Software Requirements Negotiation: Some Lessons Learned

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ABSTRACT
Negotiating requirements is one of the first steps in any software system life cycle, but its results have probably the most significant impact on the system's value. However, the processes of requirements negotiation are not well understood.

We have had the opportunity to capture and analyze requirements negotiation behavior for groups of projects developing library multimedia archive systems, using an instrumented version of the USC WinWin groupware system for requirements negotiation. Some of the more illuminating results were:

- Most stakeholder Win Conditions were non-controversial (were not involved in Issues)
- Negotiation activity varied by stakeholder role.
- LCO package quality (measured by grading criteria) could be predicted by negotiation attributes.
- WinWin increased cooperativeness, reduced friction, and helped focus on key issues.

Keywords
Requirements negotiation, WinWin , Metrics, Groupware.

1 INTRODUCTION

Involved in the projects were a dozen librarians from the USC Library (University of Southern California), about 90 students from the computer science graduate-level course *Software Engineering*, as well as faculty and students from the USC Center for Software Engineering and a group of behavioral scientists from the USC Annenberg School of Communication (the latter were asked to independently observe and analyze the software requirements process). The projects were conducted over a period of two semesters, starting Fall 1996 and continuing through Spring 1997.

During the first semester, the student teams largely consisted of six people each. Each team member was given primary responsibility for one of the six milestone elements – requirements, operational concept, architecture, prototype, life-cycle plan, and feasibility rationale.

The projects were a diverse set of multimedia archive applications desired by USC Library clients. Their client-driven, evolving nature made the set of projects more of an observatory than an experimental laboratory [4]. The projects (see Table 1) focused on different forms of multimedia data like movies, books, manuscripts, pamphlets, pictures, papers, and so on. However, the project goals were diverse because requirements of an archive for technical reports for instance are quite different from those of an archive for medieval manuscripts. The students had to think about good ways of making this wide array of multimedia data accessible. This introduced problems, which only happen in the real world such as fuzzy requirements, conflicts with resources and personnel, and so on.

Table 1: Library project topics

Team	Topic
1	Stereoscopic Slides
2	Latin American Pamphlets
3	EDGAR Corporate Data
4	EDGAR Corporate Data
5	Hancock Image Archive
6	Interactive TV Material
7	Technical Reports
8	Cinema-TV Moving Images
9	Hancock Image Archive
10	Technical Reports
11	Maps
12	Searchable Archives for Images
13	Korean-American Museum
14	Planning Documents
15	Medieval Manuscripts

2 THE WINWIN MODEL

All teams followed the same development model, called the WinWin Model. The WinWin development model incorporates a number of basic models; the *WinWin Spiral Model [2][5]*, the *WinWin Negotiation Model [3]*, *COCOMO [1]*, and others [6].

The WinWin negotiation model (see Figure 1) and its supporting tool the *WinWin System* [4] are based on four artifact types: Win Conditions, Issues, Options and Agreements. Win conditions capture the stakeholder goals and concerns with respect to the new system. If a Win condition is non-controversial, it is adopted by an Agreement. Otherwise, an Issue artifact is created to record the resulting conflict among Win Conditions. Options allow stakeholders to suggest alternative solutions, which address Issues. Finally Agreements may be used to adopt an Option, which resolves the Issue.

The WinWin system also includes a tailorable Domain Taxonomy, which enables Stakeholders to link artifacts to taxonomy items and to access those artifacts via the taxonomy. For the projects the taxonomy structure followed closely the table of contents of requirements documents tailored towards multimedia library applications. Thus, the negotiators were able to use the taxonomy as a checklist for sufficient coverage.

3 DATA COLLECTION

A wide variety of data was gathered so that we could reason about both quantitative and qualitative aspects of the negotiations.

- WinWin login times and timestamped transactions
- Structured questionnaires formulated and analyzed by behavioral scientists [9]
- Partly-structured evaluation memoranda by the Library clients
- Student critiques structured only by the question, "If we were to do the project over again, how would we do it better?"
- Questionnaire data submitted by participants on their years of practical experience, facility with English, etc.
- Grades on the students' LCO packages, based primarily on thoroughness of artifact and application coverage, and on conceptual integrity.

The projects are described in detail in [4].

