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KNOWLEDGE MANAGEMENT SYSTEM IN A COMPETITIVE BUSINESS

Abstract: The article discusses how the knowledge management system (KMS) influences the implementation of organisation's objectives and strategy and how it increases its effectiveness and competitive edge. The process of building KMS has been presented together with intelligent tools supporting these activities. The article emphasises the significance of predefining information-related needs of all management levels and the informational contents of reports with the application of BusinessObjects in order to design the data and document warehouse adequately. The structure and the processes taking place there have been discussed in terms of servicing organisation's business and information processes.

1. Introduction

The success of a contemporary business is determined by the accessibility and the adjustment of information resources and more broadly – knowledge – to organisation's decision-making needs. Both the theory and the practice confirm that any business begins with information and ends with information [Kamiński 1999]. What is more, the effective management of a contemporary organization requires not a fragmentary, but a comprehensive and consolidated knowledge of its key decision and information-related processes and of how the surrounding influences them. The comprehensive and thorough computer analysis of knowledge resources cannot be achieved in many organizations yet, as the resources remain dispersed and in disorder, despite ERP (Enterprise Resources Planning), CRM (Customer Relationship Management), SCM (Supply Chain Management) and other systems being used. This affects significantly the credibility and the utility of knowledge in organisation's decision-aiding and management informing processes. New business solutions and innovations do not depend on place or time any longer, as they emerge

spontaneously and result from information overlapping [Liautaud, Hammond 2003; Liebowitz, Wilcox 1997]. Knowledge determines correct formulation and implementation of business strategies. Consequently, knowledge is perceived as a strategic resource, therefore it needs to be associated with the organisation's strategy and with the information technology development within the organization with the strategic approach applied.

2. The necessity of knowledge management within a business

Knowledge – similarly as organization's other resources (material, financial and intellectual) – needs to be acquired, collected and processed appropriately and made available to its authorised users in adequate time and form. For these postulates to be met, the efficient management of these resources is required. Systems known as *Business Intelligence Systems* (BI) have been becoming renowned and increasingly common as organizations' knowledge management systems, BusinessObjects being one of these [Liautaud, Hammond 2003; Rymarz 2002]. In Poland, this class systems are more and more often referred to as Knowledge Management Systems (KMS).

The implementation of these solutions and technologies is determined by the access to appropriate data and the necessity of these data aggregation and transformation leading to knowledge development. Knowledge in its turn constitutes a basis for making decisions, the implementation of which should increase the organisation's added value and its clients' satisfaction and wealth. But a considerable dispersion of data showing up in various transaction systems is observed in practice, these systems not always being integrated within the organisation and with its surrounding *via* the Internet (for e-Business), the Intranet or the Extranet [Liautaud, Hammond 2003]. This context gives rise to a question, how managers should procure knowledge about business processes occurring within the organization in order to influence these processes' course and economic effectiveness? The experience shows that a need exists to consolidate elementary data coming from transaction systems being operated within the organization, to process it adequately and to subject it to further development by the means of creating data warehouses and document warehouses, using intelligent data mining methods and tools, as well as multidimensional analysis of data.

3. The concept, the function and the purpose of Knowledge Management Systems

The purpose of Knowledge Management Systems (classified as Business Intelligence, BI) is to search data from various sources (most often – from data warehouses, document warehouses and the Internet) and to process it in order to obtain decision-related information for users at all management levels. KMS may function

as independent systems and procure data directly from transaction systems (that not infrequently have not been integrated in some organizations), ERP-class integrated systems co-operating with SCM and CRM systems or they may be an element of ERP and import data from this system directly.

KMS systems support decision makers, as they provide aggregated information following intelligent identification of their information-related needs by the means of another system (from BI family), known as BusinessObjects (BO). In its turn, the BO system contains data representation tools that translate incomprehensible names of data base tables and columns into commonly used business terms that are comprehensible to their users. BO systems are also indispensable in modifying the contents of available business data sets that do not meet the decision makers' needs. This is why implementing BO system and making sets of source data for report compilation available by its means should precede the development of a data warehouse, i.e. the basic – along with the Internet – source of data and information for decision making needs. Consequently, the basic purpose of KMS and BO is to identify and aggregate the necessary data dispersed throughout various sources and not adjusted to decision making yet, thereafter – to process it into cross-sectional information available at the real time, which makes it useful for both identifying trends and for making current and future decisions at various levels of the organisation's decision-making hierarchy as well. Under the Internet access conditions (in case of e-business in particular [Liautaud, Hammond 2003]), these systems make it also possible to segment data and with elements of artificial intelligence applied – to learn querying and to carry out a multi-dimensional analysis by the means of OLAP (On-line Analytical Processing) class tools, i.e. with the gradually reduced human contribution. Hence a conviction that BO systems should be associated with a strategy of asking questions they are intended to answer and consequently – with defining future information-related needs of their potential users.

