Using Geographic Information Systems in Knowledge Management Processes

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ABSTRACT

Nowadays, organizations are required to develop quick and accurate responses to internal and external changes that gain momentum. In this context, knowledge management activities become more important to all organizations. On the other hand, Geographic Information Systems (GIS) become common more and more. GIS which address a broad spectrum of users such as public agencies, local communities, civil society organizations, the private sector, academic environment, and personal users have been aiming to solve problems which occurred in location-based areas. GIS are important to get, combine, analyze and transfer the spatial data. Common use of PCs for personal needs, digital geography and improvements of software technologies, also the need to make socially acceptable business decisions facilitated development and widespread use of GIS applications. The main purpose of this paper is to discuss using areas and contribution potentials of GIS in enterprise-wide knowledge management processes.

Keywords: Geographic information system, knowledge management, spatial data analysis

1. INTRODUCTION

Changes in economic and social environment force organizations to continuously improve their processes and activities. Organizations that cannot afford to adapt and develop will be left behind and cease to exist. Continuous improvement requires that the employees continuously develop their skills and knowledge potentials. In other words, continuous improvement requires continuous learning. It is an important requirement not only for small businesses and midsize companies, but also for well-organized international corporations. Organizations can grow, compete in the market, and sustain their competitive position, if they effectively use learning and development as strategic tools. Within this context, if it is assumed that approximately 80 percent of data used to create information and knowledge in enterprises have geographical features (Fitzke & Greve, 2010), then one could possibly say that geography-based information systems can make important contributions for effective knowledge management activities. In other words, GIS which can associate spatial data with attribute data has a substantial potential in knowledge management.

This paper mainly discusses different using areas of GIS in knowledge management processes. In this paper, at first, main knowledge management models which are widely used in theory and practice are considered. After that, a knowledge management (KM) model "the building blocks of knowledge management" developed by Probst et al. is presented in detail. In the next part, the concept GIS is defined and basic information on GIS is imparted. Next, using areas of the GIS in KM processes are evaluated on the base of the KM model mentioned above. Conclusions constitute the last part of the paper.

2. MAIN KNOWLEDGE MANAGEMENT MODELS

The knowledge spiral model developed by Nonaka and Takeuchi consists of two basic types of knowledge: Tacit knowledge and explicit knowledge. "Tacit knowledge is based on personal experiences, cannot be easily implied

and transmitted, and incorporates human-specific factors such as beliefs, perspectives, culture etc, which cannot be clearly interpreted. On the contrary, explicit knowledge can be easily implied, formalized and communicated. The person who has this type of knowledge is conscious of having it and can speak about it". (Nonaka & Takeuchi, 1995; Yılmaz, 2012). According to this model, continuous interactions/conversions between these basic types of knowledge create new organizational knowledge. There are four interaction/conversion modes between tacit and explicit knowledge. These are *socialization, externalization, combination,* and *internalization*. In socialization, tacit knowledge is converted into tacit knowledge through social interactions or experience sharing activities. In externalization, tacit knowledge is converted into explicit knowledge in a repository. In the third interaction mode, combination, explicit knowledge is converted into explicit knowledge, where it is extended with other explicit knowledge assets. In the last mode, internalization, explicit knowledge is converted into tacit knowledge by the associated person or group (Nonaka & Takeuchi, 1995).

