Enhancing Knowledge Management Through the Use of GIS and Multimedia

Petros Belsis[1], Stefanos Gritzalis[1], Apostolos Malatras[2], Christos Skourlas[3], Ioannis Chalaris[3]

[1] Department of Information and Communication Systems Engineering
University of the Aegean, Karlovasi, Samos, Greece
{pbelsis,sgritz}@aegean.gr
[2] Department of Electronic Engineering, Centre for Communications Systems Research
University of Surrey, UK
a.malatras@surrey.ac.uk
[3] Department of Informatics, Technological Education Institute, Athens, Greece
{cskourlas,ixalaris}@teiath.gr

Abstract. Knowledge is probably the most important capital for an organization, constituting thus its management an issue of high significance. The majority of existing solutions utilize static sources for knowledge (document repositories), allowing for minimum support for tacit knowledge that is an outcome of an on demand cooperation with an appropriate expert. In this paper we describe a system that introduces the concurrent integration of Multimedia and Geographical Information Systems (GIS) functions in Knowledge Management (KM) applications. In most Knowledge Management systems one of the real challenges is expert's knowledge utilization. Towards this direction, we exploit possible technological prospects and we present the architecture of a prototype developed to implement selected innovative KM components by embedding state-of-the-art multimedia Java-based applications integrated in parallel with GIS functionality.

1 Introduction

The learning process and potential ways to establish a supporting framework have been for long of primary interest to both the academic and entrepreneurial world. Knowledge has become a key resource [1], [6] for both organizations and individuals. Faced with global competition and increasingly dynamic environments, organizations are being advised to assemble people of diverse talents and deploy their expertise to gain access to new areas of knowledge and new technologies. Innovative techniques and advanced technology features are emerging on a daily basis, on every area of expertise making the effective handling of knowledge a difficult task. Therefore, there is an obvious necessity for exploiting this knowledge with the assistance of technological means and supporting it with learning techniques to allow its dissemination in order to enhance individual and organizational performance.

GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps [10], [18]. Among other things, a GIS facilitates the modeling of spatial networks and provides a number of tools for the analysis of spatial networks [7]. The incorporated capability of GIS to perform spatial analysis can be considered as similar

D. Karagiannis and U. Reimer (Eds.): PAKM 2004, LNAI 3336, pp. 319–329, 2004.

to the decision capabilities of decision support systems (DSS)[16], enhancing therefore their distinguished significance to support basic organizational tasks. Furthermore, the integration of state of the art multimedia technologies such as Voice over IP (VoIP) through Java-based applications provides a framework for expert's knowledge utilization [2], [3].

In this paper we attempt to enhance KM functions with GIS and multimedia functions. The rest of the paper is organized as follows. In section 2 we present the main technological challenges in KM implementations and we present how new technologies can be helpful, describing our contribution in relation to contemporary KM approaches, while in parallel we introduce the benefits of introducing GIS into KM techniques. In Section 3 related systems to the one proposed by us are studied and in section 4 we present the architecture of our prototype and a concise description of it. Section 5 concludes the paper, evaluating the benefits of our prototype and providing directions for further work.

2 Benefits of KM

Philosopher Polanyi [26] distinguishes knowledge in two types: tacit, which is embedded in the human brain and cannot be expressed easily, and explicit knowledge, which can be easily codified [6]. Codified knowledge can be managed through several types of applications like document management applications, intranets, repositories and databases provided with proper querying mechanisms.

Bhatt [4] argues about the distinction between individual knowledge and organizational knowledge, which yet are interdependent. In complex situations, where organizational tasks are highly interdependent and individuals do not possess necessary levels of expertise to solve interdisciplinary problems, people are required to cooperate with others to share their knowledge and expertise. Knowledge management is an emerging discipline that promises to capitalize on organizations' intellectual capital [21]. As a concept, KM appeared in the beginning of the previous decade. Among the potential benefits from establishing specific techniques to manage knowledge, according to a major study that took place over several worldwide-distributed organizations [5], we can distinguish:

- Improved decision making
- Improved efficiency of people and operations
- Improvement of innovation
- Improved products/services

Among KM benefits we could also distinguish enhanced collaboration and communication, new knowledge creation, knowledge retention and increased knowledge availability and access [21].

