Using Adaptive Hypermedia to Support Organizational Memory and Learning

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Abstract

The skills, knowledge, and abilities of today's work force require continuous improvement. As a knowledge-based global economy evolves, organizations must strive to optimize human and intellectual capital. This paper examines some aspects of intelligent organizations. In particular, it explores the use of information technology to support memory, knowledge, and learning in organizations. An adaptive hypermedia system is described which incorporates hypertext navigation, information filtering, and multimedia artifacts to provide high-level query and browsing capabilities for information repositories. Design issues for such a system are discussed along with limitations imposed by current technological constraints. The system would include tools to dynamically store and retrieve organizational memory electronically. Such a system would provide mechanisms to access information, context in which to understand past and present events, and a mechanism to bring a multitude of lessons and experiences to bear on present and future activities.

1. Introduction

Information systems can be constructed to assemble and enhance organizational memory. The use of information technologies to support organizational memory and assist in intelligence analysis and decision making has been examined by several authors [e.g., 43, 9, 24, 8, 2, 46, 22]. This paper examines methods to turn stored information (i.e., organizational memory) from media rich systems into actionable organizational knowledge. An adaptive hypermedia system could be employed to conduct mixed-initiative searches whereby information gathering and navigation choices are made jointly by the user and the system. The system could make extensive use of organizational memory to affect shared understanding and learning in organizations.

Brief discussions on memory, knowledge, and learning are presented in this section. The next section describes the role of information technology in supporting organizational memory and learning. Finally, design considerations for an adaptive hypermedia information system are discussed to illustrate how information technology can promote memory, knowledge and learning in intelligent organizations.

1.1 Memory

Memory is "the power or process of reproducing or recalling what has been learned and retained, especially through associative mechanisms" [48]. One way to distinguish among different types of memory is to classify them as episodic, semantic, or procedural [41]. Individual memory reflects knowledge of events you have personally experienced (episodic memory) as well as factual knowledge (semantic memory), such as the fact that Columbus discovered America in 1492. Procedural memory contains the skills you have learned to use, such as reading or hitting a baseball.

Schank [37] describes memory as a place where we store and process knowledge, dynamically changing what we know. He asserts that a critical component of large memory is the organizational structure which provides its superstructure, offering places to hang all the different pieces of knowledge it contains. Researchers believe that memories contain a number of different types of organizational structures which categorize and interrelate individual events for recall at a later date. This structure gives access to more specific information. Memory strategies depend, in part, on the structures which organize memory so that knowledge can be located when it is needed. Structured memories use generalizations to provide expectations, store theories under construction, and organize experiences so they can be recalled when relevant [38]. Constant searches for old information serve to prepare individuals for understanding and predicting events by comparing one experience to

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another. As new knowledge perturbs the system, it finds a place in memory in relation to what is already there.

Stored knowledge and experiences must be accessible in order to be useful. Memory influences an individual's behavior by providing insight for solving problems and making decisions. Researchers believe that acquisition, retention, and retrieval of knowledge and experience influence subsequent individual behavior [3]. Attempting to understand the general workings of human memory, its association with collective memory, and the factors which make it more accessible will help in creating a model for an "automated" memory system. Such a system could assist users in remembering and applying knowledge in order to create efficiencies and increases in productivity.

1.2 Organizational Memory

Organizational memory is a generic concept used to describe saving, representing, and sharing corporate knowledge. It supports cooperation in a multiple task and multiple user environment. The concept includes technical, functional, and social aspects of the work, the worker, and the workplace [12]. Organizational memory includes that which can be conveyed by the written record (e.g., corporate manuals, databases, filing systems, etc.) [1]. Walsh and Ungson [46] refer to organizational memory as stored information from an organization's history that can be brought to bear on present decisions. By their definition, organizational memory provides information that reduces transaction costs, contributes to effective and efficient decision making, and is a basis for power within organizations. Another example of organizational memory could be produced by joining the personal dynabases [36] of individuals who work for a company. A "dynabase" is a dynamic database which consists of notes, sketches, papers and other documents recorded by an individual. By joining the personal dynabases, information could be shared among members of the organization. This collective dynabase structure could serve as an organizational memory.

