Supporting a Shared Understanding of Communication-Oriented Concerns in Human-Computer Interaction: a Lexicon-based Approach

Simone Diniz Junqueira Barbosa[1], Milene Selbach Silveira[2], Maíra Greco de Paula[1], Karin Koogan Breitman[1]

[1]Departamento de Informática, PUC-Rio
Marquês de São Vicente, 225 / 4º andar RDC
Gávea, Rio de Janeiro, RJ, Brazil, 22453-900

[2] Faculdade de Informática, PUCRS
Av.Ipiranga, 6681, Prédio 30, Bloco 4
Porto Alegre, RS, Brazil, 90619-900

simone@inf.puc-rio.br, milene@inf.pucrs.br,
mgreco@inf.puc-rio.br, karin@les.inf.puc-rio.br

Abstract. This paper discusses the role of an enhanced extended lexicon as a shared communicative artifact during software design. We describe how it may act as an interlingua that captures the shared understanding of both stakeholders and designers. We argue for the need to address communicative concerns among design team members, as well as from designers to users through the user interface. We thus extend an existing lexicon language (LEL) to address communication-oriented concerns that user interface designers need to take into account when representing their solution to end users. We propose that the enhanced LEL may be used as a valuable resource in model-based design, in modeling the help system, and in engineering the user interface elements and widgets.

Keywords: communication-centered design, model-based design of human-computer interaction, semiotic engineering, language extended lexicon

1 Introduction

In this paper, we describe a lexicon-based representation to express domain and application concepts during the design process. We propose that, by doing so, designers, users and other stakeholders may have a shared understanding of the application, detailing its relevant concepts and their relationships. We have argued elsewhere that we need representations that will make possible a more balanced participation of stakeholders and team players from different interdisciplinary

background during design [3]. This paper will focus on the communicative concerns that (esp. interaction) designers must deal with throughout the design process. We follow Preece et al.'s definition of interaction design: "designing interactive products to support people in their everyday and working lives" [26, p.6]. This definition is in accordance with Mullet & Sano's perspective that human-computer interaction (HCI) is "concerned most directly with the user's experience of a form in the context of a specific task or problem, as opposed to its functional or aesthetic qualities in isolation" [20, p.1]. Within HCI, semiotic engineering [9,10] has emerged as a semiotics-based theory [11,24] that describes and explains HCI phenomena, adopting primarily a media perspective on the use of computer artifacts [16].

Scenarios have been used as the primary representation to foster communication among team members and stakeholders [6]. We propose that an enriched lexicon can complement scenarios by representing together the different perspectives of each sign, which are typically scattered in many scenarios. This lexicon can be used to establish a common vocabulary throughout various design stages. By doing so, we believe it would be easier to build the design models taking both the lexicon and the scenarios as a starting point. In particular, such a lexicon can be used to derive three important kinds of resources: the user interface signs, which users should understand and learn to manipulate to make the most of their interaction with application [9,10]; the help content [29, 30]; and ontologies [13, 14], which can be employed in user, dialog and task modeling, especially in adaptive user interfaces [22] and the semantic web [4].

2 Semiotic Engineering and Communication-centered Design

Semiotic Engineering focuses on the engineering of signs that convey what HCI designers and users have in mind and what effect they want to cause in the world of things, practices, ideas and experiences [9,10]. The interface signs constitute a message sent from designers to users, representing the designers' solution to what they believe is the users' problems, what they have interpreted as being the users' needs and preferences, what the answer for these needs is and how they implemented their vision as an interactive system. In particular, semiotic engineering proposes a change of focus from *producing* to *introducing* design artifacts to users [10].

Our work builds on semiotic engineering by attempting to ensure that domain concepts are well represented and understood by every team member[8] before proceeding to later design stages. We need to promote the shared understanding among the team members (for instance, by representing domain concepts and their interrelationships), and to allow designers to represent communication-centered concerns developed for improving designer-to-user communication during interaction [9,10]. Our basic assumption is that, in order to increase the chances of engineering adequate signs at the user interface to convey the designers' vision and thus properly introduce the design artifact, we need to first establish this vision and communicate it

[8] By "team members" we mean the stakeholders (clients and users) and the designers (members of the development team from various disciplines, such as software engineering, human-computer interaction, graphics design, linguistics, psychology and so on).

effectively among team members themselves, always from a user's point of view (Fig. 1).

