Gathering Information in the Digital Age Using the Semantic Web

Philip S Nitse[1]; Kevin R Parker[2]
[1]*Professor, Idaho State University, nitsphil@isu.edu*
[2]*Professor, Idaho State University, parkerkr@isu.edu*

Abstract

As business decisions become more critical and the data upon which they are based becomes more readily available, the need to access information quickly and to store it in a usable system becomes paramount. In attempting to access and store the data and information, companies are using techniques like competitive intelligence and knowledge management systems. This has given rise to more investigation into the use of the semantic web. The combination of Competitive Intelligence, Knowledge Management and the Semantic Web offers the best alternative for success in this very competitive environment. This paper outlines the relationships between knowledge management, competitive intelligence and decision making, and defines some of the many types of tools used to improve the semantic web. It also illustrates how the semantic web can augment the search process for the data that enhances the decision-making process at all levels of an organization and for the various types of decisions that need to be made.

Keywords

semantic web, knowledge management, competitive intelligence, decision-making, XML, URI, RDF, ontologies, intelligent agents

Introduction

Success for companies in today's environment is dependent on the decisions that are made. The problem is how to make more good decisions than poor decisions. If more good decisions are made than poor decisions, then the company should succeed; otherwise the company should fail. One of the potential differences between good and poor decisions is the quality and quantity of the information upon which the decision is based. Many companies use Competitive Intelligence (CI) techniques to gather and disseminate information, then use a Knowledge Management (KM) system to store and manipulate the data and information. The decisions that are made fall into three categories: Strategic, Tactical, and Operational (Anthony, 1965). Each of these areas requires different types of decisions and therefore different types of information to base the decision upon, regardless of the whether the decisions are made by an individual instinct-driven snap decision process or by a collective process in which many people are involved in the process (Johnson, 2005).

Many large corporations and businesses have developed their own in-house libraries, or Knowledge Management Centers (KMC), that are both digital and paper-based. As the availability of information began to "explode" in the 1950's and '60's, these units were used to track specific information and to provide reference data for researchers and others who did

not have time to do the work themselves. In the late 1960's selective dissemination of information was improved through the use of the first online database services. Searches could be entered once and saved, and then rerun against the database as new information became available. KMCs are highly specialized and form a basis for companies to capture, store and disseminate much-needed intelligence for companies to streamline their processes and improve their services, as well as to provide intelligence about a company's operating environment and competitors to help them gain or retain a competitive advantage in their industries. Companies are spending vast amounts of money and personnel resources on these libraries to keep abreast of the daily happenings in their very dynamic business environments.

Despite these efforts, effective information organization and retrieval continues to be problematic. While the advent of the Internet has made even more information available, human interpretation is required to understand the content of that material, despite improved searching algorithms. The problem is that today's Web lacks the capability of automatically linking documents on the basis of semantic similarities. Such linking requires human intervention to ascertain the semantic context and recognize similarities between documents. The Semantic Web offers a solution that addresses several of the problems faced by KMCs. The Semantic Web is an extension to the current Web designed to automatically link documents that are semantically similar. It proactively catalogs and delivers information and intelligence to individuals and businesses. This paper will explore the benefits of using the Semantic Web to build a KMC that will improve the value of the KMC to the organization.

Knowledge management

Knowledge management is the process through which organizational performance is improved through better management of corporate knowledge. It is the explicit and systematic management of vital knowledge (Skyrme, 1997), and includes capturing, organizing and disseminating that knowledge within an organization (Rubenfeld, 2001). KM allows organizations to generate value from their intellectual and knowledge-based assets (Santosus & Surmacz, 2001), and makes it possible to get the right information into the hands of the appropriate people at the time they need it to make decisions (Petrash, 1996).

