Journal of Universal Computer Science, vol. 15, no. 9 (2009), 1812-1832
submitted: 15/8/08, accepted: 25/4/09, appeared: 1/5/09 © J.UCS

Estimating Software Projects Based On Negotiation

Sergio F. Ochoa
(Department of Computer Science, Universidad de Chile, Chile
sochoa@dcc.uchile.cl)

José A. Pino
(Department of Computer Science, Universidad de Chile, Chile
jpino@dcc.uchile.cl)

Fabián Poblete
(Department of Computer Science, Universidad de Chile, Chile
fpoblete@dcc.uchile.cl)

Abstract: The Software Engineering community has been trying to get fast and accurate software estimations for many years. Most of the proposed methods require historical information and/or experts' judgment. Because of that, the current methods are not suitable for novice developers or persons who do not know the company development capability. In order to help overcome such need, this paper proposes a software estimation method named CEBON (Collaborative Estimation Based On Negotiation). The method is applicable to small/medium-size projects (1-6 months). It focuses on supporting estimation of Web information systems in scenarios where historical data is not available. The CEBON method has been used to estimate eight real projects. The obtained results were compared with the real projects execution, which were carried out by novice developers in Chile. The comparison indicates the method is able to deliver quite accurate results. In addition, a survey applied to the involved developers shows they feel comfortable using the estimation method. The article also describes a collaborative software application supporting the CEBON process and a preliminary evaluation of both the estimation method and the supporting tool.

Keywords: Software Estimation, Collaborative Work, Groupware System, Novice Software Developers.
Categories: D.2.0, D.2.9, H.4.m., M.0, M.8

1 Introduction

Estimating software development effort (time and cost) is a Software Engineering topic being studied for over three decades. Several estimation methods have been proposed, trying to get fast and accurate predictions for software projects.

Two groups of estimating methods can be recognized from the various proposals: (1) the parametric methodologies, which estimate based on a mathematical formula, and (2) the methodologies based on judgments and intuitions, which use historic material and the developers' experience to generate estimated values. Regardless of the prediction strategy, all of them involve elements requiring significant experience on software development. Thus, people with little experience are usually not taken

into account by a reasonable method intended to generate serious software project estimates.

Currently, there are particular projects and development scenarios where the clients prefer novice developers (1-2 year of experience) instead of experienced ones. An example of that case is the development of small Web information systems intended for relaxed software markets (details are presented in section 2). Typically these projects are low-risk and low-impact for the organization; therefore the clients prefer to employ inexpensive human resources to develop such solutions. Unfortunately, these novice developers are left without historical information or accurate methods to generate sound estimates.

This paper proposes an estimation method and a supporting tool suitable for novice developers, in order to predict the duration of small/medium-size projects using negotiation. Typically these projects involve 3-5 people working during 2-5 months. This project size was chosen considering the most common type of initiatives that is currently being developed in Chile. However, some studies show this project type could also be common in several other countries [Reifer 2000].

The proposed estimation method, named CEBON (Collaborative Estimation Based On Negotiation), was used in the final course of the Computer Science curriculum at the University of Chile. The CEBON evaluation process involved 25 novice developers (students with 1-2 years of experience as developers), and eight development projects with a duration of 14 weeks. The obtained results were highly encouraging.

Next section describes the development scenario which CEBON was designed for. Section 3 presents and discusses the related work on software estimation methods. Section 4 describes the CEBON method and the phases that compose it. Section 5 presents a brief description of the collaborative application supporting the process. Section 6 describes the evaluation process and the preliminary results. Finally, section 7 contains the conclusions and future work.

2 Development Scenario

Several studies of the Chilean software industry conducted by Sacre [Sacre 2003], Stein [Stein 2003] and IDC [IDC 2003] during 2002 indicate that most software developments correspond to Web information systems. The typical project duration is between 2 and 5 months, and usually they are conducted by an experienced project manager, having more than 7 years of experience, leading a group of 3 to 5 novice developers having one or two years of experience.

On the other hand, between 2006 and 2008 several surveys were applied by the authors to software developers in various work scenarios. The obtained results are quite similar to the previous ones. Tables 1 to 4 show a summary of the most relevant results.

These tables present information from four sources. Rows 1 and 2 present the information collected from two important Chilean software companies. The data presented in row 3 was gathered from independent software developers working for large Chilean software companies or directly for specific clients. Row 4 presents information related to the advanced Computer Science undergraduate students (1-2 year of experience as developers) at the University of Chile.

	Years of Experience				Avg. Years of Experience		# Responding Persons
	< 1 year	1-2 years	3-5 years	> 5 years	Avg Team Experience	Avg PM Experience	
1. Company A	3	12	24	13	4 Years	5 Years	52
2. Company B	11	24	23	7	2 Years	7 Years	65
3. Company C	0	10	31	42	5 Years	12 Years	83
4. U.Chile-Undergrad.	12	24	9	0	2 Years	2 Years	47
TOTAL:	**26**	**70**	**87**	**62**	**AVG: 3.25**	**AVG: 6.5**	**247**
Percentage:	**10.5%**	**28.3%**	**35.2%**	**25.1%**			

Table 1: Characterization of the development teams

Table 1 shows there is an important number of novice developers working for software companies. The average experience of the team members is two years in company B and three years in company C. In the case of the undergraduate students (row 4) the team average experience is the same as the project manager's experience; it could be indicating these persons are managing their own projects.

Table 2 shows a summary of the team size for projects being currently developed. Most people answering the survey are working on groups composed of two to five members.

	Team Work Size				# Responding Persons
	2-5 pers.	6-10 pers.	11-20 pers.	> 20 pers.	
1. Company A	37	9	5	1	52
2. Company B	28	25	8	4	65
3. Company C	47	17	5	5	83
4. U.Chile-Undergrad.	36	9	0	0	47
TOTAL:	**148**	**60**	**18**	**10**	**247**

Table 2: Work team size

Table 3 shows a summary of the project type and duration in which the developers are working on. Most of them (85%) correspond to Web information systems, and most projects have duration from three to six months.

