# Knowledge Management System and Digital Transformation of Company

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***Abstract*—The article considers the different approaches towards modelling and implementation of knowledge management systems in the context of the enterprise's digital transformation. The methodology is based on the conceptualization of the domain using Semantic Web technologies, i.e. OWL and SPARQL standards, and semantic reasoners. The purpose of this paper is to present the results of knowledge management (KM) system design. Semantic-based architecture of search engine is proposed as an instrument for strict searching and corporate knowledge exploration. The KM-system deployment is supposed to be as a checkpoint of digital transformation of a company which means that the company is eager to earn money from data considered as an asset. As a whole the advantages of ontology-based KM-system are: minimizing the mistakes made by the employees; fast adaptation and involving the employees recently hired by the company; improving the speed and quality of analytics in company; preserving the knowledge which could be lost because of staff retirement.**

***Keywords*—knowledge, ontology, knowledge management, knowledge management system, information modelling, information management, Semantic Web**

## I. Introduction

The knowledge system is an essential requirement for business success of the company. Some companies employ data stewards for managing the data as the company's values. We consider knowledge as the information directly used in company's everyday processes. In contrast, the data is the stored information which has to be extracted and interpreted for use. That means in common that the data stewards are to consolidate and operate all the accessible data resources, to produce knowledge from data. This activity literally means 'knowledge management'.

The purpose of this paper is to present the results of knowledge management (KM) system design. This KM system is aimed to aggregate, normalize and transform corporate data in accordance with the ontology model of domain.

## II. Methodology

### A. Our KM Designing Approach

KM considers the deliberate structuring of knowledge and presenting it for users by request. The functions of KM-system are:

- accumulation of useful knowledge;
- informing the company's employees of the accessibility of the knowledge;
- presenting tools for structuring, transforming and linking pieces of knowledge of different sources.

The KM-system is supposed to become a digital 'brain' of a company delivering necessary support during the staff hiring and retirement, collecting the best practices for preventing the mistakes and decisions making support. However, the term 'KM-management system' is often used for the IT-tools for specific tasks. For example, Service Desk, Help Desk or even social media or the huge unstructured collections of the files may be considered as enterprise KM-systems. These solutions do not manage the knowledge, they just collect the pieces of information according to the strict structure. Considering the limits and weakness of traditional 'KM-tools' it is highly important to establish a new conception of KM-system. We suggest that the solutions bearing this name should be based on the following principles:

- including the conceptual (ontology-driven) domain model which is based on the terms and vocabulary used in the company;
- including software tools for model management;
- addressing as many sources as possible (internal and external ones) and index the content;
- letting the users ask questions in terms of conceptual model and answer them addressing to the data sources if needed;
- including some tools for spreading the best enterprise's practices among the employees as well as informing the latter about the knowledge elements they may need;
- containing the tools to input the information which cannot be placed into any database of a company.

Usually such information corresponds to the employees' experience and therefore must be saved because of its high business value. The KM-system shall act as an 'expert' which answers the users' questions better than any human. It is a 'lens' through which a user may look at any piece of corporate data and effortlessly transform it into the task-relevant knowledge. Implementation of the KM-system in the above presented sense may appear

to be impossible for CEOs in general. But the recent decade achievements in IT and semantic technologies in particular make this task quite reachable. As for the prerequisites they are OBDA paradigm (Ontology Based Database Access) [1], corporate sources metadata annotation projects [2], [8], and conceptual formalization of natural language projects [3], [4], [5], [6]. Semantic Web technologies play the main role in the machine storage and pro-cessing of the formalized conceptual models and data. OWL and SPARQL standards, semantic reasoners are the core components of Semantic Web stack. Their advantages are: linked data operation, data management flexibility, automated reasoning and inference for consistency control and data enrichment.

### *B. Current OWL-Practices for KM*

One of the most OWL-involved industries in the world is oil and gas. All the worldwide companies use the owl modelling in geology, field managing, reequipping the wells and petroleum extracting analysis. The most relevant solutions are i-Field by Chevron, Smart Field by Shell, Integrated Operation for the High-North by international consortium of 22 members, Field of the Future by BP, Integrated Production Management by ExxonMobil, and Intelligent Field Program by Saudi Aramco. In addition to efforts from major oil and gas organizations, service organizations like Baker Hughes has devised novel approaches for capturing, encoding, and provisioning of actionable knowledge from experts deployed in the field. As part of the data management effort, it is important to adopt effective record keeping and data curation strategies that have been extensively studied and addressed in other data-intensive disciplines [2], [7].

