Larry E. Wood

Semi-Structured Interviewing for User-Centered Design

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An obvious, but critical, ingredient of user-centered design of software applications is for designers to gain a thorough understanding of potential users' work (including its surrounding context) which an intended application will support. This involves observing potential users and interviewing them about their work. The goal is to produce a descriptive model of current work practice that can be used to guide further design activities (e.g., how the worker will become more productive through introduction of a new or improved computer support application). In order to make that process more efficient, I have developed the semi-structured interviewing techniques described here. The techniques are adaptations of methods used by ethnographers [15, 16] and those used by cognitive scientists [4], and are based on previous work that my colleagues and I have done on knowledge elicitation for knowledge-based (expert) systems [5, 18].

Background

The interviewing techniques are described in the context of a software development project in which I have been involved. The purpose of the application is to expedite the ordering of telecommunications services (telephone and electronic network services) for all departments on the campus of Brigham Young University. Each academic or support unit has a designated representative to coordinate ordering of telecommunications services (Telecom Services) for their unit. Prior to the development of the application, orders were processed through memorandums following telephone and face-to-face negotiations between the unit representative and a representative from Telecom Services.

A design team for the project was organized, consisting of the manager of the Telecom Services department, the department's chief analyst/programmer, myself (acting as a usability analyst/interaction designer), and five potential users[1] of the order application. The users varied widely in their experience and scope of responsibility. Experience ranged from less than a year to more than ten years, and scope of responsibility varied from a small academic department (fifteen faculty and staff members) to the entire Law School (approximately 700 faculty and staff members).[2] Before describing the interviewing techniques, I will discuss the principles and assumptions upon which they are based. I will then present guidelines for questions to elicit relevant work "objects," followed by guidelines for eliciting information about work tasks in which those objects are used. Finally, I will offer some suggestions for using and documenting the information gathered in the interviews and producing a model of users' work.

Guiding Principles and Working Assumptions

Interviews alone are not sufficient to meet all the needs of work/task analysis. It is vitally important to observe users doing work in their natural settings, and to gather and document examples of that work. It is my goal to place interviewing techniques in the broader context of interaction design, to provide guidelines for making user interviews as productive as possible, and to offer some concrete examples of the applications of those guidelines.

One of the principles underlying the interviewing techniques concerns the nature of expert knowledge. Potential users of an application are usually experts in the work domain which the application is intended to support, whether or not they are considered experts in the use of computer software. As suggested by LaFrance [11], one reason that work/task analysis can be a difficult problem is that analysts underestimate the complexity of expertise in a given domain of knowledge. There is also a body of literature in cognitive psychology [14] on the nature of expertise that has implications for how one should work with experts to gain an understanding of how they accomplish their work in a specialized domain.

1 The term *user* refers to anyone who will use an application directly, and the term *analyst* refers to the person who is conducting interviews/observations for the purpose of modeling a user's work/tasks.

2 There are three different types of users associated with the order information: those who request the orders, those who receive the orders, and those who are assigned to actually perform the work requested (e.g., installations, upgrades, etc.). Because the current discussion focuses on the work-related needs of only the first group, I want to make it clear that the interviewing methods apply as well to the broader context involving all three groups.

Aspects of expertise which I find relevant to work/task analysis are (1) the organization of expert knowledge, (2) the tacit nature of many aspects of expertise, and (3) the potential for experts to exercise *translation competence.*

Organization of Expert Knowledge

Because concepts in human memory are associated with one another, the experience of remembering or being cued with one concept results in the recall of additional relevant concepts. Expert knowledge is generally organized hierarchically, at a macro level (i.e., various taxonomic organizations such as categories and sub-categories) [12], although many other types of relationships are also present, depending on the particular domain of expertise. At the micro level, expert knowledge is stored as organized "chunks" of frequently occurring patterns [3], with attached procedures for appropriate responses when those patterns are recognized in problem-solving situations.