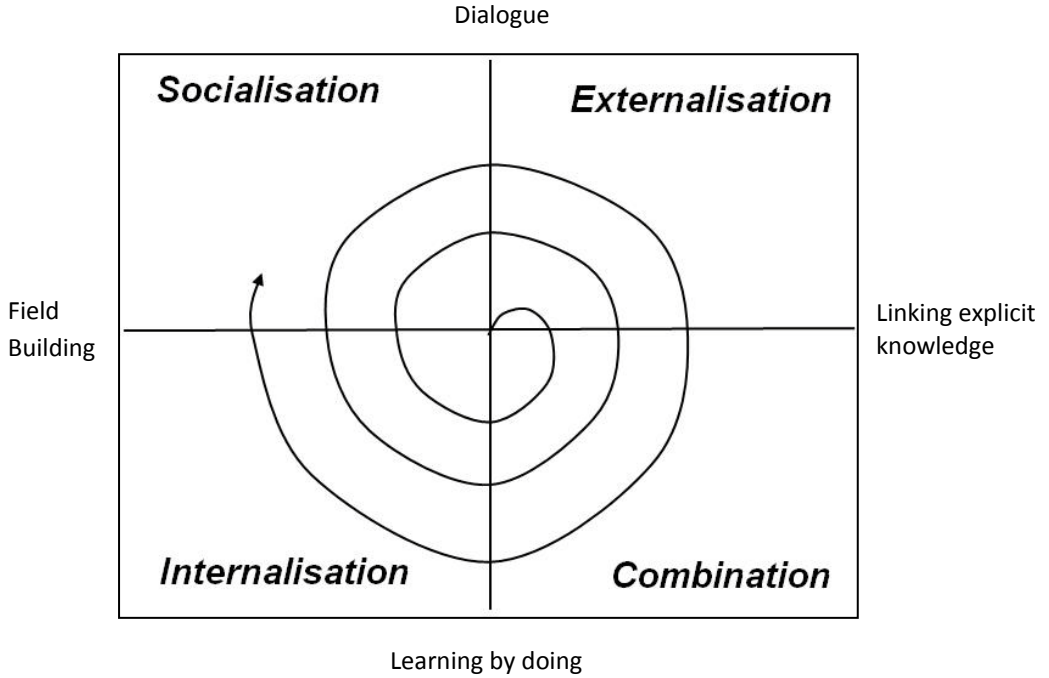

Figure 1: The Knowledge Spiral Model
(Nonaka & Takeuchi, 1995)

Huber (1991) defines four constructs which are related to KM: Knowledge acquisition, information distribution, information interpretation, and organizational memory. In the model proposed by Turner and Makhija, which was developed on the base of the former work of Huber (1991), Grant (1996), Szulanski (2000), and Thomas, Sussman, & Henderson (2001), KM consists of four processes. These are: Knowledge creation and acquisition, the transfer of knowledge to other individuals or organizational units, the interpretation of this knowledge in a manner conducive to the objectives of the organization, and the application of the knowledge toward organizational goals (Turner & Makhija, 2006). A KM model which has similarities with the model of Turner and Makhija was developed by North. The model consists of five phases, namely knowledge procurement, knowledge development, knowledge transfer, knowledge adoption, and further development of knowledge (North, 2005).

In this paper, in order to better describe the using areas of the GIS in KM processes, the relevant areas and contributions are examined on the base of "the building blocks of knowledge management" developed by Gilbert Probst, Steffen Raub and Kai Romhardt. Gilbert Probst states "To build a solid base for the development of a practical model of knowledge management, in June 1995 we founded the Swiss Forum for Organizational Learning and Knowledge Management at the University of Geneva. This Forum is a platform for practitioners who consider knowledge a strategic resource and a central tool for protecting their competitiveness... While there is no single "right" model of knowledge management, there is a simple criterion for evaluating any model: how useful is it in relation to a chosen question? Our model, which we think of in terms of building blocks of

knowledge, was developed with this criterion firmly in mind, in close dialogue with practitioners..It has proved its usefulness in many kinds of organizations" (Probst, 1998). The Building Blocks of Knowledge Management consists of eight building blocks. The model has an inner and an outer cycle. The inner cycle consists of six building blocks, namely identification, acquisition, development, distribution, preservation, and use of knowledge. They are called the main processes of knowledge management. Through the other two building blocks, knowledge goals and knowledge measurement, the model is represented as a management loop (Probst et al., 2006).