Knowledge management technology is not a single technology, but rather a broad collection of techniques that need to be adopted and integrated [6]. Some of these technologies, e.g. those derived from "artificial intelligence" tools, are not new. Some are useful not only for managing knowledge, but also managing data and information – as is true for intranets and the Web. Relatively to technology, broad repertoires of techniques have been developed [17], namely:

- Personalization: it is the activity of knowledge sharing through person-to-person contacts. This can be facilitated by investment in current IT systems.

- Codification is the activity of capturing existing knowledge and placing this in repositories in a structured manner.
- Discovery is the activity of searching and retrieving knowledge from repositories and databases, such as using the Internet and intranet systems.
- Creation / innovation is the activity of generating new knowledge, vital if an organization is to remain competitive. The role of the human factor is essential and there are almost no indications that it can be substituted by technology, at least in the near future.
- Capturing /monitoring is the activity of capturing knowledge as people carry on their normal tasks such as interacting with other people.

Implementation of IT-related KM can be built on the following cornerstones: Corporate environment, knowledge retrieval and knowledge transfer. Corporate environment refers to utilizing to the maximum extent the intellectual assets of an organization. Knowledge retrieval is mainly enhanced by database and information retrieval technologies, while as far as knowledge transfer is concerned we can identify more than a few degrees of freedom and innovation concerning the potential techniques and technologies that can be applied.

Our approach tries and succeeds in supporting the aforementioned cornerstones by capturing tacit knowledge and supporting the creation of new knowledge through the provision of means that support interaction between human networks of experts [15]. Towards this direction we attempt to exploit GIS and multimedia capabilities, for which we provide support through Java-based applications.

3 Knowledge Processing Systems and GIS

The proliferation of GIS technologies has lead to their exploitation in a diverse set of research fields including KM. Most recent work has concentrated on the development and application of methods and tools for the combination of knowledge processing and environmental informatics through the use of GIS techniques [23]. Moreover, in the area of Knowledge Management, a number of challenges concerning the development of efficient systems, focus on supporting the capture of knowledge through the socialization process [14]. The socialization process can be supported through the capabilities that multimedia applications can offer. It is for that reason that we believe that the parallel use of multimedia operations integrated in GIS applications can enhance the socialization process. This is especially the case in geographically dispersed organizations, where the consequences of distribution of human assets can be minimized through the use of GIS with multimedia-integrated capabilities. This can be achieved by combining the geographically related information (locating the expert) with the capability of establishing contact with her through the integration of multimedia functionality in our prototype.

Worth mentioning examples of systems in the area of environmental informatics with knowledge management oriented capabilities are: the DIWA system [11] aims in maintaining and using a web-archive for environmental documents. Its current version though does not support the use of archived knowledge but only components using explicit knowledge [23]. HIRN (Hypertext Information Retrieval Network) is an internet-based environmental information system for environmental regulations and laws [20]. The basic characteristic of this system is that it demands from the user to

codify manually tacit knowledge so that it can be transferred to other users. These systems as somebody could easily distinguish, implement partially selected explicit knowledge management related activities, lacking the concurrent integration of both explicit and tacit knowledge management activities.

The idea of intelligent maps for knowledge retrieval is described in [23]. With the assistance of intelligent maps, conceptual navigation can be applied [24]. This means that users select geo-objects on the map to define the geographical relationship; the system then returns all knowledge resources, which match this relationship. In a second step, users define textually other relationships to filter the resources of interest. The drawback of this approach is that the query interface would be a mixture of an interactive, graphical interface and a textual interface. The subject tree contains all thematic relationships of knowledge resources, which are indexed with the respective geo-reference. Users select one or more entries in the subject tree to define the thematic relationship for their query.

Multimedia cartography and GIS applicability for knowledge management are described also in [8]. 2-D or 3-D maps are used in a way similar to the use of conventional maps. The aim is to provide a sense of an environment able to provide information retrieval through sophisticated indexing and classification methods.

In our approach the geo-objects are being viewed as a reference to available experts, which upon selection via the map interface, provide through a user interface the ability to acquire further information about the expert's specialization area and specific skills, and upon selection to access the multimedia communication application, acquiring on-line information about specific topics of interest.