In my analyses, I distinguish between *object* knowledge and *process* knowledge. Object knowledge includes the conceptual entities and objects (both concrete and abstract) in a particular domain and their various categories and relationships. Taxonomic relationships such as types, sub-types, and parts, and distinguishing features or characteristics of objects, are particularly important. Process knowledge is the knowledge required to accomplish the intended work **using** relevant concepts and objects. Obviously the goal of interviewing is to understand how work objects are used in performing the relevant work. However, simply from a pragmatic point of view, it has proven more effective for me to focus first on the objects themselves, rather than attempting to understand the objects and the procedures used on/with them concurrently. I structure interviews for work/task analysis around this distinction.

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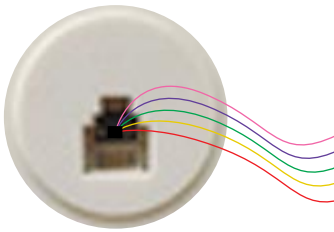
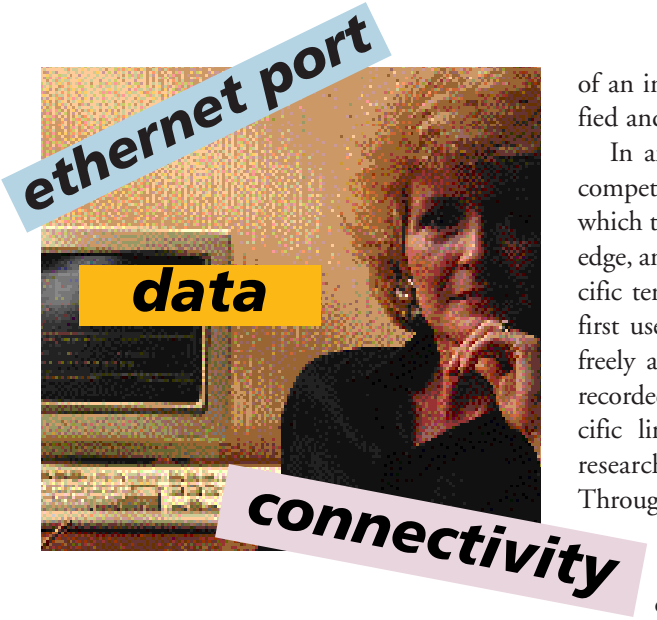
Tacit Knowledge

A potential difficulty in gaining an understanding of a user's work relates to the fact that much of an expert's problem-solving knowledge has become automatic or tacit through extensive use. There has been considerable debate about its accessibility, even to the expert [4]. In early stages of skill learning, an individual consciously considers various items of knowledge during problem solving. In well-learned tasks, much of the relevant knowledge is no longer consciously available during problem solving. Although it has not been "forgotten," it may be difficult for an expert to articulate, especially when asked to do so directly. An awareness of this potential problem can help an analyst use information about an expert's view of the domain to constrain inferences about tacit knowledge. The analyst must observe examples of a user engaged in actual work, where tacit knowledge is often manifest.



Translation Competence

Analysts are often relative novices in the work domain being analyzed. In ethnographic research settings, *translation competence* [15] may occur when cultural experts translate their view of their culture when explaining it to an outsider. The more an expert translates for the convenience



Semi-structured interviewing strategies rely heavily on the analyst being careful to elicit terminology about the work domain from potential users with minimal bias.

of an investigator, the more the researcher's view becomes oversimplified and distorted compared to that of the expert.

In an effort to avoid the errors that might result from translation competence, Spradley [15] advocates an approach to questioning in which the researcher makes minimal assumptions about experts' knowledge, and which uses information they provide (particularly culture-specific terminology) as the basis for further questioning. The researcher first uses very general probing techniques to persuade experts to talk freely about their domains in a global sense. An expert's language is recorded and then examined for category labels and other domain-specific linguistic cues. Domain-specific terms are then used by the researcher to probe experts for additional, related information. Throughout the process, it is necessary to verify that the researcher's emerging understanding of the domain accurately reflects the informant's expertise. For this reason, the interviewing strategies described here are considered semi-structured rather than structured,[3] and they rely heavily on the analyst being careful to elicit terminology about the work domain from potential users with minimal bias. Instead of designing a priori a specific set of questions to be asked in a specific order, analysts have various types of questions at their disposal to be used in opportunistic ways, depending on the demands of the situation.

