specification and should be removed"; "the item does not comply with the specification of function X"; or "the item fails to implement requirement Y".
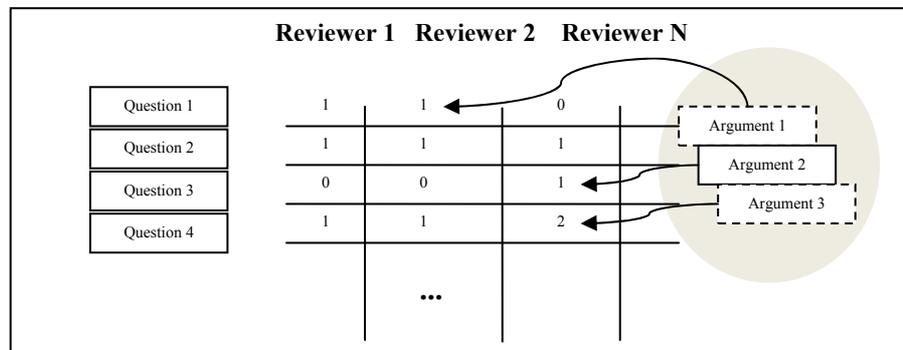
Figure 2. Argumentation of divergent positions

The positions in favor and against each proposal are automatically calculated. The divergences are displayed to the reviewers, although not exposing the identities of the opponents. In case there are no positions against, the proposal is immediate "closed" and the consensual score is immediately determined. For efficiency reasons, a proposal may not be reopened in the same session.

For efficiency reasons, the negotiation is controlled by a timeout mechanism. The moderator is responsible for setting the timeout. The reviewers are notified when the timeout time is reaching. After the timeout, the process moves to the decision activity.

Figure 2 illustrates the outcomes of a negotiation-collaboration session. Notice that in the illustrated example there are no arguments associated to the proposal 2 (row 2) because the scores were consensual.

After evaluating the arguments associated to one proposal, any reviewer may change his/her own position and add additional arguments. This procedure may be repeated until closing a proposal. All the updates to positions and arguments are immediately visible to the reviewers. The changes in positions imply a corresponding update of the associated arguments.
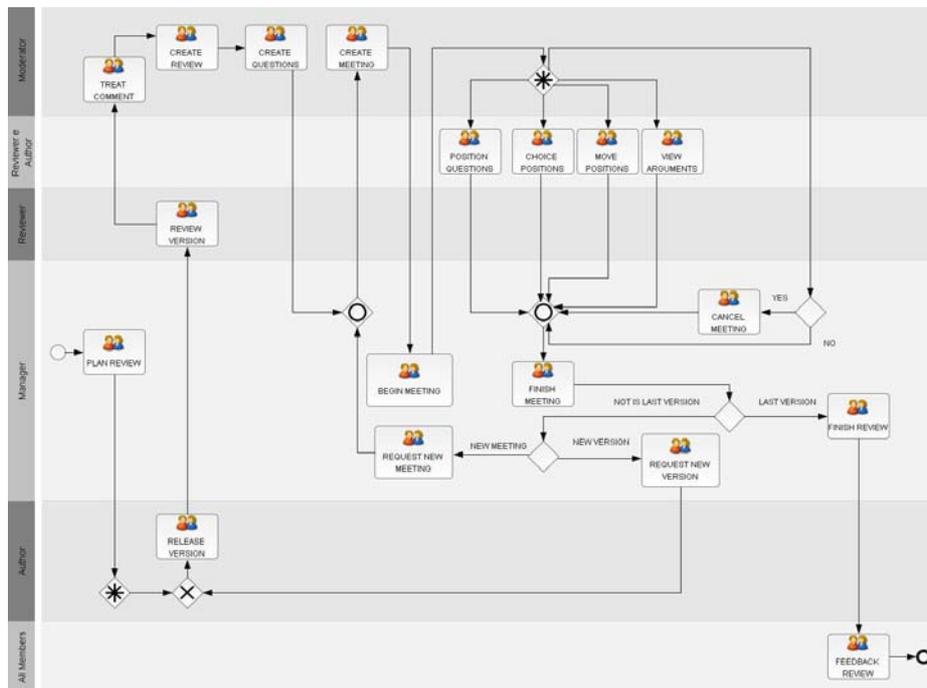
Fig 3. Illustration of the FTR process

As previously mentioned, not always a consensus score may be obtained for a proposal. The moderator may handle this situation in three different ways: majority voting, consensus and moderator's decision. The moderator should select one of these rules before starting the session and should make it public to guarantee the transparency principle. Figure 3 summarizes the FTR process.