Importance of KM

KM has several benefits and is a useful resource for any organization. Its goal is to improve the management of internal knowledge processes so that all information required for corporate decisions can be made available and efficiently used. KM "caters to the critical issues of organizational adaptation, survival and competence in face of increasingly discontinuous environmental change" (Malhotra, 1998). The importance of KM is corroborated by various research studies. A survey by PricewaterhouseCoopers International found that 95% of the CEO's who participated saw KM as an essential ingredient for the success of their company (Suresh, 2001).

Several sources (Choo, 2004; OSD, 2002; Library Co-Op, 2004) attribute a variety of benefits to a well-planned KM effort, including the following:

- KM encourages the free flow of ideas, which fosters insight and innovation and creates new value through new products or services.
- KM improves customer service and efficiency by streamlining response time.
- KM enhances employee retention rates by recognizing the value of employees' knowledge and rewarding them for it.
- KM streamlines operations and reduces costs by eliminating redundant or unnecessary processes and promoting reuse.
- KM facilitates better, more informed decisions by reducing uncertainty.
- KM contributes to the intellectual capital of an organization.
- KM boosts revenues and enhances the current value of existing products by getting products and services to market faster.
- KM leads to greater productivity by increasing speed of response.

Resources required by KM

Although KM is a useful resource, it can be prohibitively expensive for many companies. Qualified and dedicated personnel are required for a successful KM effort, as is supporting technology. The overall capital outlay may be beyond the means of many organizations.

One of the resources required for a successful KM effort is personnel. KM is based on what employees know, and how that knowledge can support business and organizational objectives. It is not a technology-driven concept, but rather it draws on human competency, intuition, ideas, and motivations (OSD, 2002). KM requires not only knowledgeable employees, but also specialized knowledge workers. A KM worker requires varying depths of knowledge in particular areas (Skyrme, 1998):

- Technical skills - information (resources) management, information technology skills
- Business knowledge - industry, markets, customers, competitors, and general business context
- Interpersonal skills - networking, listening, interpreting, challenging, teamwork, communications
- Management skills - motivating, coaching, facilitating, influencing
- Company/Organization knowledge – Knowledge of procedures and culture
- Personal characteristics - integrity, confidence, openness, trust, supportive, honesty, willingness to learn.

The financial component is also critical for the success of a KM effort. The expenditures for a serious KM effort can be quite significant. It has been estimated that the major consulting firms may spend as much as 6-12 % of revenues on knowledge sharing programs (Source: Gartner Group, May 28, 1998). A 2001 survey conducted by supportindustry.com and STI Knowledge reveals that 31 of 49 companies (63%) reporting a KM initiative spent between $100,000 and $249,000. Sixteen per cent (8 of 49) spent $250,000 to 499,999. Three of 49 spent between $500,000 and $749,999. 1 of 49 spent between $750,000 and $999,999. 4 of 49 spent between $1,000,000 and $1,999,999, and 2 of 49 spent between $2,000,000 and $4,999,999 (CRMindustry.com, 2001). None of these amounts is negligible.

Another essential KM component is technology. KM tools range from standard, off-the-shelf packages to sophisticated collaboration tools designed specifically to support community

building. Generally, tools fall into one or more of the following categories: knowledge repositories, expertise access tools, discussion technologies, knowledge representation, expert systems, e-learning applications, synchronous interaction tools, and data warehouse and data mining tools (Zhang, 2004; Library Co-Op, 2004).

Other KM products include (Murray, 1996; Nantel, 2003):

- Business Intelligence (BI)
- Collaboration
- Content/Document Management
- Data Integration
- Portal
- Search/Retrieval
- Decision Support Systems.
- Database technologies
- Help-desk technology
- Brainstorming applications
- Web mapping tools.

Many researchers take the narrow definition that KM systems have as their objective the collection, management, and sharing of internally generated knowledge. Abramson (1999) uses the phrase “enterprise knowledge” when referring to internally generated knowledge. Johnson (2000) refers to the internal focus of KM. Bagshaw (2000) refers to tacit knowledge inside employees' heads and embedded in the way that things are done. Rubenfeld (2001) defines KM as capturing, organizing and disseminating valuable knowledge within an organization.