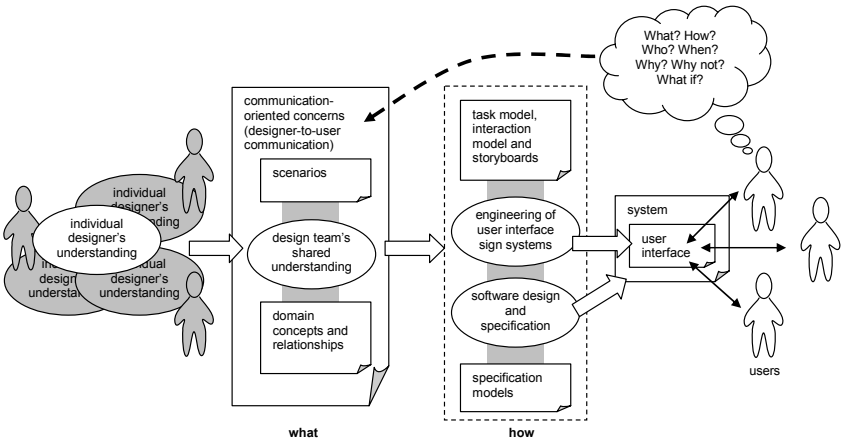

Fig. 1. Communication-centered design.

The communication-oriented concerns we will address in this paper are derived from studies about users' frequent doubts [1,28], as indicated by the dashed arrow in Fig. 1. These concerns will be described in section 4.

If designers are unable to convey their vision to each other and to every stakeholder, they will hardly succeed in conveying it to users (through carefully designing the user interface). If, on the other hand, they succeed in promoting designer-designer communication via communication artifacts, they will be better equipped to communicate with users through the user interface, i.e., to engineer the user interface sign systems. This way, we aim to take one step towards a communication-centered approach to interactive software design and development.

3 The Language Extended Lexicon (LEL)

As a starting point to building our communication artifacts, we take on the requirements engineering work of the Language Extended Lexicon (LEL) [18]. The LEL is a representation of the signs in the language of the application domain. LEL is anchored on the idea that one must first "understand the *language* of the problem, without worrying about understanding the *problem*" [18]. Researchers in different areas have pointed out the strong relationship between culture and language. In semiotics, in particular, the works of Eco and Danesi pay special attention to the web of language, culture and social environments [8,11]. In software design, the strength of using language to promote a shared understanding of the problem design domain and also of the solution accounts for the success of scenario-based approaches in various design stages [6].

To capture the language of the application domain and represent it in a Universe of Discourse (UofD), each term in LEL has two types of description: (i) *notion*, the denotation of the term or phrase; and (ii) *impact*, extra information about the context at hand[9]. In addition, each lexicon term is classified in four categories: object, subject, verb and state. The strong points in LEL are the principles of *closure* and of *minimal vocabulary*. The principle of closure attempts to "maximize the use of signs in the meaning of other signs", whereas the principle of minimal vocabulary "demands that external vocabulary be minimized and reduced to the smallest set possible". The external vocabulary is the set of terms that lie outside of the UofD. These terms should belong to the basic vocabulary of the natural language in use, i.e., be clearly known to every stakeholder.

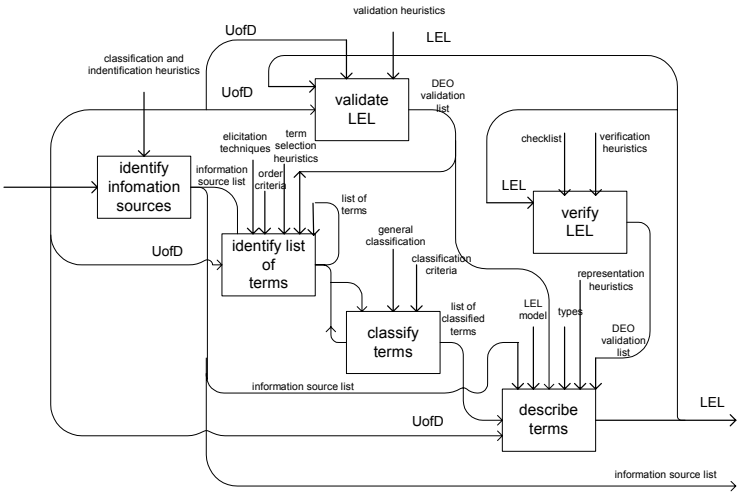

Fig. 2. Lexicon construction process [17].

Kaplan and co-authors describe in detail the process of constructing a LEL representation [17]. It comprises six steps, as depicted in Fig. 2. First one needs to identify the main information sources of the UofD, such as people and documents. Then, one must identify a list of relevant terms to be included in the UofD. By observing how people work and interviewing them, as well as by reading the documents and inspecting the artifacts they generate or use, a candidate list of terms is generated. Each term is then classified into object, subject, verb or state. The fourth step is to describe the meaning of each term —define its notion and impact—, being

[9] LEL authors state that the impact, formerly known as behavioral description, describes the "*connotation*, that is., and additional meaning of a word" [18]. From a semiotic point of view, however, the use of the term *connotation* in this sense is not accurate, and thus will not be used in this paper.

careful so as to respect the the principles of closure and minimal vocabulary. This step typically unveils additional terms to be included in the lexicon, and which undergo a similar process. In the last two steps, the lexicon is verified by inspection and validated by the stakeholders. As with scenarios, the lexicon is written in natural language, which makes it easy for non-experts to understand, question, and validate. The lexicon is also represented as a hypertext, which makes it easy to navigate between any two related terms.

