FAQ-Centered Organizational Memory

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Abstract

The value of a piece of information in an organization is related to its retrieval (or requested) frequency. Therefore, collecting the answers to the frequently asked questions (FAQs) and constructing a good retrieval mechanism is a useful way to maintain organizational memory (OM). Since natural language is the easiest way for people to communicate, we have designed a natural language dialogue system for sharing the valuable knowledge of an organization. The system receives a natural language query from the user and matches it with a FAQ. Either an appropriate answer will be returned according to the user profile or the system will ask-back another question to the user so that a more detailed query can be formed. This dialogue will continue until the user is satisfied or a detailed answer is obtained. In this paper, we applied natural language processing techniques to build a computer system that can help to achieve the goal of OM.

1 Introduction

Knowledge collection and documentation within a large organization is a critical issue. It is equally important to make the stored knowledge easily accessible within the organization. We shall address the following questions: What kind of knowledge needs to be preserved? How do we store the knowledge? How do we utilize the stored knowledge? To deal with the above issues, we have designed a knowledge representation system and a natural language dialogue system. We believe that the value of a piece of information in an organization is related to its retrieval (or requested) frequency. Therefore, collecting the answers to the frequently asked questions (FAQ) and constructing a good retrieval mechanism is a useful way to maintain OM. Our FAQ-centered OM will index the question portion of the FAQ and utilizes the stored knowledge as answers to these questions.

We use the term "FAQs" in a broader sense. Take the knowledge related to a customer service department as an example. Our FAQs will practically include all kinds of questions that are being asked to that department plus the additional ones that are potentially important. We treat the answers to the FAQs as the knowledge pieces that are valuable to the organization, which need to be preserved.

The FAQs are indexed in our knowledge representation map and their corresponding answers are stored in a multimedia database, be it a document, a diagram, a program, a database, a video or an audio recording. We believe there should be as little restriction as possible on the format of the representation of the OM. However, unlike pure text data, different media of data storages does not have a uniform management environment and there is no easy way to retrieve the desired answer. Hence, the key to the retrieval problem lies in an effective indexing mechanism. In this paper, we use a "natural language question" as an index for each knowledge piece. Such a question is more like a "title" for that knowledge piece rather than a detailed description as seen in most metadata. The answers to one question may vary depending on the users. Hence, there can be multiple links from one question to different answers.

The knowledge representation map in our system contains the ontology of the domain knowledge plus necessary linguistic knowledge for matching a user's natural language query with a correct system FAQ. Since the knowledge representation map deals only with the question portion of the FAQ (rather than the details of the answer), constructing such a map is likely to be more manageable. The content of an answer can be maintained by individual knowledge sources so that the map editor does not have to be an expert in everything.

Our hierarchical knowledge representation map allows proper representation of knowledge at different resolutions. For information not represented in natural language, our system can index them in natural language and make them easy to be retrieved. Also, our natural language dialogue system makes the retrieval of knowledge at different levels possible.

1.1 Related Work

The notion of corporate or organizational memory has been discussed for over a quarter of a century. Organizational memory is defined as the means by which knowledge from the past is brought to bear on present activities, thus resulting in higher or lower levels of organizational effectiveness [Stein 1995]. According to Walsh and Ungson (1991), organizational memory is defined as "stored information from an organization's history that can be brought to bear on present actions" [Walsh et al 1991].

Knowledge management is a process of capturing, storing, sharing, and leveraging knowledge. And the sum of all knowledge assets held by an organization can be considered to be its OM. It is necessary for organizations to (1) be able to capture and represent their knowledge assets; (2) share and re-use their knowledge for differing applications and differing users; this implies making knowledge available where it is needed within the organization; (3) create a culture that encourages knowledge sharing and re-use [Kingston et al.2000].

Different users may use different ways to state the same question, the main task of the interface is to map all these different surface forms to one representative question, which can then be used for the retrieval of the FAQ knowledge base [Winiwarter 2000]. In knowledge representation, the nodes that best represent the query are then highlighted on the map display to facilitate the exploration of the map. The document map can be considered as the knowledge management tools that facilitate the understanding of the relationships of data [Honkela 1999].