Organizational memory is both connected and retentive. If memory exists but is unconnected, it does little to aid the organization. Likewise, if memory is easily lost, it cannot be considered very useful. Temporal information and poor retention would result in a system which is less robust and less likely to be relied upon. Stein and Zwass [44] recognize this point. They indicate that organizational memory relies on knowledge that is spatially distributed throughout the processes, individuals, and artifacts of the organization and beyond its boundaries.

Researchers and practitioners recognize organizational memory as an important factor in the success of an organization's operations and its responsiveness to the changes and challenges of its environment e.g., 43, 8, 22]. One such change occurs when employees leave the organization. Personnel turnover can have a significant influence on organizational memory since much of the memory is situated in the minds of individuals [44]. While new workers challenge old assumptions and introduce new world views, the knowledge and experience of former employees is equally important in understanding the context and circumstances which contribute to organizational memory. Establishing mechanisms to capture information held by individuals while they are employed by the organization and incorporating it in an automated information system could prove to be especially valuable to organizations. Such a system could relate the collective experiences of individuals thereby providing background knowledge for understanding organizational policy, procedures, culture, and practices.

Walsh and Ungson [46] posit some advantages of cultivating and expressly maintaining organizational memories. They include the honing of core competencies, increased organizational learning, increased autonomy, integration of organizational actors, and lower transaction costs. Additional advantages are provided by management's ability to consolidate corporate-wide technologies and production skills into competencies that empower individuals and businesses to adapt quickly to changing opportunities [35]. Recollection of past events using an automated information system helps users understand the context of activities and learn how the organization has operated under past circumstances. Thus, they are better able to conduct themselves and make decisions in the context of the provided knowledge. Users would be expected to reduce decisions which "recreate the wheel." Unpleasant historical lessons are repeated less often. These benefits assume that information contained in organizational memory is valid. Human biases may influence the interpretation of what is stored and presented [34]. Validating the contents of organizational memory is an important area for further research.

1.3 Epistemology and learning

An organization's knowledge comes in part from the organization's employees. Each individual can be a prime source of information [1]. "Individuals have private knowledge that can be a basis for organizational knowledge ... Knowledge of the organization is shared knowledge among organizational members" [45 p.59].

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That individuals have private knowledge can be an advantage for organizations, because knowledge from various sources contributes to meaning [49]. Ultimately, knowledge is the assimilation and utilization of some kind of integrated learning system to support "actionable learning" [32]. Information technologies such as the Internet, local area networks and distributed databases can be used to establish the integrated learning system. Intra-organizational information could help organizations develop better recollections of past events thereby generating more informed decisions.

Learning occurs by improving actions through better knowledge and understanding [16], encoding inferences from history into routines that guide behavior [26], and developing insights, knowledge, and associations between past actions, the effectiveness of those actions, and future actions [16]. It involves the understanding of reasons beyond immediate events. Notably, learning is facilitated by structure and organization [29, 45]. Walsh and Ungson [46] maintain that cultivating and expressly maintaining memory increases learning. DiBella [11] notes that discovery and affirmation may encourage learners to employ trial and error experimentation or searching mechanisms in order to gain new knowledge. However, learning typically occurs in response to problems or needs which must be overcome in order to succeed.

Organizational learning is the development of new knowledge and insights that have the potential to influence behavior [e.g., 16, 22, 40] Organizational learning occurs when associations, cognitive systems, and memories are shared by members of an organization. Learning by organizations relies on the people and groups as agents for the transfer of knowledge. Over time, what is learned is built into the structure, culture, and memory of the organization. Lessons (i.e., knowledge) remain within the organization even though individuals may change. Shanks [39] theorizes that organizational learning improves performance, enhances value, improves mental models, facilitates effective analysis, forges commitment, and opens senses to the real world.