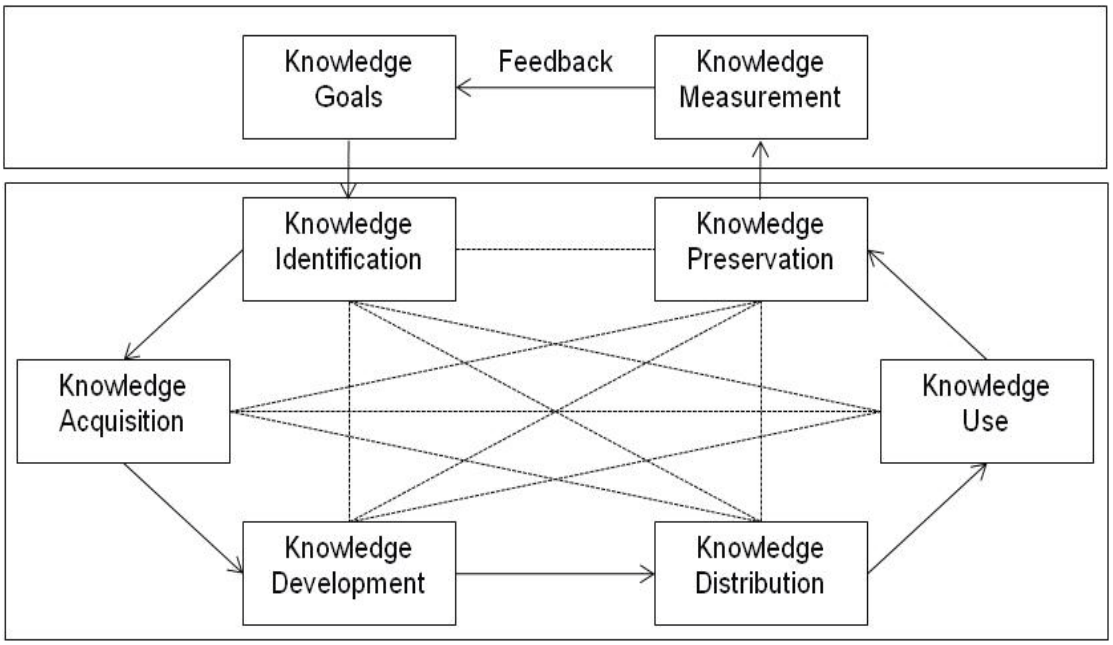

Figure 2: The Building Blocks of Knowledge Management
(Probst et al., 1998)

In the building block of *knowledge goals*, it is defined which capabilities are going to be built in which level. In other words, within knowledge goals the relevant objectives are determined. These objectives are expressed as required capabilities. After the relevant objectives respectively the knowledge assets are determined, it is analyzed which of these assets are available in the organization (*knowledge identification*). Besides, the external knowledge-environment of the enterprise is analyzed and described. In other words, within *knowledge identification* internal and external transparency about existing knowledge assets is provided (Probst et al., 2006; Romhardt, 1998). To provide this transparency and support employees in knowledge-seeking activities, different tools such as knowledge maps, yellow pages, and GIS are available (Probts et al., 2006). The gap between the needed knowledge assets described in knowledge goals and existing assets described in knowledge identification can be bridged by obtaining them from external sources such as knowledge markets, stakeholders, other enterprises, etc. or developing them in the enterprise. Obtaining the needed knowledge assets from external sources is called *knowledge acquisition*, whereas internal development is called *knowledge development.* Within the building block of *knowledge development*, it is aimed at the development of new abilities, new products, better ideas and more efficient processes (Probst et al., 2006).

Apart from department of research and development, or market research of an enterprise, it should be considered that critical knowledge for the entrepreneurial success can also develop in other fields, such as logistics, IT, and finance (Romhardt, 1998). *Knowledge distribution* should ensure that the acquired/developed knowledge assets are available to the associated action/decision instances in the enterprise. Further, herewith it should be described who needs to know what, to what level of detail. In enterprises, everything must not be known by everyone. Through knowledge distribution, experiences are shared and interpreted, simultaneous knowledge exchange is realized, thus, knowledge can directly be created. *Knowledge use* can be defined as the

ultimate goal of knowledge management. If the identified, acquired/developed, and distributed knowledge cannot be effectively used in daily transactions, then it would mean that the knowledge objectives could not be achieved. Therefore the barriers restricting the using of new knowledge, such as habits, refusing new/external knowledge, etc. have to be overcome (Probst et al., 2006). "The potential user of knowledge has to see a real advantage in order to change his or her behavior and "adopt" the knowledge." (Probst, 1998)

The next building block is called *knowledge preservation*. During reorganization processes, lean management activities, and outsourcing, an important part of the corporate memory might be lost. Therefore, important and valid knowledge assets/capabilities must be accurately selected, suitably saved, and regularly updated for future use. At the end, the enterprise must measure the success of its KM activities. *Knowledge measurement* is one of the most important challenges for knowledge management activities in enterprises. Main reasons causing this problem can be explained as follows: Compared to other management approaches, such as TQM, KM is a new approach. Therefore, knowledge management specialists mostly have no proven toolbox and measurement methods. Besides, knowledge is a human-based construct and has a specific meaning only under specific circumstances. In other words, the subjectivity of knowledge and its context-dependency must be considered in knowledge measurement activities. Further, an effective knowledge measurement system requires that from all associated fields across the enterprise data/information is gathered, processed and assessed. After this process is applied in relation to the knowledge goals determined in the first building block, different conclusions can be drawn for these goals. This feedback also means that the model represents a continuous loop which never ends (Probst et al., 2006; Yılmaz, 2010).

3. GEOGRAPHIC INFORMATION SYSTEMS

In the literature there are a large number of definitions of GIS (Dueker, 1979; Ozernoy et al., 1981; Burrough, 1989; Smith et al., 1987; DoE, 1987; Parker, 1988; Tomlin, 1990; Maguire, 1991; Gaffney & Stancic, 1991; Burrough & McDonnell, 1998; Wolf & Dewitt, 2000). In this part, the definition made by Bill and Fritsch is used. According to this definition, GIS is a computer-supported system which consists of software, hardware, data, and applications. According to the relevant point of view and the associated meaning, GIS can imply a technology, a product, or the acquisition of geographic data. With the help of GIS, geographic data can be digitally collected, organized, stored and reorganized, modeled, and analyzed (Bill & Fritsch, 1994). At the same time, these data can be alphanumerically and graphically presented. In the last step, the results of analysis of enterprise data are visually customized to evaluate them and to create knowledge. GIS can be defined as an analytical tool which analyzes existing geographic data, or creates new geographic data within these analyses.