We shall discuss several related QA systems and dialogue systems in this section. The Murax system [Kupiec 1999] determines from the syntax of a question if the user is asking for a person, place, or date. It then tries to find sentences within encyclopedia articles that contain noun phrases that appear in the question, since these sentences are likely to contain the answer to the question. The idea of FAQ matching system [Burke et al. 1997] is to match question-style queries against question-answer pairs. The system may use some standard IR search to find the most likely FAQ pairs for the question and then matches the terms in the question against the question portion of the question-answer pairs.

AskJeeves is natural language question answering system that can match users' queries into question types and the user should choose which type is more like a correct restatement of the original query. AskJeeves can provide the answer to the restated queries [AskJeeves 1998]. Human selected Web sites are first matched to a predefined set of question types. The question types are then matched against a user's natural language query. Then the user selects the most accurate rephrase of the query and the reformulated query is linked to suggested Web sites.

There are some systems [Jocobs 1993, McCune 1985, Strzalkow1999] attempting to parse natural language queries in order to extract concepts to match against concepts in the text collection. We use our knowledge map as a basis to parse the queries.

Dialogue is an important user interface in modern information retrieval. In [Baeza-Yates & Ribeiro-Neto 1999], dialogue is used to help the user to reformulate the query by dialoguing on the query or to form a retrieval process by dialoguing on the answer. Dialogue-based interfaces have been explored in information retrieval research to mimic the interaction between the user and a reference librarian. The THOMAS system [Oddy 1997] provided a question and answer session within a command-line-based interface. Belkin et al. [Belkin 1993] defined an elaborate dialog interaction models.

2 Technical Issues

We implemented a dialogue system that can demonstrate the idea of FAQ-centered OM. The system consists of a knowledge representation scheme INFOMAP, a knowledge editor COMPASS, a natural language query matching mechanism, a solution editor, and a FAQ-based dialogue mechanism. Figure 3 shows the architecture of our QA system.

2.1 Our Knowledge Representation – INFOMAP

Define the question portion of a FAQ to be a *query concept*. In this section we introduce our knowledge representation scheme that matches a natural language query to a query concept [Hsu 1999a, Hsu 1999b].

Our knowledge representation scheme is called INFOMAP. INFOMAP provides a mechanism to represent the knowledge that can reflect the number of different ways people may ask a question on the same query concept. INFOMAP has a hierarchical tree structure, though this is only a deceivingly simple statement since it does contain "references" that connect nodes on different branches, which makes it into a more general "network". The root node is usually the name of a domain or a subject such as passport, department store. Following the root node, the first level nodes down are topics that users may be interested in. These topics have sub-categories that list related sub-topics. The knowledge representation has similar taxonomy to the directory structure in most Internet yellow page. However, INFOMAP contains many different types of function nodes, which provide different relationships between the related concept nodes. The addition of appropriate function nodes will produce a much powerful result for the search.

Figure 1 shows the related information of libraries (in Academia Sinica) and some FAQs. It can be seen from the figure that the information of a library is divided into three function nodes: event, category and attributes at the first branch under the library agent. The category of library consists of a list of libraries such as chemistry library, earth science library, Chinese literature library, European and American studies library, life science library, economics library, and Information Science library. The attributes of library include admission, research sources, document collection, latest news, web databases, regulation, electronic journals, etc. The event of library can be "borrowing books from the library". Nodes under the "Category" form a hierarchy, which is taxonomy of library. Each node under "attribute" forms a new hierarchy, which is not a taxonomy of library. The nodes under "Event" are similar. The "FAQ" function node marks an end of a query concept. All the nodes from the root to the "FAQ" form a path, which is also a query concept. The nodes on the path are the key concepts of the FAQ. Under "FAQ", there is a function node "condition", which serves as a variable of one of the key concepts. The "condition" can be matched to different examples of a concept, which makes the representation of FAQs more flexible.

