Translation of Tacit Knowledge into Explicit Knowledge: Analyses of Recorded Conversations between Customers and Human Agents

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Abstract

This paper reports the preliminary results of analyzing recorded voice conversations between customers and human agents in a help-desk organization. The key to translating such raw records of experiences into reusable knowledge is finding and assigning appropriate indices for them. We have applied conversational case-based reasoning techniques to them and found that script-based indexing effectively expresses various customer situations and problems. In several conversation records, a new type of tacit knowledge played an important role when solving customers' problems. It is called cue questions given as advice by senior agents to junior agents in trouble answering customer inquiries. We have experimentally implemented this idea as an extension of script-based indexing.

Introduction

We have been developing case-based retrieval systems for customer support (Shimazu and Takashima 1997) by using conversational case-based reasoning (CCBR) techniques (Aha and Breslow 1997)(Aha *et al.* 1998)(Racine and Yang 1997). Recently, an internal client brought us cassette tapes of telephone conversations between customers and human agents at the organization. Before coming to us, they had installed a commercial help-desk tool that records customer inquiries because agents answering customer questions often want to search past inquiries to find similar cases. The tool provides a simple keyword matching method and a vector-space similarity-based retrieval mechanism, but the search quality has not been good. They therefore recorded about 150 voice conversations between customers and human agents, and asked us to analyze them and create a knowledge base from them.

This occasion has brought us two opportunities. First, we could use the conversation data to evaluate the effectiveness of our CCBR techniques. Although these techniques were based on past customer inquiries, many conversational characteristics had been filtered out since these inquiries were written in descriptive texts by human agents. This was, therefore, a good chance for us to test the effectiveness of our CCBR techniques by applying them to records of actual conversations.

The second opportunity was the chance to discover new types of tacit knowledge (Nonaka 1991) in the conversation data. For example, we found that cue questions played an important role when junior agents were having trouble answering customer inquiries. Cue questions asked by senior agents served as a type of advice that stems from experience. Since cue questions can be important, we have designed techniques to translate them into explicit knowledge.

Creating knowledge from raw records of experiences is one of the basic activities in knowledge management (Davenport and Prusak 1997) (Nonaka 1991). This paper reports the preliminary results of our recent activity.

Recorded Conversations

As a first step, we selected ten of the 150 conversations, each lasting between 10 and 30 minutes. Table 1 lists *subject*, *level*, *skill*, and *length*. *Level*, the difficulty level of inquiries, is either low or medium (med) or high. *Skill* is the skill level of the customer and is either low (novice level) or medium (intermediate level). *Length* is the length of conversations not in the units of time but as the number of utterances. These conversations have the following characteristics:

Multiple conversation styles: Customers tend to explain their problems in a variety of ways. One might describe a problem by using step-by-step action-based expressions. Another might explain the same problem by envisioning a model of a product domain (which may or may not be accurate) and using the model to explain the problem. A human agent assesses customers' problem situations and matches them to his/her knowledge or experiences. This is called *situation assessment* (Kolodner 1993)(Leake 1996).

Taking a control in conversation flow: A typical conversation has two phases. A customer explains his/her problem from his/her particular perspective,

ID	Subject	Level	Skill	Length
1	How to set up modems.	high	med	36
2	How to find applications.	med	low	24
3	How to set up modems.	med	med	26
4	Exception in an application.	low	low	30
5	How to operate sound functions.	med	low	28
6	How to operate printer functions.	high	med	36
7	How to enroll in an Internet service.	med	low	26
8	How to fix an application bug.	high	med	48
9	Where to place a PC in a home.	low	low	26
10	Recovering from application errors.	high	low	58

Table 1: Conversations and their features.

using his/her own vocabulary and referring to the domain model based on his/her limited observations of the problem (*customer presentation phase*). The agent then starts taking a control of the conversation flow by asking questions (*agent probing phase*). It is at this point that the agent identifies the problem. An excellent agent is one who asks fewest questions and infers the details of the customer problem from an imprecise explanation.

