The Art of Management and the Technology of Knowledge-Based Systems

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Abstract. Explicit knowledge is successfully transferrable into computers. As the consequence of this, we have today at hand various knowledge and expert systems. The talk provides a short overview of some basic steps towards the actual situation. Then it focuses to the role of management for effective dealing with knowledge, and to the role of special kind of knowledge – the knowledge of management. A new type of knowledge storing and processing technology, resulting in specific type of knowledge-based systems – the *Knowledge Managing Systems* – is proposed as a computer-based support for activities which form at least some part of the Art of Management.

Keywords: Workmanship, knowledge, knowledge-based systems, ontology, management, knowledge management, knowledge managing systems.

1 On the Structure of Workmanship

During the run of the historical time, the originally unstructured general knowledge has been structured according various profession, for instance, divided into several types supporting different capabilities and activities (like the common-sense knowledge, specialized experts' knowledge, craftsmen' skills, leaders' managing abilities) etc. One type of knowledge is in our times successfully transferrable into our present time computers. As the consequence of this possibility we have today at hand various knowledge-based and expert systems for improving the quality of many of our problem-solving, decision-making, diagnostic, planning, etc. activities.

The contribution provides a short overview of some basic steps towards the actual situation. Then it will focus to the role of management for effective dealing with knowledge, and to the role of special kind of knowledge – the knowledge of management.

A new type of knowledge storing and processing technology, resulting in specific type of knowledge-based systems – the *Knowledge Managing Systems* – will be then proposed as a useful, and perhaps also as an effective enough computer-based support for improving the quality of activities which form at least some part(s) of the Art of Management.

The workman's state of being a perfectly informed and skilful in his profession, in other words his *workmanship*, is a phenomenon which has been very closely related with the human knowledge for several thousands of years of human civilization.

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However, the notion of workmanship covers something more then *to know* something only. From the perspective of applying of knowledge workmanship can be divided into two equally important parts (Drucker, 2007, Chapter 5): to professional *knowledge* and to craft *skills*. The third, for centuries hidden, capacity of all masters and craftsmen, it is their competency to *organize* the effective production and efficient sale of their goods. This activity has been in 20th century's economy denoted by the trendy word *management*.

In the next sections we analyze the structure of knowledge as well as that of the skill. We concentrate to their mutual interrelations, as well as to the relation of both of them to computing, in particular to their functions in knowledge (of knowledge-based) systems.

Moreover, we will show the way how the transfer of the knowledge processing to computerized *knowledge-based systems*, and the possibility to transfer (some of) skill to automated technological processes – to *robotic systems* in particular – prepares conditions for the growth of the role of managing knowledge – for *knowledge management*.

2 On the Structure of Knowledge and Skills, and the GOFAI

Expert's specialized knowledge and skills about some field of human activity – or, using an obsoletism, any *workmanship* – is internally complicated body of rules, taxonomies, uncertainties, conditionings, exclusions, motor skills, etc. To become an expert in the particular field supposes to be well and deeply oriented in all of these aspects. To accelerate such a preparation requires dividing the general knowledge into the smaller and simpler parts, to some "nuggets" of knowledge, or, in other words, to (a finite number of) *pieces of knowledge*. Complicated (and just mentioned) relations between these pieces of knowledge form then the whole knowledge on the given field of expertise.

The skill related to any workmanship can be also divided into simpler elementary parts. We will call these parts of skill as *operations*, because they are the basic "building blocks" of any complicated modes of operations based and closely related with any master knowledge.

In order to relate operations with pieces of knowledge, let us realize one among the basic moral from the traditional artificial intelligence research, one among the corner stones of the so called GOFAI (the Good, Old Fashioned Artificial Intelligence) as presented in several university course books, e.g. in (Winston, 1977): Let us characterize the knowledge (as well as the pieces of knowledge) by its three basic attributes – its declarability, its procedurality, and its associability.