Consider the FAQ "The regulations of library" under the node of regulation. There is a condition node "library" in the figure. This condition refers to any specific library under the category of library. Thus, the function node "condition" acts like a variable to represent these libraries in related question. The synonym of regulation can be "The policy of using library" or "using library" or a template. The template

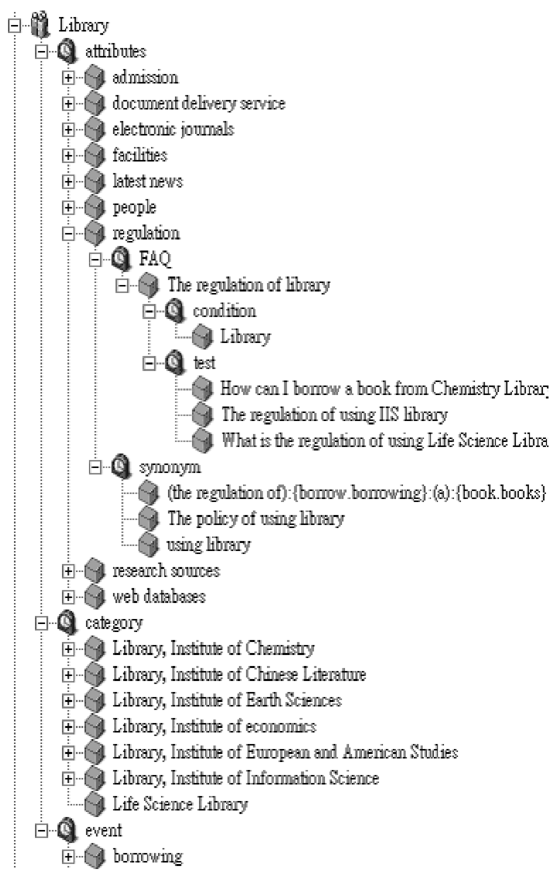

Figure 1. The partial view of the INFOMAP for the concept "library"

here means "the regulation of"(optional) + "borrow" or "borrowing" + "a book" or "books". The template can be used to match various sentences that have the same query concept. Therefore, and question like the ones listed in the test function nodes "How can I borrow a book from the Chemistry Library", "The regulation of using IIS library", and "What is the regulation of using Life Science Library" can be mapped to the FAQ.

2.1.1 Function nodes indicate relationships

In INFOMAP, there are some special nodes, called *function nodes*, to label the relationships between two nodes and their hierarchies. The basic function nodes are: *category, attribute, example, synonyms, event, FAQ, condition.* These function nodes help to represent and identify query concepts. The local synonyms of the topics are listed under the function nodes of each topic. Category and example function nodes help to construct the concept hierarchy. Attribute function nodes are used to associate the relevant attributes to each concept. Synonym function nodes are used to collect different natural language expressions of the same concept. Event function node is very similar to attribute function node, but it is to associate the relevant activities. The FAQ function node is a marker of a typical question example for the query concept. The condition node functions as a variable for a FAQ pattern. The combination of condition can help we capture many open queries in one FAQ.

1. Categories: Various ways of dividing up the concept A. For example, for the concept of "people", we can divide it into young, mid-age and old people according to "age". Another way is to divide it into men and women according to "sex", or rich and poor people according to "wealth" and etc. For each such partition, we shall attach a "cause". Each such division can be regarded as an angle of viewing concept A.
2. Attributes: Properties of concept A. For example, the organs of a human being, the height, the weight, the hobbies and etc. To facilitate linguistic analysis, we also attach the semantic categories of each noun according to various semantic trees.
3. Associated events: Actions that can be associated with concept A. For example, if A is a "car", then it can be driven, parked, raced, washed, repaired and etc.
4. Synonymous expressions: Expressions that are synonymous to concept A.
5. Examples: Instances of A. For example, if A is "hotel", then its examples can be the actual hotel names.
6. FAQ: A typical question associated with the concept node.
7. FAQ conditions: Items in a query that can be substituted by examples such as cities, hotels and etc.

There are also other function nodes that are used specifically for linguistic feature extraction and parsing:

Modifiers: We consider A's articles, modifiers and the semantic categories of these modifiers.

Grammatical constraints: Syntactic constraints on A in a phrase or sentence.