Limiting the scope of KM to internal knowledge only is an artificial and unnecessary constraint. Restricting the focus to internal data can severely reduce the potential capabilities of KM systems. Thus, another set of researchers share the opinion that not only internal, but also external, sources of knowledge are critical. Abramson (1999) notes, that KM enables companies to create and systematically use the very best internal and external knowledge that they can obtain. Grzanka (1999) observes that KM provides a methodology to leverage and manage all knowledge, whether external or internal.

Competitive intelligence

Competitive Intelligence or Business Intelligence is becoming more accepted as a means of gathering and analyzing information for use in developing global strategies. Miller (2001) defines CI as the process of monitoring the competitive environment. This competitive environment includes but is not limited to competitors, customers, suppliers, technology, political and legal arenas, and social and cultural changes. Kahaner (1996) explains that CI is a systematic and ethical program for gathering, analyzing, and managing information about competitors’ activities and general business trends that can affect a company’s plans, decisions, and operations. Note the distinction of CI as an ethical process, unlike business espionage, which acquires information by illegal means like hacking (Malhotra, 1996). CI enables management to make informed decisions about a wide variety of tactical and strategic

issues. Outcomes from a formal CI program should enable strategists to anticipate changes in the company's marketplace and actions of its competitors. CI should also uncover the existence of new competitors, new technologies, products, laws, or regulations that will have an effect on business. CI can help a business learn from the successes and failures of other enterprises, make better mergers and acquisitions, and enter new business arenas. From an internal viewpoint, CI can help a company assess its own business practices from a more open and objective perspective while helping implement new management tools (Kahaner, 1996).

The CI process is becoming even more important as the pace of business both at home and abroad continues to accelerate. CI also helps managers deal with the rapid change in the political, legal, and technical environments (Kahaner, 1996). A key goal of CI is to provide early warnings or timely alerts that allow decision makers to proactively position the company to maintain or gain a competitive advantage. Management must be able to detect changes in the market early enough to place the company in the most strategically advantageous position possible.

Often viewed as distinct research areas, there is a great deal of overlap between knowledge management and competitive intelligence. Knowledge management and competitive intelligence "have similar goals and are natural extensions of one another (e. g., manage information overload and timely/targeted information delivery, provide tools for data analysis, identify subject matter experts, enable collaboration)" (Meta Group, 1998). In fact, competitive intelligence can be viewed as a branch of knowledge management (Davenport, 1999), especially since knowledge management encompasses the processes of gathering, creating, organizing and diffusion of that knowledge (Skyrme, 1997).

Other views of knowledge management either implicitly or explicitly acknowledge that knowledge management must include the acquisition of knowledge from the external environment, and the interpretation and application of that information, i.e., competitive intelligence. Knowledge management combines "indexing, searching, and push technology to help companies organize data stored in multiple sources and deliver only relevant information to users" (Hibbard, 1997). Knowledge management "caters to the critical issues of organizational adaptation, survival and competence in face of increasingly discontinuous environmental change" (Malhotra, 1998). Knowledge management is getting the right information into the hands of the appropriate people at the time they need it to make decisions (Petrash, 1996). Therefore, it encompasses all aspects of the Intelligence Cycle from the planning to the gathering to the analyzing to the reporting phases that companies use to stay competitive (Fuld, 2001).

There are many tools available for gathering competitive intelligence from an organization's environment. However, unless those tools are equipped with an adequate specification of the variables that need to be monitored, their information gathering will be incomplete. A great deal of research has been devoted to studying *how* to look for information, while seemingly overlooking the equally vital issue of *what* information to look for. In fact, a recent review of software marketed toward the online intelligence community clearly illustrates that the ability of most software to gather *what* information is clearly deficient (Fuld, 2001).