	Typical Project Duration				% per Project Type		# Responding Persons
	1-2 months	3-6 months	7-12 months	> 12 months	Web. Inf. Systems	Others	
1. Company A	12	22	13	5	85%	15%	52
2. Company B	7	24	25	9	83%	17%	65
3. Company C	25	36	12	10	76%	24%	83
4. U.Chile-Undergrad.	17	25	3	2	96%	4%	47
TOTAL:	**61**	**107**	**53**	**26**	**AVG: 85%**	**AVG: 15%**	**247**

Table 3: Project types and duration

The first four columns of table 4 indicate how frequently these developers have to do some estimation. The remaining five columns show the estimation method they are using or they would like to use (in case of people not currently estimating). Analyzing the collected data it is possible to say that most of the asked developers need to estimate (92.3%). Moreover, 62.8% of the surveyed people usually have to provide estimates.

	Estimate/Plan Software Projects?				Estimation Method					# Responding Persons
	Never	Sometimes	Frequently	Always	Own Experience	Expert Judgment	WideBand Delphi	Ad-hoc Method	Other	
1. Company A	3	14	25	10	26	15	2	4	5	52
2. Company B	7	15	26	17	35	6	1	12	4	65
3. Company C	2	27	29	25	37	24	2	13	5	83
4. U.Chile-Undergrad.	7	17	15	8	33	6	0	1	0	47
TOTAL:	**19**	**73**	**95**	**60**	**131**	**51**	**5**	**30**	**14**	**247**
Percentage:	**7.7%**	**29.6%**	**38.5%**	**24.3%**	**53,0%**	**53.0%**	**2.0%**	**12.1%**	**5.7%**	**100.0%**

Table 4: Estimation needs and used methods

On the other hand, most of them (73.6%) use their own experience or expert judgment to support the estimates. However, most of them are not experienced developers and thus, their estimates probably are unreliable. These results clearly indicate the need for an estimation method suitable for novice developers. Besides, Table 3 shows that most of these current projects are Web information systems involving 2-6 months of duration. Table 2 shows the groups executing these projects have 2-5 developers. Considering this information as indicative, this article proposes CEBON (Collaborative Estimation Based On Negotiation), an estimation method intended to help overcome this need. Next section presents related work concerning estimation methods supported by little historical information.

3 Related Work

Several software effort estimation models have been proposed. Some of the most well known ones are Price-S, Slim, Seer-Sem and COCOMO II [Ferens and Christensen 1998, Boehm et al 2000]. These models are mainly parametric, i.e., they are based on formulas with metrics like Lines Of Code (LOC) [Phillips 1998], Function Points (FP) [Matson et al. 1994] or Web Objects (WO) [Reifer 2000]. The use of these models requires experience and a long analysis of historical data, which is inappropriate for novice developers [Ochoa et al 2003] or persons having little historical information available. This situation is also present in particular software products, such as courseware [Thackaberry and Rada 1998].

On the other hand, judgment based estimation models seem to fit well with the requirements of the estimation process. A key part of these models applicability is the possibility to do it in group. The objective of this kind of estimates is to gather every group member's viewpoint in order to reach a common agreement on the estimate to be made. Thus, the estimate will probably be less biased than estimates made by individual group members working alone. The most representative methodology adhering to this strategy is Wideband Delphi [Boehm 1981], which uses an expert judgment approach. Its objective is to gather the opinions of a group of experts regarding a certain topic, review and comment their estimates, and make new estimating rounds based on their recently discussed answers.

On the other hand, concerning ways of discussing, interesting work has been done in research areas such as Electronic Meeting Systems [Nunamaker et al. 1991] and Group Decision and Negotiation [Brodt 1997]. A noteworthy example is the Issue Based Information Systems (IBIS) model [Rittel and Webber 1973]. The IBIS model arose as an answer to try to solve "wicked" problems, for which traditional problem solving methods are unsuitable [Rittel and Webber 1973, Camillus 2008]. This model is supported by a structured discussion involving three elements: issues, positions and arguments. The group members discuss in order to clarify the issues and the possible solutions to a problem. According to Rittel, "wicked" problems should be solved in some way involving argumentation, where all given arguments are systematically confronted to the various points of view from all the team members [Camillus 2008].

Other similar model is "Beliefs, Reasons and Moves" (BRM), which introduces a set of rules to represent a type of dialog in which participants try to express agreement or disagreement about a certain topic [Zabala et al. 1999]. In our case, it could apply to the estimation of software development efforts. The three main components of this model are mentioned in its name: *beliefs, reasons* and *moves*. This representation offers a basic set of actions that allow developers to structure a discussion in order to ease the acquisition of the knowledge provided by the participants. If we could apply this model to our problem, developers not only would carry out the estimation process but would also enlarge their experience based on this knowledge sharing process.

Quignard and Barker proposed a model which is formed by a set of communicative actions [Quignard, and M. Baker 1997]. The main difference with the BRM model actions is the way the discussion ends. Here one of the participants asks the other people to end the meeting, thus he/she tries to force an agreement about the solution to be adopted.

Considering the problem we are dealing and the related work, this paper proposes an estimation method adapted from Wideband Delphi. The adaptation involves: (1) to replace the expert participation by the collaborative work of novice developers, and (2) to support the work of group members through a collaborative tool with the individual estimation and negotiation processes. Furthermore, participants do not need to be co-located to generate estimates; thus, the process can be done in a distributed way. The use of a collaborative application allows team members to do the process in either synchronous or asynchronous manner. Next section describes the CEBON method.

4 The CEBON Method

CEBON is a methodology based on judgments and intuitions, and it includes the negotiation as a key part of the process. This method was designed to be used by development teams with 3-6 members. Although team members have little historical information to support the estimates, it is assumed they have an idea about the team's development speed [Ochoa et al 2007]. This assumption is based on the fact that developers' productivity does not vary much at the first stages of their career.

Since the discussion and negotiation processes play a key role in this method, a collaborative software tool has been designed to support them. These processes help team members to validate and refine their perception about development times and costs. Thus, the sharing of experiences, opinions and arguments allows developers to build new knowledge and skills to apply during the next estimation process.

The main aims behind CEBON design were getting a methodology: (1) suitable for novice developers, (2) able to support the making of reasonable predictions and (3) let participants increasingly improve their estimating skills. CEBON is a step-by-step process that involves five phases: *discussion*, *context evaluation*, *estimation*, *voting* and *agreement* (Figure 1). It is important to note that the output of one phase is used as part of the input for the following phase. Thus, the method becomes an evolving process where not only the software estimation improves, but also the shared knowledge of the team mates. The first two phases are focused on knowledge acquisition. The next two phases (estimation and voting) deal with the knowledge elaboration and organization. Finally, the last phase determines if the team was able to arrive to a sound common conclusion. The negotiation activities are transversal to the whole process; therefore they are present in at least four of the five phases of the proposed method.