In relation to GIS, there are two main data types. These are spatial data and nonspatial data. Spatial data are mostly known as lines or symbols on maps, or pictures on photos. These data were created because of natural or cultural events. In GIS, these data are digitally positioned and as spatial objects (simple spatial objects) in form of vector or raster graphics visualized. There are points, lines, polygon(s), pixels and raster cells between these spatial objects (see figure 3).

Spatial data are associated with each other with the help of spatial references. This process is called geocoding (see figure 4). In other words, geocoding means positioning the addresses or spatial objects on the map. In order to do this, for each address coordinates are assigned, and so the addresses can be accurately positioned on the map.

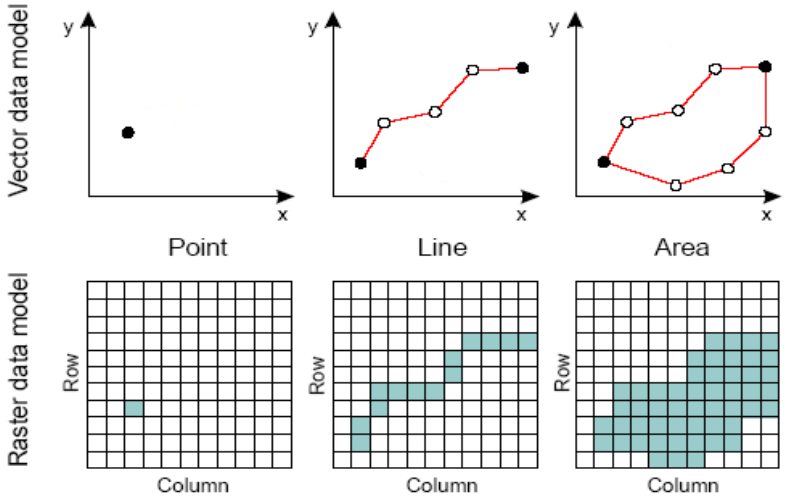

Figure 3: Spatial Data
(Oceanteacher, available at: http://library.oceanteacher.org/OTMediawiki/images/c/ca/GISraster_vector.png, accessed 11 July 2012)

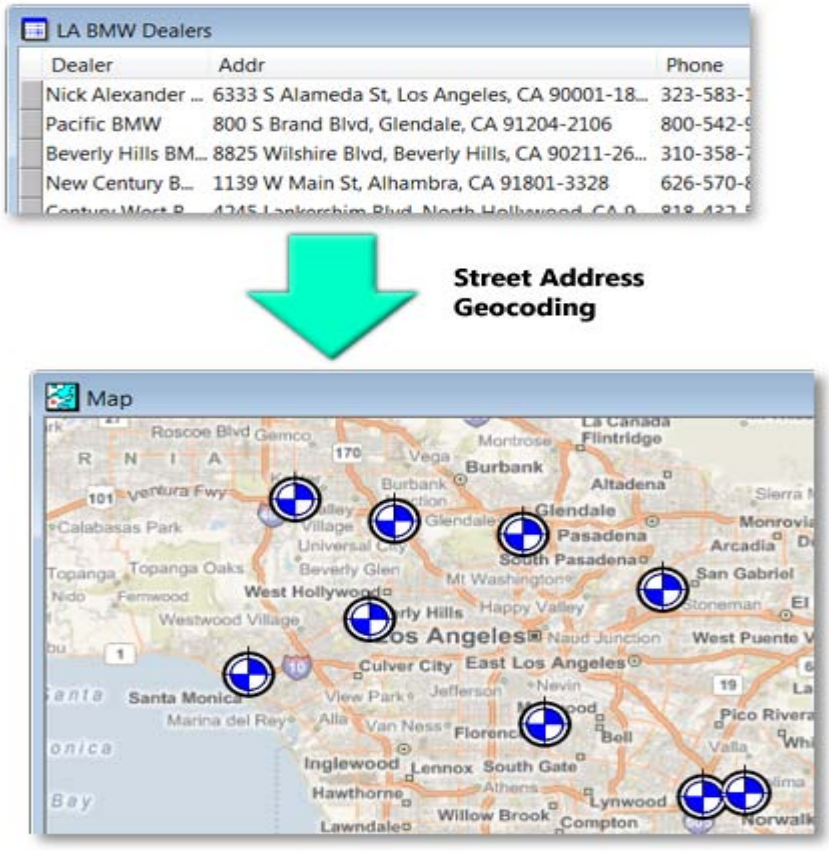

Figure 4: Geocoding
(Manifold®; Manifold® Geocoding Tools. available at: http://www.manifold.net/info/geocoding_tools.shtml, accessed 29 July 2012)

As a consequence, through using GIS-functions new information can be derived. This information enables enterprises to carry out new analyses, and to make new queries and evaluations on specific issues.