It is always important to assess the individual contributions to the negotiation-collaboration process. An inspiration for a tool to summarize relevant information given to the moderator is the *participameter* [19]. The type of information delivered to the moderator in our case is shown in Table 1.

Tab 1. Individual assessment information

Assessment	
Participation Positioning	Number of proposals from a participant in relation with the total number of proposals.
Participation Arguments	Percentage of arguments from the participant in relation with the total number of registered arguments.
Punctuality	Average of time to complete the task, as a percentage of time assigned to the task.
Contribution of Arguments	Number of arguments from a participant that contributed to the final score in relation with the total number of arguments.
Flexibility to converge	Number of score changes to converge with the majority, in relation with the total number of score changes to converge with the majority.

4.1. The FTR Tool

The tool was built using the .Net framework and the language CSharpe. Being a Web application, it can be used at any time and place. The adopted database manager was the SQL Server. To illustrate the prototype, we present two of its screens. Figure 4 shows the screen where the participants register their positions regarding the proposals specified by the moderator. The different positions are displayed to all participants. Figure 5 shows the functionality to support positions with arguments. It also allows visualizing the arguments from the other participants.

Fig 4. Registering the participants' positions.

In the screen showed in Figure 4 the desired position for each question must be selected, as a "serious", "light" mistake, " it is not a mistake " or "null" (in case of

abstaining). When the user is positioning for the first time, no positions already taken for his colleagues are shown. However, when the user positioned him already in a first time and desires to alter his position, he can know the position of the other participants; this information is available in the "position of others" column.
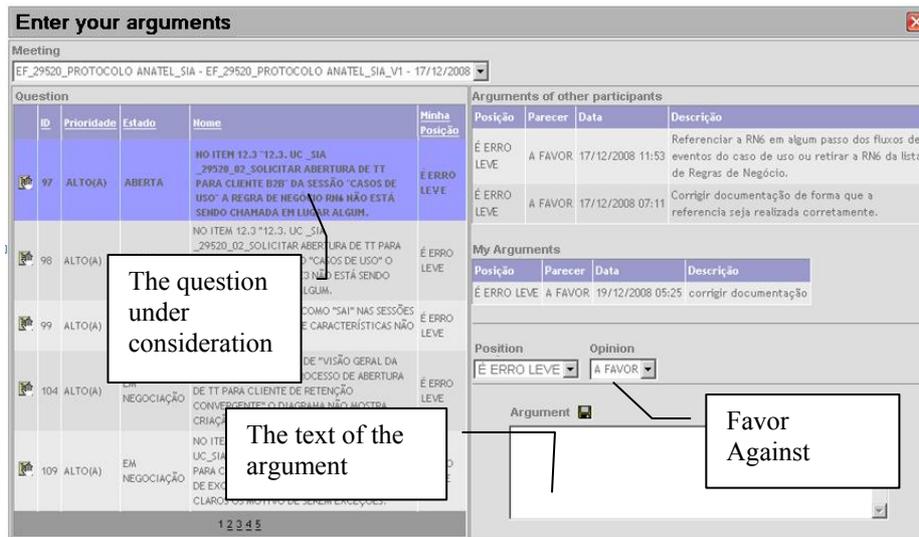
Fig. 5. Registering arguments

In the screen showed in Figure 5, the position on which is desired register one argument must be selected: either positively, with the appearance to "favor"; or negatively, with the appearance "against". After this selection, the user must register his argument and, to confirm the operation, pressing the button "save". In this screen is possible to know the arguments already registered by other participants through the field "arguments of others". The arguments of the currently user are showed in another field "my arguments".

5. Evaluation

An evaluation action was carried out in a real-world organization operating in the telecommunications industry. The main purpose of the evaluation action was getting qualitative insights about the negotiation-collaboration process and FTR tool.

The evaluation action was set up to compare two treatment conditions: the control treatment, based on the FTR process currently used by the target organization; and the experimental treatment, using the FTR process and tool described in this paper. Furthermore, two different functional specifications were subject to the above treatment conditions; and two different groups of collaborators were selected (by convenience) to participate in the two treatments. We therefore accomplished a set of 2x2 experiments.