The list of function nodes can be expanded for different applications whenever necessary. Each node B underneath a function node of A can be treated as a related concept of A and can be further expanded by describing other relations pertaining to B. However, the relations for B described therein will be "limited under the context of A". For example, if A is "hotel" and B is the "facility" attribute of A, then underneath the node B we shall list those facilities one can normally find in a hotel, whereas for the "facility" attribute of a specific hotel A_1, we shall only list those existing facilities in A_1.

2.1.2 INFOMAP Serving as The Ontology

Ontology represents domain knowledge and serves as a common understanding of the domain. Ontology consists of definitions of concepts, relations and axioms [Guarino 1999, Staab 2001].

Knowledge is stored and used according to a specific ontology for each knowledge management system. The ontology can be very simple such as keyword hierarchies or rather complex such as the WordNet [Miller 1990]. The primitives to formulate query & descriptions should be in the ontology. Information Map serves as the ontology of our QA system. Comparing with the WordNet, the following features: hypernymy, hyponymy, antonymy, semantic relationship, and synset may have a similar counter part in Information Map corresponding to Category, Event, property, and synonym.

2.2 Knowledge Editor - COMPASS

The knowledge editor of our system is called COMPASS, which is an Intranet multi-user knowledge editor based on Microsoft's management console (MMC) technology. The data is stored in an active directory system (ADS) database. Different icons show different function nodes in different color.

2.3 Matching a Natural Language Query

Our kernel program can map a natural language query into a conditioned FAQ and uses the edited knowledge to recognize the concepts in the user's queries. We use a firing mechanism to propagate knowledge in INFOMAP. This mechanism is similar to that used in neural network. When a node is fired, it will propagate to all the related nodes until some prohibiting signal is generated.