4 System Description and Architecture

One of the primary functions of a system that manages knowledge is documented knowledge handling. In order to achieve this, a repository has been created which aims to store codified knowledge. Access to the multiple documents related to the same subject can be facilitated through a search engine, implemented for this specific reason, which has the ability to bring documents related to the keywords provided by the user. Nevertheless, the real challenge is tacit knowledge utilization. Creation of knowledge [17] is one of the vital areas for the organization to remain competitive and the role of the human factor is essential. Our application focuses on providing the means to experts and users to cooperate with each other, either with an asynchronous communication module that enables the communication by users being able to send messages to groups of experts or synchronously by using multimedia components. An additional important factor of the proposed architecture is the multilingual document retrieval aspect that enables the users to search within knowledge repositories and perform specific queries upon them without having to worry about the language considerations (Figure 1). Tacit knowledge is not only exploited at runtime when a user communicates with an expert through the multimedia or the messaging application. We provide support for the recording of this knowledge in order for it to be exploitable in future cases. When such a communication occurs the expert upon completion registers the details of this interaction into a properly defined document (XML is used for this process) and stores it to the Data Store used by the Document Retrieval module. The user has subsequently access to explicitly encoded tacit knowledge.

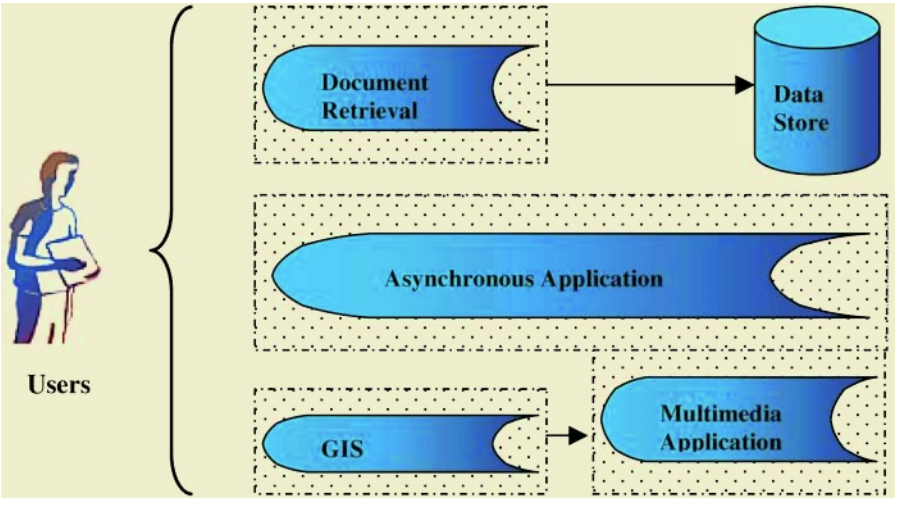

Fig. 1. General description of the KM system

The various knowledge sources that constitute the foundations of the system can be located in the same path or can be distributed throughout a network. The distribution of knowledge sources applies not only to the multimedia, but also to the document retrieval aspect, since documents need not be co-located. To support this feature we have used a simple directory server, where all knowledge sources such as a document database or a knowledge expert's multimedia module register. This architectural notion is borrowed from directory services like Jini [25]. Thus the user actually interacts with the directory server to gain access to a remote knowledge source, though she can view information for a knowledge source before the communication by querying the directory server. Knowledge retrieval and the distributed framework are presented in Figure 2.

The goal of the system is to enable users and knowledge experts to communicate with each other using audio and video techniques in a real-time environment, enhanced by the parallel presence of a GIS component. The user pursues in this way to gain knowledge regarding a domain that she is not aware of. The users are given the capability to select the most appropriate expert to collaborate with through a number of experts being presented in a GIS working space. Thus the user can base her selection in criteria like expert's background and expert availability since this information is made available to the user through the graphical interface that the GIS application environment supplies. In what follows we will present the functionality of the system by means of an example scenario, where a user contacts a knowledge expert and uses real-time, two-way video and audio communication to solve a problem.

Describing the functionality of the GIS environment implemented is considered to be outside the scope of this paper, yet an inexperienced user can consider it to be a type of interactive map. Figure 3 depicts the view of the system, where three different experts are presented on the GIS interface so that the user can select one to communicate with.