DiBella [11] makes a case for understanding learning organizations using normative, developmental, and capability perspectives. The normative view supports the notion that learning is a collective activity that only takes place under a certain set of circumstances. The developmental perspective considers evolutionary changes and learning through on-going interpretations of experience. This is consistent with models presented by Nevis et al. [32] and Huber [22] which decompose learning into knowledge acquisition and assimilation, dissemination and sharing, and utilization. Another view describes developmental learning as movement from rote memorization to understanding of concepts, integration of ideas, and finally synthesis of new ideas [10]. A capability perspective posits that there is no one best way for organizations to learn. According to this perspective, learning processes are embedded in organizational structure and culture. Learning occurs through self-discovery and reaffirmation. As new models are presented to a learning system, it considers where they fit and revises its world view accordingly.

2.0 The Role of Information Technology

Growing information requirements magnify the need for sharing and disseminating information [24]. Information technologies contribute to the possibility of automated organizational memory systems in two ways, either by making recorded knowledge retrievable or by making individuals with knowledge accessible [1]. An organization's past knowledge, explicitly dispersed through a variety of retention facilities (e.g., network servers, distributed databases, intranets, etc.) can make an organization more accessible to its members. Stein and Zwass [44] suggest that the increasing use of information systems such as communication and coordination media can leave an extensive record of processes ("through what sequence of events?"), rationale ("why?"), context ("under what circumstances?"), and outcomes ("how well did it work?"). The availability of advanced information technologies increases the communicating and decision making options for potential users.

An organizational memory supported by information technology provides some advantages since the contents that are stored in information systems are explicit, can be modified promptly, and shared as necessary. Changes can be propagated through the use of information technology. Information systems should be designed to augment the interaction between a knowledge seeker and information providers. Such systems would lead to higher levels of organizational effectiveness and learning.

2.1 Intelligent Interfaces and Agents

Intelligent interfaces use agents to carry out tasks associated with the human-computer interaction. Agents have been touted as a significant new direction in human-computer-interface design. Maes [27] describes an agent as "a personal assistant which is collaborating with the user" as the interaction proceeds. The user remains in control and decides what action to take and

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when to allow the agent to take over. The agent is expected to learn about the user, thus providing better assistance. Agents can learn by observing and imitating a user, by listening to user feedback, and through explicit training. An intelligent interface adapts its interface or interaction model to fit the "perceived" need of the user. Agents work closely with users, in the context of the task, to help them articulate and solve a problem. "When given a goal, an intelligent agent could carry out the details of the appropriate computer operations and could ask for and receive advice, offered in human terms, when it was stuck" [25, p. 192]. Intelligent interfaces could contain many small agents specialized to handle particular tasks [30, 31]. In this environment, agents that share an understanding of the task [13] will be able to work collaboratively on the task [5].

Intelligent interfaces incorporating multimedia enable systems and people to use information to their best advantage [28]. Intelligent multimedia interfaces are distinguished from more static approaches such as pre-configured hypertext by their ability to reason about how to present information to the user and how to interpret user input in the context of ongoing dialog between human and computer [13]. Mayhew [29] describes four consequences of intelligent multimedia systems which will enable systems and people to use media to its best advantage: they can increase the raw bit rate of information, facilitate human interpretation by helping to focus attention on the most meaningful or relevant information, use multiple media to effectively allocate information across media during presentations, and they provide explicit models to facilitate interface design. Maybury [28] presents a collection of articles which focus on intelligent interfaces that exploit multiple media and modes to facilitate human computer communication.