Organizations use the CI process to gather information, to add value to it through analysis, and to report the findings to managers to solve a wide variety of problems or satisfy requests

for information. This information forms the basis for much of the external information that a KMC uses. CI projects range from competitive information about competitors or customers to information on mergers and acquisitions or recruiting. The types of information needed to answer these requests may include financial information, demographics, biographies, economic indicators, news articles, and customer and competitor information. Some types of information are easily gathered, while others require greater amounts of time and money to obtain. Once the information is secured, it must be analyzed and proper reports must be generated and disseminated to the appropriate individuals within the organization.

Research has identified several problems that users of CI have with the information that they receive from the CI process. These problems include shallowness, credibility, timeliness, focus, providers, quantity, and information sharing. The source of these problems can often be traced back to the way in which the CI process is carried out. If CI providers are consulted late in the decision-making process, shallow and poorly focused information is often the result. If sufficient time is not taken for analysis then the reports are often information-based rather than intelligence-based. In addition, the sheer quantity of information contained within the reports often overwhelms the reader. Lack of lead-time also limits the sources that can be accessed, thus calling into question the credibility of the sources of information. However, if decision-makers wait for better intelligence and analysis, it may come too late to be useful in the decision-making process. Other problems include lack of clear objectives, numerous users, massive quantities of information available, organizational barriers, lack of feedback and low budgets. Each of these problems can degrade the quality of intelligence that CI professionals can provide to users.

Any organization that fails to monitor its environment to determine the conditions under which it must operate courts disaster. Identification of key economic, social, and technological issues that affect the organization, its life cycle stages, and their relevance to each other helps managers allocate attention and resources to them. CI is a fundamental, early step in the chain of perceptions and actions that permit an organization to adapt to its environment. CI must be able to uncover and provide information which will allow management to identify and fill gaps in consumer or business demand curves that are unfulfilled by the products and services that are currently being offered (Johnson, 2005).

Regardless of where a researcher stands on the issue of whether KM is or is not limited to internal sources of information, it is important to note that KM and CI complement each other. KM systems will become more robust as researchers recognize the benefits of adjusting their focus to include not only internal, but also external sources of information. The convergence of KM and CI seems to be a next step in the evolution of the two approaches to information gathering and management.

The semantic web

Before exploring the role of the Semantic Web in a Knowledge Management Center (KMC), the Semantic Web itself must be understood. Today's Web pages are designed for human use, and human interpretation is required to understand the content. Because content is not machine-interpretable, any type of automation is difficult (Lassila, 2002). The Semantic Web augments today's Web to eliminate the need for human reasoning in determining the meaning

of web-based data. The Semantic Web is based on the concept that documents can be annotated in such a way that their semantic content will be optimally accessible and comprehensible to automated software agents and other computerized tools that function without human guidance (Bonner, 2002). Thus, the Semantic Web might have a more significant impact in integrating resources that are not in a traditional catalog system than in changing bibliographic databases. For example, some scientific datasets do not have access points that convert well to bibliographic descriptions, but convey a multitude of critical concepts for the researchers that use the datasets (Rhyno, 2002).

Realization of the Semantic Web relies primarily on five core technologies: XML, URIs, RDF, ontologies and intelligent agents. The extensible markup language (XML) and its accompanying technologies are the fundamental facilitator of the Semantic Web (Berners-Lee, et al., 2001). XML provides for language customization through the definition of new tags to describe the data elements used in an XML document–hence the term "extensible." Unlike HTML, which controls how data are displayed on the Web, XML is intended to facilitate the sharing of structured text and information across the Internet. The data display remains the job of HTML. In short, XML and HTML perform complementary, rather than overlapping, functions. XML supplements presentation markup with markup that provides a context for understanding the meaning of the data, for example, <author>Gordon Davis</author>. The advantage of XML is that software programs can read the specialized tags and perform operations such as extracting bibliographic information (Adams, 2002).