Generating cue questions: A human agent having a serious problem while answering a customer's call sometimes asks a senior agent for advice. The senior agent often gives advice in the form of cue questions. A typical example is included in Conversation 6: A customer's printer does not work. An agent asks various questions, such as "Does the test-print work?" and "Is the driver correctly installed?", but cannot find the solution. A senior agent then advises the agent to ask if the cable is connected, and suddenly the solution is obvious! Such advice is useful because not only customers but also junior agents sometimes forget to ask such an elementary question. The senior agent knew that this type of situation often happened in his past experiences. We call such a question a *cue question* because it may lead to a solution of the customer's problem.

Finding Indexing Methods

The key to translating raw records of experiences into reusable knowledge is finding and assigning the appropriate indices for them. We analyzed the descriptive text of each conversation in order to find out which indexing methods are useful in solving customers' problems. Table 2 summarizes the results.

Indexing methods

Free-word search: Although a free-word search is not a CBR indexing technique, it is a technique that is widely used. Its advantage is that its maintenance and use are easy. Its major disadvantage is the difficulty of expressing a customer's situation and problem because only a list of free words is used.

Script Script-based indexing was implemented in our help desk support system for a commercial online service (Shimazu *et al.* 1994). When we designed the system, we found that there were typical categories regarding customer approaches to explaining their problems. They included, (1) Step-by-step action-based explanations/questions like "After writing body, selecting SEND, ..."; (2) Diagram-description-based explanations/questions like "Can I move this email from MAIL-BOX to my folder?"; and (3) Physical-appearance-based explanations/questions like "The upper-left switch is blinking. What does this mean?".

Analyzing customer problems, we found that most problems arise when a customer acts almost correctly but makes some minor mistakes and/or slightly misunderstands a situation. We therefore developed a script-based indexing method using scripts and nearmiss points. For each of the above categories, a set of predefined scripts that describe situations likely to arise is prepared. We have defined two types of scripts:

- **Time script:** Corresponds to the step-by-step action-based category and consists of a list of complex combinations of operations that can accomplish typical customer goals.
- **Visual script:** Corresponds to the diagram-description-based category and consists of typical descriptions of the internal models envisioned by customers. It also corresponds to the physical-appearance-based category and consists of physical views of the product as most often seen by customers.

If the problem case is one in which the customer acts almost correctly but makes some minor mistake, it can be easily indexed with a set of a predefined scripts and one or a few slight disparities (nearmiss points) between the script and the case. Figure 1 shows the "Sending email" time script, which represents a typical and correct sequence of actions taken when sending an

Indices	1	2	3	4	5	6	7	8	9	10	Sum
Free word search											8
→ with error messages				x		x				x	3
→ with bug names										x	1
→ with others	x				x	x			x		4
Time script											5
→ action sequence			x				x			x	3
→ before/after an event						x		x			2
Visual script											4
→ internal model						x		x		x	3
→ physical appearance		x									1
Check list								x			1
Cue questions	x		x			x					3
Sum	2	1	2	1	1	5	1	3	1	4	

Table 2: Applied indexing methods for each conversation.

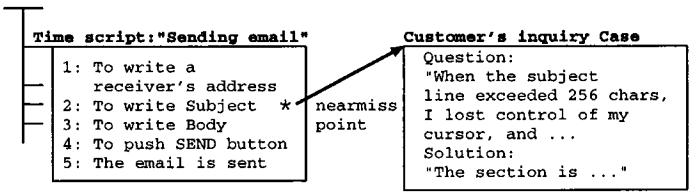

Figure 1: Case indexing with a time script and a nearmiss point.

email. A case record of a customer inquiry whose goal and actions are similar to those in the time script, but has a slight disparity is indexed by the time script and the nearmiss point.

We can see from the results listed in Table 2 that time scripts were used in five conversations and that they were used in two ways: as an original script or to express the difference between the states before and after a special event, for example "*After* I installed this program, my flash memory stopped working which worked just *before*". Visual scripts were also used in four conversations.

The advantage of scripts is their descriptive capability of various customer situations. The disadvantage is the difficulty of defining typical customer action sequences and internal models envisioned by customers.

Check list A check list contains a list of prerequisites for a customer's goal. An agent asks if the customer has already satisfied the prerequisites. If not, the agent mentions to the customer that this might be the reason for the customer's problem. The advantages are its easy definition and maintenance. Its disadvantage is that it cannot express various situations as clearly as scripts.

There are conversations that cannot be helped enough by these existing indexing methods. In several conversations, cue questions that were asked by senior agents played important roles in finding the solution. There is, however, no way to store and reuse such cue questions asked by senior agents. The following section describes knowledge structures that store cue questions as explicit knowledge.

