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KNOWLEDGE BASE CLOUD – A NEW APPROACH TO KNOWLEDGE MANAGEMENT SYSTEMS ARCHITECTURE

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Abstract

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This article aims at identifying the limitations of current approaches to knowledge management systems architecture creation and proposing innovative solutions on handling with the emerging issues of the existing methodologies. These findings should encourage the more effective handling with the created knowledge and initiate new knowledge creation with the support of the intelligent tools and systems forming the knowledge management cloud. The authors have proposed a new approach to the knowledge management systems architecture. This principle named knowledge management cloud is defined in the article including its typical characteristics and basic compounds. Finally the knowledge management cloud implementation model is introduced to help the companies with adopting this new principle into their information systems architecture and management.

knowledge management, knowledge management system, knowledge base, knowledge model, knowledge base cloud

Knowledge is considered being the key determinant of company's success on the market in generality of sectors by majority of authorities in the field of marketing management. The concept of comparative advantages has been redefined through the detection of possible sources of competitive advantages. Monitoring and consistent use of comparative advantages can be considered as a significant factor conditioning the success of firms operating in the business markets (Vilamová *et al.*, 2011). Today's turbulent environment is characterized by the rapid information systems development, intelligent self-learning decision systems and artificial intelligence systems moving from research field to the application in practice. All these systems are working with data that are either creating a base for knowledge or originated as the result of the process of knowledge transformation, storage and distribution. Knowledge as the final step in the signal-data-information-knowledge development sequence can be also characterized as the company development accelerator, business goals fulfilment instrument or floater of generating new business opportunities. According to Hirai (Hirai, Uchida, Fujinami, 2007) knowledge has come to be considered an important and an essential resource for sustaining the competitiveness of an organization.

Being able to use knowledge as a competitive advantage requires a sophisticated system of knowledge management. The main goal of knowledge management is maximum exploitation of intellectual capital in organization and knowledge of its co-workers for the sake of increasing efficiency. In the current information oriented society intangible assets often overweigh company's tangible property, thinks Mikušová. A question arises, how the manager and the investor can monitor whether the value of intangible assets is increasing or decreasing. For that reason a requirement for recording and monitoring of intellectual capital performance with the emphasis on knowledge capital is activated (Mikušová, 2008). Barth states, that knowledge management is the process of mastering and gaining competitive advantage and customer loyalty via efficiency, innovations, and efficient decision making (Barth, 2002). Nevertheless to enable the knowledge innovation process, which is the key to the company innovation strategy fulfilment, knowledge management has to concentrate on tacit knowledge as the more sophisticated form of knowledge containing the higher innovation potential. Knowledge identification and transformation to the explicit form is one of the key roles of knowledge management. It is also one of the key areas the organization implementing knowledge management should take care of (knowledge identification, storage and effective use) (Horváthová, 2011). Dalkir notes that much of an organization's valuable knowledge walks out of the door at the end of the day (Dalkir, 2005). Techniques under the term knowledge capture systems are used to capture the tacit knowledge with the real-time or possibility of latter transformation to explicit knowledge, including externalization, prototyping or knowledge engineering (Becerra-Fernandez, Sabherwal, 2010).

Companies worldwide face the decision of implementing the knowledge information system. There are several primary arrangements that have to be realized and basic questions which have to be answered when dealing with this issue: which systems should they use, how to start up the process and how to control and maintain it. Recent research of the authors Hvizdová and Miklošík concentrates on the area of knowledge creation, transformation, effective distribution and dissemination through the company knowledge management information system. In this article the authors present created models which identify related processes, determinants of their evolution and condition of their successful implementation. Innovative models including the defined knowledge base cloud principles are prepared with the accent on monitoring maximum amount of correlative interdependencies with the vision of practical application in firms' practice. The authors have identified several areas that are extremely important while transferring the knowledge management information systems theory into the day to day managerial operations. They are being analyzed in the following chapters of the text, while reviewing the factors, connections, relationships and other important issues relevant in the respective KM area.

Research problem

In the existing literature there are several approaches to the knowledge management systems architecture. Determining optimal architecture of these systems and definition of relationships to other subsystems and systems used in the company is the issue many authors are currently dealing with. In the existing sources two categories of the KMS are described – theory-driven architectures and market-driven architectures. The theory-drive architectures are usually more complex and sophisticated, as they offer a view at the optimal IS organization. Based on these models and based on empirical experience of the system architects market-driven architectures appear that best fit to the real company environment and its specifics. The authors of this article have performed a detailed research regarding both the existing theory- and market-driven architectures. Based on the findings they have aimed at defining a new optimal KMS theory-driven architecture model which is the primary objective of this article. This should be built on the existing published approaches and should offer an solution that will exploit all the new knowledge and technologies available at the same time to create the most advanced and integrated KMS architecture model.

MATERIALS AND METHODS

In this paper the research methods of analysis, synthesis, comparison, generalisation, questionnaire, construction of algorithms and summarising of findings are applied. We studied the current approaches to knowledge information systems architecture from relevant international authorities and based on the findings we have proposed our own model of the system hierarchy and organization. The proposed principle of knowledge based cloud is built on cloud principles, transforming their advantages to the company knowledge information systems hierarchy and knowledge storage and distribution.

An empiric study on a sample of 93 companies in the Slovak Republic was realized as well in 2009 and 2010, aiming on studying the relationships between knowledge, knowledge management and company innovation potential. Majority of the companies were from the small and middle size companies sector (90%) and 10% of the companies were large companies. 70% of the companies were on the Slovak market for 1–10 years, 27% of the companies between 1 and 20 years and 3% more than 20 years. The sectoral structure was as following: sales and retail (33 %), industrial companies (21 %), hotels and restaurants (13 %), telecommunications (13 %), general services (10%) and financial services (10%).