The attribute of declarability means that any knowledge is expressible in certain rigorous form of syntactically correct symbol structure, so it is symbolicaly representable. The representability of knowledge is in fact the base of its use in any traditional GOFAI systems (expert systems, knowledge-based systems).

Another attribute of knowledge is the ability to connect each piece of knowledge by another pieces of knowledge in order to express (to represent) their contextual interrelatedness, or in other word, to associate knowledge pieces which some other semantically connected pieces. This is the attribute of *associability* of knowledge. It

such a way, the semantically interrelated, associated, pieces of knowledge forms a network-like structures usually called in GOFAI as associative or semantic net(work)s and today known as one among the conceptual base for creating and application of the so called *ontologies*.

The attribute of *procedurality* refers to the possibility to manipulate the pieces of knowledge. Such manipulations may transfer them into new object(s) – the new pieces of knowledge – with their new relations to their "origins" and, possibly, to other pieces of knowledge.

Because each piece of knowledge has to reflex all of the three inevitable attributes – its declarability, associability, and procedurality – it can also be associated with some basic elementary skill(s) of its use or application. For the same reason, *operation*(*s*) related to each piece of knowledge can be expressed by procedures dealing with this piece of knowledge. Note in this context that the equality between the number of pieces of knowledge (forming the general knowledge related to some mastership) and that of the operations (into which the expert skill is divided) is not accidental.

The emphasis put to one particular attribute leads to a particular type of knowledge representation structure. The *declarability* resulted in declarative representation schemes like rules successfully used perhaps first in the field of artificial intelligence by A. Newell and H. A. Simon (Newell, Simon, 1972) or formalisms and programming tools based on formal logics and automatic theorem proving, like the famous systems, in fact a declarative programming tool, PROLOG, etc. The *associability* has resulted – as we have mentioned already – in associative networks, and the *procedurality* in different types of procedural representation schemes, like Hewitt's Planner, developed for experimentation in robotics at the former MIT AI Laboratory (Hewitt, 1972).

The effort to integrate the positive sides of all previously mentioned representation schemes, as well as to integrate them into a representational scheme of some other aspects of knowledge, like *uncertainties* (to the development of practically useful, and formalized enough methods of expressing formally and processing uncertainties the field of *computational intelligence* contributed significantly, e.g. by developing different fuzzy approaches) or *default values* (like different kinds of expectations usually related e.g. to stereotypical situations, and different types of commonsense knowledge) etc., led during the 70ties of the past century to different variations of schemes more or less similar to, but in basic principles almost identical with, the *frame representation* scheme as proposed in (Minsky, 1975) having different particular forms like *scenarios*, *scripts*, later *objects* used in the framework of the *object-oriented programming*, etc.

3 Knowledge Systems in Short

As we have already mentioned, some of the pieces of knowledge can be represented more straightforwardly in different representational formalism. Perhaps the most usual in the computerized *knowledge system* (*knowledge-based* or *expert* systems are expressions for denoting the same) are production rules. This representational scheme is usually considered as declarative one. An important consequence of the decision to use declarative representational schemes is the necessity to generalize the procedural parts of the represented knowledge, end include them in their universal form into the

general computational procedures forming the so called *inference engines* (a kind of interpreters of represented knowledge) of the knowledge systems. In the case of using more sophisticated representational schemes, however, for instance Minsky's frames, considerable part of the procedural knowledge can be expressed as part of the representation of the pieces of knowledge in frame systems, forming the representation of the whole general expert knowledge.

In any case, we are in present days faced with a situation when we have at hand sufficient representational schemes to represent (almost) all attributes of the required knowledge, and the knowledge systems are able to solve particular expert problems in the acceptable level of expertise; for more detail see e.g. (Stefik, 1995).

We can realize now that the knowledge representation as well as the exploitation of the knowledge – the use of necessary skill providing successful problem solving on the base of represented knowledge and using suitable inference engines – are activities executable using well programmed computers with a working *inference engine* and "stuffed" with a suitable amount and quality of input data (by *base of facts* describing the particular problem, and a *knowledge base* enable to knowledge systems to solve it). These activities are usually covered by the term *knowledge engineering*; for details and relations with knowledge management see e.g. (Schreiber et al., 2000).