Cue Questions as Explicit Knowledge

Conversation 1 and Conversation 3

Conversation 1: A customer asked questions about how to set values on properties at the [control-panel]-[modem] screen in order to install a modem. A junior agent asked the customer for the PC name and connected peripherals to check device resource conflicts. Because there was no conflict and the property values looked correct, the agent could not fix the problem. [1] When the agent eventually asked a neighboring senior agent for help, the senior agent said, "Did you ask the customer if the modem is built-in or external?" The junior agent repeated the question to the customer. The answer was "built-in", so the solution suddenly became obvious. The agent explained that the customer had only to go to [control panel]- [system]-[device manager], delete *all* the existing modem icons on the list, and restart Windows.

The following is how we think the junior agent thought during the conversation:

The reasoning of the junior agent: I know this PC has a built-in modem. If the customer uses the

[1] This problem might occur in the following situation: The customer installed a new external modem, detached the hardware with keeping its device driver installed, and tried accessing the Internet using the built-in modem. Because the device driver of the external modem still occupied the resource, the device driver of the built-in modem was not detected by Windows.

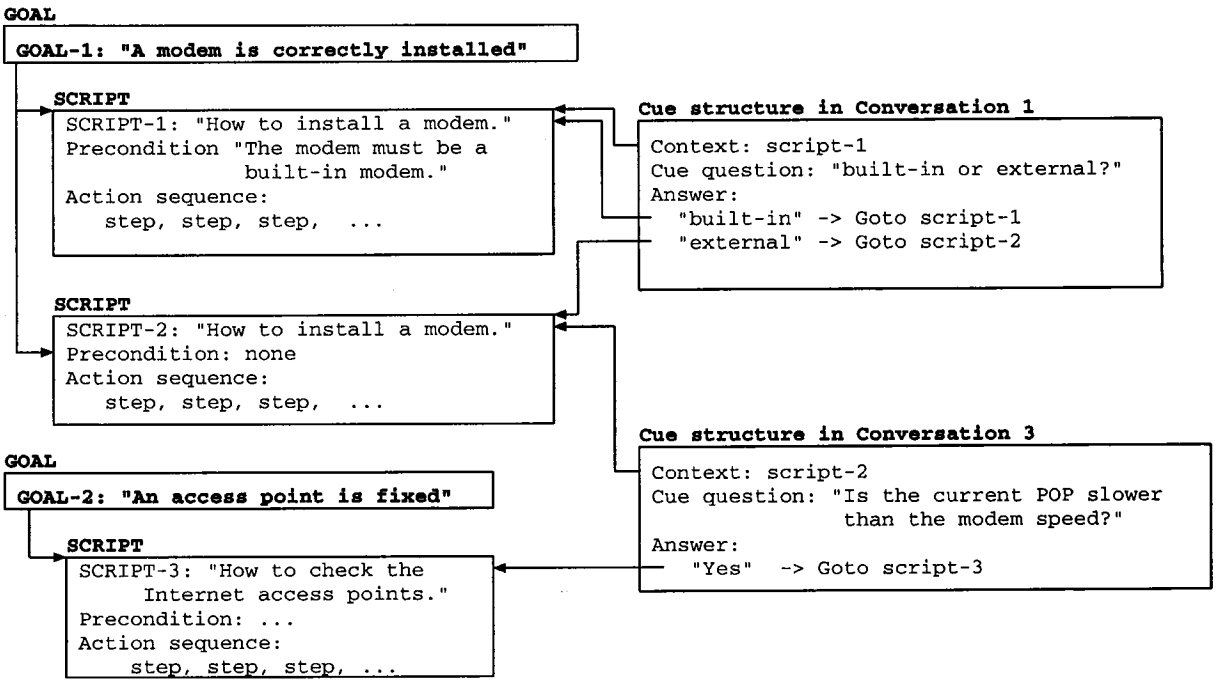

Figure 2: Goals, scripts and cue questions.

built-in modem, there shouldn't be an installation problem. But the customer now has an installation problem, so perhaps the customer is installing a new *external* modem.

His reasoning was incorrect. The senior agent may have had similar experiences before and therefore gave the junior agent a simple but important question to ask. This type of question is called a cue question.