Existing approaches review and comparison

Theory-driven models review

Several prestigious authors have published their studies regarding the KMS architecture. They have tried to determine the optimal architecture of the company information systems. These approaches differ in the way they handle the KM access and distribution process. We have compared the works of (An, Wang, 2010), (Jiang, Liu, Cui, 2009), (Weber, Gunawardena, 2008), (Shannak, 2010), (Yaoming, Fengxiang, 2009), (Zaki *et al.*, 2008), (Maier, 2007) and many others. Based on our research we consider Maier's model to be the most complex and practical-oriented at the same time (Maier, 2007). In his model he builds the KMS architecture on 6 levels using the bottom-up approach: data and knowledge sources, infrastructure services, integration services, knowledge services, personalization and access services. All elements in the model are logically grouped to these layers forming a unified KMS. We are building on this concept and define further dimension of the KMS architecture to form a unique KMS architecture model enriched by the principles of cloud computing later in this study.

Market-driven approaches – traditional KMS organization hierarchy and relationships

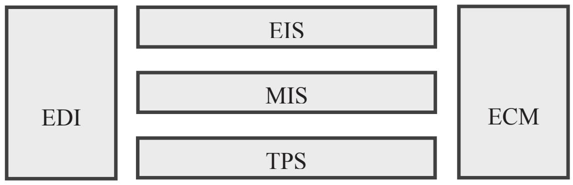
Many authors actively publicising in the field of KM are dealing with the knowledge management information systems (KMS) architecture, modelling and consolidation. There are several possible starting points where the company begins with the analyses of KMS adoption, modification or evaluation. Based on the global information systems architecture in the company we have identified these three highly typical set-ups:

a) The company is creating its information systems structure from scratch. It was highly probably founded recently or grew from the size that did not require usage of advanced information systems.
b) The company has several information systems in usage. Its management did not apply KM principles before and now it decides to implement the KM principles best practices and supportive information systems into the existing IT architecture,
c) The company stays before complete IT systems reengineering. The management is oriented at knowledge management, tries to obey the KM principles and has or wants to implement the unified information system for KM implemented replacing or interconnecting the current subsystems used for partial knowledge storage and distribution.

Each situation described requires a different approach. The last scenario is the most complicated, not only because of the existing and probably not well organized data and systems architecture and structure, but, and mainly, because of all the processes and practices that are to be influenced by the changes in KM introduced. At the Fig. 1 authors visualise the typical hierarchy of information systems within the global ERP (Enterprise Resource Planning) architecture. These systems are commonly used for managing the company at different managerial levels. Each of the subsystems or modules of the company information system carries information that can be categorized as knowledge and should be integrated in the company knowledge base.

Legend and architecture logic description

TPS ....Transaction Processing System – the category for systems that are used to manage the operative activities of the company. These systems are strictly sector-specific, that means they differ considerably between different sectors.



1: *Traditional company information system (ERP) architecture*
Source: (Mariaš, 2007)

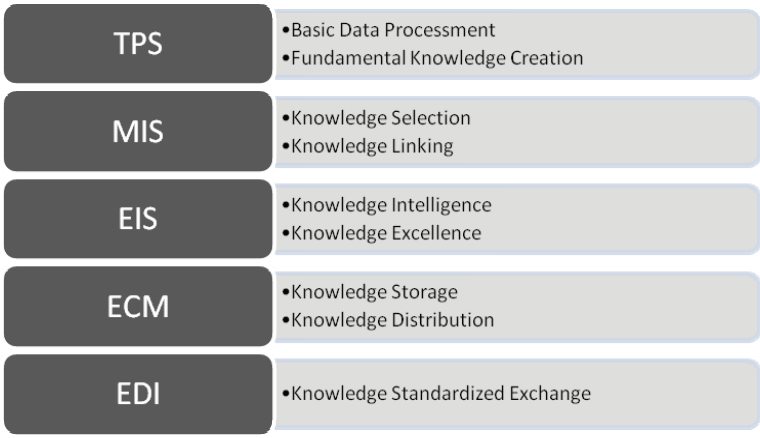
MIS ....Management Information System – this category consists of the systems at the medium level of decision making. The systems concentrate process and analyze the data coming from the lower level systems. These are presented in the way to support the important managerial decisions in the company.

EIS......Executive Information Systems – the top level decision making supportive systems. These systems are used by top management and aggregate only the most important information sources from strategic decision making. Because of this reason these systems are only gathering information from the middle level systems (MIS). These systems operate with the advanced logic on behind and one category of these systems, the ES (Expert Systems) is used to simulate the decisions made by experts in the field.

EDI ....Electronic Data Interchange – in the strictest point of view the standardized data interchange used in international corporations and governments to transfer documents and data. In the more general understanding, the term is used to express the interface to communicate with external environment and to exchange structured information.

ECM...Enterprise Content Management – system for storing and managing all content in the company. It is a broader term compared to the DMS (Document Management System) which is used to store documents in the electronic form.

In the past the companies did not need to enrich this system by other components. Each of the 3 main pillars of the ERP architecture (TPS, MIS, EIS) is generating information and knowledge which is used to improve the decision making process, optimize the production, company effectiveness, etc. To store the knowledge, typically represented by documents, the ECM subsystem was used. The EDI subsystem was than exploited to exchange the knowledge with the outer environment. Although the accepted standards in EDI worldwide are used to exchange standardized documents containing rather information than knowledge, this system in its roots can be named as the basis for standardized knowledge sharing. As going from bottom to top in this hierarchy, more and more sophisticated forms of knowledge use to originate in the system. In



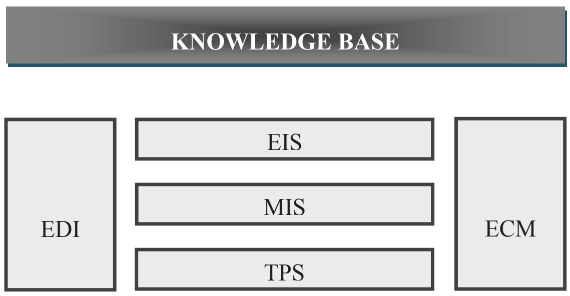
2: *The role of primary ERP subsystem levels within the knowledge management activities*
Source: composed by the authors

TPS a lot of quantifiable data are produced, stored and distributed by the system. With the use of the process of knowledge selection (Holsapple, 1999) these data have been summarized and visualized in the above systems to help the managers to make well-founded decisions. These basic knowledge management principles were widely used in this fundamental ERP system architecture. Visualisation of the subsystem roles is depicted at the Fig. 2.