If the user clicks on an available knowledge expert's location a popup menu appears that allows the user to either view information regarding that particular expert,

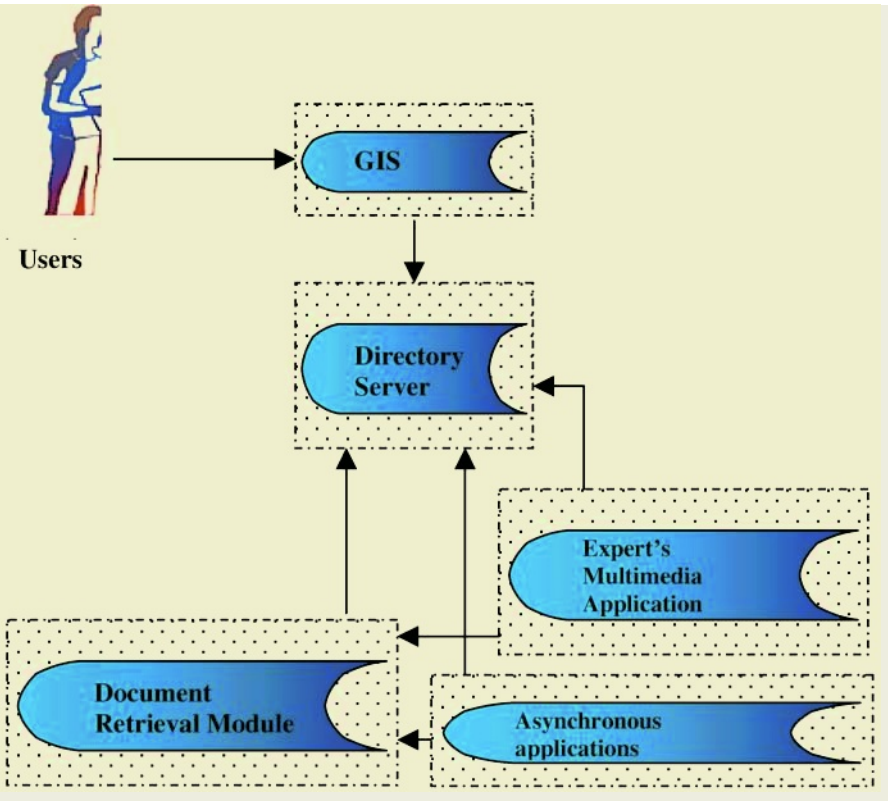

Fig. 2. Distribution Of Knowledge Sources And Knowledge Retrieval Mechanism

or to commence a Live Video conference with the expert. In the case of the latter the system in the background translates the expert's geographic location into an IP location using a custom directory service and then informs the expert that a user is attempting to communicate with her. The next step is for both parties of the upcoming communication to configure the sound and video devices that they will be using.

After having configured the device-related options, the user and the knowledge expert are given the option to set their preferences regarding the video and audio streaming, namely the quality of the received and transmitted streams, the size of the video frames and the volume of the audio input. The communication is now ready to commence. By using the associated controls, the user and the expert can start, pause and stop their live video chat.

To prove our point of view that the convergence of GIS and multimedia technologies with KM techniques can lead in the design of more effective KM applications and tools, we have implemented a prototype system that incorporates the set of the aforementioned technologies. The system is implemented entirely by using Java [13] and can thus be considered as highly interoperable with many diverse platforms, provided that the Java Runtime Environment is installed. The system architecture can be conceptually divided in 4 major components.