The tools used in each phase of the process are part of the collaborative application supporting CEBON. These tools were integrated in an active space [Arroyo et al. 2008] that helps team members to manage the shared knowledge. Team members' competencies, in the form of their technical and cognitive capabilities, are closely related to the ability of the team to exploit existing knowledge and to create new one. [Braga de Vasconcelos et al., 2003].

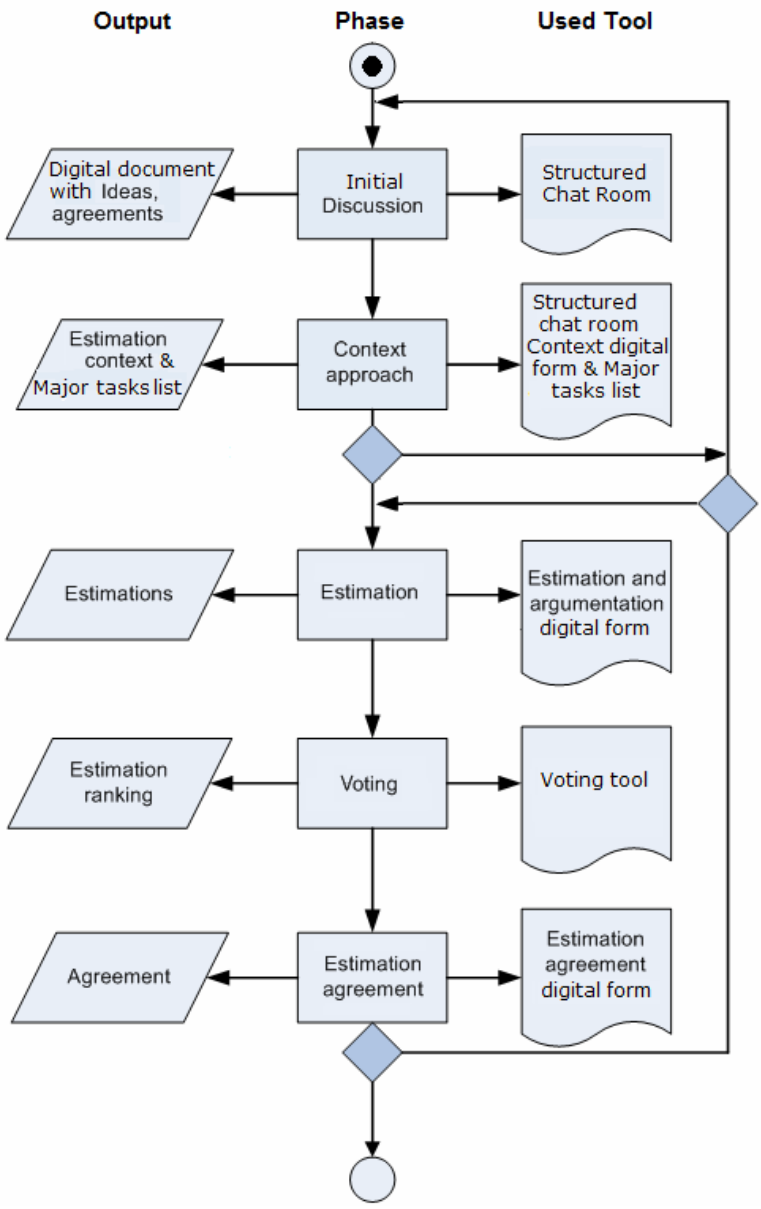

Figure 1: Flow of the CEBON process

4.1 Initial Discussion

This phase is the starting point. All team members participate in a meeting trying to develop common knowledge about the project scope, risk and its main challenges. This meeting can be face-to-face or distributed.

Before the meeting, all team members must read the documentation on the problem to solve. Developers who have a better understanding of the problem (e.g. persons who met with the client/users) describe the problem to the rest of the group. The goal is to create a discussion about the elements that, as a group, they think should be taken into account for the estimation process. Also, the existing resources should be analyzed, such as available tools and the knowledge and experiences that group members have had with similar projects.

When the discussion is conducted in a distributed way, the tool supporting this activity is a structured chat. This chat structures the contributions as a discussion forum, but also it allows contributions access as soon as they arrive. Thus, it is possible to take advantage of the benefits not only of a chat but also a discussion forum.

The inputs to this phase are the ideas presented by team members to each other, whereas the output corresponds to the written discussion about these ideas and agreements. The formal output is a digital form with a set of ideas and agreements to be considered during the estimation phase. The tool supporting the CEBON process is in charge of keeping this digital form accessible for the team members.

4.2 Context Approach

Users will be able to do the following activities in this phase: (1) re-think the ideas and agreements reached in the previous phase, and (2) define a list of major tasks to be estimated. The first activity intends to determine the context on which the estimate will be based, and the ideas and agreements that will be used for the estimation process. During this activity each user will be able to express these agreements from his/her own viewpoint, and discuss them if new information indicates they need to be changed. The goal is to count on a sound base to carry out the estimation process. The discussion should continue as long as the team members do not feel comfortable with the agreements supporting the estimation process.

On the other hand, the discussion process should not take a long time because it increases the estimation effort; particularly the time required to generate an estimate. Therefore, it is important the team members' contributions are presented in a concise manner. In addition, the tool supporting this process and the asynchronous work should also contribute to reduce the estimation effort.

A digital form containing the estimation context is used to record and organize the shared knowledge the participants have to consider during the next CEBON phases. It includes the knowledge a person may have about a task being analyzed, as well as the external factors that may affect its development project. This information is stored as a digital form by the collaborative application supporting CEBON, which implements an organizational memory of the project. Thus, it keeps available such information at the moment that an estimation session is being held. The input to this activity is the digital form reached in the previous phase, while the output corresponds to the context digital form.

On the other hand, the second activity of this phase wants to reach an agreement about the major tasks that need to be estimated in this project. Therefore each developer has to list the major tasks (no more than ten) and send them to a coordinator by using the supporting tool. The coordinator joins the contributions, eliminates the redundancy and generates a preliminary list of major tasks. This list is

discussed and refined in order to summarize the project by including at most ten major tasks. The context digital form and the list of major tasks are inputs to the next CEBON phase.