In this traditional approach, companies use to integrate the KM information system at the top of the main blocks of the ERP system. This system can be a large database named as Knowledge Base or a real knowledge management system. There are several categories of these software including the less sophisticated wikis, forums, chats, through the groupware software up to the advanced KM modules and software supporting the collaborative KM activities in the company.

At the Fig. 3 authors depict the standard architecture enriched by the knowledge base element. The knowledge base is in this concept by most companies interpreted as a software or module which is used to save, transfer, modify and present the explicit knowledge. However the KB can consist of tools enabling the tacit knowledge exploitation as well. To distinguish the Knowledge Base from the ECM these typical characteristics can be enumerated:

- KB is a system with a logic built over the existing systems,
- KB logic is process-oriented,
- KB does not store documents typically,
- KB may use the ECM to store related documents,
- KB tools accelerate knowledge creation,
- KB tools are designed to initiate and support knowledge sharing.



3: *Traditional company information system (ERP) architecture with knowledge base system integrated*
Source: composed by the authors

There are two common mistakes occurring typically when trying to adopt the knowledge management principles in the company. These have been identified by the authors when realising the empiric study on a sample of 93 companies in the Slovak Republic.

1. Typical mistake: explicit knowledge concentration

   In the KMS the explicit information / knowledge is stored. Only this form of knowledge can be interpreted by the system and distributed to the person that will use it by decision-making. However not only explicit knowledge should by the object that the KMS deals with. This is often assessed by the authorities in this field as the basic primary step that has to take every company to sustain its position. Implement the KM principles concentrating on explicit knowledge is less complicated making the process smooth and relatively fast. The responsible manager can present the positive impact of the changes on company's operation to the top management / owners proving that the project was successful. The more complicated but nevertheless more sophisticated process is creating a system of processing the tacit knowledge. In the recent sources tacit knowledge is characterized as the form that has the primary impact on the company's innovation potential (Kroph, 2000). The knowledge manager has to concentrate on the processes of identifying the tacit knowledge in the company, combining the knowledge, finding the procedures to initiate its conversion and final storage for latter reuse. From this point of view, not only tacit knowledge is crucial to the KM implementation but also tacit processes (Hirai, Uchida, Fujinami, 2007). From one point of view the KMS adapting to the existing known processes, both explicit and tacit. From the other point of view to assure the implementation is successful a complete change of thinking of the people should be realized adopting new or optimized processes that are required to manage the knowledge in the company.

2. Typical mistake: low persistence.

   The companies use to find the optimal information system for KM, implement the system, create processes of knowledge management etc. The knowledge base starts to grow, people start to use it actively and the company starts to benefit from creating the knowledge management processes. At this point the following effort is stopped and the status quo if often preserved. Other reason for reducing the activity of KMS exploitation is the insufficient trust level. The trust is considered being one of the major indicator of KMS implementation success (Alavi, Leidner, 2001). However, the most complicated point but also the point which can add the most extra value into the KM process, is the last one – the evaluation and consolidation of all other systems and subsystems in the company to participate on the KM process introduced.

To determine the best practices for the KM implementation many authors have developed the process models or KMS architecture models representing the optimal constellation of KM inputs, procedures and outputs.

RESULTS

Cloud computing – new generation of IT infrastructure defining the principles for KMS

Cloud computing as the new concept, model or generation of IT infrastructure organisation is the trend and inspiration also for the proposals of KMS organisation. The cloud has been defined in the area of cloud computing as computation, software, data access, and storage services that do not require end-user knowledge of the physical location and configuration of the system that delivers the services. Clouds are widely applied in many areas of IT infrastructure solutions. They are formed to create integrated blocks that consist of many interconnected subsystems (mainly hardware – servers, computers, hard drives) which are represented as one integral unit when connecting from the outer environment. This enables to create a huge computing strength, large disk spaces and other applications that can be used when performing extensive calculations or storing large amounts of user data. Recently announced commercial product using the cloud computing principles is the iCloud from Apple enabling the users to store multimedia data in the iCloud and access them from any device that will support this service.

The concept of cloud computing can be perceived as the fifth generation of IT architecture. The first one was started in the era of isolated large computers and mainframes. From 1980 the architecture clients/server was adopted. In 1990 WAN networks and web defined a new model of IT architecture. The fourth model is SOA (Service Oriented Architecture) which was widely accepted as the new generation of IT architecture in 2004 by the experts. The advancement of cloud computing was assumed to be only another marketing buzz-word at the beginning. With the further development of this concept it is beyond dispute that cloud with the connection with virtualisation will be massively adopted in the future creating the source of competitive advantage for the companies. According to Brad Anderson, senior vice-president of Microsoft, the shift from isolated private IT architectures operated currently by most of the businesses to the globally operated clouds can be compared to the beginnings of electrification. In 1900 more than 50 000 private local power plants were in operation. 20 years later more than 70% of electricity was produced and distributed by global powerhouses (Microsoft, 2011).

Typical characteristics of cloud in this point of view are:

- unification of resources to form one or more bigger entities,
- the resources are fungible and failover of one resource does not affect the performance of the whole system in a respectable manner,
- the physical location of the resource is not known to the user accessing the system,
- resources allocated to the respective user can be changed dynamically based on defined rules,
- the resources are easily supplemental,
- by adding new resources the overall system capacity will grow.