Nonspatial data, also known as attribute data, describe geographical zones or define characteristics of spatial objects. For example, the salary or age of a customer residing at a specific address are attribute data, whereas the address itself is a spatial data. The most important component of the GIS is the so-called geographic database. This database ensures that spatial data and attribute data are associated with each other.

The economic success of enterprises depends on a large number of different factors. In today's business world, data, information, and knowledge-based factors become more and more critical. Therefore, enterprises must have comprehensive, consistent, and significant data on their markets and customers. Further, they must use these data in compatibility with other data/information in their value creation processes. This requires that distributed stored data are brought together, intensified, associated, and visualized, because data stored in tables cannot be easily understood and evaluated. If it is assumed that approximately 80 percent of data in enterprises have geographical features, then one could possibly say that transfer of data/information stored in tables into GIS is quite important for companies to make improvements in their strategic management activities.

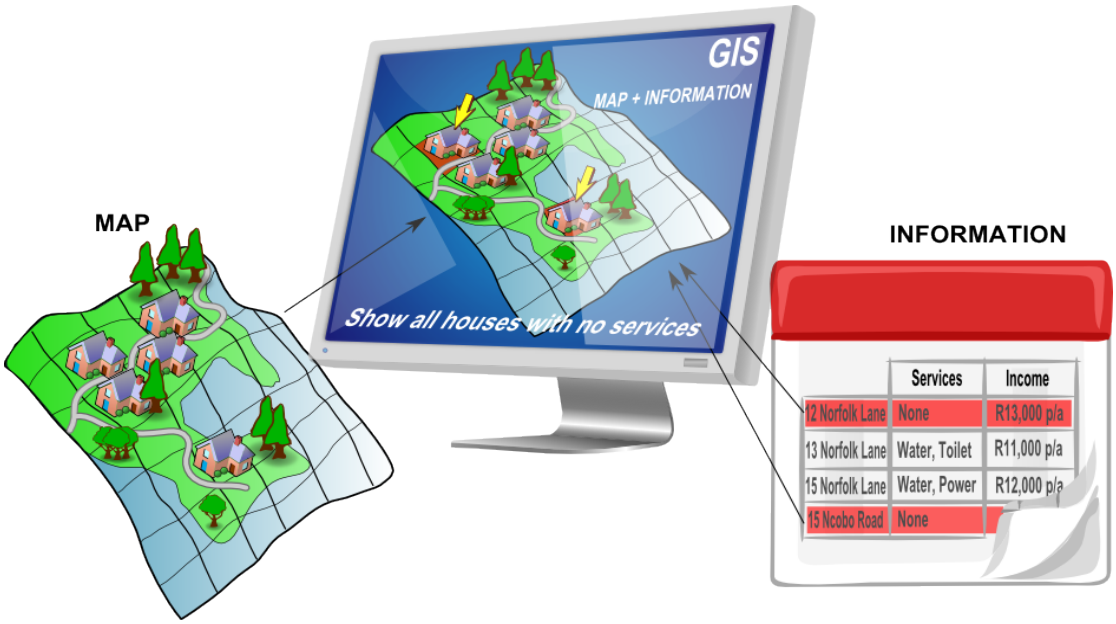

Figure 5: What is GIS?
(ecsecc, What is GIS? available at: http://www.ecsecc.org/spatial-explorer/what-is-gis, accessed 30 July 2012).

Main functions of GIS in enterprises can be stated as follows: (1) to process huge amounts of data, (2) to transform them into information, (3) to associate them with data of different systems, such as customer information systems, logistics tracking systems, order tracking systems, market analysis systems, etc. (4) as a result of these functions, to create knowledge for enterprise strategies, tactical steps, marketing activities, logistics support and sales support. To carry out these functions, the so-called "layer-concept" which is at the base of GIS is used. According to this, on an empty field map different application shells containing alphanumerical and graphical data are placed one above the other. GIS organizes spatial data in thematic layers and table sets. With geographic referencing, spatial data available in GIS get a real-world position, so they imply more than a table.