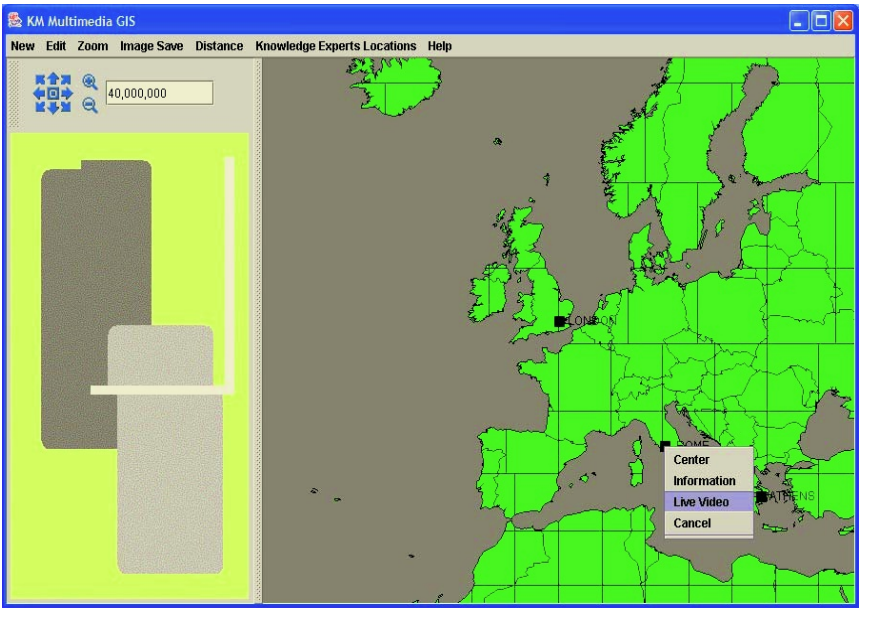

Fig. 3. User interface of the system – GIS Aspect

- KM module
  The KM module is responsible for handling all the knowledge information from various sources, mostly experts around a particular domain. The grouping of the various knowledge fields and the unified presentation of them to the users of the system is a feature that this module is designed to support. Also the KM module provides a means to locate knowledge sources and identifying them, enabling the communication capability with them on behalf of the user.
- GIS module
  The GIS module is responsible for providing the functionality of a standard GIS to the system. The users are capable, through this module, to access multi-layered maps where in conjunction with the KM module, knowledge information is presented as well. The basis for this module is the layered architecture it adopts directly from the GIS background. We have extended the notion of this architecture to encompass layers that are not directly map-related to support knowledge sources representation on the interactive maps. We can identify two sub-modules to this module: the GIS interface and the service module that handles all network connection and discovery issues required for the communication between the knowledge expert and the user.
- Multimedia module
  The multimedia module is responsible for enabling the direct and in real-time communication between the user and a knowledge expert that she has selected through the GIS interface. The communication can be either by Voice over IP or in a more elaborate way it can be a live video chat with the knowledge expert as long as both parties are online. The RTP (Real Time Protocol) protocol is extensively used to enable the best communication possible [22].

- Multilingual Document Retrieval module
  Having assumed that knowledge is codified in semi-structured text documents, this module provides the means to query these documents regarding a certain keyword and responds by returning the documents located on the data store that comply with the search string. A simplistic yet extensible ranking of the documents returned is performed according to the number of occurrences of the keyword. An important parameter to be considered is the multilingual support for this procedure, which can prove to be very significant in geographically distributed environments like the one we chose to view.

Figure 4 describes in detail the architecture and the interactions amongst the modules that were previously mentioned.