Interviewing Strategies

The goals of work/task analysis to be supported by the interviewing techniques described here are similar to those of Contextual Inquiry [7]: to develop a work model describing users' current work practices, and then to develop an enhanced work model (proposing ways in which the users' work can be redesigned and enhanced by introducing a software support application).

Object Identification

The interviewing techniques described here are centered around the distinction between object and process knowledge, described earlier. Because information about relevant objects and their related categories and concepts is reflected in a user's use of domain-specific terminology, it is important for the analyst to elicit and document work-related language from the user. A word or phrase need not be obviously unfamiliar to an analyst in order to be important. For example, in the domain of Telecom Services, the term *ethernet port* might have little meaning to an analyst unfamiliar with a networking domain and would be an obvious point of focus in an interview. Most analysts are familiar with data and might not realize that the term data connection has special significance in this domain (i.e., a connection from a computer workstation to the campus network through a Rolm® telephone set). Analysts should give particular attention to all terms and phrases which are frequently mentioned by the user to make certain that such assumptions are tested.

The goal in the early stages of interviewing is to direct the user's attention toward the task of describing the structure of the work domain. The analyst must enable the user to describe the work practice

3 For a description of a structured method of questioning for similar purposes (knowledge elicitation for expert systems), see Gordon & Gill [6].

in a natural way, using domain-specific terms for important objects. The analyst should also guide the general direction and flow of the interview, while letting the user freely and naturally express her/his conceptualization of it.

One way to elicit a large sample of work-related terminology is to ask Grand Tour [15] questions, which encourage the user to verbally "show the analyst around" the physical, temporal, and conceptual space of the work domain. Examples of such questions are shown in Table 1.

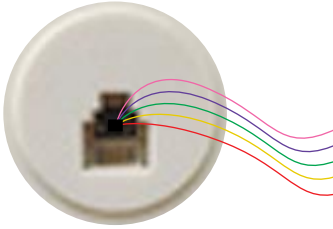
Object Identification Questions

TABLE 1

Question Type	Example
Grand Tour	
Task-Related	*"Could you discuss the major steps you go through in filling a request for services from a member of your unit?"*
Guided	*"Could you show me one of the previous orders you have placed and guide me through the different parts?"*
Typical	*"Could you tell me about a typical request from one of the members of your unit?"*
Case-Focused	
Example	*"Can you show me an example of a face plate template?"*
Personal Experience	*"You've probably had some interesting experiences dealing with requests for face plate configurations. Could you tell me about some of them?"*
Native Language	
Direct Language	*"What do you call the buttons that allow one to select a particular line on a set?"*
Hypothetical-Interaction	*"How would you describe the various types of jacks to another Telecom services liaison?"*
Use	*"What purpose does the auto-intercom feature serve?"*

Grand Tour questioning is particularly useful in early analysis, but may be used whenever the user reveals a new subproblem. Because the analyst's ultimate goal is to understand the tasks (and their interrelationships) that are required to perform a user's work, Task-related and Guided questions help keep the user focused on relevant aspects of the work domain without narrowing the focus too early. Asking about typical problem-solving episodes (using Typical questions, Table 1) often elicits general categories used in frequently occurring situations.

Case-Focused questions (adapted from [15]; see Table 1) are also useful in eliciting work-related terminology, and are used to characterize work-related objects by evoking the user's description of the characteristics and details of particular problem-solving situations. They also keep the interview focused on relevant topics, especially if a user tends to get sidetracked. Case-Focused questions also require reference to specific examples of work and provide the basis for further questioning



about process knowledge. Their main function in the early stages of analysis is to provide cues for retrieval of information about work-related objects—abstract as well as concrete.

Example questions and Personal Experience questions (adapted from [15]; see Table 1) help the analyst obtain more detail about terms already identified. Hypothetical-Interaction questions (adapted from [15]; see Table 1) provide the analyst with indirect access to a larger "community" of users (as experts). Communication between experts within this community about work-related problems and knowledge is one of the processes which fosters the development and use of specialized domain terminology, or jargon [15].