The only part of the workmanship, unmentioned up to now I n our consideration concerning the influence of information technologies to functioning of knowledge in production process, is the *management*. We will continue with it in the following Section.

4 Knowledge Management and Knowledge Managing Systems

The rapid progress in developing and application of information technology, esp. the progress in the fields like information systems development, and the growing field of application of knowledge-based systems in different areas of the research, industry and administration caused that the problems concerning the right management of knowledge becomes perhaps equally (but might be in some branches of professional activities more) important topic as the knowledge acquisition and knowledge-based problem-solving. The reason is obvious. Despite the enormous size and number of applications exploiting computerized knowledge, there is a wide area of knowledge that cannot be so easily captured and expressed in the form of pieces showing features of declarability, associability or procedurality to the degree that would allowed their (fully- or semi-) automated manipulation.

Knowledge management means in our context – similarly to (McElroy, 2003) – the large spectrum of activities connected with management of company's shared knowledge in the meaning of corporate knowledge decomposition, distribution, innovation, acquisition, accessibility, preservation, etc. The activities connected with satisfying of such requirements form the relatively traditional meaning of knowledge management. They are performed perhaps in all of the enterprises as the corporate knowledge is an important part of their function.

The direct use of the knowledge is often shifted to information technology – to knowledge-based (or knowledge-) systems. However, in connection with the use of knowledge-based systems some new kinds of problems appear. The solution of these kinds of problems requires some specific knowledge of management, and skills, too:

It is necessary to know how to organize the right conditions for effective and high quality knowledge acquisition process during the development of knowledge-bases of knowledge systems. It is necessary to organize the work of knowledge systems in the right way with respect to the requirements of users in different positions in the organization (often from the top management up to the product of technology engineers or technical support staff). The knowledge about why, when, and how to change the knowledge bases of knowledge systems used in the company or institution is necessary, etc. This is the second meaning of the knowledge management, specific for the enterprises which exploit the knowledge systems support.

Up to now, the transfer of activities specific for knowledge management to knowledge systems is rare. However, we see that this knowledge has – at least from the computational point of view – practically the same character as other knowledge already processed by computer-based knowledge storing and processing systems. The difference consists only in the problem space, but this fact has no crucial importance for an effort to develop specialized knowledge-based systems for storing and use of the knowledge necessary for (at least parts of) the activities important for the practice of knowledge management.

So, for the future, the discovering and developing technologies for construction and right use of computerized systems which will support knowledge management activities and will solve real problems of knowledge management practice – some kind of computerized *knowledge managing systems* (KM Systems, for short) – seems to be a promising field of research and engineering in computerized knowledge processing.

Because of the growing role of the knowledge management in the enterprises functioning, and the amount of specific knowledge and skills required from knowledge managers, it seems to be effective their specialized university level education, which provide not only the basics of the management in general, but complete their professional profile by knowledge and skills specific for the activities connected with managing knowledge in specific social and economic conditions of the *information* and *knowledge society*. For economic aspects of both see e.g. (Foray, 2004), end for first information on university education of knowledge management see (Kelemen, Hvorecký, 2008).

5 The *Gratex Knowledge Office* – An Example of a KM System

According to the common experience, up to circa 90% of all company information in the industrial countries exists in the present days in hard copies. According the same experience, from all of documents processed on daily basis, 90% are non-categorized and incomplete, while the average annual increase of the amount of documents in companies reaches circa 22%. So, e.g. the following complications can be observed:

Information and documentation are stored at several places which means that they are often incompact and disorganized, and often many of the documents are archived only in hard copies. Stored information is duplicate or not complete. Physical presence of persons participating in processes is required. In other words, *managers must be physically involved in decision-making processes and final approvals*.

Managerial information about resources is insufficient. So, to gain the information about availability and condition of available resources, more time is needed.