There are several implementation models of cloud computing. The public clouds are operated globally and its services are accessible for broad spectrum of users. Private clouds can be defined as clouds running within strictly configured boundaries. This mode could be also named as internal IT outsourcing. The IT department operating the infrastructure in the cloud is offering the services to the rest of the company. Of course in this model the operation of the cloud can also be provided by the third party. Also, other two types exist, which typically represent a mix of the two primary types – the hybrid cloud and the community cloud. The hybrid cloud consists of one or more clouds of the first two types which are interconnected and to the outer environment presented as one space.

Also, several models of cloud computing services can be defined. Three basic categories have crystallized in the recent years: IaaS (Infrastructure as s Service), PaaS (Platform as a Service) and SaaS (Software as a Service). In the first model – IaaS – the needed infrastructure is offered to the company thus the IT department does not need to configure and operate own servers in a housing. In PaaS the hardware and also software platform is provided minimizing the need for installing and configuring software environment for developers. By SaaS the complete software is offered to the end users running online. By this model only the really used services are paid by the customer.

Knowledge Base Cloud as the optimal KMS organization model

Current research on cloud computing defines the CC as virtualization of on-demand and scalable services and resources (Laplante, Zhang, Voas, 2008; Lenk *et al.*, 2009), Balding pointed out a new view at the CC being the abstraction of services rather than a virtualization (Balding, 2009). We build on this conceptual view of CC when introducing our KBC model. Our KBC model helps the organization to go through this important phase in the application of KM principles to finally put the advantages of implemented systems to a complete new level. In this introduced case the KMS should not be called KM system or similar anymore as it is not a regular module or system equivalent to other modules used in the company. The authors introduce completely new term Knowledge Base Cloud (KBC) being a more relevant expression to be used to express the character of the components that are present in the overall architecture.

This definition of cloud applied to KM can describe the character of the KM systems architecture and hierarchy that is desired to originate in the company dealing with KM principles implementation. KBC can then be defined as knowledge sources, appearances and distribution that do not require end-user knowledge of the physical location of these sources and configuration of the system that delivers the services. Other characteristics of cloud computing can be also adopted to characterize this new term. The cloud should involve provisioning of dynamically scalable and often virtualized resources.

KBC approach aims to help the companies to gain the excellence in the management of explicit knowledge and in the process of transforming other forms to this form of knowledge. KBC can be defined using these propositions:

- Company's memory – it helps the company to not forget the already acquired knowledge. It is directly comparable to the memory of a human being. The knowledge is stored at a specific position and in specific relationships. When the request for knowledge comes it is being restored. It depends on its position and on the quality of the systems used in the KBC how quickly and in which amount the information is restored. The advantage over the humans' memory should be that it is not forgetting – the knowledge should be stored and developed for long time. However, even in this topic there exists a parallel – in case of a emergency incident the systems can lose their data completely or any part. This risk is one of the major when handling with the systems thus the company has to make all possible.
- The top level layer over existing information systems and over existing processes architecture in the company – the logic, relationship matrix and intelligence that enables the company to create the knowledge and use it in most appropriate ways.
- Fundamental principle – orientation of company which is driving the company to the informational and innovation excellence.
- The biggest and most important competitive advantage – implementing this principles, systems configuration and management procedures in the company means that it is much more efficient in finding the knowledge, building knowledge and also in the field on the knowledge application and marketing compared to the competition. This can be defined also as knowledge excellence which can drive the company to leading position on the regional and global markets.

There are several analogies of the cloud computing models with the desired KMS functioning – KBC. KBC principles are very similar to the CC Private cloud model. The infrastructure is created and operated on own servers in own private data network. The whole infrastructure is under the control of the IT department. The cloud services are offered to the various departments and project that require variable computing capacity. In KBC the services and knowledge concentrated in the KBC is offered to the participated departments and organizational levels. The KBC is under full control of the IT department; however the users of this service are not aware of the physical location of the respective service/system. In specific cases the system can be also interconnected to public sources creating a form of hybrid cloud in the field of KBC. From the models of CC services the KBC concept can be compared to the PaaS model with some characteristics of SaaS being present. In PaaS the complete platform integrated hardware and software is offered to the users. KBC also combines hardware and software assets creating one cloud presented as one integral unit to the users/clients. As the services in PaaS are offered via internet, the term cloudware is used to characterize this kind of service. One of the main operating principles of KBC is the distribution of outputs via internet as well. When analyzing the analogy to SaaS we can observe the same principle regarding the software operation. The users are using the software and are not limited by the complete infrastructure. They are not aware of the physical location of the software and are using only those services that are required at the moment or are allocated by the access rights distribution model. The analogy of KBC to CC can be found also in the fundamental characteristics of the CC:

