Experiences in Development and Implementation of Knowledge Management Systems

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Abstract. The paper describes experiences of the Knowledge Management System (KMS) development and implementation in the Army of the Czech Republic. The literature review presented the KMS area and compared them with the team results. The used methodology and technology environment based on SW ATOM is explained. Follows the KMS examples: MENTAL, MilUNI, CEFME, Lessons Learned from the missions and experiences from the KMS education. The next step will be the KMS in security of information domain that correspond with the actual theme of cyber defense. Problems with adoption of the KMS are mentioned.

Keywords: Knowledge Management System; ACR; experiences; methodology; ontology; Topic Maps; ATOM

1 Introduction

Twenty-first centuries is very often called as "the century of knowledge". The everyday usage of available information, business and internet technologies in overall activities confirm that this true reality. Increasing amount of data lead us to data overload. Overload of data is making knowledge management more important. Knowledge management system (KMS) helps executives cut through the noise, share information, and improve their decision-making.

Use of the KMS is becoming more common also in military area. Knowledge management systems can facilitate better more informed military decisions. The U.S. Army's After Action Reviews are an example of a KMS that has helped build the Army into a learning organization by making learning routine. The Army of the Czech Republic (ACR) started first systematic activity covering this issue from 2008. The defense research project 'Network Enabled Capability (NEC) KMS – MENTAL' was the first project (2008-2011) dealing with Knowledge Management at the Ministry of Defence in the Czech Republic [1]. Working on the MENTAL project, the

team members were also inspired by other topics suitable for the knowledge system development. One of them is the topic of Lessons Learned (LL) from operations. People of the defense sector, to whom the results of the MENTAL project were presented, mostly found the ATOM [2] software interesting and suitable for creating even more knowledge systems.

Another successful practical example of ATOM SW technology is knowledge system Military Universities (MilUNI) providing an explicit platform for the cooperation of military universities in teaching, research and exchange of teachers and students. Some results and experiences conclusions are now available and have been already introduced to teaching in the subject Designing of CIS at the University of Defence (UoD) in Brno. The paper describes experiences from development and the practical use of several KMS based on ATOM SW technology created as the result of the MENTAL project and other following projects. The team decisions in KMS were published at the conferences, for example [3, 4].

2 The Literature Review

When we look at the knowledge management field in general, we can find quite a lot companies involved [5, 6, 7]. But, if we focus only on Topic Maps (TM) theory background, there are about 10 different implementations we can consider. Usually, the solutions are free to download and use [8]. Probably the most advanced open source solution provides Ontopia [9]. Their product is highly mature; the first version was released in 2001. Many commercial products use their platform in custom solutions, for example, as mentioned on the Ontopia web pages [10], the US Office of Naval Intelligence uses the software to maintain information about foreign fleets and ships. Other significant software packages utilizing TM include Moresophy [11] or xSiteable [12].

Ontopia is a set of tools which contains everything you need to build a full TM-based application. Using Ontopia you can design ontology, populate the topic map manually and/or automatically, build the user interface, show graphical visualizations. The core of Ontopia is the engine, which stores and maintains the topic maps, and has an extensive Java API. On top of it are built a number of additional components. The architecture of a knowledge system based on Ontopia is structured into several layers: data, session, presentation and application. The data layer contains available data, such as data collections, documents, document bases, databases, information sources. The session layer connects classes with their occurrences i.e. knowledge (given by ontology) with data. In the presentation layer, the ontology which passes on information and knowledge to the application layer is implemented. The application layer presents information and knowledge to the user.