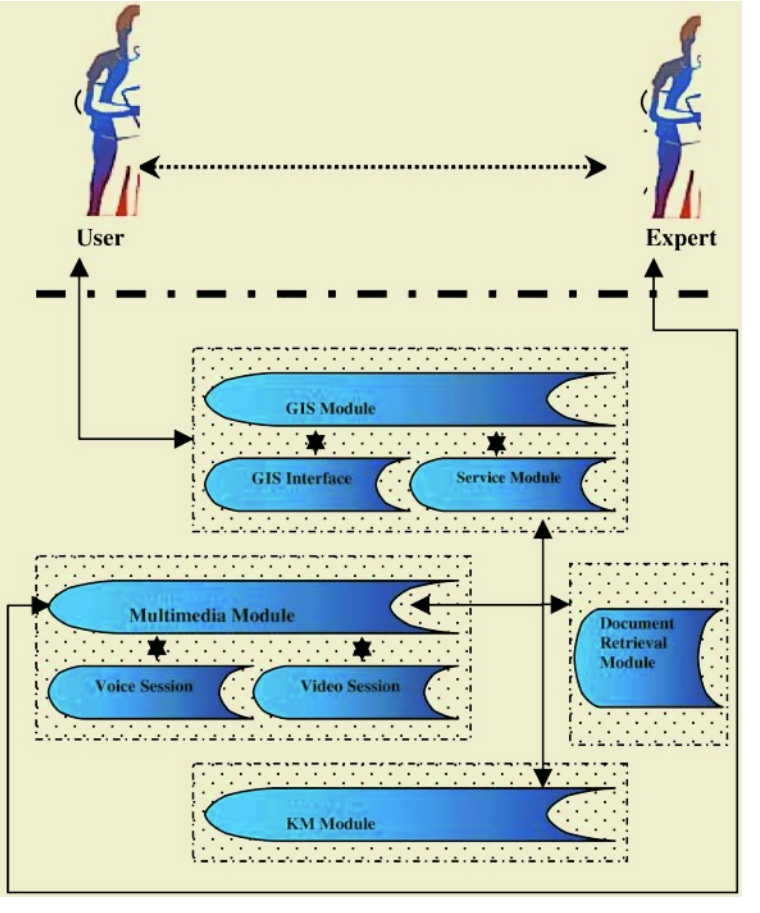

Fig. 4. Detailed Architecture Of The System

The JDK version used for the implementation of this system was 1.3 but tests proved that there is no version incompatibility with more recent JDK releases. The system has been tested on both Unix-like and Windows operating systems. The

graphical user interfaces of the entire system, ranging from the user to the expert and administrator views were implemented using Java Swing. To enable the GIS capabilities of the system an open source Java library from BBN Technologies was used, titled OpenMap [19]. OpenMap is actually a JavaBean Component that was used to enable GIS features in the application. The version of OpenMap used was 4.5 and for the purposes of this specific applications some alterations were made in the original source code in order to accommodate the need to load data on the GIS interactive map through relational databases and XML [9] files. The video and voice communication modules were implemented using the Java Media Framework API [12] and by grasping the benefits of the RTP protocol over the UDP transport, while the KM module is a set of Java classes with no dependency on external libraries.

5 Conclusions – Further Work

The research domain of knowledge management can grasp a plethora of benefits through the use of multimedia GIS. Knowledge management systems enhanced with geographic capabilities presented in a user-friendly manner with the deployment of multimedia techniques can aid users of such systems in extracting and handling knowledge in a more effective way. Two aspects of multimedia GIS systems are fundamental for the amelioration of current knowledge management systems:

- Visual aids
- More practical data presentation

The exploitation of multimedia GIS in knowledge management systems implies the delivery of the data in the knowledge management system that have a geographic perspective (i.e. addresses) in a more concise and helpful way, by presenting them on maps. In this way the user can be assisted in extracting knowledge through the use of the map, by selecting for example to deal only with the information located in her vicinity. The primary concept behind GIS is their layered architecture, where multiple layers are combined and a unique view is delivered to the user. This notion can be easily adapted to the knowledge management realm by providing users of such systems one single view of the whole of the data, rather than projecting a series of varying views usually in a spreadsheet manner like existing knowledge management systems perform. Considering the Human-Computer Interaction factor, this visual representation of data is more effective for users and will subsequently result in higher performance metrics.

In our current system prototype we have used GIS to present the locations of nearby certain knowledge domain experts, with whom the users of the systems can interact using the video / chat system module. Expanding this research to support better and more multimedia options does not lie within our research agenda. We consider this as a mere implementation issue, which can be developed by a group of software engineers. Our prototype serves as a proof of concept and a roadmap to future systems that integrate multimedia GIS capabilities into knowledge management systems.

Our prototype, innovates on combining both GIS characteristics and the possibility of making experts from remote locations available to all organization members. Through the current implementation and the graphical interface, the geo-referenced objects of the GIS refer to expert location and through the distributed multimedia

components experts make their experience available the moment it is needed, in contrast with existing related systems that focus mainly on explicit knowledge reuse.

In our future work we are looking of ways of integrating the notion behind GIS into the knowledge management domain. That is how to combine knowledge into group of layers and visually presenting them to the users, without the necessity of knowledge having a geographic reference. Another index apart from the combination of longitude/latitude can be used to bind knowledge layers and the exploitation of this index can lead to more successful knowledge systems and more efficient knowledge systems users.

Acknowledgments

This work was co-funded by 75% from E.E. and 25% from the Greek Government under the framework of the Education and Initial Vocational Training Program – Archimedes.

