

# Supporting Visual Access to a Distributed Organizational Memory Warehouse in the Web Environment

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## ABSTRACT

*Organizational memories play a significant role in knowledge management but several challenges confront their use. Artifacts of OM are many and varied. Access and use of the stored artifact is influenced by the user's understanding of these information objects as well as their context. Topic maps are used in this implementation to represent user cognition of contextualized information. Topic maps allow for access and analysis of stored memory artifacts. The paper presents the design and development of an organizational memory warehouse with web access via topic maps.*

## 1. INTRODUCTION

Today an organization has to be able to make use of all of its available information in order to be competitive. In particular researchers have noted that organizational knowledge may be accumulated and retained using several organizational memory systems [6, 14, 15]. Advances in information technologies have helped in accumulating knowledge but the paradigms applicable to collecting and storing the knowledge do little to motivate its use by managers and decision makers. Accessing and using organizational memories, have been a challenge because of the multifaceted nature of memories and knowledge sources. Moreover, characteristics of the decision tasks where the knowledge and memory support are used, pose interesting challenges in designing and developing knowledge management systems. In this paper we describe the use of topic maps to navigate the network of organizational memory and employ appropriate knowledge management and analysis tools.

## 2. ORGANIZATIONAL MEMORY

Organizational memory (OM) is a stored, interrelated collection of organizational history reflected among the many parts [19]. It includes both stored records and tacit knowledge and covers the various facets of organizational tasks, employees, and their task environments [3, 5, 10, 16]. Because it can grow rapidly and become a vast repository of information and knowledge, several researchers have recognized the import of this organizational memory in effecting organizational performance [2, 4, 8, 9, 11]. Ackerman and Halverson [1], however, take a critical view of prior research on OM and argue for a theoretical base to properly define and empirically validate future research. They state that as socio-technical systems, organizations and their memories conform to social structures and norms while employing technical models. They use the theory of distributed cognition to develop a theoretical foundation for organizational memory. The basic tenets of this theory are that knowledge evolves from a community of practice and that cognition and inferences result from the shared meaning among the participants (hence the distribution) [7]. Communities of practice fulfill a number of functions with respect to the creation, accumulation, and diffusion of knowledge in an organization through exchange and interpretation of information, by retaining knowledge, by stewarding competencies, and providing homes for identities [20]. Collective thinking creates knowledge that otherwise would not be evident. Using

empirical data and qualitative methods, Ackerman and Halverson [1] illustrate application of the theory of distributed cognition to validate the use of organizational memory in decision making.

Our paper presents the design and development of an organizational memory warehouse that supports the distributed cognition theory. We have adopted the design-science research paradigm to present our system design. Hevner et. al [25] argue that design-science research must address important unsolved problems in unique or innovative ways or solve problems in more effective or efficient ways [25]. Design-science research proponents identify six nominal process steps, namely problem identification and motivation, objectives of a solution, design and development, demonstration, evaluation, and communication [17]. The first four process steps are considered suitable for doing design research. In addition, when systems are built for testing and validating theory, the appropriate entry point for design research is indeed the design and development process. At this stage an artifact is built and theory is tested using the artifact. The main purpose is to yield a proof of concept of the theory and the system that supports it.

As social and linguistic dimensions of knowledge become pertinent, users need appropriate tools to support the search and analysis of knowledge. Topic maps are one such tool.