The example of the knowledge bases development on the TM principle, using ONTOPIA SW, was prepared in the team a solution to compare it with using the ATOM SW. The related application was published in [13]. The solution began by ontology scheme preparation using Ontopoly editor. Using the Ontopia knowledge system software was necessary to analyze its interface and the way how the user applications are connected.
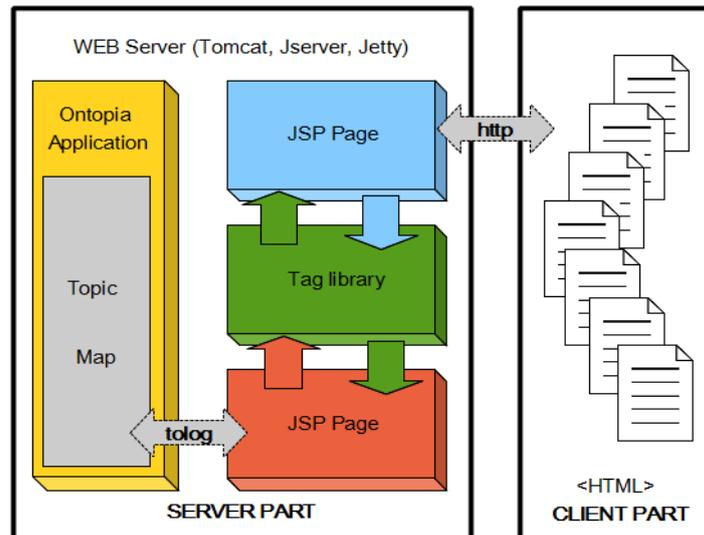
Fig. 1. The architecture of KMS with data flow (Source [13])

The ontology layer was provided by Ontopia software, the session layer is ensured by the TOLOG language, which obtains knowledge from the ontology. The application layer is formed by JSP (Java Server Pages) components in J2EE (Java Enterprise Edition) and Apache HTTP server, see Fig. 1. In comparison with ATOM tools that we use in our projects, the solution using ONTOPIA strictly applies the TM theory. The outputs are usually more complex; the ATOM outputs are easier to take in and its performance is accordingly lower to solution using the ATOM SW.

3 The Theory and Technology of the KMS

The main characteristics of the used theory in KMS development are mentioned and the SW ATOM technology environment is described in the chapter.

3.1 ISO Standard 13 250: Topic Maps

Why we have started to create the solution of the knowledge system based on the Topic Maps (TM) principle? The main reason was that knowledge representation is intuitive; it keeps information in context, and conforms to human thinking more than so far known other knowledge organization principles.

The TM model consists of the three basic elements: topic, association between topics, and occurrences of the topics [14]. The TM is standardized in ISO/IEC 13250:2003. The new promising development possibilities of the TM include filtering by scopes, TM merging and TM Query Language (TMQL). The topic contains denominated subject of interest. It stands for a subject we want to discuss; it is its

substitute in the computer. Each topic represents just one subject. It is a place in TM where all known information on the given subject is available by means of relations and occurrences. Subject is a part of the real world, which is described in TM. Each subject is represented by one topic and it can be anything: a person, thing, entity, process, etc.

The subject is unambiguously addressed by identifiers:

- Subject Locator – for information sources.
- Subject Identifier – for other subjects.

Associations represent relationships between topics, are bidirectional, and express relationship between subjects; they are not oriented and may have an arbitrary form:

- Unary – represents the characteristic of a subject, e. g. has-seaside.
- Binary – forms a relation between two subjects.
- N-nary – generic relation, e. g. export (from where, to whom, commodity).

Occurrences are formed by information relevant to a given topic; they can refer to information or they might just contain it. There are two types of occurrences:

1. Internal occurrence that represents the topic characteristics and is placed directly in TM.
2. External occurrence as a reference to an external information source. It connects the information and the knowledge layers.

3.2 Implementation of TM in SW ATOM

One of the goals and benefits of the SW ATOM is to support the implementation of projects of knowledge management systems, especially effective development of powerful web applications. This has necessitated some extensions or specification of the TM standard.