In the context of the semantic web, there is a growing need to represent the semantics of the applications [4]. The need is fully met by the LEL, which provides both the meaning and relationships among its terms. However, the fact that the LEL is coded in natural language format prevents is from being automated by machines. Ontologies, in our understanding, are the formalization of the concepts captured by the LEL in a machine processable language, e.g., DAML+Oil or OWL [15, 19]. Readers who are interested in deriving formal ontologies may refer to [5], which describes how to derive a machine-processable ontological representation from the lexicon.

We argue that the quality of the resulting lexicon depends highly on the experience and domain knowledge of its builders. Moreover, in following a semiotic engineering approach to HCI, we would like the meaning descriptions to reflect the designers' assumptions about the users' knowledge and expectations of the domain and application. As we will see in the next sections, these assumptions may be captured in the form of answers to questions related to the users' most frequent doubts. In this context, this paper proposes to extend LEL to enhance its capacity as a communicative artifact among team members, and as a concrete resource for model-based design of interactive artifacts.

It is important to note that we do not suggest to use LEL in isolation. Instead, we propose to use it to complement scenarios [6]. Scenarios give all stakeholders an understanding of the domain and of the application being designed, in a contextualized manner. However, we felt the need to centralize the definitions of goals, tasks, agents and objects, because if they are scattered throughout scenarios, problems of inconsistency and incompleteness may prevent designers to build an adequate conceptual model of the domain (and later of the solution). This would make it harder to engineer the signs that will be conveyed to users through the user interface. Designers need both the contextualization of the scenarios and the different perspectives that LEL gathers together for each sign.

4 Communication-oriented concerns in model-based interaction design

Although LEL is a useful tool for representing domain concepts and their interrelationships, we want to shift the focus to communication-oriented concerns involved in user-system interaction. These concerns were explored in previous work on communicability evaluation [25] and help systems design [29]. In this section, we outline the communication-oriented concerns that, we believe, need to be represented throughout the design process.

Traditional model-based approaches to user interface design are rooted in cognitive theories or ergonomic approaches, which focus on the human interacting with the system image [21]. Our work is based on semiotic engineering [9], which takes on a communicative perspective to HCI, viewing the user interface as a metamessage sent from designers to users. This message is created in such a way as to be capable of exchanging messages with users, i.e., allowing human-system interaction. In semiotic engineering, the high-level message sent from the designer to users can be paraphrased as follows [9]:

> *"Here is my understanding of who you [users] are, what I've learned you want or need to do, in which preferred ways, and why. This is the system that I have therefore designed for you, and this is the way you can or should use it to fulfill a range of purposes that fall within this [my] vision."*

Because semiotic engineering brings to the picture designers themselves as communicators, we need to provide tools to better support them in this communicative process, ultimately via the user interface. One way to accomplish this is by investigating communication problems users experience when interacting with an application. These problems may be expressed by their frequent doubts and needs for instructions and information, i.e. help content. In the literature about help systems, we find that users would like to receive answers to their most frequent doubts, as summarized in Table 1 [1,28].

Table 1. Taxonomy of users' frequent doubts.

Types of Questions	Sample Questions
Informative	*What kinds of things can I do with this program?*
Descriptive	*What is this? What does this do?*
Procedural	*How do I do this?*
Interpretive	*What is happening now? Why did it happen? What does this mean?*
Navigational	*Where am I? Where have I come from? Where can I go to?*
Choice	*What can I do now?*
Guidance	*What should I do now?*
History	*What have I done?*
Motivational	*Why should I use this program? How will I benefit from using it?*
Investigative	*What else should I know? Did I miss anything?*

We propose that the questions related to the users' most frequent doubts be explicitly addressed throughout the various design stages, starting from requirements elicitation (and the construction of the LEL). Our ultimate goal is to provide designers with a comprehensive understanding of the domain and of the effects of their design decisions on the final product (i.e. the user interface), as viewed from a user's point-of-view. By using these potential user questions, we help designers to reflect while they make important design decisions, engaging in reflection-in-action [27]. At the same time, we would want to encourage the representation of these design decisions, thus building the design rationale of the envisaged application.

From the users' point-of-view, we make use of communicability and help utterances that allow users to better express their doubts during interaction [29] (Table

2). By anticipating users' doubts during design, the team members will be better equipped to deal with the users' communicative needs, either by designing applications that avoid interaction breakdowns altogether, or by giving users better chances for circumventing them [31].