A *firing* is a labeling action from a node to its parent or to

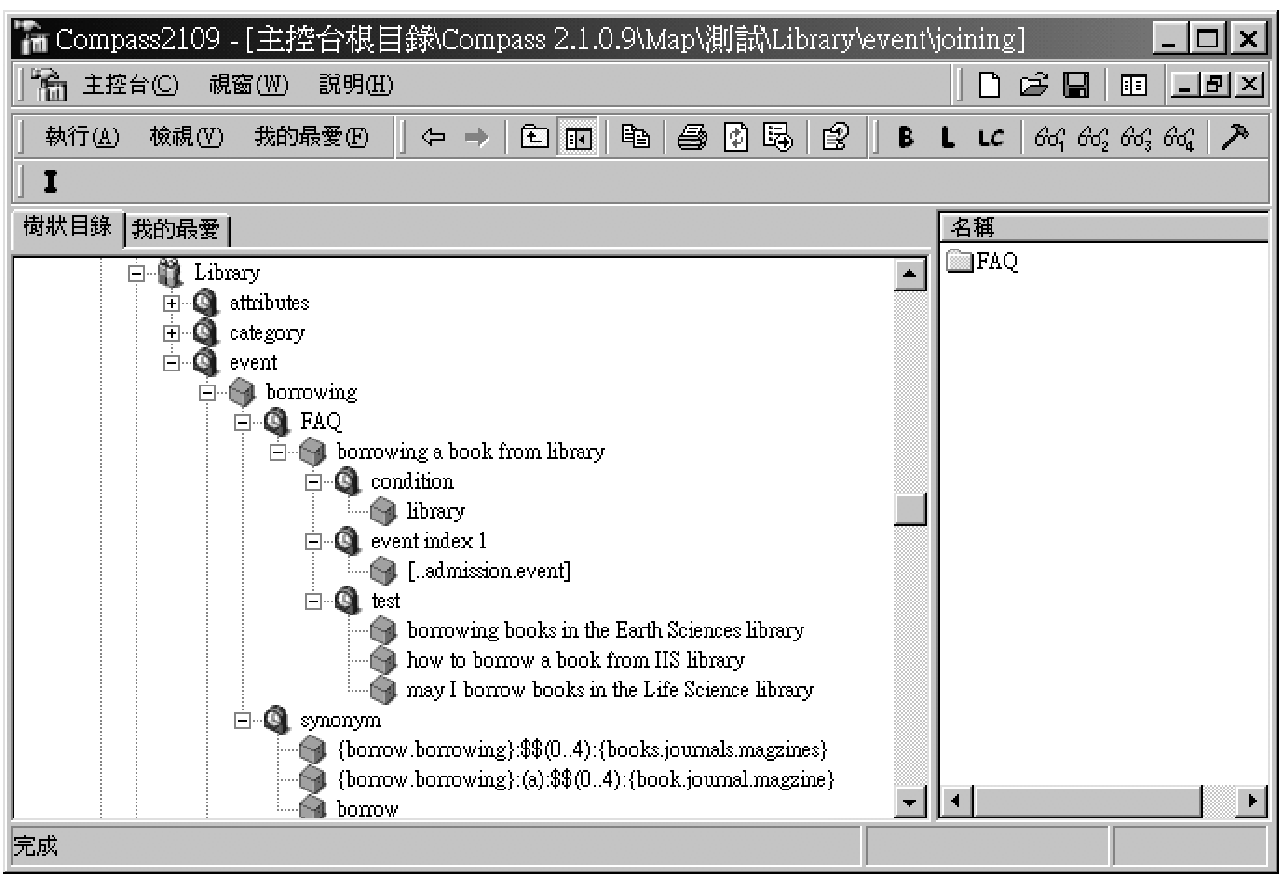

Figure 2. The screenshot of Compass

one of its children. For example, if node *a* fires *b*, then *b* is labeled from *a*. A firing from a node to its parent is called a *bottom-up firing*. A firing from a node to one of its children is called a *top-down firing*. A bottom-up firing often continues from a node to its parent and then to its grandparent and so on so that a node can fire all of its ancestors if necessary. The purpose of a bottom-up firing is to find the "context" of a given text that is either a sentence or a paragraph. Suppose we want to find the event of the following sentence: "How do I invest in stocks?" Suppose the interrogative word "how" can fire the word "method". Along the path from "method" to "stock" the above sentence has fired the concepts "stock" and "invest". Hence, the above sentence will correspond to the path:

stock - event - invest - attribute - method

On the other hand, the purpose of a top-down firing is to locate a related concept of interest such as finding a related event or script. INFOMAP provides a mechanism to represent the knowledge that can reflect the number of different ways people may ask a question on the same query concept. First of all, the synonymous expressions for each word concept can fire that word so that it can be substituted in a sentence. Secondly, synonymous events can create sentence-level substitution. Such substitution can cover synonymous expressions of a FAQ. Besides these semantic constraints, the firing mechanism can incorporate various syntactic structures (and templates) plus combinations of both semantic and syntactic structures. Therefore, INFOMAP can be used to parse Chinese sentences provided enough knowledge about the event structures are given.

A complete description of the INFOMAP would more than double the size of this paper and shift the focus of our current topic. Hence, we shall only touch upon a few features. Interested reader can refer to [Hsu 1999a].

In INFOMAP, a query concept is usually a path from the root to a node though it could also form a cluster of nodes. The path could consist of a noun (or its synonyms) and a verb or another noun (one of its attributes) or a series of them provided that they form a meaningful event. Since the tree-like knowledge structure can be very deep and very wide, a query concept can also be very deep and wide. If one concept in the hierarchy is fired, all of the hypernymy are fired by propagation since a hypernymy can be a general representation of all of its hyponymy. But this propagation will stop if the hypernymy is a function node, such as "Event" or "Attribute", which are relationships indicators.

Given a natural language query, the system matches the characters and words in the query sentence against node names in the INFOMAP to locate the desired query concept. In general, there is a weighting scheme to select the most probable query concept. If most of the nodes are located on the path of an FAQ, then we say that the FAQ is fired, i.e.,