2.2 Digital Data and Distributed Hypermedia

Digital processing has many advantages including the ability to store, retrieve and transport multimedia data without loss of quality. Once digitized, information can be processed and managed by a computer. However, there are limits to how effectively multimedia can be incorporated into a system based on available equipment and infrastructure. Golshani and Dimitrova [21] provide a review of the different data types, their usage, and problems associated with them. Successful retrieval of associated multimedia objects depends on the ability to accurately discover the contents of the object. The semantic (i.e., meaningful) retrieval of data types based on object contents is a difficult problem [e.g., 42, 8, 18]. Much more research needs to be conducted to establish reliable mechanisms for determining the semantic content of multimedia entities.

A mediabase is a computer database whose purpose is to store a multiple media types and information. Mediabases give meaning and access to the formal characteristics of media contents [4]. A mediabase can be used as a practical tool to support shared invention, production, and delivery of both interactive and linear media. Storage of multimedia objects in a robust object oriented database system can establish a way for creating associations between objects thereby assisting in the development of an automated memory information system. Presumably, the addition of multimedia data will enhance information systems used to support organizational memory. Additional research must be conducted to determine how, which, and whether multimedia modalities (sound, video, images, animation, etc.) could be used to support memory. Analysis would strive to demonstrate a positive association between digital media and memory. Building a mediabase for use in enhancing organizational memory would be a dubious exercise if positive relationships between digitized multimedia and memory cannot be established.

Distributed systems have evolved from the need to share information and allow users to define their own workspace. It plays an important role in the design and development of systems which incorporate the use of multimedia information distributed across wide areas. It provides for dynamic construction of spatial and temporal links based on attributes defined by the [24]. In this way, users are able to construct memories by generating ideas, concepts, and understanding from information provided by the hypermedia system. The combination of hypermedia and distributed systems enhances effectiveness in information management and dissemination [20]. Hypermedia systems can provide for conceptually related pieces of information to be connected, even though they may reside on different machines. This characteristic is important in creating and using effective organizational memories through the application of information technologies.

3.0 Design Considerations

In either individual or organizational memory, attempts to recall events or information at spatially different times can share starting and stopping points but traverse completely different paths to reach the same conclusion. Vannevar Bush [7] described this random search mechanism as non-sequential thinking. In human memory, instances of experience and knowledge are loosely tied together by a series of neurons. Searching

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through the information spaces of the mind causes triggers to fire bringing related experiences and knowledge to the forefront. In organizational memory, instances of experience and knowledge could be loosely tied together by a network of cables and wires connecting information systems. Searches of organizational memory could return information deemed to be related and important to a particular problem or decision. An intelligent agent could be used to gather information from distributed information sources. The agent would consider user inputs along with past and present searches to build search strings dynamically. Working in concert with the user, the system could suggest the relative fit of information found to the decision task or problem at hand. Subsequent searches of available information would allow the decision maker to narrow the focus to pertinent data, thus, providing access to knowledge and insights which would lead to more informed decision making. Using intelligent agents to build search strings and retrieve information presents several technical challenges which must be addressed in order to implement the system described in this paper. Some of those challenges will be discussed throughout the remainder of this paper.

Sociologists consider the relationships established between actors (i.e., people, objects, or events) to be an important aspect of behavior. We hypothesize that creating associations based on the relationships between similar events will give context and meaning to other events. Berryman and Hockenhull [4] maintain that current hypermedia systems are based on a hunting paradigm in which users arbitrarily navigate space to find information. In contrast, they describe an associative paradigm which allows for the "gathering" of information in global contexts and subsequent arrangement to form local contexts. Using an associative paradigm, a viewer builds contexts through interaction with his or her work.

An associative paradigm would take advantage of metadata characteristics to develop context. Metadata refers to a collection of attributes giving an object meaning from which associations can be made to other objects. More succinctly, metadata is data which describes other data. Metadata subsystems capture and retrieve attribute information. Storage and retrieval of correct and meaningful metadata is the cornerstone upon which effective organizational memory information systems should be built. Huynh et al. [24] remind us that creation of meaningful metadata should incur minimal overhead - the systems should extract as much information about the resources as possible automatically, and users should be able to submit and modify metadata for their own resources conveniently. Metadata schemes should be extensible to accommodate future attribute information as the system grows to assimilate new types of resources. The scheme should also allow users to interrelate resources to express inter-dependencies.