Although most of the Object Identification questions are designed to elicit natural domain descriptions in an indirect way, there will undoubtedly be times when this strategy will fail. Spradley [15] warns that cultural experts tend to translate their knowledge into terms they believe the interviewer will find easier to understand. Direct Language questions (adapted from [15]; see Table 1) can help alleviate this problem.

One technique often used by ethnographers to elicit informants' natural descriptions of terms and concepts is to ask how terms, tools and concepts are *used* rather than what they *are* or *mean.* Direct questions about meaning tend to encourage an expert to translate. Use questions (see Table 1) prompt the informant to describe the context in which a particular term or object plays a role. This description provides information which can be used to structure more in-depth questioning, as needed.

Perhaps the most important aspect of the techniques described here, given the focus on language, is for the analyst to phrase questions to a user in work-related terminology that has been elicited by a more general question (e.g., Grand Tour). Otherwise, an analyst's consistent use of terminology different from that of the user will encourage the user to translate. Using specific work-related language provides a context of familiarity and encourages a user to focus on the work domain itself rather than the analyst's methods and unfamiliarity with the domain.

Whenever possible, it is preferable to interview users in their natural work setting

Whenever possible, it is preferable to interview users in their natural work setting [1, 7]. The familiar surroundings serve as further cues to the knowledge users rely on to perform their work. There is evidence [12, 16] indicating that individuals select a limited number of all possible associations for reporting in any given interviewing context. It would be premature to conclude that knowledge about a given term or topic is *tacit* and unavailable to users simply because they fail to respond in a particular questioning context. Rather, it is advisable to extend questioning about each term over a number of interviewing sessions in normal contexts in order to maximize the total amount of information retrieved.

Object Relationships

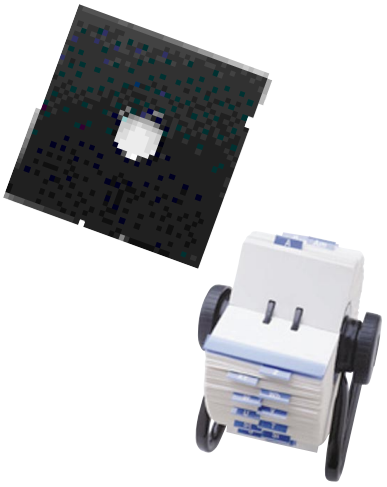
Once important work objects have been identified, an analyst can use questioning techniques that explore the rich, integrated organizational structure of a user's knowledge.

These techniques are based on the general principle that concepts in memory are associated with one another and that remembering or being cued with one or more domain concepts will result in the recall of additional related concepts.

It is important to phrase questions to the user using work-related terminology that has already been obtained in responses to previous questions. For object relationships, an analyst needs to look for category labels. A particular category term may be associated with a number of subcategories, each of which are related to the category label by a particular functional relationship. Examples of Object Relationship questions (adapted from [15]) are presented in Table 2.

Suppose, for example, in answer to the task-related Grand Tour question listed in Table 1 above, a Telecom Services coordinator replied "I ask department members if they will need any network applications, in addition to their normal types of telephone use." This statement indicates that at least two sub-category terms in the domain are defined by the category term *use* and the relationship *types*. These two entities are both types of telecommunications use, and the user can provide further information about other types and make meaningful distinctions among them.

Generally, the most fruitful way of eliciting knowledge about relationships among work objects is to first identify the category label and functional relationship from a sample of a user's language elicited through Object Identification questions (see Table 1). Then a list of