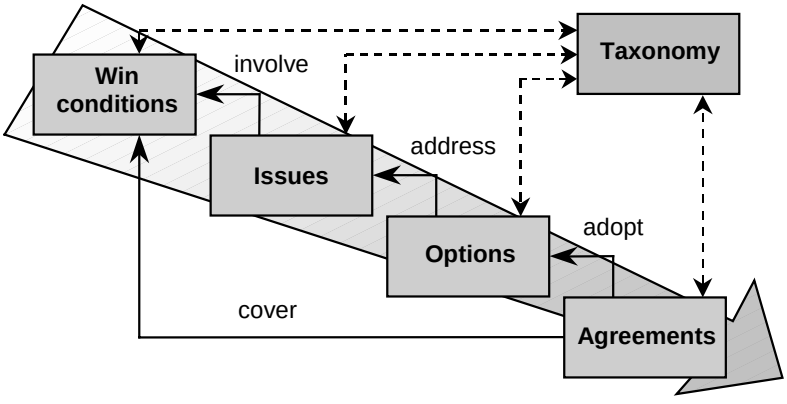

Figure 1: WinWin Artifact Relationships and Taxonomy

4 RESULTS

Extensive results are reported in [8] and on our Web site, http://sunset.usc.edu/TechRpts/electronicopy.html, entry USC-CSE-97-508.

Negotiation Complexity

Most of the stakeholder Win Conditions were non-controversial (were not involved in Issues). Also, most Issues were decoupled from other Issues and were easy to resolve. This implies that requirements negotiation support systems should focus at least as much on handling simple relationships well as on handling complex relationships well (see Table 2 and Table 3).

Table 2: Complexity of win conditions and issues

Condition	Number of Artifacts
Win conditions involved in issues	232 / 513
One option per issue	123 / 179
More than one option per issue	56 / 179

Table 3: Ratio of 1:1 vs. 1:m relationships

Artifact types	Ratio
Agreements : Options (and vice versa)	8.3
Agreements : Win conditions (and vice versa)	5.2
Options : Issues (and vice versa)	6.2
Issues : Win conditions (and vice versa)	3.0

Schedule and Effort

The time duration it took the teams to negotiate requirements did not correlate positively with the quality of the results (LCO grade, etc.). Teams who negotiated their requirements in just a few days achieved better scores than others who negotiated much longer. Further, time duration had only little to do with effort and the effort, teams put into the negotiation, was a much more important quality driver.

For Rapid Application Development this could mean that the schedule of negotiation and the first draft version of documentation can be compressed. However, you need to make sure that the team experience is high enough. Low team experience and little effort and participation yielded lower quality! Another factor to reduce schedule is finding people with the proper domain knowledge.

Domain Expertise

One thing all stakeholders had in common was a high-level of domain knowledge in computer science (they were all CS students).

Table 4: LCO grade, negotation approach and results (rating: very low to very high)

Predictor	1	2	3	4	5	6	7	8	9	10	11	12	13	14
LCO grade	H	M	L	VL	M	M	H	VL	VH	H	M	M	L	VH
Experience	L	M	VL	VL	VL	M	L	M	H	L	M	M	VL	M
Iterations	M	L	L	L	VL	VL	H	H	L	H	H	L	L	VH
Productivity	VH	VH	H	M	VH	VL	M	M	VH	VL	VL	H	M	VH

Observations have shown that in all categories of the domain taxonomy the stakeholder needed a similar amount of time from introducing a goal until coming up with an agreement. The exceptions were the taxonomy items development/process and evolution/maintenance, items where the stakeholders' domain knowledge fitted the best. In this particular cases the domain knowledge accounted for roughly 30% savings in schedule.

Negotiation Impact

The first major milestone after negotiation was the LCO (Life Cycle Objective) roughly 4 weeks after negotiation had ended. The LCO package includes requirements, operational concept, architecture, life-cycle, and feasibility rationale documents. It was found that LCO package strength and consistency (measured by LCO grading criteria) could be predicted from three attributes (team experience, non-sequential negotiation, and efficiency in producing negotiation artifacts). Table 4 shows the team rating for those predictors and their LCO grades.

Stakeholder Roles

Negotiation activity varied by stakeholder role. Users and customers were more active in the early stages; developers and customers in the late stages (see Figure 3).