Table 2. Communication-oriented utterances related to users' doubts during interaction breakdowns.

Original Communicability Utterances	(Additional) Help Utterances
What's this?	How do I do this? (Is there another way to do this?)
What now? (What can I do? What should I do? Where can I go?)	What is this for? (Why should I do this?)
What happened?	Whom/What does this affect?
Why doesn't it (work)?	On whom/what does this depend?
Oops!	Who can do this?
Where is *it*?	Where was I?
Where am I?	
I can't do it.	

An answer to the "What's this?" communicability utterance can be easily found in the *notion* part of each LEL term. For other utterances, however, the answers are not so straightforward, and depend highly on how meaning is described as an *impact* in LEL. In the next section, we describe how LEL definitions may include key elements needed in our design approach.

5 Enhancing LEL to provide a communicative artifact for design team members

In the previous sections, we have argued for the importance of providing a common vocabulary to promote the stakeholders' shared understanding of the domain using the LEL, and how relevant design decisions should be addressed and represented from a communication-oriented standpoint while building the design models. In this section, we explore how these two approaches may be coupled, i.e., how the answers to important design decisions can be recorded as part of the LEL, making it easier to take advantage of them in later design and specification stages.

Taking into consideration the communication-oriented concerns described in the previous section, we propose to enhance the LEL to incorporate the various communicative dimensions related to each concept or relationship. By doing so, we aim not only to create consensus among team members, but also to provide solid grounds for engineering the user interface sign systems that will minimize the effects of interaction breakdowns.

To show how our approach can be put to practical use, we briefly describe a case study we've developed: a system for managing conference submissions and reviews. Before building LEL, we felt the need for some guidance in identifying the first relevant signs. Inspired by traditional HCI work, we decided to start by building

scenarios describing some of the users' roles, goals and tasks (Fig. 3). From the users' roles, we identified candidate roles (subjects in LEL), and from the goals and tasks we extracted a first set of verbs and objects.

Scenario 1. PC chair assigns submissions to reviewers. *The **deadline** for the ABC 2004 **conference** has arrived, and Mark, the **PC chair**, needs now to start the **reviewing** process. First he **assigns** the **submissions** to the **reviewers**, based on the **maximum number of submissions** each **reviewer** has determined, as well as on the expertise level of each **reviewer** with respect to the**conference topics**. He would like to have at least 3 **reviews** of each **submission**. To avoid having problems of fewer **reviews**, he decides to **assign** each **submission** to at least 4 **reviewers**. […] One month later, Mark **receives** the **reviews** and must now **decide** upon the **acceptance** or **rejection** of each **submission**. Since there are a few **borderline submissions**, whose **grades** do not make clear whether it should be accepted or rejected, he decides to **examine** the **distribution of submissions per conference topic**. In doing so, he decides, from among **submissions** with similar **ratings**, those that will **ensure** some **diversity** in the **conference program**. However, this is not enough to **decide** about the **acceptance** of all **submissions**, and thus he **assigns** the remaining cases to additional **reviewers**, asking them for a quick **response**.*

Scenario 2. Reviewer judges submissions. *John, an HCI **expert**, **accepts** Mark **invitation** to become a **reviewer** for ABC 2004. He tells Mark that he will only be able to **review** 3 **submissions**, though. To help Mark with the **submissions assignment**, he **chooses** from among the **conference topics** those he wishes to **review**, i.e., in which he is an expert and interested. […] He **receives** 4 **submissions** (one more than he'd asked for), but decides to **review** them all. He carefully **reads** every **submission**, and **grades** them according to the **form** Mark gave him, with the **criteria** of: **originality**, **relevance** to ABC 2004, **technical quality**, and **readability**. For the **submissions** that he **judged** acceptable, he **makes** some **comments** that he thinks will help **authors** to **prepare** the **final version**. For the **submission** he thinks must be **rejected**, his **comments** suggest **improvements** in the **work** itself, for future **submissions**.*

Fig. 3. Sample scenarios, describing user roles, the corresponding goals and tasks, and highlighting the candidate LEL signs in boldface.

By coupling LEL's basic elements — object, subject, verb and state— with communicability utterances, we allow design team members to thoroughly represent and understand the domain concepts from a user's point-of-view. At later design stages, designers may also use it to reflect on how the application should support users' tasks in this domain [27]. For each pair <element, utterance>, we suggest the

identification of key elements that are needed to respond to the corresponding utterance. These questions work with LEL in a way analogous to the systematic questioning of scenarios proposed in [7]. Tha major difference is that the questions we use are grounded on users' most frequent doubts.

In the following, we relate the possible kinds of answers to each pair <element,utterance>, as well as the elements designers should try to include in their phrasing in order to provide such answers (Tables 3 to 6).