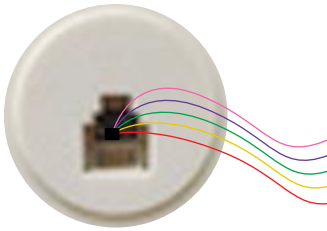


Object Relationship Questions

TABLE 2

Question Type	Example
Relationship	
Category Label	*"What are the different types of telecommunications uses?"*
Category Member	*"Are network apps and FAX/Card Readers both types of telecommunications use?"*
Contrast	
Directed Contrast	*"Could you look through this order memo and show me what other items are considered network apps?"*
Dyadic Contrast	*"What differences are there between intercom groups and pick groups?"*

category members may be elicited by asking Category Member questions (see Table 2). Any objects for which the analyst is uncertain regarding category membership can be clarified by asking additional Category Membership questions. Once the user indicates that there are no more members in a particular category, the analyst should elicit the relevant features and dimensions of contrast which distinguish the members of a category from one another in meaningful (for work) ways. This is accomplished by asking a number of Contrast questions (see Table 2). As before, it is important to attend to a user's terminology for these dimensions and features. Although I have emphasized categorical relationships in this discussion, other important relationships



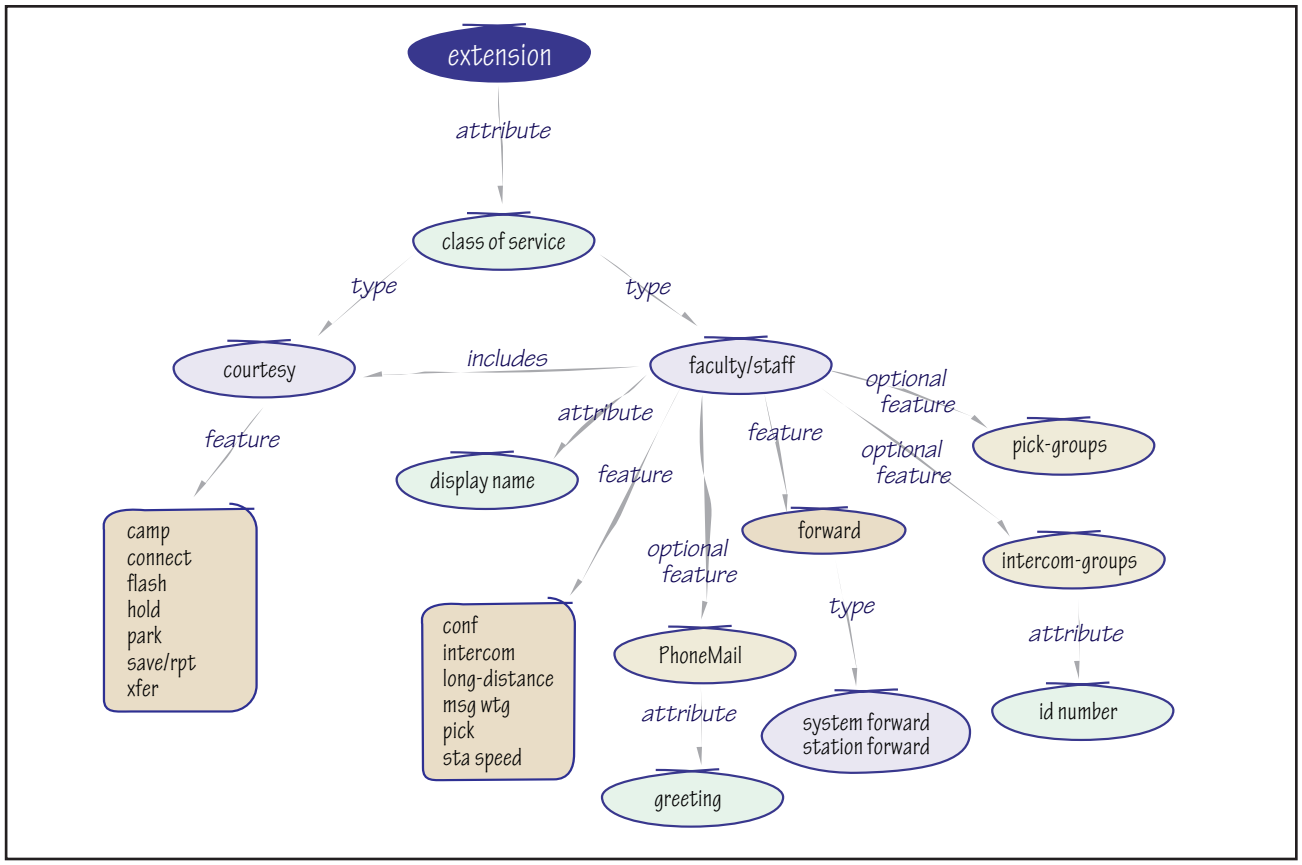


Figure 1
Part of the object hierarchy from the Telecom Services order project

must be understood (e.g., part-whole, attributes, cause-effect) [13], depending on the domain being analyzed.