4.3 Estimation

At the starting point of this phase the users access a digital form which asks for estimates on the major tasks identified in the previous phase. Particularly, the team members have to assign to each task their bets on cost, duration, starting and ending dates. The application supporting the process will compute the time periods and it will automatically determine the project duration estimate.

At this stage, each estimate is made by each individual. Team members have to work alone to get their own estimate and write them down on the corresponding fields of the digital form. These predictions could include arguments, which are stored in the same form. At the end of the estimation form, users will see the various points of view regarding the context of the estimate, as they were expressed by the participants in the previous phase. This is done to give them as much information and opinions as possible before the users generate their estimates.

The context expressed by the team members in the previous phase, which is input to this phase, will be shown on the lower part of the computer screen. It gives team members a broad view of the problem they have to solve.

Once all team members have provided their estimates, the supporting tool organizes that information in a hierarchical way, allowing team members to access it. Thus, they can review their partners' estimates and the supporting arguments, and they may change their own estimates just once. Typically, when team members see the other estimates and arguments they often modify their own ones. The negotiation of the requirements to be considered in the project could be supported by a multi-criteria preference analysis [In and Olson. 2004].

This phase is closed after this adjustment. The deliverables are the adjusted estimates performed by the team members, and the arguments given to back them up.

4.4 Voting

At the starting point, the tool supporting CEBON presents an opinion form to developers. It allows each participant to see the adjusted estimates generated in the previous phase, and their corresponding arguments. An anonymous voting method is used to avoid the bandwagon effect present in the original Wideband Delphi model [Leibenstein 1950]. Members must provide a score to each given estimate, depending on how they think it solves the presented problem.

The voting process is conducted task by task: cost, duration, and starting/ending dates. A participant who proposed a certain time interval as his estimate may give a better score to another user's one if he thinks now that it is more adequate to the problem, or if the supporting arguments are sounder than his own. Outputs of this phase are the scores given to the previous phase estimates, based on each team member's criterion.

4.5 Estimation Agreement

The supporting tool computes an indicator which is the average acceptance for each estimate based on the results of the voting process. This information is organized in a list and it is published in order to allow team members see and discuss the results.

At this point, the developers must decide whether they agree on the estimate with the highest score, or they think a new iteration should be carried out. If the users are satisfied with this estimate, the current process is finished. Otherwise, a new estimation round begins. In both cases, the estimation meeting can be resumed later, and the proposed dates, costs, arguments and presented context from previous iterations of this estimation process can be reviewed.

The output of this phase is the agreement reached by the participants on whether the estimate with the highest score is good enough for the problem they are trying to solve. This determines either the need for a new iteration or if the end of the estimation session.

Action	Description
Inform i1 because a1	The *information* i1 is communicated to the group. It is backed up by *argument* a1. Information i1 may be a problem specification or a context description.
Estimate e1 because a1	The *variable* e1 is estimated by a member for the topic being discussed, basing his estimation on a1, where a1 may be one or more of the arguments presented on a previous phase, or a new one. The metrics for variable e1 will change according to the topic being discussed.
Accept end of session	A member tells the rest of the group that he wishes to end the current estimation session. Acceptance means that the member thinks that the reached estimate is acceptable, or that the meeting has reached a reasonable time limit. This action is communicated to the rest of the members in an anonymous way.
Reject end of session	A member tells the rest of the group that he does not want to end the current estimation session. A rejection means that the member thinks that they reached an estimate which is not acceptable as an answer to the problem being solved. This action is communicated to the rest of the members in an anonymous way.
Not i1 because a1	A member informs the rest of the group the information i1 is not valid due to argument a1. If this communicative action is presented, it implies that there is a disagreement on the arguments presented by the participants. If a2 is accepted as valid, the information supported by the original argument is not valid anymore.
Agree with i1	A member informs the rest of the group that he thinks that information i1 presented by another participant of the discussion is supported by enough valid arguments to regard the presented information as valid.

Table 5: Communicative actions

4.6 Communicative Actions

A set of communicative actions was defined in order to effectively carry out the CEBON process using a supporting Web tool (Table 5). These actions may appear during an estimation session and they are useful to structure the discussion and negotiation processes.

These actions are a simple representation of the most basic sentences that developers can use to express their ideas on a meeting. They were designed based on the phases presented previously. The goal is to encourage the discussion of proposals among the group members, and to guide the estimation process towards a final result based on arguments presented by the participants, and supported by the majority of the group.

5 Collaborative Tool Supporting CEBON

A supporting tool was created to ease and guide the interactions among team members during the several phases of the process. This tool intends to reduce the estimation effort and allows remote users to participate in the process.

The architecture of this tool is simple. The physical architecture includes three layers (Figure 2): clients (represented by a Web navigator), work environment (composed by the tool functionality) and the knowledge base (implemented through a database). The most complex layer is clearly the work environment. The logical architecture shows a gross-grain view of this component (Figure 2), which implements two logical layers. The upper layer implements all the tools supporting the collaboration process: an estimation tool, the digital forms, the structured chat, a voting tool, users/sessions management and a setup tool.

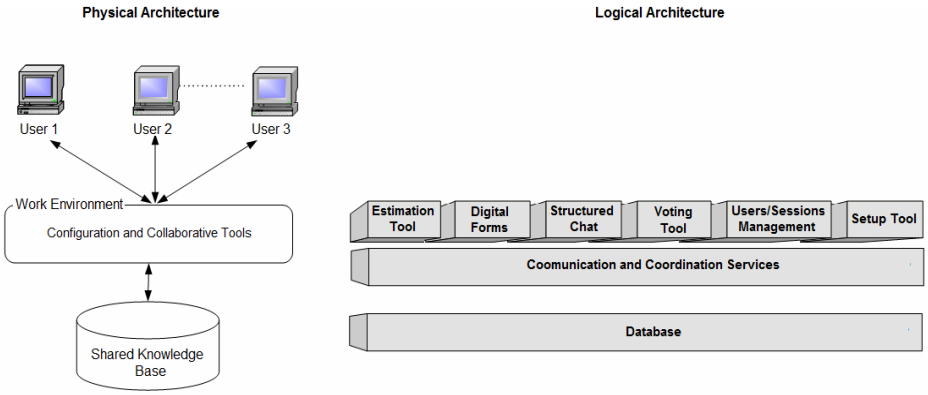

Figure 2: Physical and Logical Architecture of the Supporting Tool

On the other hand, the lower layer implements the communication and coordination services required to support the collaboration. For example, floor control, access control to shared resources, tracking of users' activities, and message delivery. These two layers communicate to each other through an Application

Program Interface (API). Similarly the communication between the service layer and the database in established through Data Access Objects (DAO).