Table 3. Communicative utterances and suggested content for the description of LEL subjects.

subject	elements included in the sign meaning	comm. utterances
basic notion	13. what goals the subject {may | must | must not} achieve;	*What's this?* *What's this for?*
impact	14. which goal(s), task(s) and action(s) are available; 15. what task sequences (are assumed that) the subject will prefer for each goal 16. breakdowns that hinder the performance of an action or task, or the achievement of a goal	*How do I do this?* *Why should I do this?* *What now? (What can I do?)* *What happened?*

Table 4. Communicative utterances and suggested content for the description of LEL objects.

object	elements included in the sign meaning	comm. utterances
basic notion	17. object type, with respect to a generalization/specialization hierarchy of object-signs;	*What's this?*
	18. object composition, with respect to a partonomy of object-signs and a set of attribute-signs	
impact	19. which goal(s) {produce | destroy | modify | require } the object;	*What's this for?*
	20. which task(s) or action(s) {produce | destroy | modify | require } the object, and why (associated with which goal)	
	21. which subject(s) {may | must | must not} { create | destroy | modify | view } the object	*Who can do this?*

Table 5. Communicative utterances and suggested content for the description of LEL verbs.

verb	elements included in the sign meaning	comm. utterances
basic notion	22. subtasks or subordinate atomic actions;	*What's this?*
	23. what objects are {produced | destroyed | modified | required}	

impact	24. subjects who {may | must | must not} achieve the goal;	*Who can do this?*
	25. subjects who {may | must | must not} perform the action or task	*(I can't do it.)*
	26. associated user goal(s);	*What's this for?*
	27. reasons for choosing this task or action over another that achieves the same goal(s)	*Why should I do this?*
	28. task or action sequences available for achieving the goal	*How do I do this?* *Is there another way to do this?*
	29. possible outcomes of the action;	*What happened?*
	30. for outcomes that may represent a breakdown, actions for circumventing it	
	31. subjects affected by the achievement of the goal or performance of the task or action;	*Whom/What does this affect?*
	32. the possible resulting status of the objects after the goal, task or action	

	33. preconditions for performing the action or task, or for achieving the goal;	*On whom/what does this depend? (I can't do it.)*
	34. subjects that restrict the achievement of the goal or performance of the task or action;	
	35. the necessary status of the objects before the goal, task or action	
	36. task sequence(s) necessary to reverse the action	*Oops!*

Table 6. Communicative utterances and suggested content for the description of LEL status.

status	**elements included in the sign meaning**	**comm. utterances**
basic notion	37. objects or subjects to which this status corresponds	*What's this?*
impact	38. tasks or actions that change this status	*What's this for?*
	39. how this status can be reached (through which task(s) or action(s))	*How do I do this?*
	40. explanation on how the current state was (or may have been) reached;	*Oops!*
	41. corrective measures to allow the user to reverse the effects of the task or action	

	42. how to change the status to achieve a goal;	*What now?*
	43. for status that may represent a breakdown, suggested actions for circumventing it	*(I can't do it)*
	44. how the status was reached	*What happened?*
		Where was I?

In these tables, we have extended the LEL to include some of the communication-oriented utterances, but we have maintained the independence of the technological solution. To answer the remaining utterances (*Where is it?, Where am I?, Where was I?*, and *Why doesn't it?*), it is necessary to provide more detail with respect to the interactive solution. The level of detail represented in LEL, in our view, should reflect the design decisions that have been made at each design stage.

While modeling the tasks or designing the interaction, it should be possible to answer the following questions (Table 7):

Table 7. Descriptions of LEL elements to be completed during interaction design.

Subject

LEL	**elements included in the sign meaning**	**comm. utterances**
impact	45. at each interaction step, the current "position" relative to a goal	*Where am I?*
	46. at each interaction step, the previous step;	*Where was I?*
	47. how to go back to the previous step	

At a later stage, while designing the user interface, it should be possible to answer the following questions:

Table 8. Descriptions of LEL elements to be completed during user interface design.

Object

LEL	elements included in the sign meaning	comm. utterances
impact	48. widget that corresponds to the object;	*Where is it?*
	49. location of the widget at the user interface	

Verb

LEL	elements included in the sign meaning	comm. utterances
impact	50. the kind of feedback issued after triggering the action;	*Why doesn't it?*
	51. the associated goal(s) to detect mismatches between users' goals and user interface elements	

Many of the responses associated to the pairs <element, utterance> are interrelated. The hypertextual nature of LEL makes it easier for team members to traverse from one concept to related questions in another concept, using the utterances as a navigation aid [18]. This mechanism is analogous to the layering technique used in the minimalist approach [12] and to the help access mechanisms proposed in [29,30].

Table 9 presents a sample of the enriched LEL for the conference management system described in the aforementioned scenarios.

Table 9. Sample of the enriched LEL for the conference management system[10].