3.1 Adaptive Hypermedia Information Systems that Support Organizational Memory

An adaptive hypermedia information system would make use of multiple information technologies, support multiple users, and work on multiple tasks. Its contents would be spatially distributed and dynamic. Interfaces to the system would make use of hypermedia and intelligent agents. Elements of memory (i.e., objects) could be associated with explicit links or through encapsulation and inheritance. The system would need to incorporate fast, flexible search mechanisms, adapt to the needs of individual users, and readily share information. A multisensory, multimedia component would enhance the users experience when interfacing with the system. Automatic, continuous scanning for new knowledge and lessons would ensure that the system maintained a current representation of the organization.

An adaptive hypermedia information system would rely on several inputs. Explicit and tacit knowledge collected from individual, organizational, and environmental sources could provide a foundation from which the system would operate. Explicit knowledge is information that can be described easily in facts and figures. This type of information could be easily obtained from typical organizational databases. One advantage of explicit inputs is that they can be digitized, stored, and represented by computerized systems. Tacit knowledge refers more to the knowledge of experience. It relies more on insights, instincts, hunches, and intuition [33]. Explicit elements help support and enhance the tacit nature of some inputs. However, tacit knowledge is much more difficult to build into an information system. Tacit knowledge is most often represented in the form of rules or heuristics. Tacit inputs are dependent upon the individuals interacting with the system. The use of intelligent agents to assist users implies some sort of tacit capabilities. Intelligent agents in our system would attempt to build proxies for tacit knowledge into the system. Agents would try to “guess” a user’s intentions and desires based on models constructed over time through the user’s interaction with the system. Sophisticated information filters would serve as gateways providing security and directing components as they are brought into and retrieved from the system.

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Individual inputs to the system might include notes, sketches, memos, and assorted miscellaneous documents. Characteristics more tacit in nature (i.e., memory, ethics, morals, personal knowledge and experience, skills and abilities, etc.) would determine an individuals level of interaction with the system. Organizational inputs to the system might include policies, procedures, practices, history, and structure. More tacit organizational elements could include goals, strategies, culture, morale, and politics. The organization's willingness and desire to support the system as a whole would greatly affect its use and acceptance. Environmental elements which contribute to the system explicitly could incorporate governmental regulations and guidelines, infrastructure, organizational boundaries and certain market information. However, the system must still depend on the user community for societal norms, ethical and moral standards, ecological considerations, and certain market forces (e.g., competitors strategies, customer preference, etc.). Each of the above elements would be considered part of the organization's memory.

Recall that three processes associated with memory are acquisition, retention, and retrieval. Several tools could be used to support these processes in an adaptive hypermedia information system. New knowledge can be created in many ways. The system could continuously scan the environment for new inputs and attempt to place them relative to other information it contains. Discovering and acquiring knowledge on the Internet is accomplished with robust search engines such as Lycos™ or AltaVista™. Adaptive hypermedia would employ similar search engines while simultaneously monitoring a user's interactions. In addition, on-line information sources could be periodically accessed and "processed". Mixed-initiative searching introduces a way in which choices for gathering information are made jointly and concurrently by the viewer and the system. Associations would be constructed intelligently by using the results of previous searches. As a viewer builds up his or her workspace structure, successive searches tend to find objects that "work," thus the system could support continuity and style. The artifacts of the searches may then be preserved and shared as memory with searchable contexts. Appropriate database structures must be designed to support the required collaborative relationships.