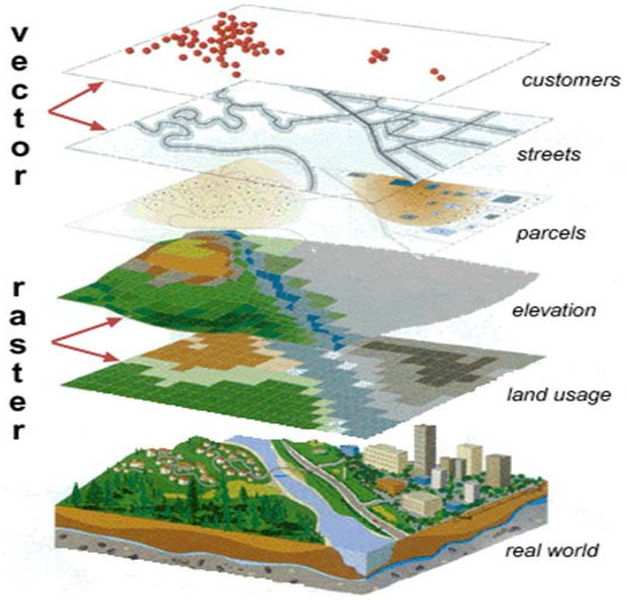

Figure 6: Layer Concept of GIS
(Buibas, M, GIS Assignment. available at: http://www.neiu.edu/~mbuibas/391/gis_concept_link.jpg, accessed 30 July 2012)

4. USING AREAS OF THE GIS IN KM PROCESSES

In this part, using areas of the GIS in KM processes are evaluated on the base of the model the building blocks of knowledge management (Probst et al., 1998; Probst et al., 2006). As previously mentioned, the first and last building blocks, knowledge goals and knowledge measurement, transform the model into a management loop. Therefore, hereafter only the main processes, knowledge identification, acquisition, development, distribution, preservation, and use are focused on in relation to relevant contribution potentials of the GIS in them.

4.1 Knowledge Identification

Before huge investments are made to gain new capabilities, knowledge assets available inside and outside of the enterprise should be determined. In today's business world, many enterprises experience problems regarding transparency. In other words, they cannot efficiently track their knowledge assets and capabilities. As a result of this, wrong/inadequate decisions are made because of insufficient data/information, and some activities are redundantly carried out. Therefore, first, enterprises should determine the level of existing internal and external capabilities. In order to do this, GIS can provide important contributions. If it is assumed that approximately 80 percent of data in enterprises have geographical features, then one could possibly say that spatial data and attribute data on different issues can be stored in separate databases. After that, through the GIS these data can be topographically visualized.

This contribution can be better understood by examining a simple case: An enterprise producing diapers wants to develop a new product to increase sales. The success of the new product depends on the fulfillment of requirements of existing customers. Here, important questions arise, such as: Where do the existing customers whose requirements will be considered live? How much do they earn? How old are they? These questions can be answered with the help of data stored in tables in databases of the enterprise, but it is also possible to use a single cartographic map including all this information. With GIS, all existing information can be displayed on a map. If the relevant field on the map is clicked, then one can see all existing information on customers located in that field. Through the "white spots" on the map, following information can be seen at a glance: Fields where

there is no customer, the geographic distribution of customers with low income, and distribution of young customers.

In the figure below, each pin represents a customer, where red pins represent customers with high income, and green pins customers with middle-level income.