Eight employees with different professional expertise participated in the experiments. The participants were organized in teams of five and three persons. The team of five, constituted by three reviewers, a review leader and an author was subject to the experimental treatment. The team of three, consisting of three reviewers, one of them acting informally as leader, was subject to the control treatment. The facilitator role, which is required by the experimental treatment, was fulfilled by one of the researchers.

We selected the following evaluation criteria: (1) number of considered proposals; (2) number of considered arguments; and (3) number of changed positions toward consensus. The comparison was directed by the assumption that high quality means: more considered proposals; more registered arguments; and more changed positions toward consensus.

The functional specifications selected for the experiments were controlled to ensure they possessed the same level of complexity and quality.

5.1 Preliminary evaluation results

Comparing the control and experimental treatments, we observed that the experimental treatment resulted in an increased number of arguments and number of changed positions towards consensus. This may be a sign that the FTR tool supports the negotiation-collaboration and promotes higher levels than the traditional FTR process.

In the detailed presentation of the experimental results we will refer to the functional specifications as FE2950 and FE22520. First, it should be noted that FE2950 and FE22520 were rejected in both the control and experimental treatments.

Regarding the control treatment of FE2950, we had 4 proposals, 6 arguments and 2 changed positions. The experimental treatment of FE2950 resulted in 31 proposals, 15 arguments and 3 changed positions.

Regarding the control treatment of FE22520, we had 9 proposals, no arguments and no changed positions. The experimental treatment of FE22520 resulted in 23 proposals, 1 argument and 3 changed positions. The results from FE22520 show that the participants (and in particular the leader) took the immediate decision to reject the functional specifications, which explains the absence of arguments.

Comparing the control and experimental treatments, we may notice that the experimental treatment shows a higher number of proposals, arguments and position changes than the control treatment. This gives preliminary hints that the FTR tool stimulates the argumentation-collaboration.

The number of proposals was much higher in the experimental than the control treatment. This may not only be caused by the FTR tool. One influence to pounder is the team that participated in the experimental treatment is not only larger but also more diverse.

Apparently, the simplicity of the proposed process and the short training required before the evaluation are sufficient to accomplish the review with success. We noticed however that the arguments were not always used as such. For instance, several comments were inserted as if there were arguments. Comments such as "I agree with the item above" are not real arguments but appeared as such. This may impact the

above comparisons. From a total of 78 registered arguments, only 47 (about 40 %) were actually identified as real arguments.

5.2 Questionnaires

The participants in the experimental treatment were requested to complete an open questionnaire about the FTR tool. The answers to the questionnaire seem to point, in a general way, that the tool supports the dynamics of the negotiation-collaboration process and promotes collaboration in formal technical reviews.

The main advantages pointed out by the participants were: (1) it was easy to learn; (2) had clear rules; (3) managed knowledge evenly; and (4) preserved the history of the argumentations.

Also, the support to asynchronous and geographically distributed meetings was identified as an advantage. Though the participants emphasized the face-to-face meetings ease the understanding between the persons and offers more possibilities for expressiveness.

It is important emphasize that the participants, in general, valued the capability to register all the arguments in an organized way. This seems to ease changing positions towards consensus and enriches the review as a whole.

One of the principal problems identified in the FTR process currently utilized by the target organization is that the review repeats itself several times without necessity, only because the review's recommendations seem to be unnoticed by the authors. The FTR tool was seen by the participants as a mechanism to overcome this problem.

Overall, the comments produced by the participants indicate that the solution presented in this paper is coherent to the desired objective: supporting collaboration and negotiation. The participants in the experiment indeed recommended the adoption of the FTR tool in their organization.

6. Conclusions

We developed a negotiation-collaboration process for FTR and a tool to support it. The research allowed us to understand the dynamic of the negotiation-collaboration. The observations and the results we obtained from the case study provided some insights about people's behavior in view of a somewhat contradictory process. The experimental results indicate the proposed process and tool is capable to support FTR.

The experiments also allowed us to identify some points that may constitute subject for future developments. Nevertheless, some challenges to continue this research include: (1) apply the FTR tool throughout the whole software engineering process; (2) develop more functionality, especially promoting argumentation; (3) improve the strategic visualization of the negotiation-collaboration process. And finally, we should complete the experimental evaluation of the FTR tool and process, adding new experiments, selecting different organizations, and covering more reviews cycles.

Acknowledgments

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