Although Object Identification questions and Object Relationship questions have been discussed in different sections of the paper, the information need not be sought from users in any rigid order. Various types of questions can be used opportunistically. I usually find it convenient to mix the two types of questions to suit a particular situation and set of goals.

Work Model Development and Documentation

I will now consider the logistical issues involved in interviewing, such as how to document the information obtained. I prefer to limit my interviews to approximately one hour, and I tape record each one for later analysis and interpretation. During the interview, I take only enough written notes to enable me to ask additional domain-related questions to keep the interview flowing. Although I prefer not to interrupt users, I am unable to capture all that they are telling me without doing so unless I rely on subsequent analysis of the recordings. Thus, following each interview, I review the tapes and my notes, and analyze and document the results in the form of a work model description. I then ask the user to review the description prior to a subsequent interview. At the beginning of each subsequent interview, I invite the user to correct any errors in interpretation (which inevitably occur), and then we continue to extend and expand the work model description through additional interviews and observations.

Larry E. Wood
Dept. of Psychology
Brigham Young University
WoodL@byu.edu

Because the goal of interviews/observations regarding users' work is to develop a work model, an analyst must obviously decide how to describe the model. In that regard, I have found it helpful to construct object hierarchies to provide an organized summary view of the growing object structure.[4] I then expand/revise the hierarchy following each interview, until it appears to the user to be complete. Part of the object hierarchy (related to telephone extension options) from the Telecom order project is shown in Figure 1. The object hierarchy is included as part of the work model description reviewed with the user. Also, details describing each object are placed in an object glossary.

Process Knowledge

Once a large portion of the Object knowledge has been documented, the analyst can proceed to an examination of how users employ work objects in accomplishing their work. Perhaps the most widely-used technique developed in cognitive science to investigate problem-solving strategies is think-aloud protocol generation and analysis. The term *protocol analysis* represents a family of techniques used to examine participants' verbalizations about their problem-solving processes. Ericsson and Simon [4] have observed that the analysis of a verbal protocol must be preceded by a domain definition phase, during which the researchers should exhaustively catalog the labels for objects, concepts, etc. referred to in a protocol. This is consistent with my own concern regarding object knowledge and with my particular use of protocol methods in user work/task analysis.

While one could begin a user work/task analysis with think-aloud protocols generated in the context of work-related tasks, I have found it most useful to first obtain a preliminary understanding of the relevant work objects. As I use them, methods for protocol generation can then become additional interviewing techniques. Reasoning and problem-solving strategies emerge from a variety of think-aloud protocols generated by asking users to describe their thought processes as they engage in representative work tasks.

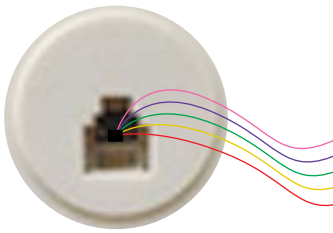
At least three types of protocol-generating procedures have been used in studying problem solving. As shown in Table 3, Concurrent Think-Aloud questions simply request an expert to report the contents of conscious awareness during the solution of a domain problem. Eric-

4 I have no formal method for generating these hierarchies. I simply attempt to describe what users tell me, while encouraging them to make connections.