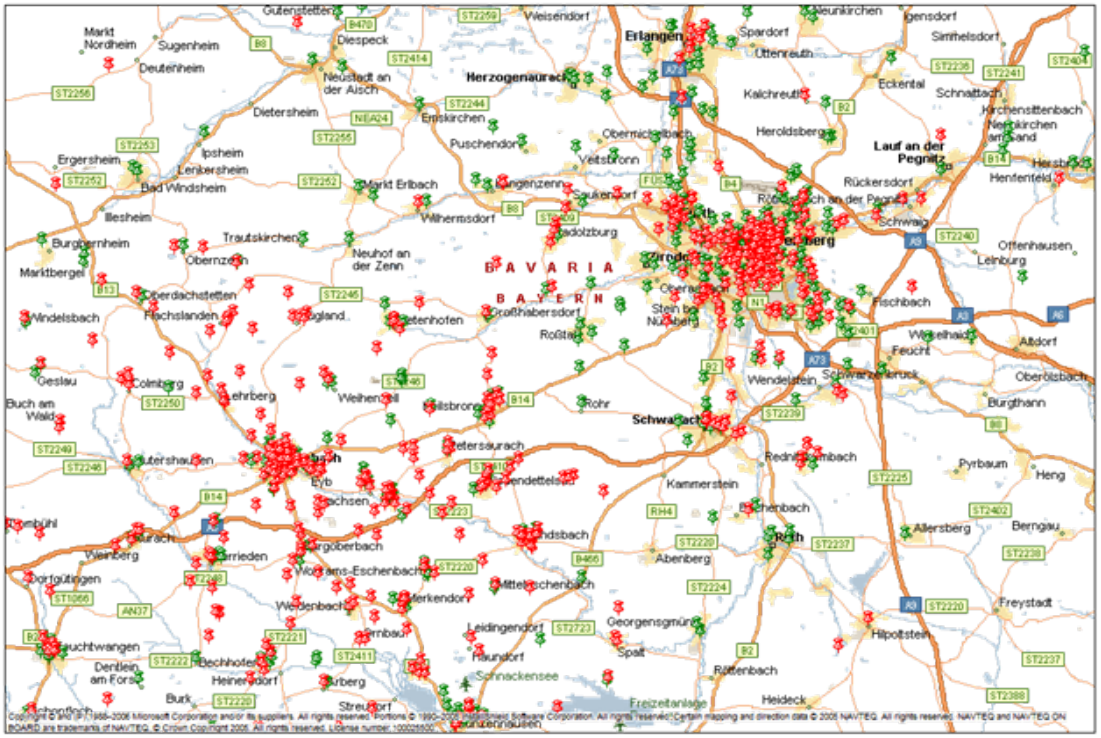

Figure 7: Visualizing Customer Data with GIS
(KARAS, available at: http://www.karas-getraenke.de/index-Dateien/KarasKunden2008.htm, accessed 1 July 2012)

4.2 Knowledge Acquisition

With the help of Web 2.0, GIS become more dynamic and open. Today, individuals come together under virtual communities, and so they create important information containing location-based components. Social networks and modern IT systems enable customers, suppliers, and employees to communicate with each other, and exchange their views on different issues, such as enterprises, products, etc. Therefore, if enterprises build platforms for "corporate GIS", then communication process can easily become more effective and efficient. Through this platform, customers, suppliers, and other associated stakeholders acquire information on location-related issues, and make discussions, which would mean that the enterprise acquires information from their external stakeholders. In this way, the enterprise can have a more clarified view in relation to unidentified or urgent problems, and customer requirements.

For example, the Municipality of Cologne (Germany) has built a successful interaction platform for its citizens. On the GIS-supported platform called „Unortkataster Köln", citizens living in Cologne can make location-based marks regarding problems of the city on the plan of Cologne. Furthermore, the citizens can define the problem, and evaluate it. The question whether the "problem point" determined and marked by a citizen is also valid for other citizens in the same region can be evaluated by „Unortkataster Köln". The principle lying behind this concept is the idea that the citizens of a region have valuable local information. In this way, the citizens are involved in work in the phase of design of city planning.

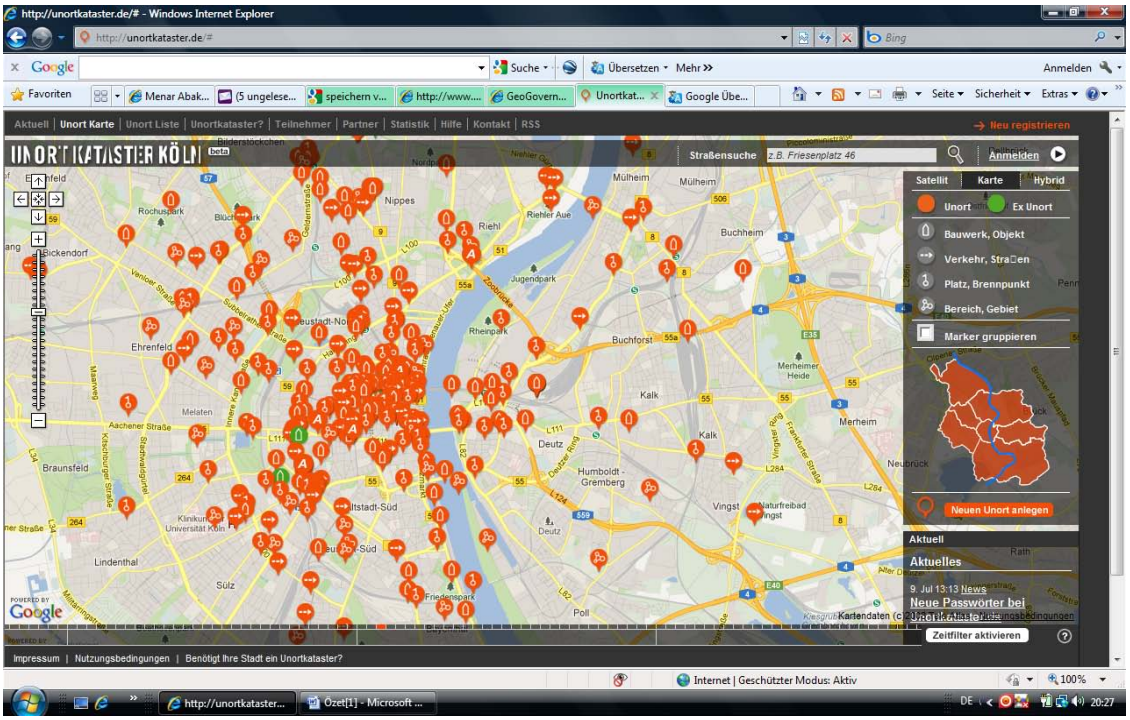

Figure 8: "Unortkataster Köln"
(Unortkataster Köln, available at: http://unortkataster.de/, accessed 25 July 2012).