References

1. Bell D. (1976). "The Coming of Post-Industrial Society", Basic Books, New York, NY, 1976.
2. Belsis P., Chalaris A., Malatras A., Drakopoulos I. (2004a). ''Supporting the learning process through knowledge based systems". Proceedings of Workshops on Computer Science Education, Jan. 2004, pp. 43-49, Nis, Serbia.
3. Belsis P., Gritzalis S., Skourlas C., Drakopoulos I. (2004b). "Implementing Knowledge Management techniques for security purposes", Proceedings of the ICEIS 2004 conference, vol.2, pp. 535-540, April 2004, Portugal.
4. Bhatt G., (2002). "Management Strategies fro individual and organizational knowledge", Journal of Knowledge Management, vol. 6, number 1, 2002, pp. 31-39.
5. Chase R. L. (1997). "The knowledge-based Organization: An International Survey", The Journal of Knowledge Management, vol. 1, No 1, 1997.
6. Davenport T., S. Volpel (2001). "The rise of knowledge towards attention management", Journal of knowledge management, vol. 5, No 3, 2001, pp 212-221.
7. Derekenaris, G., Garofalakis, J., Makris, C., Prentzas, J., Sioutas, S., Tsakalidis, A. (2001). Integrating GIS, GPS and GSM technologies for the effective management of ambulances. Computers, Environment and Urban Systems, vol. 25 (2001), pp. 267-278
8. Dodge, M. (2000), An Atlas of Cyberspaces http://www.cybergeography.org/atlas/atlas.html
9. Extensible Markup Language Specification (XML), http://www.w3.org/XML/, accessed March 2004
10. Franklin, C. (1992). An introduction to geographic information systems: linking maps to databases. Database, 15(2), pp.12-21.
11. Henning, I., Ebel, R., Tauber, M., Tochtermann, K., Pursche, K., Kussmaul, A., Schultze, A. (1999). Internetbasiertes Dokumentenmanagement heterogener Umweltdokumentbestände, in [Rautenstrauch/Schenk, 1999], pp. 376-388.
12. Java Media Framework (JMF), http://java.sun.com/products/java-media/jmf/index.jsp, accessed March 2004.
13. Java Technology, http://java.sun.com, accessed March 2004
14. Kida, K., Shimazu, H., (2002), ''Ubiquitous Knowledge Management – Enabling an office work scheduling tool to corporate knowledge sharing'', Proceedings of the IEEE Workshop on Knowledge Media Engineering, Japan.

15. King W., Marks P., McCoy S., (2002). "The most important issues in Knowledge Management", Communications of the ACM, Sept. 2002, vol.45, No. 9
16. Mennecke, B., Crossland, M., (1996), ''Geographic Information Systems: Applications and Research Opportunities for Information systems Researchers'', Proceedings of the 29th International Conference on System Sciences, Hawaii.
17. Milton N., Shadbolt N., Cottam H., Hammersley M, (1999). "Towards a knowledge Technology for Knowledge Management", Int. J. of Human-Computer Studies, (1999) 51, pp. 615-641.
18. Muller, J. C. (1993). Latest developments in GIS/LIS. International Journal of Geographic Information Systems, 7(4), 293-303.
19. Open Systems Mapping Technology, OpenMap TM, http://openmap.bbn.com, accessed March 2004
20. Riekert, W.-F., Kadric, L. (1997). A Hypertext-based Information Retrieval Network for Environmental Protection Regulations. Proceedings of the 11th Symposium on Environmental Informatics, Straßburg, Metropolis Pub. Marburg, pp. 475-482.
21. Rus I., Lindvall M., (2002). "Knowledge Management in Software Engineering, IEEE Software, vol. 3, pp.26-38, 2002.
22. Schulzrinne, H., Casner, D., Frederick, R. & Jacobson, V., (2003). RTP: A Transport Protocol for Real-Time Applications, IETF RFC 3550, July 2003
23. Tochtermann T., Maurer H. (2000). "Knowledge Management and environmental informatics", *Journal of Universal Computer Science, vol. 6, no. 5 (2000), pp. 517-536*
24. Veltman, K. H. (1997). Frontiers in Conceptual Navigation, International Journal on Knowledge Organization ISSN 0943-7444, 24 (4), pp. 225-245.
25. Waldo, J. (2000) & The Jini Technology Team, "The Jini Specifications", Addison-Wesley Pub Co., 2000.
26. Polanyi M. (1966). "The Tacit Dimension", Routledge & Kegan Paul, London, 1966.