KMS provide aid to decision-makers, therefore they belong to the class of decision supporting systems and are used for analysing trends and for combining the outcomes of these analyses, giving answers to difficult "what – if" questions. On the other hand, knowledge provided by KMS facilitates answering "what happens" and "what will happen" questions, contrary to those systems where qualitative data prevail over quantitative data providing cognitional tools for determining "how it happens" [Gołębiewska 2002]. This is how KMS systems enable one to define questions they are intended to answer their future users, who are not aware of their information-related needs yet as a rule and consequently – they are not able to specify these needs. But the demand for KMS depends not so much on users' unrealised information-related needs as on the strategic approach to information technology application and particularly to organisation's strategy of using the Internet, the Intranet and the Extranet, planning its future activities in the field of winning new markets and clients and offering products and thereafter – monitoring and auditing the outcomes

of these activities by the means of activity-based costing and controlling. This is why the significance of this costing method and of the controlling module grows. They are becoming compulsory elements of ERP-class integrated IT system which is more and more frequently built of components instead of ready-made modules. In the opinion of KMS developers and providers, the growth of organisation's stock exchange quotation is the best measure of system's implementation and operation efficiency and in case when CSM and CRM are implemented – this measure is represented by the growth of organization's value for its stockholders and for itself, which is equivalent to the business effect, i.e. strategy implementation and measuring the effects of these achievements. One should not forget however that developing and implementing KMS is an initial stage of creating and using a knowledge base with classification of decisions, proposals and negotiation models taken into consideration [*Efektywne zarządzanie a sztuczna inteligencja* 1994; Gołębiewska 2002; Liautaud, Hammond 2003; Mulawka 1996]. It is expert knowledge used in organization management, its human teams leading and these teams' decision-making processes that make it possible to draw conclusions from particular situations on the basis of various factors (a set of facts, dynamic model's initial conditions, situation description, etc.). Nevertheless, it is worth tracing the process of developing and implementing KMS first.

4. The process of developing KMS

The process of developing KMS consists of the following stages:

1) acquiring knowledge from the Internet, the Intranet and the Extranet, as well as from source documents recorded in various transaction systems being operated within the organization and thereafter imported to the data warehouse,

2) building a data model adjusted to the nature of the organization and its IT design,

3) developing selection criteria for data warehouse implementation methods and techniques,

4) selecting tools to aid the process of the multi-criteria data analysis,

5) developing application software [Kamiński 1999].

Acquisition of knowledge from documents enables one to analyse the course of events, operations and processes taking place within the organization. But it is necessary to aggregate data included in particular documents in order to be able to assess the course of a transaction, operations and activities of individual employees, to define and to follow trends, to describe the organization's market breakdown and its competitive standing. Classical systems of transactional processing do not guarantee any efficient operation of this analytical work, as they do provide neither the specific structures of elementary data, nor the sufficient computation capacity for processing a large quantity thereof. Neither do they meet specific system-related or technological needs.