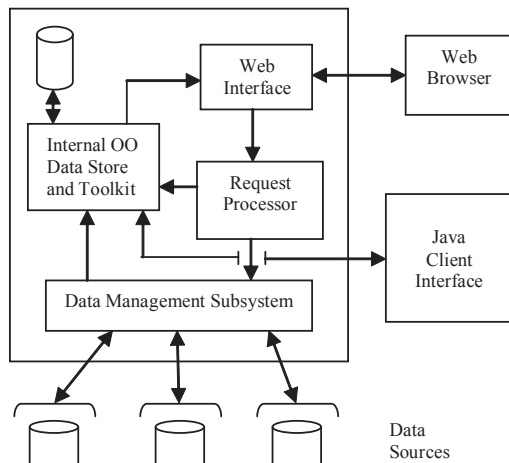
### 2.1 Topic Maps

Smolnik and Erdman [18] state that topic maps provide strong paradigms and concepts for the semantic structuring of link networks and therefore, they are a considerable solution for organizing and navigating large and, continuously growing network of organizational memories. Topic maps provide a subject based classification of resources where each resource represents a real world object. In topic maps, three constructs are provided for describing the subjects represented by the topics: names, occurrences, and associations. These describe the names, properties, and relationships of subjects, respectively. A name may be assigned to more than one topic and a topic may have more than one name. In addition by defining scope and types a name can become rich and complex. An occurrence links to one or more real knowledge sources. An occurrence, however, is not part of the topic map. Associations describe relationships among topics and are independent of the real knowledge objects. Associations add value through the relationships. An object in topic map would be a knowledge object such as a memory collection or a resource (e.g., an email analysis tool) that acts on the information object (e.g., an email collection).

## 3. WAREHOUSE MODEL

The goal of any organization is to make optimal use of the business knowledge that it has accumulated over the years. To do this, it is necessary to determine the sources of business knowledge and provide members of the organization access to it in a timely matter. Here we focus on the latter issue of providing access and assume that business knowledge sources are employee knowledge and artifacts (both internal and external).

Figure 3.1. Block diagram of the distributed organizational memory data warehouse model



The proposed environment has been designed to provide support for accessing and analyzing the collective memory of the organization. We start by providing a simplistic overview of the model and then briefly examining the important components in more detail.

3.1 Overview

An organization’s memory can be seen as consisting of a space that includes knowledge of the expertise of current employees, artifacts, and the tools required to locate and/or interpret available information. The memory space is distributed across the organization and beyond.

Any organizational memory warehouse must be able to deal with the distributed nature of the memory space and be able to fully integrate the memory’s information with the necessary tools. To deal with this problem, we introduce a distributed organizational data warehouse.

We see our contribution as being the development of an environment that provides a complete and easy to use solution to making the most of an organization’s memory. The distributed format of the proposed warehouse provides a realistic mapping into the organizational memory space that is typical in organizations. Perhaps more important, the proposed model is highly scalable.

A block diagram of the complete model is shown in Figure 1. Artifacts and information about the expertise of current employees can either be stored in the data sources or in the Internal Object-Oriented Data Store and Toolkit. Artifacts in the data sources can be stored in any format to take advantage of existing software or compression techniques. To simplify communication between components and provide for standardization within the model, object views [21] are used to define data types. Data from the data sources are converted into object view instances using local interface views [21].

A topic map that supports visual access to the organization’s memory space via a combination of search terms and tool interfaces serves as the user’s entry point to the warehouse. Use of the topic map interface provides the user with an easy to use mechanism for defining search terms and choosing the appropriate interpretation/analysis/learning tools.

The remainder of this section briefly examines the main components of the model.

3.2 Object Views

The object view type [21] is defined as being an extension of the object model (EOM). The views have a traditional object structure (attributes and methods) with the restriction that they support a derivation method. The derivation method is used to generate the public and private attributes of each object instance created through a local interface view

3.2.1 Local Interface Views

The individual data sources are expected to have local control. The local interface view [21] is a view object type that is used by the local data administrator to provide a mechanism to make the local data accessible to the proposed model in object form. The local interface allows distribution transparency and representation transparency, while hiding or converting (mapping) some of the data from the data source. The local interface view belongs to the data source. It interacts directly with the data source and passes the result to the wrapper which controls communication with other components of the proposed model. A given data source and its wrapper can support multiple local interface views in order to present its data in different ways to different applications or users.

3.3 Topic Map

A topic map is used in the model to provide users with visual access to both search and analysis. It is this interesting blend of semantic search and analysis that motivates its use in the model.