Uniform Resource Identifiers (URIs) are another foundation of the Semantic Web (Berners-Lee and Miller, 2002). A URI is much like a URL, but it does not have to map to a real web address. Further, a URI can represent concepts ("author"), living entities ("Gordon Davis"), and virtually anything else (Rhyno, 2002). Thus, URIs provide the capability to uniquely identify not only resources, but can also indicate the relationships among resources (Berners-Lee and Miller, 2002).

The Resource Description Framework (RDF) leverages URIs and XML to provide interoperability between Web applications that must exchange machine-understandable information (Brooks, 2002). RDF provides a structure that, in functional terms, expresses the meaning of Web documents in a way that specialized software can understand (Adams, 2002). Through RDF, authors can specify the contents of pages and how those pages relate to one another and to other known bodies of data (Bonner, 2002). An RDF description can include various types of metadata such as the authors of the document, the date of its creation, the name of the sponsoring organization, intended audience, subject headings, etc. (Adams, 2002).

The next element required for the realization of the Semantic Web is an ontology that can formally describe the semantics of classes in the many domains of interest and the semantics of properties (or attributes) used in Web documents (Sadeh and Walker, 2003). Hendler (2001) defines an ontology as "a set of knowledge terms, including the vocabulary, the semantic interconnections, and some simple rules of inference and logic for some particular topic." Ontologies allow computers to communicate with each other by providing (1) a common set of terms–vocabularies–and (2) rules that govern how those terms work together and what they mean. Ontologies define terms and then lay out the relationships among those terms (Adams, 2002).

Intelligent software agents are software entities that carry out operations and process information on behalf of a user or another program with some degree of independence or autonomy, directed by some awareness of the user's goals or needs. Agents are used when the software must possess human-like capabilities such as the ability to perceive and assess the environment, proactive behavior in pursuing a goal, ability to learn from their experiences, and social behavior (Ermolayev, et al., 2004). In the context of the SW, intelligent agents typically gather, sort and process information found on the Web without human interaction. Agents should be able to discover content that is appropriate given the customer's preferences and requirements (Kungas and Rao, 2004).

How do the various parts tie together? The Semantic Web requires that Web pages be developed (or redesigned) in XHTML, which incorporates XML. XML tags can be used to describe the contents of the document. In fact, RDF triples (subject, predicate, noun — all of which can identify the location of, content of, and relationships between resources) are expressed in an XML representation to publicize semantic connections between documents in machine-processable form. RDF schemas and ontologies describe the meaning and relationships between the various vocabularies that are used to describe Web content and allow software to convert between them to establish a common vocabulary that enables communication and understanding. Intelligent agents examine RDF schemas and ontologies and use inference to locate documents that are semantically related, parse and interpret information from those documents, and integrate data from the various sources to arrive at a solution to whatever query or problem that they are intended to address.

The enabling technologies that underlie the Semantic Web, including XML, URIs, RDF, ontologies, and intelligent agents, are rapidly maturing. With the advent of the Semantic Web, search engines will no longer require users to guess at proper keywords in order to locate Web resources, but will instead allow them to provide a description of the resources they are seeking. Queries will evolve beyond Boolean searches based on keywords and will instead allow natural language queries. Information is only meaningful when associated with context, and the Semantic Web will provide that context. The Semantic Web will attribute meaning to the content of Web pages, creating an environment in which information can be readily located and integrated. The Semantic Web holds great promise that tomorrow's Web will be a Web of semantics with far greater capabilities than today's Web of text.

Components of a knowledge management center

Several steps must be undertaken for companies to utilize these technologies to develop KM centers. First, companies must develop domain ontologies to help categorize resources for their specific business. A domain ontology provides a specification of a shared conceptualization to be used for formulating knowledge-level theories about a domain (Domingue and Motta, 1999; Guarino, 1997). Specific domains can be identified and a common ontology can be defined to map vocabularies of specified terms with generally accepted definitions (Gruber, 1991). "Ontologies inform the system user of the vocabulary that is available for interacting with the system and about the domain and the meaning that the system ascribes to terms in that vocabulary" (Farquhar et al., 1997). A domain ontology is an explicit formal specification of all the basic concepts (objects, concepts, and relationships) that are assumed to exist in some area of interest. The goal of domain ontologies is to specify

the conceptual vocabulary and representational framework for the classes of a domain. Tools like the Ontolingua Server can assist in the construction of ontologies (Farquhar et al., 1997).