Multiple, distributed repositories would form a broad knowledge-base to provide semantic content for our hypermedia system. The knowledge-base contains a wealth of information which could be disseminated and shared among members of the organization. One advantage of the knowledge repositories is their ability to store multiple media types in a variety of formats. Our system would rely heavily on such media rich systems. However, many media types are described as "opaque data." Such data may be captured, stored, retrieved and presented, but are difficult to examine, search, transform, and digest in such a way that the computer may perform independent actions based on the media's content [42]. The convergence of computing, communication, and cable technologies necessitates the management of vast amounts of digital audio and video data. However, there are no formal data models which capture and manipulate the structure of such data [18].

We believe an adaptive hypermedia information system could produce many outputs beneficial to the organization. The system would store information about how knowledge was created or acquired. Users could trace back the path of knowledge creation, thus lessons could be generated to help other members of the organization understand the knowledge. By supplying explicit knowledge to users and using intelligent agents to assemble the knowledge in a "meaningful" way, the system could provide direction to decision makers. As such, it could act as a decision support system for members of the organization. Members of the organization, in concert with the system, populate the knowledge base and organizational memory. Access to the system and shared resources creates synergy among the users possibly leading to increases in efficiency and productivity. Finally, knowledge generated by the system can be used in subsequent knowledge discovery expeditions. Overall, the system would provide many mechanisms for organizations to retain and build upon elements of organizational memory and knowledge.

3.2 Limitations

Contingencies which may limit the implementation and use of an organizational memory information system include the redistribution of organizational power, incomplete implementation, lack of use, improper use and underachievment [44]. As organizations go through multiple reorganizations, memory becomes too obscure to recover or recreate. Events that can lead to poor organizational memory also include instances when principle decision makers are not consulted in subsequent decision making situations. Ignoring what is retained in organizational memory creates a lack of understanding for the context in which past decisions were made. Finally, if information is unavailable for some reason, (e.g., it was never recorded, decision makers have left the organization, individuals are unwilling to provide information, etc.) it becomes difficult to build up a structure which supports meaningful recall of information which would support present decision

making. Developing the necessary structure is critical to establishing a complete, consistent, and valid system.

Demonstration of increased organizational memory and learning through adaptive hypermedia interfaces does not necessarily guarantee proper use. Walsh and Ungson [46] discuss improper use of organizational memory in general. Misuse of past information and abuse of organizational memory resulting in autocratic entrenchment are two reasons a system may be used improperly. Such use can introduce incorrect or incomplete information.

The use of intelligent agents in the interface introduces a host of limitations. Incorrect user modeling, lack of situated cognition, and limited world views could prevent the agent from giving the correct advice or performing the appropriate tasks. Care must be given to constructing the interface and designing the agents, recognizing that it will be difficult to incorporate informal and tacit knowledge into the agents. Similar to the agent problem, the varying knowledge levels and experience levels of users could limit the effectiveness of the system.

4.0 Conclusions

An adaptive hypermedia information system incorporates intelligent agents, hypertext navigation, distributed storage mechanisms, and multimedia artifacts to provide high-level query and browsing capabilities for information repositories. The system provides information resources for answering a variety of questions and navigation to those resources. Such a system is a dynamic tool for storing and retrieving organizational memory electronically. It provides mechanisms to access information, context in which to understand past and present events, and a tool to bring lessons and experiences to bear on present and future activities.

Adaptive hypermedia information systems could draw upon and populate organizational memory facilitating learning for members of the organization. The use of intelligent agents to automatically acquire knowledge about users further populates memory. When users are able to explore, discovering and reaffirming knowledge on their own, they are likely to learn along the way.

Effective organizational memory provides a mechanism for organizations to bring information about past decisions to bear on present decisions. Used correctly, it can enhance decision making and make organizations more productive and efficient. Automating the information acquisition, retention, and retrieval aspects of organizational memory will protect organizations against losses of individual memory through personnel turnover by providing a place where past information can be kept and not forgotten.

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