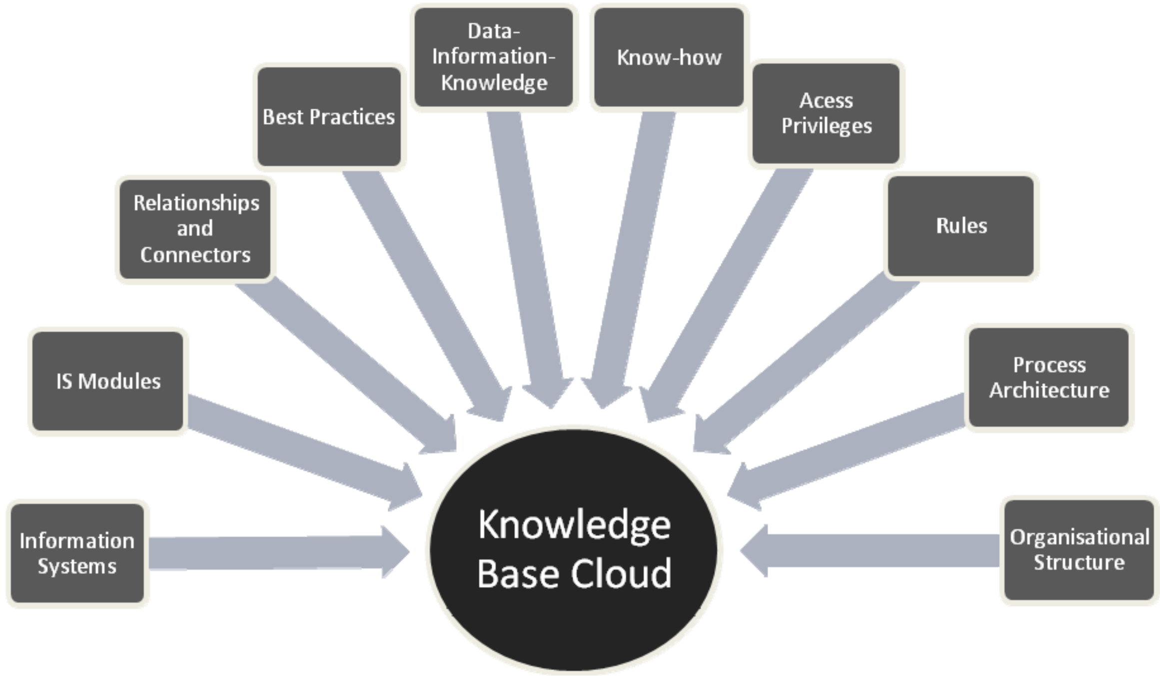
- It is a self-service system, where the users can order, configure and use the service without the need to think of the infrastructure on the background.
- The sources are accessible from anywhere – the services are distributed via standard http to a wide palette of end user devices (clients). This is also the ambition of the KBC model. If configured to all or chosen data can be accessed via internet with the use of necessary security arrangements as VPN (Virtual Private Network). One of the goals is that the KBC supports as broad spectrum of client devices as possible to dismantle the technical access barriers.
- Sharing sources is locality-independent. All the capacities and systems are shared by the users no matter where they are physically located.
- Scalability and elasticity – the hardware and software sources are quickly adapted to the current requirements.
- Paying for the real system usage – this principle should be obeyed also in the KBC concept however it is not to be implemented easily. Dimensioning of the system and organization of the software licenses should be negotiated flexible when their usage varies in time and intensity.

There are several issues, characteristics and risks that can be compared between classic KMS organisation and the KBC. They cover the following areas: data safety, security, performance, costs, etc. If the CC principle od IaaS in private cloud is applied in KBC, it can bring major advantages to the company that are typical for CC services. Cost savings are typical when talking about the initial costs when purchasing the architecture hardware and software components. The other source is also the energy savings. In the cloud the servers computing capacity is allocated to the users depending on the real-time requests. There is no need to run separate physical server for each software platform. In combination with virtualisation there are possibilities to achieve major savings for energy bills. Another savings can be identified in the area of maintenance. The qualified manpower requirements are minimized with the new system architecture. The TCO (Total Costs of Ownership) are thus optimized in all its components. There are some doubts regarding the data safety and security being presented by the IT professionals. As the KBC can be described as a form of private cloud, majority of the risks is dismantled by this constellation. At the moment the high level of security and reliability can be guaranteed even by the public clouds thanks to the professional teams of IT personnel that have their hand-on monitoring and servicing the clouds and thanks to various novel security solutions and schemes which are aiming to increase the security of a cloud solution. One of the recently introduced protection systems ACPS (Advanced Cloud Protection System) is aiming at guaranteeing increased security to cloud resources with the use of virtualisation. ACPS can be deployed on several cloud solutions and can effectively monitor the integrity of guest and infrastructure components while remaining fully transparent to virtual machines and to cloud users. ACPS is the most advanced solution when comparing its features to other systems such as TCPS, KvmSma or KvmSec (Lombardi, Di Pietro, 2011). Also other security issues have been recently solved covering the DDoS (Distributed Denial of Service) attacks. Regarding the performance the widely discussed issue covers the possibilities of parallel data processing in the cloud. Several companies offering public cloud services have built their own frameworks to simplify the development of distributed applications to enable parallel task distribution to available nodes – MapReduce from Google (Dean, Ghemawat, 2004), Dryad by Microsoft (Isard *et al.*, 2007) or Map-Reduce-Merge from Yahoo (Chih Yang *et al.*, 2007). However, instead of embracing its dynamic resource allocation, current data processing frameworks rather expect the cloud to imitate the static nature of the cluster environments they were originally designed for, e.g., at the moment the types and number of VMs allocated at the beginning of a compute job cannot be changed in the course of processing, although the tasks the job consists of might have completely different demands on the environment. Therefore new processing frameworks explicitly designed for cloud environments have originated such as Nephele - the first data processing framework to include the possibility of dynamically allocating/deallocating different compute resources from a cloud in its scheduling and during job execution (Warneke, Kao, 2011).

Knowledge Base Cloud Compounds

The basic architecture of KBC is designed in analogy to Private Cloud concept. It consists of three main components which are interconnected and cooperate in interoperation: the hardware – server part, software (both system and application) and connectivity. In the layer of cooperative functioning there exist very important parts of the architecture – rules and processes. They define the framework for the system and user behaviour in specified and defined circumstances. As for the KBC concept definition we take a view that the parts that our study needs to concentrate at are the software layer and the processes. At the Fig. 4 the major KBC components are depicted as identified in this area by the authors.

Information systems are integrated systems with their own system architecture that can be relatively complex. Thus their integration into KBC needs a deeper review when defining their position, access rights, relationships and connectors. Depending on their configuration the modules can be interconnected with the KBC directly or they can be integrated as a whole system with its internal logic emerging as one integral element in the KBC system. The relationships and connectors



4: *Knowledge Base Cloud software and process components*
Source: composed by the authors

define the position of each compound regarding the other parts of KBC. The relative position of one element to the other(s) can be dominant, balanced or submissive. Based on SOA new basic services can be created and re-used to lower the requirements on system resources and data transfer capacity. When cloud / grid applications need to integrate and analyze data from geographically distributed data source, the DIS (Data Integration Systems) are becoming paramount. In our logical scheme DIS is a subpart of Relationships and Connectors. DIS gathers data from multiple remote sources integrates and analyzes the data to obtain a query result. There are several methods of query processing optimization that have been constituted to minimize negative impacts of long response times in wide-area networks (Chen *et al.*, 2011; Lynden, 2009).