These conditions are fulfilled by a *data warehouse* and a *document warehouse*[1], development of which should be preceded by implementation and application of KMS-family solutions, and more precisely – BusinessObjects systems and tools. These systems and tools enable one to pre-define and to modify the scope and the contents of business data for creating reports necessary for meeting the future information-related needs of potential decision makers at all management levels. In particular, this applies to the operating level managers, whose participation keeps growing as a result of implementing flexible organisational structures and modern management styles (total quality management, process management, just-in-time, etc.). On the one hand, pre-definition, modification and initial analysis of data and information necessary for creating reports required by managers of various management levels enables one to identify the expected, but often unrealised scope and contents of information-related management needs and on the other hand – it provides a relatively complete scope of information-related needs the final users intend and have to analyse. Using the systems and the tools pre-defining information-related needs and reports contents for decision-making purposes and indirectly – using initial assumptions for developing and using later data warehouses and document warehouses is becoming even more important, especially that elementary data and also data resulting from its necessary aggregation, recorded in the data warehouse or the data store and the document warehouse, is not sufficiently synchronised with On-line Transaction Processing (OLTP) class systems data, as they are subject to periodical up-dating (at fixed intervals) instead of current (real-time) updating. The relational database system stores up-to-date data which is not surplus (i.e. it is standardised), while the data warehouse and the document warehouse collect surplus data in a non-standardized form, but this accelerates any analytical operations and report creating considerably [Kamiński 1999]. Both the data warehouse and the document warehouse – similarly as BusinessObjects, enable integration of elementary (source) data due to the fact that a uniform semantic base is established, which covers definitions of names, measures, objects and object attributes [Gorawski, Konopacki 1999; Póchniewicz 1999].

5. The KMS structure

Data warehouses (with structured data prevailing) and document warehouses (storing data without any specific structure)[2] are principal components of a KMS.

[1] Data warehouse is a separate IT system functioning on a separated database and supplied with data from various sources, supporting queries, reporting and analyses. Document warehouses (they are not often developed yet) ensure storage of documents and non-structured data (text documents, presentations, films, etc.) and of document description by specialised programmes analysing document semantics.

[2] In some specialist publications and in practice, data warehouses are identified with Business Intelligence systems, which is am excessive simplification. Data warehouses encompass high-structured data see also [Żmudzin 2002]).

Data warehouses are used for data multi-dimensional recording and modelling and for fast and mass reading which occurs in analytical applications. Structures of these data and methods of processing them are described by the means of metadata. This way, effective access to data is provided and knowledge of data significance and arrangement (structure) grows and as a result – data mining is expanded.

Document/text warehouses are used to store non-structured documents, i.e. text documents, presentations, shorts (films), etc. The contents of these documents – similarly as in case of the data warehouse – is described in metadata. Following the model of Internet search engines, the required data is acquired by the means of searching text or by the means of document description. The document description may be generated automatically by specialist software (analysing document semantics) or it may be developed by the data user.

The effective use of a KMS requires adequate *data and information management*. This means that a uniform data and information coding system has to be used, i.e. a uniform identification of objects instead of multiple translation of various codes of the same object which is reflected in particular modules of organization's IT system. The uniform coding system requires uniform data recording and modification procedures to be implemented, with the existing sub-systems taken into consideration. Moreover, efficient *data management* and searching information in own resources and in external sources imposes the requirement to introduce some coding standard recognized by various organisations[3]. Data exchange standards used in analytical applications are particularly important here. For example, exchange of data structured by the means of XML format eliminates EDI and supplies operational data to data warehouses, despite of the fact that it defines the syntax and the structured description of documents contents only partly. These limitations do not apply to Dublin Core standard. From the point of view of transactional systems and analytical applications, this syntax is completed with RosettaNet and CommerceOne standards, whereas the exchange of non-structured data is facilitated and simplified by RDF (Resource Description Framework) standard.

6. The model of information flow to data warehouse and to document warehouse and models of their structures

Bearing the so-far presented assumptions in mind, one may develop a model of data flow from various sources to the warehouse and a model of its structure. The data flow model encompasses the following four layers: a source data layer (historical data, data from transactional systems and external data, e.g. from the Internet, the Intranet, the Extranet), a data and document warehouse layer (data placed in the

[3] Such standards are referred to here as EAN/UPC (European Article Number/Universal Product Code) used in coding materials, which is transformed into GTIN (Global Trade Identification Number) and DUNS numbers (codes issued by Dun/Bradstreet) ascribed to business partners (see: [Żmudzin 2002].

central data warehouse or in data stores), an analytical applications and multidimensional analysis layer (data mining tools, mathematical modelling tools, artificial intelligence systems including neural networks and expert systems and others), a presentation layer (i.a. applications containing graphic interfaces and others).