The fulfillment of assigned tasks is not controlled efficiently. After a period of time or after personnel changes, the *responsibilities and the extent to which the tasks were fulfilled are not clear.*

The allocation of assets and authorities to employees is not transparent. Allocated resources and the authority of the employees to carry out particular activities, i.e. use the resources, are not registered properly.

Decision-making competencies are not clearly personalized, decisions are not registered, and a *summary of impact of the decisions on the development of the company is missing*.

5.1 The Running Solution

Gratex Knowledge Office (*GKO*) is a knowledge based platform designed for the effective management of company knowledge base, control of a company's internal processes and project management. It can be used in a wide variety of companies with diverse specializations and eliminate some of the above mentioned troubles and insufficiences. The architecture of the planned new modul of GKO combines the advantages of expert system developing environments (like Jess, Clips, for instance), datamining methods and indexing systems. A knowledge base in GKO is a searchable database which contains the accumulated knowledge of specialists in a particular field of documents interpretation and processing. The knowledge base should support canned answers, FAQs, customer interaction histories, solved problems, and self-help question and answer pairs. It should also facilitate easy integration of new expertise as it becomes available. The system work with a given document (its inference) starts with scanning ontologies and using the graph algorithms to find relevant documents. Then it is possible to fire prepared rules as well as discovered associative rules in the supporting expert system knowledge base. In this manner, dynamic ontologies increase the knowledge of the system whole system on how to deal with the given document, how to understand its contents and its relevance for other documents in the systems depository.

5.2 Main Ideas and Features

GKO.NET is now a user-defined document workflow and content management system based on the overall framework of *GKO*. Its variability, wide control options, and document distribution make a company's control system more effective and transparent. It enables an internal information sharing and management, based on predefined unified procedures and regulations. Information is transmitted via electronic documents of diverse types, saved on the central server. These types of documents register the development of internal processes in companies. *GKO.NET* enables also to define the roles and powers of employees transparently. It is an appropriate tool for global organization control, and effective teamwork. It represents the result of the further development, motivated by the effort to incorporate knowledge management aspects, of a previous similar tool developed by Gratex International, that won a prize in the *Microsoft Enterprise Solution of the Year 2001* competition.

GKO.NET offers the opportunities for effective management of key company processes, such as:

Standard processes (like business administration, decision-making processes, quality management, purchasing, sales, etc.).
Safety management (management of information systems and storages, assignment of system rights and accesses to individuals and groups, risk monitoring, monitoring of weaknesses, threats, and damages, etc.).
Document administration (registering, sharing, updating, backup and printing of various documents, and templates administration).
Human resources (hiring, profiles, qualification, trainings, and courses etc., availability information, as attendance, absences, sick leave, business trips, payroll administration, etc.
Asset management (registration and categorization of assets, allocation of work tools to the employees).
Project management (definitions of project teams, scopes of delivery, deadlines, risks, assumptions, documentation, task planning, recording suggestions and changes, quality management, controlling etc.).

5.3 Structure of the System

Access of users to *GKO.NET* is simple, enabled through common network, or the Internet, and its implementation requires no significant changes in the existing infra-structure. The application is easy to adapt to customer specific needs. It provides for a