Think-Aloud-Protocol Generation questions

TABLE 3

Question Type	Example
Concurrent Think-Aloud	*"Think out loud while you generate an order for adding an ethernet connection to a faculty member's office as described in this request. Do not worry about talking in complete sentences or making sense."*
Aided Recall (retrospective protocol)	*"As we review this tape of the order you just generated, say whatever you remember about what you were thinking. Stop the tape or rewind whenever you want."*
Cross-examination	*"How did you decide which type of jack splitter to request for the installation of this new ethernet connection?"*



sson and Simon [4] caution that this procedure can only yield meaningful results when the task being performed concurrently with the protocol does not require the use of verbalization or other processes which overly tax available mental resources. Even then, a problem solver is likely to provide an incomplete account of the cognitive aspects of a process. However, the results will still be valuable because they provide information about the sequence in which the user (as expert) attends to various problem features and the various subgoals for which these features are relevant.

Aided Recall questions (see Table 3), a type of retrospective (rather than concurrent) protocol generation, can be used to follow up results obtained in concurrent think-aloud protocols. This technique, which has been used successfully in eliciting descriptions of expertise [9], involves video or audiotaping the performance of an expert engaged in problem-solving and then reviewing this record (along with any artifacts associated with problem solving) with the problem solver at a later time regarding her/his thoughts at a particular stage of problem solving. This procedure creates a situation in which recall of processing is cued by an unbiased record of the problem solver's own performance. A variation on aided-recall, called cross-examination (see Table 3), has been used successfully to probe the limits of knowledge directly [10]. After completing a concurrent think-aloud protocol on a particular problem, the expert is asked specific questions about it, particularly aspects that seem vague or uncertain to an analyst.

Any use of protocol generation should be done in the context of the user's work.

In developing work/task models of users' work, the *problems* users attempt to solve are those that define the relevant work. Therefore, any use of protocol generation should be done in the context of that work. It should be obvious in the context of any user-centered design approach that observations relate to naturally occurring work situations from which more general descriptions can be derived.

Process knowledge, like object knowledge, must be represented in some manner in a work model description for future reference by the analyst and other members of the development team, including potential users. Particularly for review purposes, I have found it helpful to represent work task descriptions both at an abstract/summary level and at a more detailed level. For the abstract level, I am currently exploring various alternatives such as structured outlines, flow charts, and work flow diagrams as potential representations. For more detailed descriptions, some form of scenario development is very important [2]. A segment of a structured outline for a task scenario from the Telecom order application obtained early in the analysis is shown in Figure 2.[5] I find it particularly important to have representations that are understandable to the users whose work is being modeled. Otherwise, it is very difficult for them to verify that the task/work models are valid and complete from their perspective.

I document segments of task descriptions as they emerge during early phases of analysis, and then fill out details through think-aloud protocols generated in the context of specific cases or examples. These are validated against specific work examples, as discussed below.

5 As with the object hierarchies, I do not attempt to closely follow any formal method for generating the outlines, even though there is a loose resemblance to pseudo code.

Work Model Validation

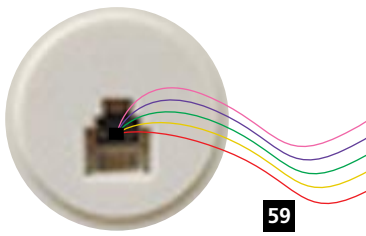
A continuing concern during work/task analysis is to develop a valid model of the work performed by users—including the ways they think about it—which a potential application will support. There are limitations to what can be obtained using the interviewing techniques discussed here, including any static description, with its combination of verbal and graphic representations. I typically conduct a series of interviews with time between to analyze the results, update the work model description, and allow the user to review the material prior to or at the beginning of each subsequent interview.

```
Receive request from client (usually in the form of an e-mail message)
Choose Use type (telephone, network applications, FAX/Card Reader)
        If telephone Then
         Choose Service type (Add, Move, Change, Disconnect, Remove)
          If Add Then
            Draw floor plan of the appropriate room
            Specify current jack locations in room
                  If jack(s) is/are present
                  Then Determine jack number(s)
                     Otherwise request new jack installation
            Map extensions to new or existing jack (by number)
            Select set type for new telephone(s)
            Select face plate configuration from tables
                  Select line appearances
                  Review and select needed features
        If Move Then (see details on following page)
            . . . . .
        If network applications Then (see details on following page)
    . . . . . .
Draft a description for request
```

Figure 2
A segment of a structured outline of Telecom Services order task.