Conversation 3: A customer replaced his modem with a much faster one, but the WWW download speed did not change. He changed various properties at the [control panel]- [modem] screen in Windows, but the situation did not change. When the consulting junior agent asked a senior agent for help, the senior agent said, "Did you check the maximum modem speed of the dial-up connection?". This was the cue question of this problem, since the customer was using a POP slower than the new modem.

Goals, scripts and cue questions

We have introduced scripts, goals, and cue questions as new knowledge structures to record such cue questions as those in Conversation 1 and 3. *Script* is a time script with one or more *preconditions* that must be satisfied before the script is applied, and the *goal* is the description of the expected state after the chronological sequence in the script occur. A goal has one or more corresponding scripts. Because an action in a script may refer to another goal, goals and scripts construct a tree structure.

Figure 2 describes Conversation 1. $Goal_1$ is "A modem is correctly installed", and there are two corresponding scripts: $Script_1$ and $Script_2$. $Script_1$ has a precondition, "the modem must be a built-in modem" because the actions of sequence relate only to installing the built-in modem. $Script_2$ has no precondition and has actions of sequence for installing a general modem. The actions of sequence in $Script_2$ are more complicated than those in $Script_1$.

A cue structure stores a cue question and related information. It is represented as a triplet <*Context, Cue, Answer*>, where *Context* is a current script to which this cue question is attached. *Cue* is a descriptive text of the cue question, and *Answer* is a set of actions to be performed. The choice of actions depends on the answer to the cue question, In Figure 2, *Answer* has the value ["built-in" $\Rightarrow$ Go to $Script_1$, "external" $\Rightarrow$ Go to $Script_2$] and means that if the answer to the cue question is "built-in", $Script_1$ is recommended; otherwise $Script_2$ is recommended.

Figure 2 has another cue structure. It represents the cue question in Conversation 3 and is linked to $Script_2$ as a context. *Cue* is "Is the current POP slower than the modem speed?", and if the answer to the cue question is "yes", $Script_3$ ("How to check the Internet access points") is recommended in a different goal-script tree.

We have experimentally implemented this idea in our CCBR tool ExpertGuide. The user interface is as follows: A user sees a script and if the user pushes the CUE button, ExpertGuide shows the list of cue

questions linked to that script. The CUE button plays the role of a senior agent.

Table 2 lists the results of a hand-simulated experimental evaluation of how the cue question structures are useful in the actual conversations. These structures can be applied in three of the ten conversations.

Discussion

Nonaka assumes the existence of tacit knowledge and articulated knowledge in his theory of organizational knowledge creation (Nonaka 1991). He observes that organizational knowledge spreads through the process of (1) socialization, (2) articulation, (3) combination, and (4) internalization. In the socialization process, unskilled members work with senior members to acquire the skill on the job. In the articulation process, the group documents the skill so that some tacit knowledge is articulated. These documents are then combined and distributed so that new knowledge is created. In the fourth process, the knowledge acts on the basis of a new knowledge creation cycle.

The activity described in this paper can be explained with Nonaka's theory. The socialization process was recorded in cassette tapes where tacit knowledge such as cue questions were transferred from skilled members to unskilled members. Discovering the concept of "cue questions" is a part of the articulation process. Finding and assigning appropriate indices into raw records are explained as the combination process. The next step will be to create a knowledge base so that they can be distributed to other groups. This will activate new internalization processes within the other groups.

The concepts of goals and scripts have been used in traditional AI programs (Hendler *et al.* 1990) and we have been most inspired by those taking a cognitive science approach (Schank and Abelson 1977)(Wilensky 1978). The cue question idea is also based on Schank's *reminding* idea (Schank 1982).

Conclusion

This paper reported the preliminary results of the analyses of recorded voice conversations between customers and human agents in a help-desk organization.

The key to translating such raw records of experiences into reusable knowledge is finding and assigning appropriate indices for them. We applied our CCBR techniques to ten of the 150 conversations as the first step. We found that script-based indexing, time script and visual script, were useful to express various customer situations and problems.

In several conversations, we found that cue questions played an important role when solving customers' problems and experimentally implemented this idea by adopting new knowledge structures; script, goals and cue structures. Because these structures can be added as extensions of script-based indexing in ExpertGuide, they will be implemented in the future version of ExpertGuide.

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