5.1 Application Structure

The supporting tool groups its functionality behind its main menu options: collaborative tools, projects, estimation and exit. Figure 3 shows how the Web application structures such functionality.

This functionality can be mapped to the main structure of the tool user's interface (Figure 4). The interface pattern is composed of three main areas: (1) main menu, (2) secondary menu and (3) information display area. The first one allows a user select a category. Once one of them is chosen, the secondary menu is updated with the options available for such category. In the case shown in Figure 4 the secondary menu is displaying the options available for the "Tools" category. All the functionality implemented in this supporting application can be accessed in the same way. The information display area is used to present the information requested by the user.

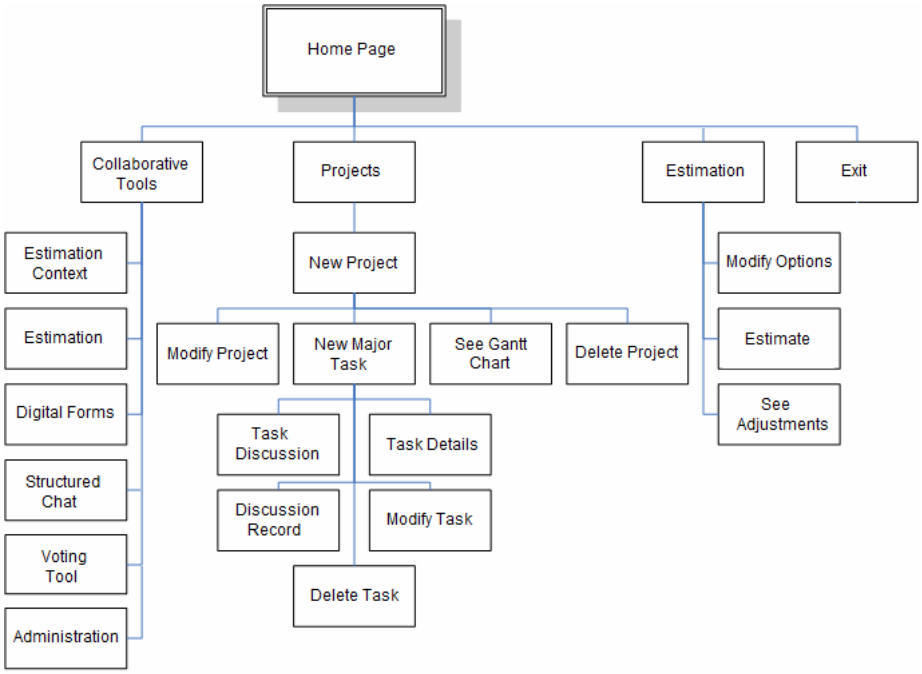

Figure 3: Functionality of the estimation supporting tool

One of the main components of this tool is not visible through the user interface. Such component is the coordinator which is responsible for guiding the users through the CEBON phases and to coordinate the team members' actions. This component is part of the lower layer of the logical architecture, and it has been implemented as a service. The options available through the user interface during each phase of the process are controlled by this coordinator.

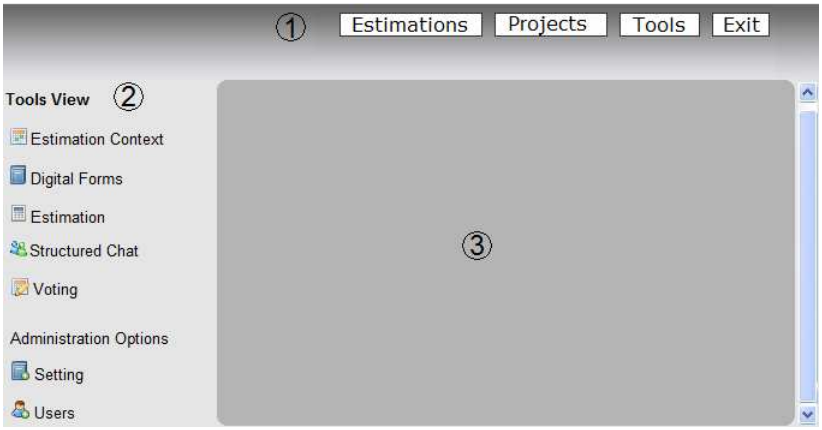

Figure 4: Structure of the user interface

5.2 Estimating the Development Effort

The supporting tool provides team members with an environment in which they can estimate the time needed to complete each major activity (Figure 5). Each member has to propose the starting and ending dates for these tasks using a Web form. They also have to support these bets with arguments. A task cost estimate and its arguments should be given by each team member.

After the developers have had some estimation sessions, the tool shows them the arguments provided by other team members in support of their estimations, and the gap that may exist among their different opinions. The idea is the developers will acquire the skills and knowledge that will allow them to improve the quality of their future estimates. They will be able to do that by studying this information, by learning from the experiences of other team members, and the practice of continuous estimation,

Since the tool supports the users' participation in a distributed way, it embeds some special features designed for such scenario. For instance, a user may join the session not necessarily at the beginning of an estimation process. The cyclical nature of the process allows this, although of course, participation of all members is desirable at all times. The coordinator component is in charge of controlling these events. This component redirects users to the corresponding form, depending on the estimation phase currently being executed.

On the other hand, the tool gives the users anonymous points of view from the rest of the participants, which may make them look at the problem on a different way. The users' opinions are equally weighted, regardless of whether or not they were physically present when the estimation meeting was held.