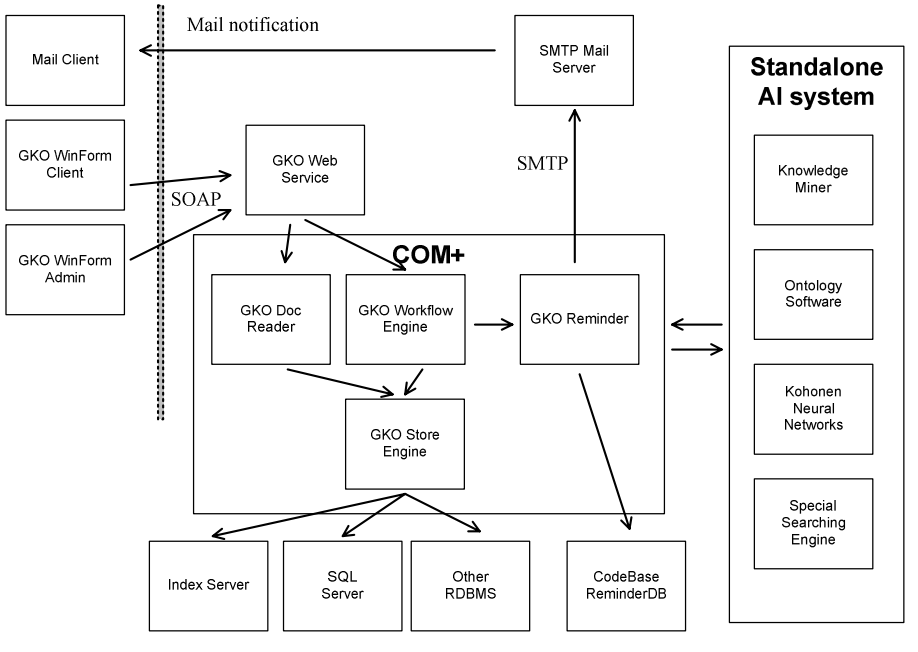

Fig. 1. The schematic view of the *GKO.NET*

flexible administration and specification of security rights and rules. It can be integrated with other systems. Multilevel data security and localization into selected languages are included. Thanks to its comfortable and easy-to-use graphical interface and low software and hardware requirements, *GKO.NET* is a convenient and affordable solution even for the smallest businesses. The overall scheme of the *GKO.NET* in the context of some other support systems is depicted in Figure 1. *Standalone AI system* communicates with business layer, which contains bussines logic (*Doc Reader*, *Workflow Engine*, *Store Engine*, *Reminder*).

5.4 How the Systems Works

System is supposed to manage existing documents of an institution in order to help the user to create new one. Figure 2 shows the process of extracting knowledge from various types of documents by using prepared ontologies and the *Knowledge System* (in the left side of the schema) and the process of creating new document and searching relevant knowledge from prepared knowledge base in the right part of the diagram. Process *Searching Relevant Knowledge* offers interesting information and knowledge as the parts of other documents for the new one. It needs extracted and indexed knowledge from existing documents, parsed by the ontology, and the knowledge software. The *New Document* item could be documentation, some agreements or a source code.

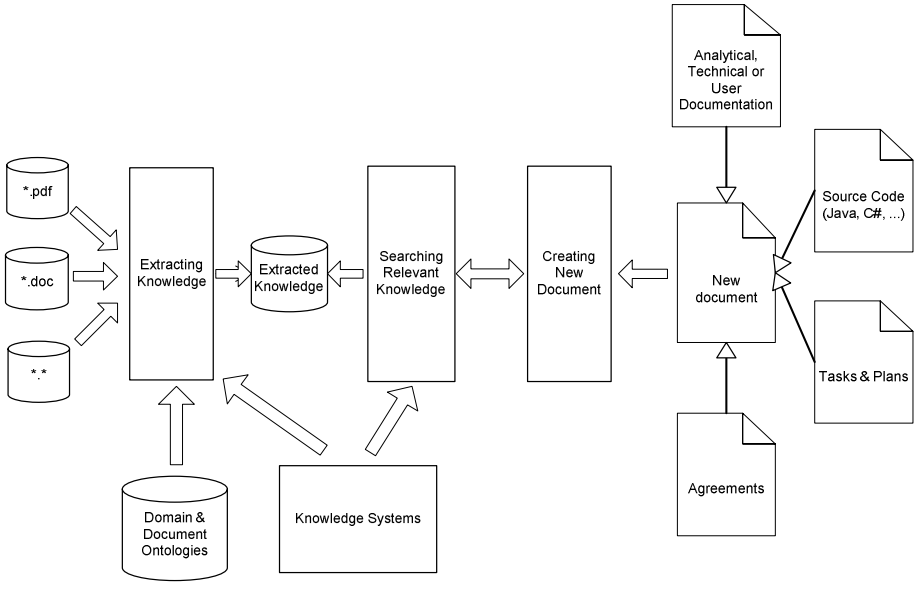

Fig. 2. The process of extracting knowledge and creating a new document

System needs to understand the structure of the workspace for searching the knowledge. Required structure is saved in the domain ontology. Thanks to its elements and the understanding of the knowledge management the system uses the appropriate rules to find other relevant documents.