Building a domain ontology requires a thorough understanding of the domain; therefore the process should start with determining common industry terms, organization specific terms, and even project specific terms. Ontology construction can be directed through the use of needs identification tools like key intelligence topics (KITs) or the multi-class interest profile (M-CLIP), generally used in conjunction with CI. Herring (1999) proposes the concept of KITs to help identify intelligence requirements by considering strategic decisions, early-warning topics, and key players. The KITs process can help identify and define critical intelligence needs. The M-CLIP (Parker and Nitse, 2001), provides a strategically aligned framework based on the various types of information needs in order to insure that key items within each domain are accounted for. Thorough needs identification guided by a structured, multi-dimensional framework increases the likelihood of successful ontology development. A complete domain ontology encompasses a wide spectrum of corporate interests, thus providing the means to access a greater percentage of relevant information. A specialist trained in knowledge engineering can greatly assist the specification of key concepts for the domain ontology.

Second, as individual documents are added to the business' collection, natural language processing techniques can assist in determining the contents of each digital document. The document collection will consist of resources from both internal and external sources. There are a variety of external sources. These may include items stored at other company locations, or items provided by pay-for-use services such as Dow Jones, Hoover's Company Data Bank, Standards & Poor's, NewsEdge, or free information sources such as SEC's Edgar system, and corporateinformation.com (Breeding, 2000). The business may also subscribe to specialized databases from third-party vendors (Dialog, Lexus/Nexus), press release and newsfeed collections (WavePhore's Newscast Access or NewsEdge's NewsObjects), product literature, competitor Web sites, archived design specifications, company profiles and financial statements, and numerous other sources (Johnson, 1998). Internally generated knowledge refers to that knowledge within the minds of their employees. In order to handle internally generated knowledge the system should provide an interface to allow users to store information that will be sharable with other users of the system.

Finally, the Semantic Web will be used to semantically link the company's resources, so that semantically related documents can easily be retrieved or delivered. The company may wish to contract a knowledge engineer on staff to assist in specifying their information needs.

The semantic web in a knowledge management center

The Semantic Web promises to give well-defined meaning to the Web by incorporating well-defined semantics into Web documents. Agents should be able to determine the semantic linkages between Web resources by following links from Web pages to topic-specific ontologies. The meaning of vocabulary terms or XML tags used in a particular Web document would be defined by a topic-specific ontology. For example, ontology cross references would make it possible for an agent to understand that "blouse" and "dress shirt" are similar concepts (Adams, 2002). Using a semantically based view of web resources, intelligent agents will be able to automatically discover, interpret, and evaluate web content

(Arai, et al., 2003). Searchers will specify multiple search parameters to narrow the search focus and target specific references. Results can be delivered on a push or pull basis to provide ongoing competitive (and other) intelligence.

"The real power of the Semantic Web will be realized when people create many programs that collect Web content from diverse sources, process the information and exchange the results with other programs" (Berners-Lee, et al., 2001). As the Semantic Web grows in use, the value of a KMC will grow since the value of the information stored within will become more valuable in the decision making process. The easier it is to link data from many sources and turn that data into useful information for decision making, the more likely it will be used in the decision making process.

Conclusion

Regardless of whether a decision is an individual snap decision based on one's expertise or the expertise of a collective group, the Semantic Web will allow CI professionals to gather more and better knowledge for decision makers by using tools like XMLs, URIs, RDFs, ontologies and intelligent agents. This data and information will be stored, semantically linked, and recalled from a KMC at the appropriate time for strategic, operational or tactical decisions, providing decision makers with a more complete set of information upon which to base their decisions. This should, in turn, result in more good decisions and their associated benefits.

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