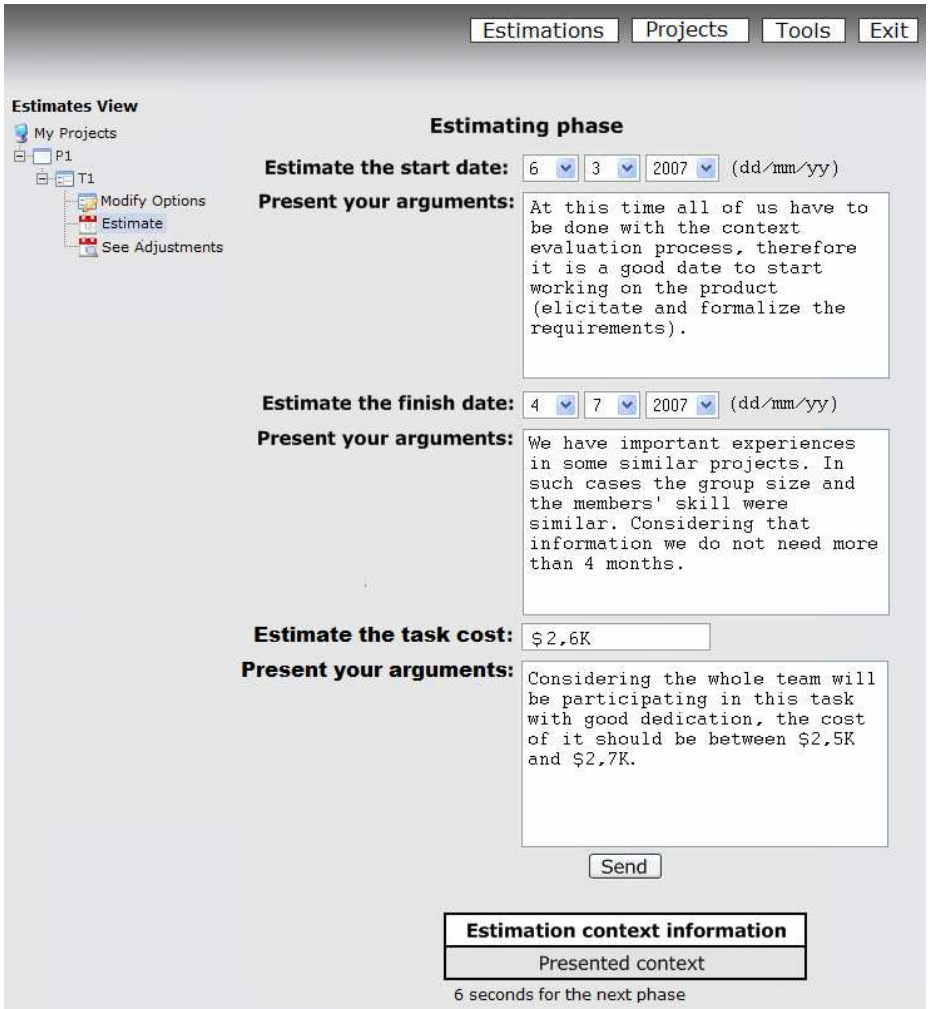

Figure 5: User interface for the project estimation

6 CEBON Evaluation Process

The usefulness of the tool and the supported estimation process was evaluated by novice developers. This experience was carried out as a part of a regular course on Software Engineering at the Computer Science Department of the University of Chile. Participants were senior undergraduate Computer Science students with one or two years of experience as part-time developers.

A total of 25 students participated in the exercise, which was carried out during two semesters: Autumn 2007 and 2008 respectively. These persons used CEBON supported by the collaborative tool in order to estimate the development effort of five

real software projects. All of them were small-size Web information systems. The projects were specially selected for this experience.

At the beginning of the exercise, students were assigned to groups (3-4 members per group). Each group was assigned to a different software project on which several adverse conditions were present, and the project had to be completed in spite of them.

All projects required an introductory discussion in order to be able to understand the problem to be solved. Besides, in a couple of teams no person in the group knew the programming language that had to be used to develop the software. This implied the development team would have to dedicate some time to learn how to use the language first.

Students started the estimation process by creating an entry for that project using the supporting tool. Then, they assigned an initial time span for the project based on a group consensus. Next, they divided their project in the major tasks (or major activities). At least one task was assigned to each team member. These persons were responsible to lead the estimation of the tasks assigned to them. Therefore, each student registered on the application his/her assigned tasks, and worked on getting a better understanding of the activity assigned to him/her. Afterwards, they communicated the acquired knowledge on the assigned major activities to the rest of the team.

Then, the CEBON process was performed until an agreement was reached on the development time and cost for each task. Those individual task estimates were added up and a total time and cost were obtained for the whole project. Finally, the initial development time and cost agreed by the team were compared to the estimates obtained used CEBON. Such comparison indicates the students feel estimates using CEBON are most accurate. The same feeling had the instructors of the course, who are experienced software developers.

At the end of this activity, the students were asked to answer a questionnaire. The questionnaire was intended to evaluate CEBON as estimation method and also the collaborative supporting tool as a way to reduce the estimation effort. Next section presents the obtained results.

6.1 Obtained Results

Twenty five students completed this activity and the questionnaire: eleven persons during 2007 and fourteen during 2008. The questionnaire asked for their opinion about the methodology and the supporting application. This evaluation tool included the following statements.

S1: The reasoning behind your estimate changed once you saw the arguments presented by the rest of the group in the estimation phase.

S2: Because of CEBON, your group reached an agreement faster than in a regular estimation process.

S3: The reached agreement is more accurate than the one you could have reached in a traditional estimation process.

S4: The functionality/usability of the software tool supporting the process was adequate to perform the assigned activities.

S5: This tool is useful to register/retrieve the information behind the main tasks composing the project.

S6: This tool could help you improve the time estimates you perform when working in a group, and to learn from past experiences.

Figure 6 depicts the students' answers to each statement. A general analysis of this information indicates there is an important degree of agreement with each proposition. This particularly occurs with those used to evaluate the supporting tool to the CEBON process (statements 4, 5 and 6).