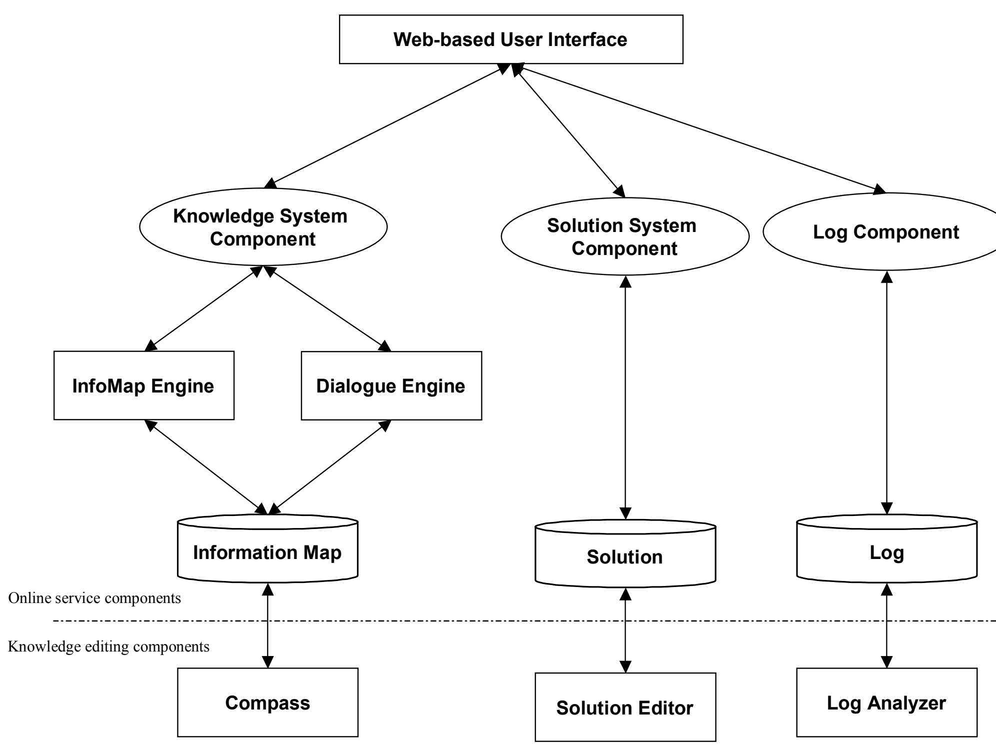

Figure 3. The System Architecture

we matched the open query to this FAQ.

2.4 Interactive Behavior - Dialogue System

The dialogue system uses the same knowledge base and can guide the user to query from a shallow concept to the deeper ones. In previous sections we explained how to match a natural language query to a query concept using INFOMAP. In the following subsection, we shall demonstrate how to accommodate the knowledge of a dialogue system in INFOMAP.

2.4.1 FAQ Triggered Dialogue

One can imagine that an "answer" to a high level query could simply be a strategy that intends to guide the user to a deeper query concept. Such a strategy can be context dependent, namely, it varies based on the user profile and the sequences of questions and answers that this user has just been through in this session. Thus, our INFOMAP has function nodes (simply called "dialogue" nodes) to accommodate the implementation of these strategies. Within each dialogue node, there are ask-back questions, each associated with profile conditions and expected actions. Each profile condition specifies when this particular ask-back question should be returned. The Expected actions intend to let the user focus on predefined actions (such as a selection menu) so that a meaningful dialogue between the user and the system can continue.

A transition diagram can be used to describe each strategy where the nodes in the diagram are the dialogue nodes in our INFOMAP. The activity sequences are controlled by the profile conditions under each dialogue node. If the user digresses from expected actions, then the system will assume the user has initiated a new query and start a new session.

2.4.2 The Dialogue Model

Our INFOMAP currently is designed to represent relatively "simple" query concepts, or in other words, simple events. For questions about the comparison of two distinct query concepts or those consisting of "composite" events (such as events describing the noun of another event), our system decomposes such a complex query into simple query concepts first, and then decipher the relationships among these simple concepts. Since our INFOMAP already contains basic query concepts together with the knowledge about various relationships, the mechanism for the decomposition is very similar to the dialogue strategy described in 2.4.1 where we designed a flow chart to guide a high level query down to more specific ones. In this manner, we can regard our dialogue principle simply as a process of decomposing a fuzzy query into specific query concepts through a strategy.