4.3 Knowledge Development

GIS is a decision support system. GIS enable enterprises to transform and combine attribute data and spatial data (raw data), to analyze them, and to visualize the results of analysis through maps with the help of cartography. Considering the enterprise above, which produces diapers, it aims to increase revenue and profit. In order to achieve this aim, it plans to produce diapers for young, high educated families with middle-income. If it can determine the regions of the country where young, high educated families with middle-income are located, then one could possibly say that the enterprise would gain knowledge on the market where the new product would be successful. GIS enables the enterprise to develop this knowledge. The map created by the analysis of target regional market is the developed knowledge. Thus, with GIS knowledge is developed.

Figure 9: Analyzing the Target Customer Group with GIS

(GfK Geomarketing; Optimizing car dealership locations based on potential levels. available at: http://www.gfk-geomarketing.com/en/customer_magazine_enews/gfk_geomarketing_magazine/042008/optimizing_car_dealership_locations_based_on_potential_levels.html, accessed 29 July 2012)
With GIS, not only for marketing department, but also for logistics department through route planning, and for finance department through risk analysis new knowledge can be developed.

4.4 Knowledge Distribution
In relation to knowledge distribution, electronic mail is nearly an obsolete method of distribution. According to estimates, approximately 89-97% of e-mails daily received by a person are spam mails. Today, state-of-the-art distribution tools are Instant-Messaging, Skype, Twitter, Facebook, etc. In other words, in communication activities long sentences written in e-mails are not preferred, but on the contrary, short sentences and interactivity. Thus, cartographic images are very useful in this communication environment. Instead of huge statistical data, thematic maps derived from these data enable persons to understand the issue at a glance. Besides, PowerPoint-presentations cannot be understood, if font size or font character is small. Instead of long sentences written in e-mails, cartographic thematic maps can be used to distribute the same knowledge. In other words, maps are small and compact knowledge stores. Knowledge and maps developed by GIS, also used data, can be distributed via social networks. Alternatively, these assets can be shared with internal and external customers who need them through an interface (Ladstaetter, 2012).

4.5 Knowledge Use
As mentioned above, spatial data available in GIS are associated with each other through spatial references. This process is called geocoding. Through using GIS-functions, new knowledge can be derived from these spatial data which are geographically coded. Furthermore, it is possible to make new queries, analyses and evaluations by incorporating them again as information into the GIS. Therefore, GIS have the ability to reuse the “intermediate knowledge” which it developed by itself as an information, thus it also has the ability to create new information and knowledge.

4.6 Knowledge Preservation
Different knowledge-based tasks in enterprises are carried out by different employees in associated departments. For example, the most intensive knowledge on customers is acquired by customer representatives who act as the first/primary point of contact for customers, or by employees working in after sales services. All the information assets might easily be lost in enterprises, where the circulation of personnel is high, or in large enterprises, where the hierarchical structure is very “deep”. In relation to small and medium enterprises, if some employees resigned, then a substantial part of valuable knowledge might be lost, which means a managerial problem. With using GIS, “locatable knowledge” can be passed on from generation to generation.

CONCLUSIONS

KM processes and activities have always been critical factors for the sustainable economic success of enterprises. On the other hand, organizational learning can be considered as the *modus operandi* of KM. In today’s business world, only the enterprises that are more creative, dynamic, and flexible than their competitors will stand out. In order to do this, organizations are required to have more effective KM and organizational learning processes, management systems, and technical tools. In other words, in today’s knowledge society, where knowledge-intensive intelligent products are manufactured and consumed, effective KM and organizational learning activities become vital for all kinds of organizations.

To manage knowledge effectively, a large number of KM models have been used in theory and practice. Among commonly used models is The Building Blocks of Knowledge Management developed by Probst et al., which consists of eight building blocks interacting with each other. Although GIS is an enterprise decision support system which can process spatial and nonspatial data, it is also a technology which can be used in realization of all (six) main building blocks of the model mentioned above to enable and support knowledge-based activities. In other words, if enterprises build GIS, then they can facilitate their KM and organizational learning processes, and carry out more effective activities both on individual and collective level.

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