Here we define a topic map to be the directed acyclic graph  $T = (N, E)$ , where  $N$  is the set of topic map terms, data types, or search/analysis tools. The directed edges in  $E$  are of the type  $(n1, n2)$ , where  $n1$  is a topic map term or a data type and  $n2$  is a topic map term, a data type, or a search/analysis tool. An implicit node, called the root, points to the topic map terms, data types and/or tools that make up the first level of the topic map. Nodes with out degree zero are said to be leaves of the topic map. Leaves point to the information in the organization’s memory and carry any search terms and/or data types accumulated on the path from the root of the topic map to the leaf. Note that leaves that are either search terms or data types make use of an implicit search tool. In addition each non-leaf level of the topic map has a search tool that can be used to initiate a search based on the topic map terms that have been traversed to get to the topic level. To implement the topic map, we use duplication of nodes to convert the directed acyclic graph into a tree structure.

Topic maps are presented to the user via either the Web Interface or the Java Client Interface depending on the access mode chosen by the user. Regardless of the user’s access mode the visual structure and use of the topic map interface remains unchanged. The primary difference between the modes is in the details of their respective implementations.

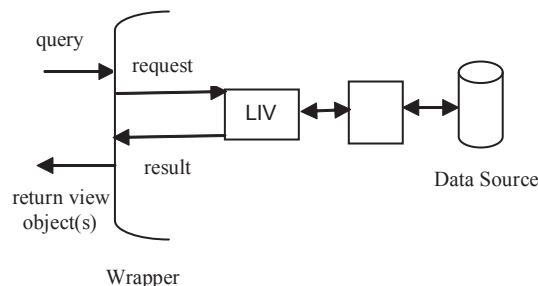
3.4 Data Types

The data types supported will depend to some extent on the nature of the organization. Typically, the data types will include the people that the organization relies on for expertise and the artifacts that make up the organizations’ memory. In the implementation described in Section 4, the data types used are the typical artifacts, e.g., emails, meeting minutes, reports, and presentations. Extending the supported data types is simply a matter of ensuring that the appropriate tools for search and analysis are available in the set of supported tools.

3.5 Data Sources

A block diagram of the transformation of a data source is shown in Figure 2. The query is translated to the appropriate request string and passed to the local interface view (LIV). The LIV passes the request string to the data source and converts the response into the objects defined by the LIV view type. The set of

Figure 2. Data source node layout and request/data flow for retrieval



result view objects are then passed back to the Data Source Access Module and cached in the Internal Object Data Store for analysis.

### 3.6 Internal Object Data Store

The Internal Object Data Store is based on our earlier work on object-oriented data warehouses [13]. The Internal Object Data Store combines tools and the cached data to allow in depth analysis of artifacts. The tool set consists of a set of built in (kernel) tools for managing tools and data and a set of user added tools for creating and analyzing data [12].

### 3.7 Request Processor

The request processor receives a Request object from the User Interface Controller that defines the search criteria and the result format required to complete the request. The tool type and action required is built into the class structure by employing the Polymorphic design pattern. Each tool that is added either implicitly or explicitly to the topic map requires the definition of a class that extends the Request class. These new classes add any additional information/actions required by the tool.

## 4. IMPLEMENTATION

To illustrate the feasibility of the proposed model a prototype has been developed. Figure 4.1 shows the initial screen encountered by a user via his/her web browser. The topic map nodes are shown as either ovals or rectangles. Figure 3 shows the

nodes in first level of the topic map. Any rectangles shown represent tools and the ovals represent topic nodes containing topics. Note that either type of node can occur at any level in the topic map.

Navigation in the topic map is flexible and can be controlled either by clicking on a topic map node (oval or rectangle) or using the level navigation icons at the top of the screen. Clicking on an oval moves to the next level below the oval and adds the associated topic to the path label for the user's current topic map search.

The icons have the normal meaning, i.e., the house allows the user to return to the starting topic map screen (Figure 3), the back arrow allows the user to move back one level in the topic map, and the forward arrow allows the user to move forward in the topic map. The actual forward move depends on the user's previous operation. If the previous operation was the result of clicking either the home or the back arrow, clicking on the forward arrow will return the user to her/his previous location in the topic map. If the previous operation was a click on a topic map node, then the forward arrow moves the user one level down in the topic map using one of the nodes as the default node. For example in both Figure 3 and 4, the default node is the Search By Topic node.

As expected, using the back and home icons strips the term(s) from the path label so that it is correct for the resulting topic map level. Using the forward arrow icon either reestablishes the previous path label or adds the topic associated with the default node to the current path label depending on the type of operation used before clicking on the forward arrow icon.