Best Practices can be defined as a set of proceedings when handling a specific task regarding the system. They include both system and user layer. They are defined to accelerate the system usage, find the desired resources in a short time and with minimal effort. Best practices form a notable compound of the KBC assisting the reaching the optimal KBC utilization. Access privileges and rules are a layer of KBC which defines not only user rights regarding specific parts of the system. It also designates the profoundness of intelligent system resources allocation to the user requests on the system. Each user, based on the user groups and rules, disposes of the allocated capacity (resources, databases, intelligent agents, storage, services, etc.). Process architecture is designed as an organized tree of processes regarding the system operation and usage. In the accepted taxonomy of knowledge management processes there are three types of processes distinguished (Maier, 2007):

- the knowledge-intensive (operative) business processes – business processes or their parts relying substantially on knowledge,
- knowledge process – which supports the flow of knowledge between knowledge intensive operative business processes (submission process, search process, knowledge acquisition process, community management process, maintenance process of the organizational knowledge base) and
- knowledge management process – a kind of meta process, responsible for the implementation of the KM initiative, the design of organizational and ICT instruments and for knowledge controlling and knowledge process redesign.

In the proposed scheme the Process architecture represent a combination of selected knowledge process components (particularly the maintenance process of the organizational knowledge base) and the knowledge management process components. The following tangible operation levels are included: system maintenance, system scaling, accessing the system and its data, handling typical system requests, system usage in different departments, environments, locations, etc.

The fundamental of the KBC are stored data which should be stored in their original form and also in the form of information and even knowledge that was created in the process of KBC usage either by the system intelligence or in combination with the users' knowledge. There are four basic methods of integration services that are used to transfer knowledge elements from the external sources to the KMS and to define new relationships between existing data to create new knowledge (Maier, 2007): manual integration, automatic integration of knowledge elements, generation of knowledge elements from internal sources and statistical data analysis – techniques and functions known as business intelligence (data mining, knowledge discovery in data bases, on-line analytical processing, decision support systems, statistical software packages such as SAS or SPSS). This layer cannot be perceived as the classical database with fixed structure and tables, however as an intelligent self-learning and flexible body. This has to be taken into account when preparing the analysis of the database model in the future KBC. Another issue regarding the data is to ensure minimum redundancies which result from the relatively complicated KBC systems structure and interoperability.

Relationship to other subsystems carrying the knowledge and information

KBC is the most abstract term that is positioned over all the systems used in the company that carry a certain amount of knowledge and participate in the knowledge creation and distribution in the company. Building the KBC requires dramatic change in the company orientation and management system to become fully concentrated on the knowledge building and thus innovation driving in contrast to the other management styles.

The relationships of the term knowledge base cloud with other terms defining the relevant information systems or modules supporting knowledge management implementation in the organization can be described as following:

Expert Systems (ES) – these systems are used to simulate the decision making process of the experts. This type of information systems is using the most advanced logic and intelligence available. The goal is to make a "learning system" which will learn from past entries and inputs from the users. The ES can also be qualified as a system used in the knowledge management at the highest level of decision making in the organization. The system is intended to store highly structured and complicated information, create connections between the data, create behavioral models and simulate the human behavior by the decision making process. The ES are intelligent and self-learning thus they are closest in this point of view, to the KBC term introduced. The communication with MIS systems is usually one-way, because of the knowledge that is generated in EIS becomes source of competitive advantage and subjects to most strictest level of privacy. Only several people in the company should have access to these information. However, the communication flow between EIS and KB and KBC should be created to ensure, the information is saved to KB in the respective structure and after creating the intelligent package of the generated knowledge with other relationships and records, these enriched knowledge package is becoming part of the created KBC.

Groupware (GW) – this term can be defined as any form of software that is supporting the team or group work on a specific topic. These systems are less complicated than ES however they support coordination and cooperation of large teams working on a project or issue. There are many forms of these systems. They include the systems of keeping, creating and organizing the explicit information that is building the knowledge base in the company. Wiki is one of the widest applied forms of groupware used to store and distribute the company knowledge in all departments. Other collaborative tools are also part of the groupware software family including the publishing software, office packages and other kinds of software that are able to function in a network.