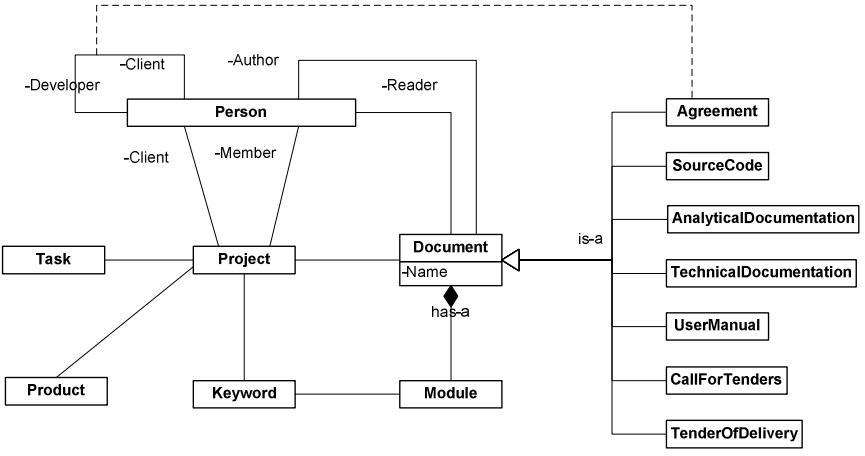

Fig. 3. A semantic model as a draft for a domain/document ontology

Figure 3 shows a draft of the semantic model as a basis for the domain and the document ontology. We can mention the relationship between a project, a document and some keywords. Therefore we could prepare searching knowledge with the keyword vectors using graph and clustering algorithms, the *Self Organizing Maps*, and mining associative rules.

Also we can find the relation between users, authors and the documents and prepared corresponding rules about the user history and authors of different artifacts for the knowledge system. Except the title and the authors, document contains modules (chapters, appendices, classes, packages, paragraphs). It is specialized to the independent types with their proper ontology (source code is quite different from the analytical document). In addition to the visual model of the ontology for the designers we need also the XML code for the parser.

An interesting feature of the system is the ability to serve in a many types of companies. *GKO* serves e.g. in Arca-capital (www.arcacapital.com/sk/), in Hornex (www.hornex.sk), Milking (www.milking.sk), in Elvea (www.elvea.sk), in Gratex International (in all the internal and economic processes of the organization), and also in Gratex SLA (in service level agreement) for Allianz. Our today experience is that at the beginning of the integration and implementation processes it seems to be important to identify needful entities with their state spaces and report criteria, data joins, and user filters. This is the way how to create the model of the company and monitor its life. For all users it is a need to create their own *entities* with *attributes* and their *State Spaces* with the special activities in the states. This is the first step to implement a particular knowledge management into a company. The next step is to implement input and output forms with their rules, triggers and criteria to report the actual situation in the company.

6 A General Conclusion

The historical process of distribution of activities related with the use of knowledge in expert activities leads to professional specialization of human beings in workshops first, then to specialization of activities in larger enterprises, like factories, the time of information technologies leads to the transferring some activities based on knowledge (some expert problem-solving activities) to computerized knowledge systems. In the just actual conditions of the beginning of 21st century when we have enough of knowledge about how to manage knowledge, but the task is more and more complicated and it is a real need to make the managing process faster and faster, the fulfilling of the requirements becomes to be a harder and harder job for human specialists. In such a situation, it is the time to start with research of possibilities and conditions, and then to developing of computerized knowledge managing systems.

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