Object: Submission

LEL	elements included in the sign meaning	comm. utterances
basic notion	52. A document describing a research work that is submitted by an author to be considered for publication in the conference.	*What's this?*
	53. Is reviewed with respect to quality.	
	54. May be accepted or rejected.	
	55. PC chair must assign submissions to adequate reviewers.	*What's this for?*
	56. PC chair must decide about acceptance of borderline submissions, either by assigning submissions to additional reviewers or by checking for diversity of submissions with respect to conference topics.	*Who can do this?*
impact	57. Reviewer tells PC chair how many submissions he'd be willing to review, so that he doesn't receive too many submissions.	
	58. Reviewer grades submissions to review.	
	59. PC chair ranks submissions according to reviews.	

[10] For reasons of clarity, these tables do not show the hypertext links. As in the original LEL, if any LEL sign A is found in the meaning of the current sign B, A would be marked as hypertext link to the LEL definition of A.

Subject: Reviewer

LEL	elements included in the sign meaning	comm. utterances
basic notion	60. Expert in some of the conference topics.	*What's this?*
	61. Responsible for reviewing submissions.	*What's this for?*
impact	62. May set number of desired submissions to review.	*What can I do?*
	63. May define expertise and expectations with respect to keywords/topics, to review only submission for which you are an expert.	
	64. Must grades and comment submissions according to their quality.	
	65. May need to decline an assignment due to conflict of interest or lack of knowledge.	*What happened?*

Verb : Review (submission) [11]

LEL	elements included in the sign meaning	comm. utterances
basic notion	66. To evaluate the quality of the submission.	*What's this?*
	67. To comment on the content of the submission to guide authors in preparing the final version, if the submission is acceptable, or a future submission, if it is unacceptable.	*What's this for?*
impact	68. Reviewers must review the submissions assigned to him.	*Who can do this?*
	69. Own authors and interested parties must not review the submission.	*(I can't do it.)*
	70. Non-experts should not review the submission.	
	71. No one may review a submission not assigned to him.	
	72. To help the PC chair in deciding on the acceptance or rejection of submissions.	*What's this for?* *Why should I do this?*
	73. There must be grades to the following criteria: originality, relevance to conference, technical quality, and readability.	*How do I do this?* *Is there another way to do this?*

[11] A verb in LEL typically corresponds to a goal, task or action, but we define it in terms of the objects it manipulates.

74. The PC chair decisions about acceptance or rejection depend on the reviews.	*Whom/What does this affect?*
75. A review may be completed and sent in time, or may be late or missing.	
76. The PC chair is responsible for assigning submissions for reviewers to review.	*On whom/what does this depend? (I can't do it.)*
77. If the reviewer makes a mistake in the review, he needs to be able to modify or destroy it.	*Oops!*

By exploring the answers to the questions related to each LEL element from the users' standpoint, designers not only move towards achieving a shared understanding of the domain and how the application should support the users, but also are able to envisage the consequences of their design decision with respect to the user's future interactive exchanges with the application. Also, by doing so designers are developing a large portion of the help content for the final product *pari passu* the design decisions [30]. We believe this may facilitate not only the application evolution, but also the generation of user interfaces for multiple platforms and devices.

From the responses to the communication-oriented questions, designers may then proceed to modeling the application. Fig. 4 illustrates a possible schema for modeling the designers' concerns [29] as related to the communication-oriented questions.

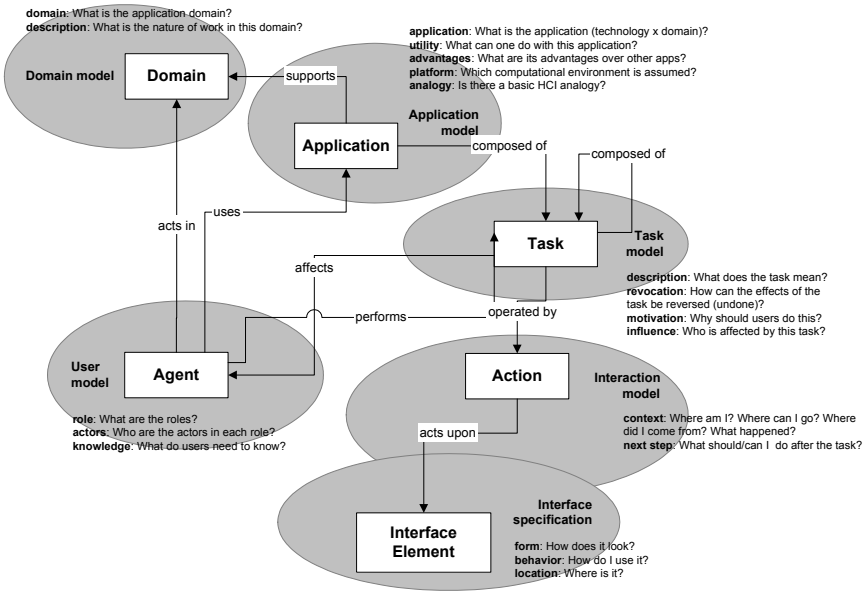

Fig. 4. Schema for representing information in model-based design of human-computer interaction.