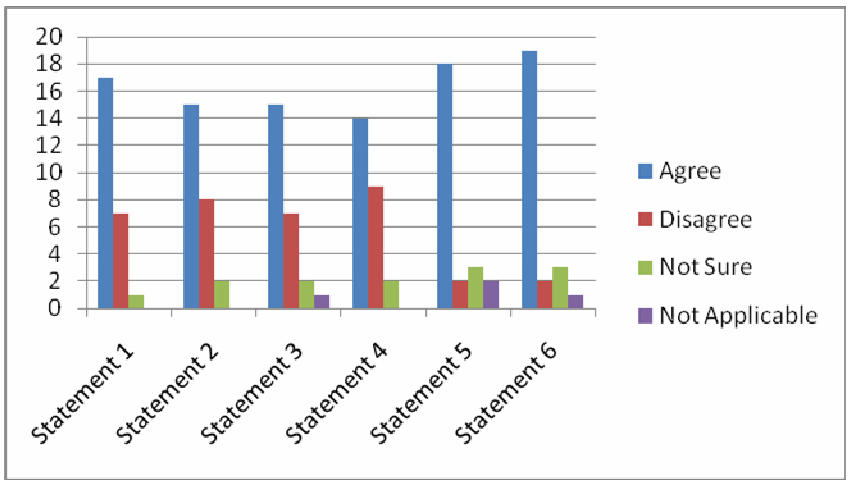

Figure 6: Students' answers

On the other hand, the results gathered for the statements evaluating the CEBON method (statements 1 to 3) indicate the method helps to correct the estimates individually done by the team members (statement 1), and they feel more comfortable with the estimate if it need to be agreed (statement 3). Besides, the participants feel the estimation method helps to reduce the time required to generate an estimate, if it is compared with a process carried out through typically (unstructured) estimation meetings (statement 2). Some of the most representative answers are presented in Table 6.

The opinions gathered from the students who used the application indicate several positive impacts. As a summary it is possible to say they appreciate the guidance provided by CEBON and the support given by the supporting tool. Most of them think the method supported by the tool is appropriate for novice developers. They also highlighted the inexistence of some negative factors in the process, that are present in a traditional estimation meeting, such as fear to express the ideas or difficulty to close an estimation process because there are members who do not feel comfortable with the reached estimate. Furthermore, it was regarded useful to keep a record of a project and its tasks. Students considered that it could help them to improve their estimation

skills through learning from previous iterations and the experience provided by other users.

6.2 Empirical Validation

The instructors of the course individually estimated each project in terms of cost and time in order to evaluate the accuracy of the estimation process. The instructors used Wideband Delphi because it is a method they typically apply for such activity. The standard deviation between the time estimates of the instructors and the students was in the range of 15-30%, which is highly acceptable. In case of cost estimates the standard deviation was in the range of 35-50%. Although this difference is not so small, the instructors think it was because the students are more familiar with the development time than with the development costs. In addition, the time spent by the instructors to give their estimates was about 70% less than the average time spent by the teams. It could also be justified because the instructors are experienced persons: they knew well the process to be followed to get such estimates, and typically a group of two persons is more productive (per capita) than one composed by a larger number of members.

Based on those estimates the instructors asked each team to reduce the assigned project scope in order to be developed in fourteen weeks (almost a semester). After an instructor's review, the projects were executed. Four of these projects were finished on time and put into production. The last one was not successful because the team work failed. However, the reduction of the project scope was good, and the project was finished in 14 weeks. Therefore, the empirical results show CEBON is able to support estimates by novice developers and provide quite accurate predictions.

During the execution of this experiment the authors realized the value of the negotiation when the knowledge used to make decisions is poor or uncertain. This negotiation process leads to an equilibrium and consensus, which is vital in the described work scenario. Since all participants are able to present their proposals, argue and choose their best options, the process is perceived as fair. Therefore, the persons feel comfortable if they have to use it to estimate future projects.

The process is non-invasive for the users since each phase of the proposed method involves activities that are known by the participants, and these activities are well integrated in a workflow. Most users indicated the estimation method was natural and easy. However, the authors believe this feeling is also a consequence of the use of the supporting tool. Fortunately, the tool has shown it is a good support for the CEBON method. Otherwise, the estimation process could have had some problems, for example: (1) for sharing knowledge, (2) to allow a flexible participation of the team members, or (3) to obtain a comprehensive view of the contributions.

Stat.	Developers agreed because	Developers disagreed because
P1	The arguments from the rest of the group gave me a general view of the problem they were solving. Thus I can realize the challenges involved in the execution of each major task.	Since we had previously discussed initial and final dates, I knew which answers my partners were going to give when we were in the estimation phase.
P2	The pre-established time limit set for each phase helped to manage the flow of the estimation session. This time limit is hard to control in a face-to-face meeting. Moreover, the step-by-step process helps a lot to keep the control of the process, and the supporting tool helps to reduce the estimation effort.	I am an experienced developer. I think I could get a sound estimate in the same time period, even without this method.
P3	I am feeling comfortable providing an estimate that has been approved by all of us. Because I do not have too much experience estimating, I prefer something agreed. In fact, most of the individual estimates changed during the first review.	At this point we do not know how accurate our estimate is. We have to validate this number against the real project development to see how accurate this method is.
P4	I think the way projects and tasks are shown on screen is useful, and it eases the execution of each phase of the process. In addition, the tool gave us anonymity when we participated in a remote way. It avoid the persons be influenced (in favor or against) by the partners.	There was no way to coordinate the members of the groups once we were in the application. In addition, there was not enough awareness about the actions of my partners, and that the chosen color scheme was inadequate.
P5	The application stores all conversations and meetings held, the initial estimates, and this information can be accessed at any time of the estimation process. The information is well organized, so I was able to find everything just with two or three clicks. It really helps!!	There are other ways to show the arguments supporting the estimates without a need to take actions to retrieve them.
P6	I learned a lot from this experience. I think I got more elements that will allow me to give more accurate estimates. About the time, I feel the supporting tool has a key role to keep the time involved in each phase of the process controlled.	The tool does not allow including in the context, the capabilities of each student, the working cohesion of the group and the uncertainty of the system requirements.

Table 6: Reasons for agreement and disagreement

7 Conclusions and Further Work

CEBON is a simple estimation method based on negotiation, which is intended to support novice developers in that process. It is easy to apply and it seems to be able of generate sound estimations. Since there is no estimation methods particularly designed for novice developers, CEBON represents a first step in that direction. The study presented in section 2 shows there are several scenarios without experienced developers where accurate predictions on software project efforts are needed.

In order to support people using CEBON and trying to reduce the CEBON application effort, a collaborative supporting tool was developed. Such tool partially automates the CEBON process and allows team members to participate in the process phases not only face-to-face but also in a distributed way. The CEBON model determined the requirements behind the design and implementation of the tool functionalities to support the phases of the process. CEBON also defined the information that is required as input from the participants in each stage of the estimation process, and the output of each one.

Several elements were considered in the design of this supporting tool, in order to allow the users to work collaboratively. For example, the guiding component, which is in charge of aiding all group members in the way they have to input their contributions to the discussions. Thus, such contributions become easy to read for the rest of the participants and to use (in the best way possible) during the time dedicated to hold these meetings. The early definition of a communication protocol based on communicative actions was extremely useful to reach this goal.