Traditionally, dialogue model has two categories, the dialogue grammar model and the plan-based dialogue model [Cohen 1996, Flycht-Eriksson 1999]. Our work has a dialogue grammar, which has expectations and can handle exceptions. This is different form the traditional adjacency pairs.

2.4.3 Six Different Dialogue Roles

The interaction of a simple question answering system should develop into a sequence of questions and answers so that each action must be in one of these two modes, i.e., the grammar of naïve question answering system has only two roles. In the dialogue system, there can be 6 possible roles of the dialogue grammar. They are query, answer, ask-back question, expect answer, expect query, and exception. Our system is developed based on the latter.

3 Case Study

We have implemented a question answering system that can perform FAQ-based dialogue using INFOMAP.

3.1 Academia Sinica Question Answering System

Academia Sinica is a government funded research organization and has several thousands of employees. The amount of information in the Web site is very large. The number of Web pages is well over 80,000. It is hard to find deep information from the Web pages of 26 independently running institutes in a unified manner. Therefore, we have constructed the Academia Sinica QA System.

We have collected 590 distinct FAQs. With the possible combinations of different conditions, the number of query concepts can be as much as 12,501. Among them, 9971 query concepts have associated URLs that answers the query. The remaining query concepts have no answer. See Table 1 for the examples of the distinct questions. The number of condition is the number of possible values of the variable in a distinct question.

Figure 4. The screenshot of the Academia Sinica Question Answering System

Table 1. Partial view of the 590 distinct FAQ

No	FAQ	Conditions	With URL	Without URL
1	How do I use elm system in the Institute of Information Science?	1	1	0
2	The related information of 921 earthquake reconstructions	1	1	0
3	How do I set a dinner party at the academic activity center?	1	1	0
4	How do I apply for a parking permit?	1	1	0
5	Where is the nearest road to Academia Sinica?	1	1	0
6	The significance of the Academia Sinica	1	1	0
7	The research groups in an institute	23	23	0
8	The technological transfer in Academia Sinica	1	1	0
9	The regulation of using library	24	24	0
10~587 is omitted				
588	The research fellows of the Institute of European and American studies	39	39	0
589	The research fellows of the Institute of Bio-Agricultural Sciences	13	13	0
590	The research fellow of the Institute of Chinese Literature and Philosophy	22	22	0
	Total	12501	9971	2530

3.1.1 Top User Queries and Top FAQs

The colleagues of our institute have tested the Academia Sinica QA System. The data is as follows. The count number shows how many times the question has been asked. FAQ are the predefined question that stored in the knowledge base.

Table 2. Top 11 User queries

No.	User queries	Count Num.
1	Academia Sinica	1325
2	BLANK	261
3	How do I go to Academia Sinica by bus?	158
4	Where is the lotus pond in Academia Sinica?	117
5	Where is Academia Sinica?	108
6	How do I drive to Academia Sinica?	102
7	What is the telephone number of the president of Academia Sinica?	96
8	The latest news and events of Academia Sinica.	90
9	The information of the life around AS.	89
10	Where is the parking area in Academia Sinica?	78
11	How do I use Academia Sinica QA system?	70

Table 3. Top 12 FAQ

No.	FAQ	Count Num.
1	About Academia Sinica	1114
2	BLANK	635
3	Ask the information of Academia Sinica	397
4	The location of AS	175
5	The Institutes and Administration Offices of Academia Sinica	173
6	Bus Guide / Transportations (to Academia Sinica)	161
7	Ask about the phone & e-mail of AS present president.	133
8	The locations of buildings	126
9	How to drive to Academia Sinica?	125
10	The transportations to Academia Sinica.	124
11	The people in AS.	119
12	The information of the life around AS.	115

3.1.2 QA System Log Report

We collected 3747 logs of user queries. There are 1501 different questions. The system constructed 496 distinct FAQs. The top 20% distinct user queries cover about 66% of the logs. The top 20% distinct FAQs cover about 80% of the logs.