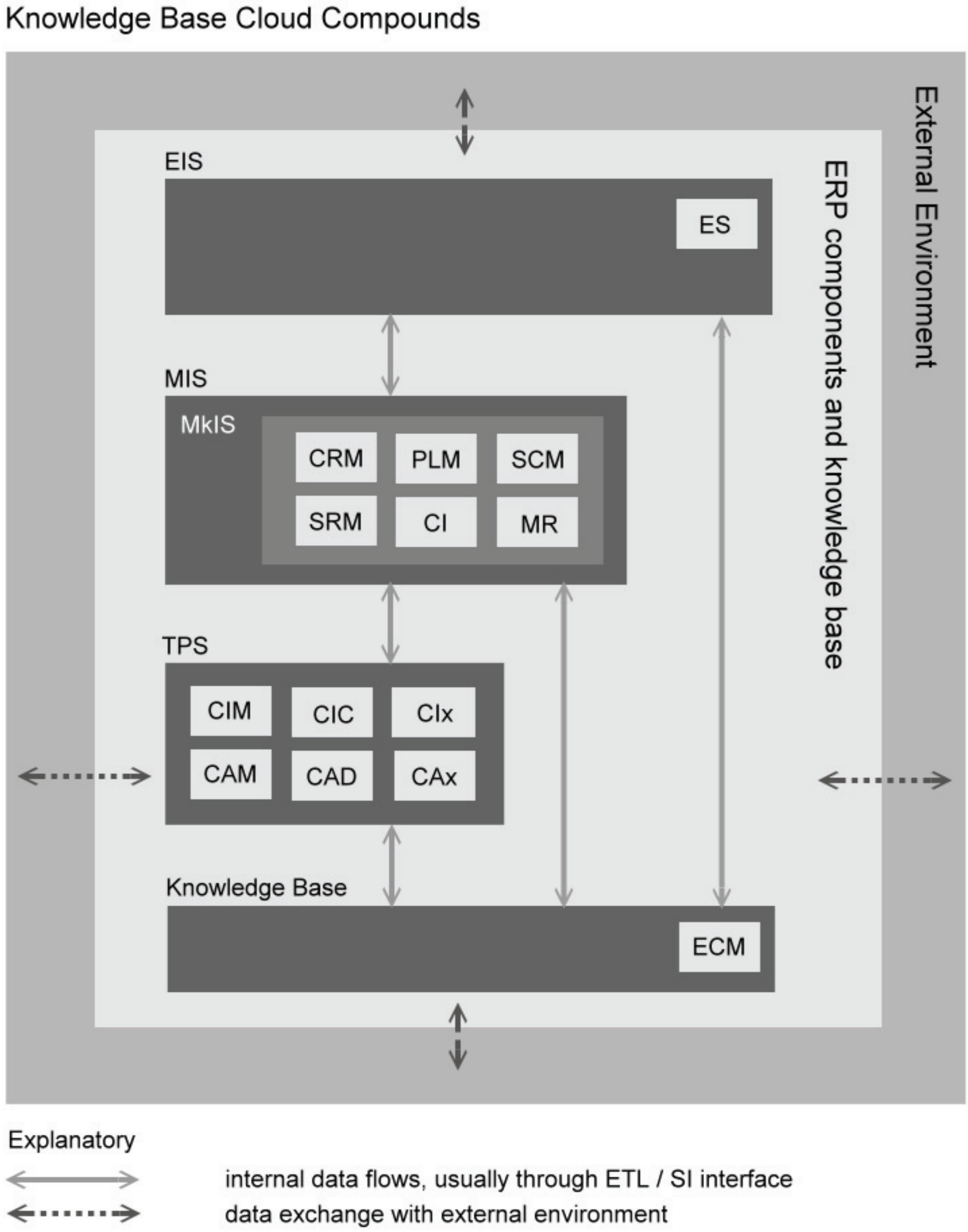
Central database of knowledge (CDK) – the central database is a central primary storage that stores all data in the modern architectures. The goal is to minimize data redundancies, their storage on various places in various forms. In the IT terminology also the term DWH (Data Warehouse) is often used. Central database of knowledge is necessary also in the schema with Knowledge Base Cloud. It plays an important role in the architecture supporting easy and quick manipulation with data and its transfer to the point of use.

System integrators (SI) – they are integrating various subsystems in the architecture to build a unified information workflow. The system integrators work usually at one level over or under the subsystems which are connected to the integrator. Often the term ETL (Extraction, Transformation and Loading) technology or server is used as a synonym of SI. However ETL in the exact means is only one part of SI which servers the SI and coverts all the information that come from one subsystem to a consistent form to be saved to the database or transported to other places in the architecture. In the KBC logic the autonomic character of the subsystems remains valid however their integration is much deeper compared to the SI model. However the model of the information system integrated on the base of SI is the nearest to the logic of KBC. It can be perceived as the predecessor of the KBC model.

If we would like to describe the mutual position of these systems to KBC, we could state that the KBC as the most advanced concept, logic and IS architecture is a combination of the principles and relationships that are characteristics to each of these 4 approaches / systems:

$$KBC = ES \cap GW \cap CDK \cap SI.$$

The architecture model in the KBC model is visualised at the following scheme. The three main blocks of the company ERP system – TPS, MIS and EIS are present in the architecture. TPS and its



5: *KBC architecture compounds and relationships*
Source: composed by the authors

subsystems are helping the organization to manage the operational activities on the ground basis. In these systems lots of information are generated which are then distributed to the higher level platform – the MIS. The data are filtered and saved to the knowledge base as well so the company can access the data when required.

If we take a closer look at the differences between the sub-systems that are playing role in the company knowledge management, we can formulate several theses:

1. These systems generally use to store data, which can be transformed to information. This transformation is done at the moment when the manager queries the system for specific data, these data are provided, visualised in a certain way and finally, this data become information when they fulfil the information requirement that was defined from the information need.
2. This information is not saved into the system in this form – which should combine the explicit information as output from this respective system, the objective information requirement from the manager and the tacit information from the manager that should be combined into one part of the knowledge base.
3. These systems are not generally constructed to follow relationships between the data or

information, that are stored in the system. Although the systems have defined architecture with relationships between the data, between the different tables or subsystems, these relationships are formal and static rather than dynamic and intelligent.

4. System intelligence is not the primary compound of these systems. Only few systems are used to integrate the intelligence principles (Articificial Intelligence – AI) to provide extended value for the system user. The expert systems are self-learning in a specific manner, however they are still only using knowledge that is entered to the system and generated from the relationships. However, these systems are the highest technological and logical platform available in the KBC scheme.
5. The systems are limited to information in a specific form. They are not constructed to handle well with the modern information processing forms such as podcasts, video, audio etc. The KBC, at the other hand, has to operate with these kind of information and knowledge.
6. The systems do not carry the complete knowledge. The knowledge is not a synonym with information. In contrary to the term information, knowledge carries different aspects and added value. It is the way, manner, best practice, etc. of handling with the respective information. Knowledge states e.g. how to market the information, what channels to use, which method to use when trying to find the needed tacit information, etc. The KBC has to know and advice, how to do things, what are the best practices in the company, rather to tell the plain information, never mind how attractive and sophisticated it could be presented or visualised.