The proposal was evaluated through five projects; all of them were small Web information systems. The experimental validation activity was carried out by 25 senior undergraduate students at the University of Chile. The validation process involved an estimation exercise where the results were compared with the instructors' predictions. Based on the obtained results it is possible to say the proposal is able to deliver quite accurate results, the novice developers feel comfortable using it and they feel they are able to improve the estimation skills because of the feedback gathered during the process. Additionally, an adaptation of such projects (with an estimated development effort of 14 weeks) was defined and executed by each team. 80% of these projects were finished successfully indicating there was a correspondence between the estimated effort and the real effort. The other 20% (corresponding to one project) was unsuccessful not because of a wrong estimation but a coordination problem inside the group that does not allowed team work. These empirical results support the previous ones, indicating the proposal would be able to provide quite accurate estimations when it is used by novice developers.

On the other hand, more experimentation it is still required to get strong conclusions. Particularly, it is important to determine the role of the supporting tool in the success of these predictions. The authors are sure the feedback gathered in future experience will allow improving the estimation method and the supporting tool. In addition, the authors want to evolve this proposal to enhance the learning process the users can follow to improve their estimation skills.

Acknowledgements

This work was partially supported by Fondecyt (Chile), grants Nº: 11060467 and 1080352.

References

[Arroyo et al. 2008] Arroyo, R.F., Gea, M., Garrido, J.L., Haya, P.A., Carro, R.M.: "Authoring Social-aware Tasks on Active Spaces"; Journal of Universal Computer Science 14, 17 (2008), 2840-2858.

[Boehm 1981] Boehm, B.: "Software Engineering Economics"; Upper Saddle River, NJ: Prentice Hall PTR, (1981).

[Boehm et al 2000] Boehm, B., Abts, C., Brown A.W., Chulani, S., Clark, B. K., Horowitz, E., Madachy, R., Reifer, D., Steece, B.: "Software Cost Estimation in COCOMO II"; Prentice-Hall, 1st Edition, (2000).

[Braga de Vasconcelos et al., 2003] Braga de Vasconcelos, J., Kimble C., Rocha, A.: "Organizational Memory Information Systems An example of a Group Memory System for the Management of Group Competencies"; Journal of Universal Computer Science 9, 12, (2003), 1410-1427.

[Brodt 1997] Brodt, S. (ed.).: "Innovative Approaches to Research on Group Decision and Negotiation"; Group Decisions and Negotiation. Springer (1997).

[Camillus 2008] Camillus, J.C.: "Strategy as a Wicked Problem"; Harvard Business Review, 86,5 (2008), 98-106.

[Ferens and Christensen 1998] Ferens, D.V., Christensen, D.S.: "Calibrating Software Cost Models to Department of Defense Databases – A Review of Ten Studies"; (1998), URL: www.amc.army.mil/amc/rm/files/proj_decalogue.pdf.

[IDC 2003] International Data Corporation (IDC) Chile: "The Chilean Software Industry"; A Study for Japan External Trade Organization (in Spanish), (2003).

[In and Olson. 2004] In, H.P. and Olson, D.: "Requirements Negotiation Using Multi-Criteria Preference Analysis"; Journal of Universal Computer Science 10, 4 (2004), 306-325.

[Leibenstein 1950] Leibenstein, H.: "Bandwagon, Snob, and Veblen Effects in the Theory of Consumers' Demand"; Journal of Economics, 64, 2, (1950), 183-207.

[Matson et al. 1994] Matson, J., Barret, B., Mellichamp, J.: "Software Development Cost Estimation Using Function Points"; IEEE Transactions on Software Engineering 20, 4, (1994), 275-287.

[Nunamaker et al. 1991] Nunamaker, J. F., Dennis, A., Valacich, J., Vogel, D., George, J.: "Electronic meeting systems to support group work"; Communications of the ACM 34, 7, (1991), 40-61.

[Ochoa et al 2003] Ochoa, S., Bastarrica, C., Parra, G.: "Estimating the Development Effort of Web Projects in Chile"; Proceedings of the First Latin American World Wide Web Conference (LA-WEB 2003), IEEE CS Press, Santiago, Chile, (2003), 114 – 122.

[Ochoa et al 2007] Ochoa, S.F., Pino, J.A., Andrade, D.: "Strategies to Estimate the Development Effort of Web Projects in Immature Scenarios" (in Spanish); Revista de la Pontificia Universidad Católica del Ecuador, 81, (2007), 125-171.

[Phillips 1998] Phillips, D.: "The Software Project Manager's Handbook"; IEEE Computer Society Press, (1998).

[Quignard, and M. Baker 1997] Quignard, M. and Baker, M.: "Modeling Argumentation and Belief Revision in Agent Interactions"; 2nd European Conference on Cognitive Science (ECCS 97). Manchester, U.K., (1997).

[Reifer 2000] Reifer, D.J.: "Web Development: Estimating Quick–to-Market Software"; IEEE Software, 17, 6 (2000), 57–64.

[Rittel and Webber 1973] Rittel, H. and Webber, M.: "Dilemmas in a general theory of planning"; Policy Sciences, 4, Elsevier Scientific Publishing Company (1973), 155-169.

[Sacre 2003] Sacre, E.: "A Methodology To Develop Web Applications in Small and Medium Size Enterprises"; Master Thesis (in Spanish). Computer Science Department, University of Chile (2003).

[Stein 2003] Stein, W.: "A Web Software Process for Small or Medium-Sized Projects Focused on the Chilean Scenario"; Engineering Thesis (In Spanish). Computer Science Department, University of Chile, (2003).

[Thackaberry and Rada 1998] Thackaberry, C.W., and Rada, R.: "Estimation Metrics for Courseware Maintenance Effort"; Journal of Universal Computer Science 4, 3, (1998), 308-325.

[Thompson 2007] Thompson, P., Iqbal, R., James, A.: "Supporting Decision Making in CSCW Design"; Proceedings of the 11th International Conference on Computer Supported Cooperative Work in Design (CSCWD'07), IEEE Press, (2007), 651-656.

[Zabala et al. 1999] Zabala, S., Lara, I., Gener, H.: "Beliefs, Reasons and Moves in a Model for Argumentative Dialogues"; Proceedings of the CLEI'99 Conference, Paraguay, (1999).