The model of data and document warehouse, consistent with the star model rules, contains tables of facts (quantitative data characterising the subject and the course organisation's activity) and tables of dimensions (descriptive data reflecting the subject of organisation's activity, e.g. the market, the client, the product, the time, etc.). Any data and document warehouse model [Gorawski, Konopacki 1999; Póchniewicz 1999] has to allow for orientation to the subject (operational data concerning the object of studies, e.g. the client, the product, the market need to be stored in a separated area of disk memory), data integration (for the purpose of determining name and value standards, solving inconsistency problems in data representation, linking shared values, revealing identical data from various sources of origin, etc.) and data invariability in time (data are entered to the warehouse at some defined intervals, while new data or changes in existing data are added).

SAP Polska – unlike other developers and providers – has introduced a new generation of data warehouses based not only on experience from various sectors and industries, but also adjusted to various business-related requirements, special needs of individual organizations and their business processes and even to various functions, goals and tasks of the given organization's individual employees. This approach includes "Business Contents" and "Map of Solutions" facilitating the recognition of its application when accessing business data and indicators. The organization of data within the "Business Contents" is based on ordered extraction of data, its storage and presentation on the background of business processes aided by R/3 system and metadata models being used in this system. The approach which includes business contents covers such decision-related areas as strategic management, finance, human resources management, research and development, procurement, production, sales, distribution and customer care and service. SAP's map of data warehouse solutions groups its processes and functions within the cross-section of the business contents mentioned above in the following order:

1) presentation,
2) analysis,
3) data storage and management,
4) data transformation and loading,
5) data extraction,
6) data administration,
7) system administration[4].

In general, apart from pre-defining and modifying reports, data and document warehouse modelling requires one to define the object or objects of future analysis, to specify data selection areas and methods of integrating and aggregating elemen-

[4] Compare: www.sap.com/poland.

tary data taken over from transactional systems and other sources. This enables obtaining – following suitable conversion of collected data by the means of analytical application – answers to questions concerning markets, clients, products, potential sources of income, costs, profit and other economic indicators necessary in controlling, planning and decision making.

The processes specified within the warehouse's map of solutions are executed with the use of a number of various analytical applications that will be shortcut associated with these processes.

Hence, the process of *presentation* uses such analytical applications as standard reporting, *ad hoc* queries, catalogue browsers, network distribution, geographical data visualisation. The process of *analysis* uses basic and extended OLAP, the basic data query, the factor of reporting and accessing ODS and OLTP. The process of *data storage and management* uses data models, basic data, hierarchies, aggregations and operational data storage. The process of *data transformation and loading* uses such analytical applications as metadata synchronisation, transformation rules, coding with the geographical location taken into account and data validation, while the process of *data extraction* uses R/3 total selection, R/3 delta selection, R/3 archived data selection, data extraction from a file and data extraction from other systems. For the process of *data administration* users choose Schema Designer, data rewriting, archiving and multiplication. And finally, the process of *system administration* uses planning, load monitoring, access monitoring, capability planning and security. These solutions differ much from solutions offered by other producers.

7. Solutions enabling integration of knowledge within the business

Business Intelligence system offered by SAP includes a number of solutions enabling data integration, extraction and transformation of data into information, transformation of information into knowledge and knowledge into activities leading to achievement of organization's objectives and strategy. From among these solutions, *data warehouse* should be focussed on first. It enables intelligent transformation of data, acquisition from internal and external sources and carrying out analyses on this basis, as well as making decisions at all levels of organisation management. Moreover, data warehouse has been adjusted to individual and specific needs and to distribution of information throughout the organization and its surrounding. Flexible *reporting and multidimensional analyses* using Internet information and OLAP technology have been intended for the purpose of decision making at various levels of decision hierarchy. *Business information collecting* consists in combining internal and external information and distributing it – following analysis – to receivers by the means of various methods and channels. *Planning and simulations* enable one to combine strategy formulation with definition of operational goals, simulation of financial and operating performance resulting from changes being made, scenario analysis with owners' expectations taken into account. *Strategic chart of outcomes* is

intended for visualisation of assumptions and possibilities concerning organisation management and for monitoring implementation of organisation's general strategy and functional strategies. *WWW pages contents management* consists in context-based dissemination of information inside and outside the organization and also in using the options of regular procurement of the required (ordered) information. *Internet information cockpits* are based on roles. They make information available in the Internet in an efficient and unsophisticated manner and ensure integration of organization's portals (as mySAP Enterprise Portals for example). Finally, analytical applications are used for the purpose of assessment and optimisation of logistic chains, relations with clients, online marketplaces and organization's whole activity. Besides, they enable integration of data from various areas (internal, external) into studies and identification of cause and effect relationships or finally – maximization of knowledge and experience utilization throughout the organization in the process of achieving goals and executing tasks imposed by the organisation's strategy[5].