From a first version of this schema, HCI designers may then proceed into detailed interaction modeling [2,3] and storyboarding, whereas software designers have resources to specify the system's functional aspects.

6 Concluding Remarks

In this paper, we have described a communication-oriented design approach that brings together a technique for eliciting requirements and a design method driven by users' frequent doubts. Our goal was twofold: to create a shared understanding of the domain and how the application should support users in that domain, and to provide resources (and possible the underlying design rationale) for designing the interaction and engineering the user interface signs.

We illustrated the proposed approach by briefly describing some aspects of a case study system for conference submission and reviewing. During the case study, we noticed at least two important benefits of the proposed approach. First, the communication-oriented utterances, coupled with the elements to be included in the sign meaning (described in the tables at the previous section), helped designers inspect LEL, uncovering additional signs and refining previously-defined meanings of existing signs. Second, by explicitly representing the communicative concerns associated with each domain concept, design team members succeeded in forming a

comprehensive vision of the domain and the application, and could thus envisage alternative technological solutions at the users' workplace. The case study described in this paper is still underway, and we plan to evaluate the communicability of the resulting application, and also a usability inspection to compare it with an existing application of a similar kind.

To gather stronger evidence about the advantages of this approach, we are currently developing multiple case studies, in the following domains: web content publication and location-based instant messaging in mobile devices. One of the issues we want to explore is whether the LEL structure or its classification should be changed to better accommodate the communicative concerns and the evolution of each concept's definition during different design stages, to capture the underlying design rationale and to provide different levels of focus and detail to address the relevant design concerns at each moment. The reason for investigating whether LEL structure should be changed is that, in our case study, at times we were tempted to structure LEL's descriptions according to users' goals and tasks, as in common HCI practice. Also, we felt that some elements do not fit well into LEL's classification, such as "expertise" or "submission deadline". We intend to analyze in the future whether modifiers and constraints should also receive a first-class status in LEL and thus be considered relevant signs with their own set of communication-oriented questions. For now, we have treated them as generic signs, for which the only associated question is "What's this?".

As future work, we intend to elaborate a set of guidelines for deriving communication-oriented interaction models [2] and for engineering user interface signs [9] from the enhanced LEL. In addition, we want to investigate the benefits of adopting the approach described in this paper in the design of an adaptive system, by deriving formal ontologies and explicitly incorporating to these systems the users' beliefs, goals, and plans.

Acknowledgments

Simone D. J. Barbosa, Maíra Greco de Paula and Karin Breitman would like to thank CNPq for providing financial support to this work. Simone D.J. Barbosa, Milene Selbach Silveira and Maíra Greco de Paula thank their colleagues at the Semiotic Engineering Research Group at PUC-Rio for many discussions that have contributed to this work.

References

1. Baecker, R.M. et al. (1995). *Readings in Human-Computer Interaction: toward the year 2000*. San Francisco: Morgan Kaufmann Publishers, Inc.

2. Barbosa, S.D.J.; de Souza, C.S. ; Paula, M.G. (2003) "The Semiotic Engineering Use of Models for Supporting Reflection-In-Action". *Proceedings of HCI International 2003*. Crete, Greece.

3. Barbosa, S.D.J; Paula, M.G. (2004) "Adopting a Communication-Centered Design Approach to Support Interdisciplinary Design Teams". *Bridging the Gaps II: Bridging the Gaps Between Software Engineering and Human-Computer Interaction*, ICSE 2004 workshop, Edinburgh, Scotland.

4. Berners-Lee, T.; Hendler, J.; Lassila, O. (2001) "The Semantic Web", Scientific American, May 2001. Available online at: http://www.scientificamerican.com/article.cfm?articleID=00048144-10D2-1C70-84A9809EC588EF21&catID=2

5. Breitman, K. and Leite, J. (2003) Ontology as a Requirement Engineering Product .In: *11th IEEE International Requirements Engineering Conference*. Monterey Bay, California, USA, pp. 309-319.

6. Carroll, J.M. (ed., 1995) *Scenario-based Design: Envisioning Work and Technology in System Development.* New York, NY. John Wiley and Sons.

7. Carroll, J.M.; Mack, R.L.; Robertson, S.P.; Rosson, M.B. (1994) "Binding Objects to Scenarios of Use", *International Journal of Human-Computer Studies* **41**:243-276. Academic Press.