The ontology models consider reducing or even avoiding the ambiguity of the information referred to oil and gas exploration. It is possible because of semantic enrichment of the ontology model with the metaproperties. Especially in Petroleum Geology, properties like identity and unity can help in defining what exactly are the entities of reality that are being modeled in the database and also provide a good support to integrate models in the several scales of analysis (microscopic, well, reservoir, basin scales) into the petroleum chain [9].

The ontology approach is quite flexible. So it can be managed as 'stable' data as 'real-time' data which is transferring from multiple sources in variable-length time intervals. There are some solutions in oil and gas companies (Chevron, for example) focused to the monitoring of petroleum infrastructure. The current status of the oil wells is presented in live mode. Being gathered such information is recombined and classified by the logical rules based on the ontology of events. As a result the information about the well status is delivered to a user as knowledge relevant to the specific moment of time [10].

As presented above the ontology modelling in combination with Semantic Web technologies can be implemented as a core of high-rated IT-solutions.

## III. Implementation

We stated above that we see a corporate KM-system as an expert system which can find any information required by the user and to answer user's queries. The user experience starts with the query formulation interface. It may be implemented as a controlled natural language input tool, which hints the user the appropriate terms which can be used in request text and prevents from entering the sentences which sense may not be recognized. Another option is a graphical request constructor, allowing user to compose the query conditions using visual blocks, each of which represents one of the interrelated informational objects participating in the search.

The result of the first step is a query which include conditions on the several entities, for example: *the companies which has ordered a survey which costs more than USD100,000*. To answer this query, the system has to identify the entities (*company, survey*), their properties (*cost*) and relations (*has ordered*), find the sources of appropriate information in the corporate data storages, extract the objects matching the conditions and finally complete the query answer.

Obviously, it is impossible to develop a physical repository specially for KM-system. The Logical Data Warehouse is an appropriate architecture which allows users to get access to any information, independently of the physical server/database where it is stored. Logical Data Warehouse has to determine the information required to fulfill the user's search request, gather data from sources, aggregate it and present the results. The search requests must be formulated using the master-data set. It means that when a user refers to some business object (a customer, an asset etc.) in the search request, this object has to be identified according to the master data. It intends that MDM-system and KM-system should be integrated or KM-system should become a source of the master data. As KM-system retrieves the data from different sources (like an aggregator or a feed-reader) it should be able to access these sources, which can be mediated by ESB. ESB (Enterprise Service Bus) allows to read the information of as many company's databases as there are and deliver it to KM-system in order to answer the users' questions. Due to such an integration KM-system may become one of the key components of the IT-infrastructure of a company [Fig.1].

The semantic approach towards data conceptualization (including search and transformation) is very flexible. So, it may be used for narrow or wide purposes as well. The opportunity to process strict and complex search requests makes ontological tools very useful in the enterprise data management. They allow to extract

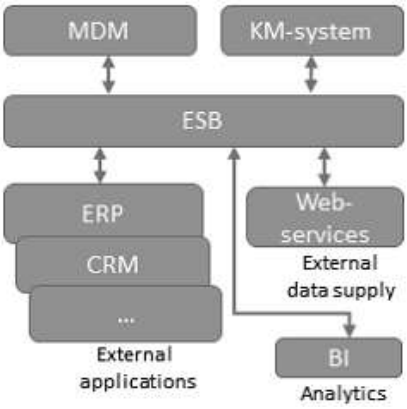


Figure 1. KM-system among the IT-infrastructure components

all the data answering the specific search request, but not only "the most relevant" or "the first n-entities" as the usual Internet search machines do. This strict search can be implemented with the ontology-structured data model. In other words, the search should be ontology-driven. Classes, objects and attributes of the ontology are the entities which represent the domain of company's business activities. Therefore the ontology model turns to be a framework of KM-system. The ontology data model links the entities and operates during the search request procedures. The basics of this framework can be pictured as follows: [Fig.2].