8. Data mining tools and multidimensional data analysis

KMS ensures not only integration and aggregation of data acquired from dispersed resources, but its multidimensional analysis and intelligent mining as well. This requires working out and using methods of intelligent mining of large data sets and also identifying significant interrelations between the analysed objects and business operations and processes. These functions are performed by Data Mining analysis activities [Cabena et al. 1998; Groth 2000], acquisition of knowledge by the means of statistical methods (e.g. Statistical Enterprise system which includes an integrated package of tools aiding statistical analysis of data and its further processing with the use of neural network technology) and econometric methods, artificial intelligence methods (neural networks, genetic algorithms), hybrid systems and expert systems.

In turn, the multidimensional real-time analysis of data is ensured by On-Line Analytical Processing (OLAP) tools that are more and more commonly integrated with operating tools (office applications, such as MS Excel spreadsheet and other). Their interactive use supports significantly the process of creating reports according to criteria (dimensions) defined by the final user and optimises the process searching through large sets of data by the means of automatic generation of SQL queries. The effect of multidimensional analyses of data in the form of multisectional reports may also be published in the Internet by the means of WWW server software (e.g. Internet Information Server) and a standard browser (e.g. MA Internet Explorer).

9. Expert systems and hybrid systems

Expert systems (ES) are most widely used in solving complex and difficult decision-related problems. Their practical use involves comparing the current situation

[5] See also www.sap.com/bi.

with experts' gathered and systematised knowledge (recorded in the base of knowledge) of a problem showing similar symptoms, which has occurred in the past and using this as a basis for drawing conclusions concerning potential solutions. Thus, ES functioning consists in "execution of the conclusion drawing process which in the light of known facts leads to the confirmation of hypotheses or to drawing new conclusions. Credence is lent to the process by illustrating explanations" [Simiński 1996]. It is worth stressing that besides comparing the analysed situation to the model situation included in knowledge bases, ES enables one to conclude under the conditions of partial uncertainty, incompleteness of information, by the means of certainty factors (CF) method, probabilistic methods andblurred logic. It is ES's great advantage that it enables one to obtain expert analyses representing a very high professional level by using clear and comprehensible rules. The systematic fall of ES prices gives realistic chances for them to be used in ERP class systems too.

Hybrid systems (HS), due to the combination of various branches of artificial intelligence (neural networks, genetic algorithms, ES) strengthen the potential of IT management system which is unachievable by the means of a chosen method of solving heterogeneous, complex problems. HS applications require processing large quantity of digital data which can hardly be described by any precise analytical model. Moreover, difficulties arise also with accurate description of cause and effect relationships that can be recorded in the form of rules in ES knowledge base. Despite these limitations, in practice there have already been many explicitly expressed economic rules of a general and detailed nature that facilitate the application of HS [Simiński 1996]. Intelligent System for Financial Analysis (ISAF) is a positive example of HS application on the Polish market. The system includes such modules as: data downloading and storage, data interpretation and presentation of information. The knowledge base consists of such topic-oriented sources as financial liquidity assessment, profitability evaluation, capital management assessment, financial standing overall assessment, assessment of the company's position in its business sector, sector attractiveness assessment and sector risk assessment.

It is expected that HS will also be used in solving transport-related problems (troubleshooting, traffic monitoring, shipment progress on the route, selection of an optimal route, etc.), logistic problems (resources' optimum size and timing), production control, etc.

10. Conclusions

To improve the process of making operating and strategic decisions as well as the process of business control, monitoring and auditing, it is required to use KMS, BusinessObjects systems, as well as tools aiding multidimensional (multi-sectional) analysis of data and intelligent data mining. Development and implementation of KMS enables integration and aggregation of data coming from various internal and external sources. On the other hand, it requires designing and establishing a data

warehouse and a document warehouse preceded by pre-defining – by the means of BusinessObjects system – information-related management needs and reports containing the required sets of decision-related information. When solving difficult and complex decision-related problems of business processes one should use expert systems and hybrid systems combining various branches of artificial intelligence and co-operating with ERP, CRM and SCM class systems.

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