We think that it is necessary to define the position of KBC more exactly also by defining if IKBC is a completely new system or it is a new type of system. To answer this question we need to define the term more closely and look at the aspects and connections to other systems described above. KBC is a concept, not a concrete system. It is the idea, logic, intelligence concept rather than a concrete form – a system. We can state that KBC is a form of *theory-driven KBC architectures* (in contrary to the vendor-specific and market-driven architectures). The KBC is the concept the currently used or applied system should interact, be connected together to fulfil the actual requirements from the innovating company concentrating on the knowledge management. KBC is a model based on holistic KMS concepts that are designed to bridge the gap between the two classical categories of KMS – integrative systems and interactive systems (Maier, 2007). However, if we take a closer look at the information systems that are currently used in the companies to manage knowledge, we can also make some point on how to transfer these systems so they start to perform the role of KBC. The common concept in the modern companies is to operate the knowledge base. It is a kind of database or system that is used to store, distribute knowledge in the company and also outside the company when applicable. If we are thinking of transforming the architecture with the knowledge base to the KBC, we have to look for the solution on how to put advanced logic to the system and support the collaboration with the outer environment. This is a very important part of the KBC – it should create collaborative environment that creates the perspectives for enabling and supporting the product, communication, logistics collaboration and other areas of collaborative marketing. By integrating the customer and partners into these activities a new level of knowledge will originate and by the means of KBC this knowledge will be easily made reusable by the company employees at all organization levels.

The authors identify and state the following processes the company should go through when deciding to implement the KBC concept. It is defined as the KBC principle implementation model:

1. Redefine the company mission, priorities and strategic goals towards the innovative excellence through the excellence in the area of knowledge management.
2. Prepare the strategic plan of implementation advanced KM principles in the company.
3. Audit the current infrastructure – technical and technological background. Make overview of the systems, subsystems, that partially carry and information potentially forming the knowledge.
4. Audit the personal infrastructure.
5. Audit the processes.
6. Prepare the new model of the integrated knowledge management infrastructure to build the complete new organizational structure supporting the KBC concept.

In this process the following rules or recommendations have to be obeyed:

1. take enough time to realize this process and adapt to its results – this is a strategic decision and thus also the implementation phase needs to 3–5 years typically,
2. motivate constantly – all members of the team at any level need constant motivation to retain the process and continue to the final goal,
3. think forward – the architecture of used systems is dynamic and changes in time thus the concept of KBC needs to be able to adapt to these conditions,
4. detach the required amount of sources in all steps of the process – including money, people, conditions, assets and other important sources.

Identification of all subsystems that carry fragments, information or knowledge in the specific field and thus should be available in the created knowledge base cloud is necessary in the process of KBC implementation.

DISCUSSION AND CONCLUSIONS

Companies are constantly looking for new methods on how to work with the knowledge more effectively. These methods include knowledge creation, transformation distribution, dissemination, storage, reuse and many others. Current theory and practice driven model and architectures of knowledge management systems are lacking to provide desired parameters in flexibility, stability, safety, consistence and other requirements. The proposed model of Knowledge Base Cloud described by the authors together with the implementation processes after transformation to the practical information systems architectures provides a unique approach for the companies on how to handle with the knowledge information systems integration issues. This model is composed to drive the positive effects of knowledge management initiatives and support the added value and competitive advantage which these managerial approaches create. We except further scientific discussion on this topic, model confrontations and other scientific, expert and practical activities to incorporate this model in to the wider knowledge management implementation concepts and implementation practice.

SUMMARY

The primary aim of this article was to identify and propose the optimal model of working with the knowledge in the company with the use of the information systems available. In the article we studied the current approaches of internationally accepted authorities to the knowledge management systems architecture. The research was accompanied by an empirical study based on 93 companies in Slovakia to obtain primary data on the topic of knowledge handling. In the theory different models of knowledge information systems architecture are presented. Current trends in the information systems operations and architecture are strongly cloud-oriented. More and more companies are transforming there is portfolio and moving the services to cloud. Based on the theoretical approaches, results of our empirical study and identification of the latter trends and perspectives in the global markets we introduced a new model of an optimal knowledge information systems architecture which we named the knowledge base cloud. This was defined as knowledge sources, appearances and distribution that do not require end-user knowledge of the physical location of these sources and configuration of the system that delivers the services. Other characteristics of cloud computing can be also adopted to characterize this new term. The cloud should involve provisioning of dynamically scalable and often virtualized resources. Further in the article we define the relationship of knowledge base cloud to other subsystems carrying the knowledge and information. We identify and characterize the basic knowledge base cloud compounds including information systems, IS modules, relationships and connectors,, best practices, data-information-knowledge, know-how, access privileges, rules, process architecture and organisational structure. Finally, we compose the implementation recommendations to endorse the practical implementation of KBC in the innovative companies and transform it to the architectural concept applied in the real environment conditions.

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Abbreviations index

ACPS.... Advanced Cloud Protection System
AI.......... Artificial Intelligence
CAD ..... Computer Aided Design
CAM .... Computer Aided Manufacturing
CAx...... Computer Aided Activities
CC......... Cloud Computing
CI.......... Competitive Intelligence
CIC....... Computer Integrated Commerce
CIM...... Computer Integrated Manufacturing
CIx .... Computer Integrated Activities
CRM..... Customer Relationship Management
DMS..... Document Management System
DWH ... Data Warehouse
ECM..... Enterprise Content Management
EDI....... Electronic Data Interchange
EIS........ Executive Information System
ERP....... Enterprise Resource Planning
ES .... Expert System
GW....... Groupware
KB......... Knowledge Base
KBC...... Knowledge Base Cloud
KM .... Knowledge Management
KMS..... Knowledge Management System (Knowledge Management Information System)
MIS ...... Management Information System
MkIS.... Marketing Information System
MR........ Market Research
PLM ..... Product Lifecycle Management
SCM ..... Supply Chain Management
SI........... System Integrators
SOA...... Service Oriented Architecture
SRM ..... Supplier Relationship Management
TCO ..... Total Costs of Ownership
TPS....... Transaction Processing System
VPN...... Virtual Private Network
WAN.... Wide Area Network

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