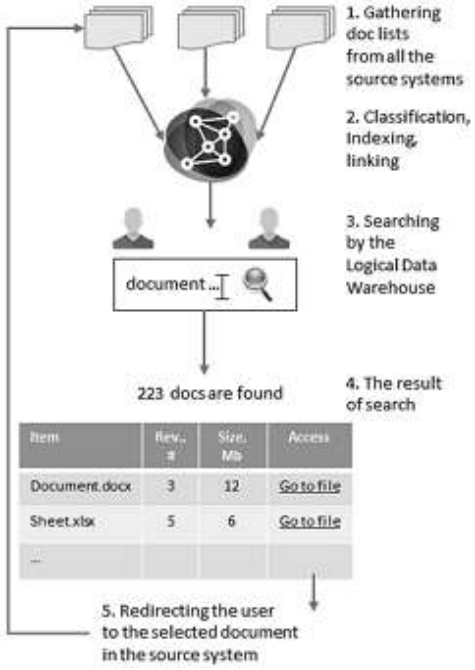


Figure 2. Searching by KM-system.

Presented scheme of data management procedures puts the KM-system into the center of an enterprise IT-landscape and provides a lot of benefits for the users, mostly because of the instruments of linking, aggregating and searching knowledge. These instruments are beyond the traditional (non-ontology) methods. The semantic search can easily deal with different types of data (texts, graphics, sheets and so on). Also the semantic enrichment can be managed by multiplying the connections between entities during the automatic text mining.

The KM-system can be involved in several scenarios:

- complex analytical system deployment which processes the data in a variety of dimensions, such as purposes of business activities, staff, territories of operations and so on;
- managing the arrays of information according to the selected task (for example, all the company's documents about specific type of asset);
- searching for the analog of entities in corporate data (i.e. documents, objects, processes etc.);
- accessing the enterprise data by the management and/or staff through a single access point;
- integration of the different enterprise software (document flow system, consumer relationship management system – CRM, personnel management system, project management system and any others);
- optimization of staff's efforts for collecting, validation and transforming the information;
- supporting the exchange of employees' experience and collecting pieces of one's experience in a structured and catalogized way.

The KM-systems addressed to these scenarios are being implemented in Russia [11] and other countries [12].

## IV. Discussion

According to our experience, there are some restrictions which usually make some difficulties to bring the KM-system into company's life. Firstly, it is due to lack of CEOs' readiness to start the process. Secondly, it is because of the low level of IT-infrastructure development in a company. As for the first restriction, it is possible to inform or even educate the managers and CEOs about the advantages of the KM-approach. As for the second one, the most effective way is employing an IT-company as a contractor for KM-system development. And later the local IT-specialists will have an opportunity to enrich their competence in ontology design. Another field for discussion about KM-system addresses towards the economy sector limits. Can ontology-based KM-system be effectively used in all of them? We suppose that it is directly appropriate for the companies of industrial sector (focused on energy, engineering, machinery and so on). For service companies or social-media companies the KM-system should probably be accompanied by the machine learning and predictive analytics technologies.

Finally, KM-system implementation requires the development of the ontology model which requires collaboration of the analysts aware of conceptual modeling methodologies and domain experts, which is a resource-intensive task for an organization.

## V. Conclusion

The most of the currently implemented corporate KM-systems are unable to transform the vast amounts of corporate data into an actionable knowledge. To accomplish this task, the view of a corporate KM-system should be shifted toward semantic information processing. The modern KM-system shall operate the meaning of information, not just the text or database records. The ontologies and Semantic web technology stack are the most appropriate tools to accomplish this task.

We claim that the functional features of KM-system include:

- supporting the structural management of data model which is based on conceptual domain model. The data model should have an implemented multi-point view approach [13].
- transforming all the accessible corporate information in correspondence with the structure of data model. This is a way to utilize it not as data (i.e. items stored in a warehouse) but as knowledge. The corporate end-users will be able to operate such knowledge in active and proactive mode in their professional activities and without exerting any interpretation effort.

The KM-system deployment is supposed to be as a checkpoint of digital transformation of a company which means that the company is eager to earn money from data considered as an asset. As a whole the advantages of ontology-based KM-system are:

- minimizing the mistakes made by the employees;
- fast adaptation and involving the employees recently hired by the company;
- improving the speed and quality of analytics in company;
- preserving the knowledge which could be lost because of staff retirement.

The expenses needed for the KM-system deployment should be considered as the strategic investments for the digital future of a company.