8. Danesi, M., Perron, P. (1999) *Analyzing Cultures: An Introduction and Handbook*, Indiana University Press.

9. de Souza, C.S. (in press) *The Semiotic Engineering of Human-Computer Interaction*. The MIT Press.

10. de Souza, C.S. (in press) Semiotic engineering: switching the HCI perspective from producing to introducing high-quality interactive software artifacts. *Interacting with Computers* **16**-6. Forthcoming.

11. Eco; U. (1979) *A theory of Semiotics*, Bloomington, IN: Indiana University Press.

12. Farkas, D.K. (1998) "Layering as a Safety Net for Mini-malist Documentation". In J.M. Carroll (ed.) *Minimalism Beyond the Nurnberg Funnel*. The MIT Press, Cambridge.

13. Fensel, D. (2001) Ontologies: a silver bullet for knowledge management and electronic commerce, Springer.

14. Gruber, T.R.(1993) "A translation approach to portable ontology specifications", *Knowledge Acquisition*, 5 (2): 199-220

15. Hendler, J.; McGuiness, D. (2000) "The DARPA agent Markup Language", *IEEE Intelligent Systems*, 16 (6), 2000. pp.67-73.

16. Kammersgaard, J. (1988) "Four different perspectives on Human-Computer Interaction", International Journal of Man-Machine Studies 28:343-362, Academic Press.

17. Kaplan, G.; Hadad, G.; Doorn, J.; Leite, J.C.S.P. (2000) "Inspección del Lexico Extendido del Lenguaje". *Proceedings of the Workshop de Engenharia de Requisitos, WER'00*. Rio de Janeiro, Brasil.

18. Leite, J.C.S.P.; Franco, A.P.M, (1992) "A Strategy for Conceptual Model Acquisiton". *Proceedings of the IEEE International Symposium on Requirements Engineering*, IEEE Computer Society Press, Pags. 243-246, San Diego.

19. McGuiness, D.; Harmelen, F. (2003) *OWL Web Ontology Overview*, W3C Working Draft 31 March 2003.

20. Mullet, K., and Sano, D. (1995) *Designing Visual Interfaces: Communication-Oriented Techniques*, SunSoft Press, Mountain View, CA.

21. Norman, D. e Draper, S. (eds., 1986) *User Centered System Design*. Hillsdale, NJ. Lawrence Erlbaum.

22. Oppermann, R. (1994) *Adaptive user support : ergonomic design of manually and automatically adaptable software*. Hillsdale, N.J. : Lawrence Erlbaum Associates.

23. Paternò, F. (2000) *Model-Based Design and Evaluation of Interactive Applications*, London, Springer-Verlag.

24. Peirce, C.S. (1931-55) *Collected Papers*. Cambridge, Ma. Harvard University Press. (excerpted in Buchler, Justus, ed., Philosophical Writings of Peirce, New York: Dover, 1955).

25. Prates,R.O., de Souza, C.S., Barbosa, S.D.J. (2000) "A Method for Evaluating the Communicability of User Interfaces". *ACM Interactions*, 31–38, Jan-Feb 2000.

26. Preece, J., Rogers, Y., and Sharp, H. (2002) *Interaction design: beyond human-computer interaction*, John Wiley & Sons, New York, NY.

27. Schön, D. (1983) *The Reflective Practitioner: How Professionals Think in Action*, New York, Basic Books.

28. Sellen, A.; Nicol, A. (1990). Building User-Centered On-line Help. In Laurel, B. *The Art of Human-Computer Interface Design*. Reading: Addison-Wesley.

29. Silveira, M.S.; Barbosa, S.D.J.; de Souza, C.S. (2001) Augmenting the Affordance of Online Help Content. *Proceedings of IHM-HCI 2001*, Lille, Springer-Verlag.

30. Silveira, M.S.; Barbosa, S.D.J.; de Souza, C.S. (2004) Model-based design of online help systems. Proceedings of CADUI 2004.

31. Winograd, T. and Flores, F. (1986) Understanding Computers and Cognition: A New Foundation for Design, Addison-Wesley, Reading, MA.

Discussion

[Fabio Paternò] There is a tool that takes scenario and associates with objects and with tasks. Do you think that your method can be supported by a tool able to derive more structured information?

> [Simone D.J. Barbosa] The current approach is merely oriented for a designer analysis. We are not thinking about tool support.

[Philippe Palanque] Where does your taxonomy, presented at the beginning of the talk, comes from?

> [Simone D.J. Barbosa] This comes from work on help systems

[Philippe Palanque] So it does not come from a semiotic engineering analysis?

> [Simone D.J. Barbosa] No, but Semiotic Engineering would be useful to build this kind of taxonomy

[Ann Blandford] You said there is no such thing as a typical user. How do you deal with the usability across users?

[Simone D.J. Barbosa] What we are reasoning about is what is expected of users and how those expectations are communicated to them.