The two additional icons represent a keyword search (magnifying glass icon) and help (question mark icon), respectively. The keyword search initiated by clicking on the search icon generates a search tool screen that allows the user to use a vector space search of the organizational memory artifacts [22]. The search tool screen uses the current topic map path label to set up current conditions. Any topics that are in the path label are added to the search keyword list in the screen. If the topic map session was started by clicking on the Search Memory Collection oval, then the topic map moves to the level depicted in Figure 4. The Search Memory Collection topic is set as the current path label. When the user clicks on the Email, the topic map level shifts to the topic map screen shown in the top portion of Figure 5 and the artifact type (Email) is added to the path label. The artifact type in the path label will be used by the search tool to provide an initial choice of artifact type to search.

Figure 3. Initial screen representing the first level of the topic map



Figure 4. Screen shot of the topic map level for memory artifacts



Figure 5. Screen shot showing the results of using the email frequency analysis tool

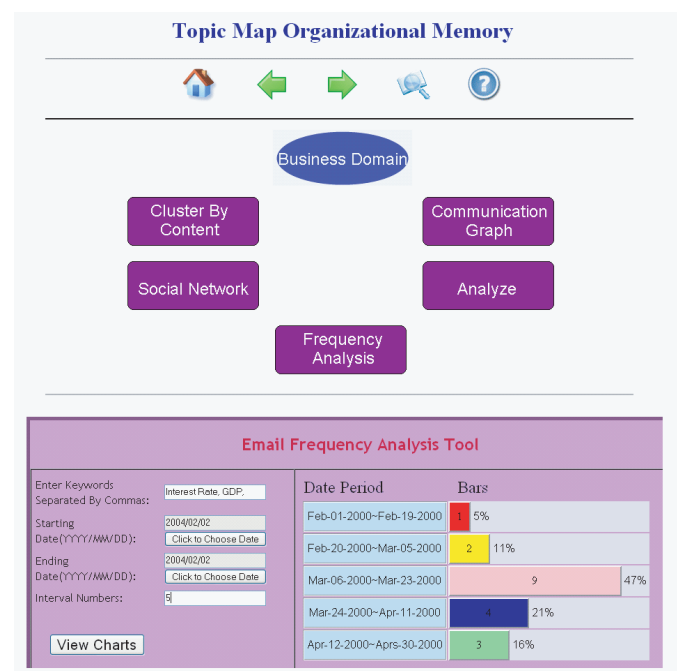


Figure 5 illustrates the use of a topic map tool in the web environment. To reach the topic map illustrated in Figure 4, the user would have clicked on the Search Memory Collection oval and then chosen the Email artifact type. Clicking on the Email Frequency Analysis tool rectangle opens up the input screen shown on the lower left corner of the screen. The tool allows the user to choose the keywords used to search the email collection, the start and stop dates of the time interval that the user is interested in and the number of intervals that the user wants the total interval divided into. Clicking on the View Charts button generates the bar graph shown in the lower right hand corner of the screen (Figure 5).

The topic map interface has been implemented using Ajax to simplify its use. As a result, the input page and the resulting bar graph for the Email Frequency Analysis tool are added to the same page and the status of the topic map remains unchanged. The Google Web Toolkit [23] has been used to generate the JavaScript that supports the generation of the topic map interface and the navigation with in the topic map. In the Email Frequency Analysis tool bar graph, the Date Period fields are viewed by the JavaScript for the page as buttons that bring up a new window containing the list of emails indicated by the associated bar.

The Web Interface has been implemented using Struts[24]. The Internal OO Data Store and Toolkit has been implemented in Java and Poet based on our earlier work on object-oriented data warehouses [12].

## 5. CONCLUSIONS AND FUTURE CONSIDERATIONS

A model of a distributed data warehouse using a topic map to access knowledge from an organization's collective memory has been presented. An initial version of the model has been implemented using Java as the programming language, Poet to store the objects, and Soap to communicate to data sources external to the system.

Future releases will make use of either Java Data Objects or a tool like Hibernate to replace the Poet database system.

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