## References


[1] E.Kharlamov et al. “Ontology Based Data Access in Statoil”, Web Semantics: Science, Services and Agents on the World Wide Web. vol. 44, pp. 3–36. 2017.

[2] C.Chelmis, J.Zhao, V.Sorathia, S.Agarwal, V.Prasanna “Towards an Automatic Metadata Management Framework for Smart Oil Fields”, SPE Economics and Management. vol. 5, is. 01. 2013.

[3] N.V.Loukcshevitch, B.V.Dobrov “Proektirovanie lingvistich-eskikh ontologii dlya informatsionnykh sistem v shirokikh pred-metnykh oblastyakh” [Modelling of Linguistic Ontologies for IT-solutions in Various Spheres], Ontologicheskoe modelirovanie [Ontology of Designing], 2015. Vol.5. no 1., pp.47-69.

[4] V.F. Roubashkin Ontologicheskaya semantika. Znaniya. Ontologii. Ontologicheski orientirovannye metody informatsionnogo analiza tekstov [Ontology Semantics. Knowledge. Ontologies. Ontological Methods of Text Analysis]. Moscow, Fizmatlit, 2013. 348 p.

[5] V.F.Roubashkin Predstavlenie i analiz smysla v intellektual’nykh informatsionnykh sistemakh [Representation and Analysis of Meanings in Intellectual IT-systems]. Moscow, 1989, Nauka. 192 p.

[6] Ph.Cimiano “Ontology Learning and Population”, Text. Algorithms, Evaluation and Applications. Springer. 2006.

[7] Digital Oilfield Ten Years On: A Literature Review. Energysys. 2016. p.11.

[8] R.Werlang, M.Abel, M.Perrin, J.Carbonera, S.Fiorini Ontological foundations for petroleum application modeling. Research Gate. 2014. https://tinyurl.com/ybp73euy (accessed 2018, Oct).

[9] M.Abel, M.Perrin, J.Carbonera, L.Garcia Ontologies and data models: essential properties and data modeling for petroleum exploration. Research Gate. 2016. https://tinyurl.com/yd4l8yeu (accessed 2018, Oct).

[10] Zhu T., Bakshi A., Prasanna V., Cutler R., Fanty S. Semantic Web Technologies for Event Modeling and Analysis: A Well Surveillance Use Case. SPE Intelligent Energy Conference and Exhibition. Utrecht, The Netherlands. 2010. p.2-3.

[11] https://serge-gorshkov.livejournal.com/48835.html (accessed 2018, Oct).

[12] http://www.kmworld.com/Articles/News/KM-In-Practice/Oil-company-integrates-service-and-information-management-128131.aspx (accessed 2018, Oct).

[13] S.Gorshkov, S.Kralin, M.Miroshnichenko Multi-viewpoint Ontologies for Decision-Making Support. Springer, 2016. Knowledge Engineering and Semantic Web. Vol. 649 of the series Communications in Computer and Information Science. pp 3-17.


## СИСТЕМА УПРАВЛЕНИЯ ЗНАНИЯМИ И ЦИФРОВАЯ ТРАНСФОРМАЦИЯ КОМПАНИИ


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**Аннотация:** Статья посвящена подходам к проектированию и внедрению систем управления знаниями в условиях развития цифровых трансформационных процессов в различных отраслях экономики. Методология основана на представлении концептуальных моделей предметных областей с использованием технологий Semantic Web (стандарт представления концептуальных моделей OWL, язык доступа к графовым базам данных SPARQL, машины логического вывода). Цель статьи- представление результатов проектирования системы управления знаниями.

Предлагается собственная архитектура поисковой системы, основанной на семантических технологиях. Данная система рассматривается в качестве инструмента по точному поиску и извлечению корпоративных знаний. Реализация подобной поисковой системы выступает в качестве "контрольной точки"в процессе цифровой трансформации компании, что предполагает извлечение прибыли в ходе обработки данных, которые рассматриваются как актив компании. В целом преимуществами систем управления знаниями, основанных на онтологиях, являются: уменьшение количества ошибок со стороны работников; быстрая адаптация новых работников и их активное включение в деятельность компании; повышение скорости и качества аналитики в компании; сохранение знаний, которые могут быть утрачены в связи с уходом работников из компании.



Received 09.12.18