It is imperative that the work model be based on naturally occurring work examples and products. Not only does this help ensure accuracy of the work model in early stages of development, but the examples and products (as long as they are reasonably representative) can be used to verify a final version of the work model and to develop more general scenarios. If the model can *run* with representative examples of naturally occurring work, then the analyst can be reasonably confident about its validity at that stage of development [8]. Furthermore, the examples and scenarios developed from them can be used to verify decisions across further stages of development (e.g., interface prototyping, and formal usability testing of a running application). Although it is beyond the scope of this article, once the work model is judged complete, it can then serve as the basis for further development (e.g., an enhanced work model and its transformation into low- and hi-fidelity prototype interface designs).[6]

6 Interested readers are referred to Wood [17] for detailed descriptions of a variety of approaches to user-centered design methods, focusing on activities that follow the creation of user work models.



A strategic question which I have not yet addressed has to do with combining the results of interviews from various users, given the Telecom Services order application to which I have made reference here. In this particular case, I chose to work extensively with one user to develop a comprehensive model of the work involved in constructing orders.

Copies of the description of that model were then circulated to the other members of the development team,[7] and they were asked to review it. The user members of the team were asked to add their particular perspectives during individual interview sessions with each of them. Those different perspectives were then incorporated into a revised model and re-circulated to all members for their further review. A final interview was then conducted with each member of the team and further revisions were made to the model until we collectively arrived at a composite work model with which everyone was satisfied. Appended to the final version of the model were scenarios and samples of representative orders previously requested by various users. In addition, various suggestions from team members regarding ideas about how an application could enhance the ordering process were also appended.

The user members of the team were asked to add their particular perspectives during individual interview sessions.

Combining interview results from multiple users as outlined here has both advantages and disadvantages. The biggest advantage is its efficiency, compared to the time required to develop complete work models independently with several users and then to combine them into a representative, composite model. One disadvantage is the risk of biasing the responses of all but the first interviewee. I have not collected formal data on this question, but I have found this to be another area in which samples of naturally occurring work examples and products play an invaluable role. Analysts must be attentive to work samples from users not involved with the development of the initial model that do not coincide with the initial description of the model. This is an indication of a potential bias. Further work with the new user can potentially correct the omission/error in the composite model. I often find that the differences arise not from bias or conflict among the various users, but as a result of non-overlapping areas of their work experience.

Summary

I have described a methodology for structuring interviews with users to assist and analyze in modeling their work in early phases of application development. I have developed my approach by importing and adapting methods from disciplines which have a history of related activities. In doing so, I have been influenced by several considerations. First, I have been guided by the nature of expertise, some important aspects of which are: (1) a high degree of tightly integrated domain-specific knowledge, (2) the fact that a substantial portion of the knowledge is tacit and difficult for an expert to articulate, and (3) the tendency for an expert to engage in *translation competence.*

The nature of expertise has led me to place a heavy emphasis on the use of work-related language in the interviewing methods to reveal the

7 I wish to express my appreciation to other members of the team for their cooperation in working with me in the research and development mode. Those individuals are: Ken Greer, Gary Buckway, Jennifer Chiara, Irene Fuja, Lynn Edwards, Carol Sant, and Alan Higley.

organization of expert knowledge and to avoid the potential sources of bias. The interviewing strategies are composed of various types of questions that can be used in an opportunistic manner in a series of semi-structured interviews. Object Identification questions and Object Relationship questions are designed to explore the organization of domain concepts, objects, and their distinctive characteristics.

Another consideration guiding the development of my approach has been the early elicitation of object knowledge, which is then used to assist the understanding of process knowledge and the development of work scenarios. This is done primarily through the use of verbal protocol generation activities in the context of naturally occurring work examples and products.

Finally, I have found it important to document and describe the work model iteratively, and in a way that can be reviewed for verification by users and other members of a development team. Adequate descriptions include both abstract summary forms of task representations such as structured outlines and flow charts, and more detailed representations such as work scenarios and object glossaries that can be used in validation of work models and in later stages of interaction design.

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