Table 4: Logs statistical information

Logs	Distinct Open Question	Distinct FAQ	Distinct IP
3747	1501	469	164

Table 5: The top 20% distinct FAQs covering 80% of the logs

Top FAQ	Coverage
0%	22%
10%	69%
20%	80%
30%	85%
40%	90%
50%	92%
60%	95%
70%	96%
80%	97%
90%	99%
100%	100%

Table 6: The top 20% distinct user queries covering 66% of the logs

Top Open Question	Coverage
0%	20%
10%	57%
20%	66%
30%	72%
40%	76%
50%	80%
60%	84%
70%	88%
80%	92%
90%	96%
100%	100%

3.2 Financial Question Answering System

The same mechanism has been implemented to build a financial consulter system. Linguistic knowledge has also been incorporated in the INFOMAP. Consider the example in Figure 5. Where the FAQ "Why futures prices change". The keyword "reason" is associated with an interrogative category, which consists of "why". Therefore, the interrogative "why" will fire the concept "reason".

"Dr. E" is a Q & A System in the Polaris (a stock trading firm) Web Site. Internet users can use natural language to query financial information, which is organized by Polaris staff. Financial knowledge is an important asset and organization memory in Polaris. It is stored in many internal document and web sites. Polaris collected 6000 FAQs and used INFOMAP to represent the hierarchical knowledge of concept and language.

4 Conclusions and Discussions

Since it is impossible to record all useful information of an organization, our system shall only deal with the most frequently asked information. Whenever it is difficult to gather statistics on what are asked most frequently, the map editor has to make a subjective decision. Our process of knowledge acquisition consists of two phases. In the first phase, collect questions whose answers are important to the organization. Then store the questions in INFOMAP. In the second phase, find appropriate answers to the questions and store them in web pages.

Our INFOMAP consists of two types of knowledge: linguistic knowledge and domain knowledge. Our FAQ-centered dialogue system has been applied to customer service and web CRM. Future research is to design abstract conceptual script to extract the desired knowledge automatically. He idea of a semantic abstract map and sample map will become increasingly important.

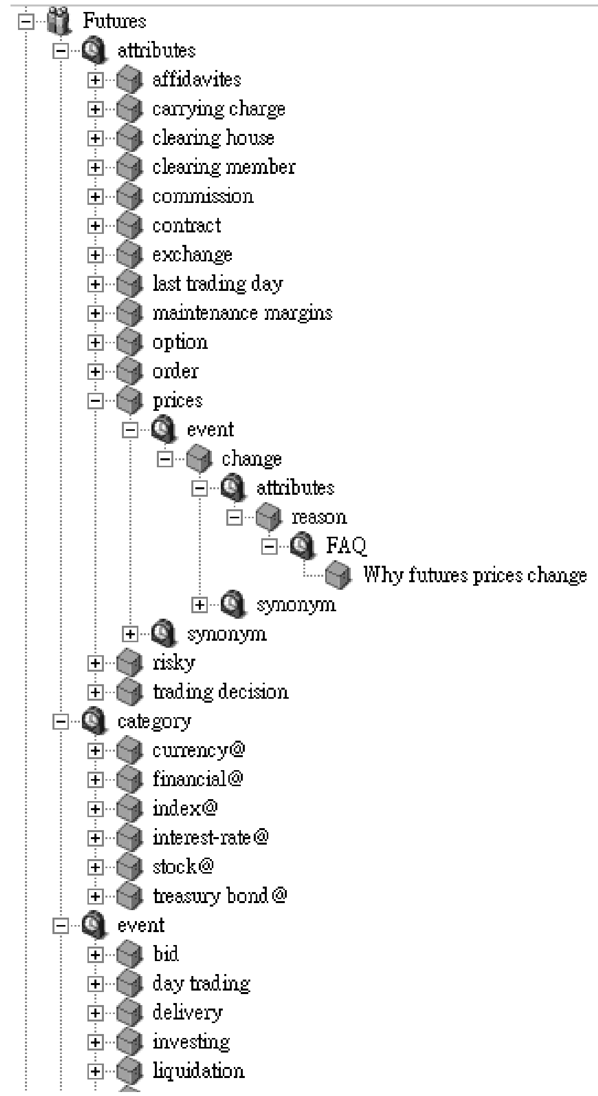

Figure 5. The partial view of the INFOMAP for the concept "Futures"

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