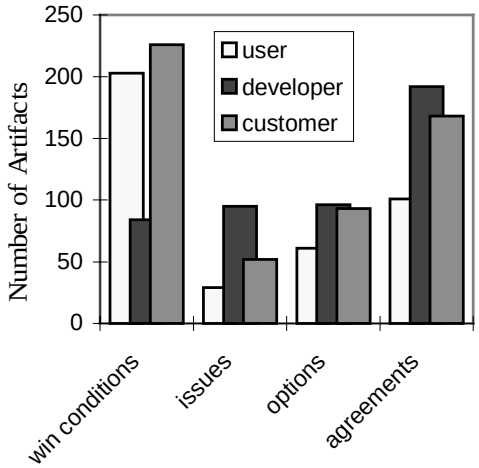

Figure 3: Number of Artifacts per Role

Spiral or Waterfall-like Negotiation Approach

A number of teams have chosen the follow a rather waterfall like negotiation approach starting with win conditions, issues, and options, and completing them before starting agreements. Other teams followed a more iterative process. They may have started off the same way but they still continued introducing new win conditions after voting had started.

The differences in the results were strong: If the process was more iterative then the teams ended up with a *medium* to *very high* LCO grade. If a more waterfall like approach was followed then only a *very low* to *medium* LCO grade was achieved.

Team Experience

High- and medium-experience people/teams needed often only medium to low effort. Low-experience people/teams tended to have the highest efforts. Medium- to high-experience teams achieved medium to high LCO scores in 6 out of 7 cases. However, some low-experience teams were also able to get high scores. However, those teams were only able to get high scores if they invested a lot of effort or excelled in artifact iterations and participation.

WinWin and other Negotiation Aids

The WinWin tools did not completely replace other modes of interaction. Figure 2 indicates that the WinWin tool was used for about one fourth of the negotiation time. This was the result of the independent behavioral study [9].

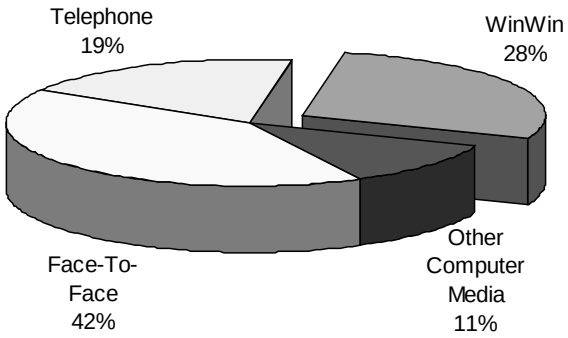

Figure 2: Usage of Negotiation Media

WinWin Contributions

The strongest positive effects of using the WinWin approach were increasing cooperativeness, focusing participants on key issues, reducing friction, and facilitating distributed collaboration. The student critiques further showed that WinWin helped focus on key issues, reduced friction and equalized participants.

Similar findings were made by the independent survey [9]. There it was concluded that if a team's group norm involved the understanding that giving feedback, having collective responsiveness, and having flexible approach; then the group would also be more satisfied with both project topic and negotiation approach.

Table 5: Comments of USC Library Customers (1-strongly disagree; 3-neutral; 5-strongly agree)

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Good rapport	-	-	1	5	-	5	-	-	-	-	5	-	-	-	5
Good responsiveness	4	4+	2	5	4	5	3	5	5	5	5	5	4	5	5
Good results	5	4+	3	5+	4	5	4	5	4+	4+	5	5	4	5	5
Frequent communication	3	3	2	3	4	5	1	4	4	5	5	-	2	5	4
Better understanding of software considerations	4	5	4	4	5	5	-	-	5	-	5	-	4	-	5
Increased confidence, trust, willing to do it again	4	5	3	5	4	5	3	5	4	4	5	5	4	5	4

Table 6: Student Critiques Summary

Positive Comments about WinWin	Count	Negative Comments about WinWin	Count
Promoted more cooperativeness and mutual understanding	9	Need more pre-WinWin homework	14
Should continue use of WinWin	9	Too much overhead in WinWin mechanics, bugs decreased negotiability	10
Focused team on key issues	8	Prototype concurrently with WinWin conflict identification	10
Objective artifacts reduced frictions, equalized loud and quiet participants	6	Should have direct Librarian involvement	6
Helped in distributed collaboration	5	Complement WinWin with email, whiteboards, video conferencing, etc.	5
Helped create better requirements	4		

Needed WinWin Improvements

Based on the student critiques, the major improvements for the WinWin approach (now being implemented) were increasing WinWin training, reducing usage overhead, and concurrent negotiation and prototyping (see Table 5 and Table 6).

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