Changes in the processing of occurrences of classes, work with associations and development of the user interface, to name some of them. A simple set of basic features for TM Internal Occurrences has been renamed to a Variant type property. The following data types have been further complemented:

- Code and Ident – for the unique identification of the entity, where uniqueness is checked directly in the SW.
- Group Tree – a simple built-in taxonomy. Taxonomy is the fundamental building block of knowledge systems; in the TM standard it is necessary to create them always from the beginning, which is time consuming and difficult to maintain.
- Selection – forms a one-level code list, applied cardinality 1: N and M: N.
- Text – this feature allows inserting text in XHTML; it is provided by the built-in text editor.
- Picture, File –storage of images and files.

In the definition of associations the following changes were finalized:

- Order (Sort) – each association can provide a structure of occurrences.

- Relationship in % (Rate), e.g. to express supplier-consumer relationship.
- Hierarchy – a special type of association for Parent-Child relations.
- The starting types of the ATOM SW associations are binary associations. Unary associations are replaced by extended set of features; especially Group Tree and Selection. The main reasons for the use of N-nary associations are addressed through Sort, Rate and Hierarchy.

The above mentioned changes in associations are appropriately reflected in the creation of web applications reaching higher performance of applications and further in saving the lines of code which is needed for the service. The SW ATOM has been designed to build knowledge based applications. Such applications require a precise application layer and work with users. The authorization of users shall be under control, i.e. the settings of the activity in the SW ATOM which can the user perform in the knowledge system. It is necessary to monitor the user's activities, i.e. what object the user has created, modified or even opened in the knowledge system.

3.3 Structure of the technology environment

The technology environment consists of the three layers:
1. ATOM Studio: Schema Designer, user administration, batch data operations.
2. Data Editor: Includes data into database via ontology.
3. User Portal: User approach to KMS.

At first, create ontology of your problem domain in the Schema Designer. You can design the ontology by drawing which is similar to drawing on a flip board or writing it through filling in forms and using pre-prepared templates and adjusting them to your needs. Immediately you can enter data through the forms which are generated on-fly from the ontology in the Data Editor. And after that you are able to work with data, realize information retrieval or even visualize them and complete by user portal.

4 The Methodology of the KMS Development

The methodology of the KMS development was prepared in the first project MENTAL and then many times evaluated and improved by the production of the other systems and in the education process at the UoD, too. The team has verified the following methodological procedure:
1. The initial analysis of documents and the selection of concepts for ontology.
2. The ontology design and implementation in SW ATOM.
3. The knowledge base preparation.

The key step of the KMS preparation is the ontology preparation. The methodology of the KMS ontology development and implementation is presented and its implementation in the ATOM environment is documented. The procedure and method of methodology is explained in particular example from the domain of

scientific conferences that is used as example in education.

"*Analyze the information sources of the conference; produce an overview of the information systems field, the processing of knowledge, social networks and communication systems that were discussed at conferences. Create a knowledge base on the conference; within the knowledge base, process selected articles on information systems, knowledge processing, social networks and communication systems*".
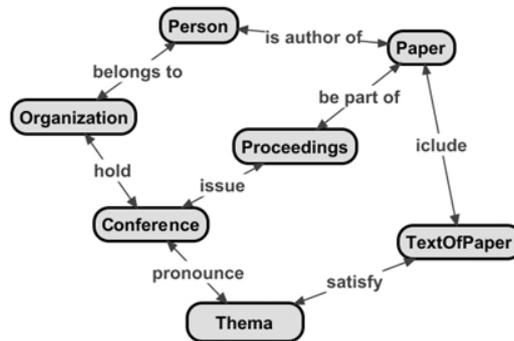

Fig. 2. Ontology design on conferences [Source author]

After analyzing of the information sources were found candidates for the ontology classes are picked up and evaluated in the team discussion. It results in the ontology design in Visual Understanding Environment [15], see Fig 2; and characteristics definition and their assignment to the classes, and see Tab. 1. The associations design is in the table form similar as the characteristics (Tab. 1).

Table 1. Classes and their characteristics [Source author]

	Conference	Proceedings	Paper	TextOfPaper	Theme	Person	Organization
Name	X	X					X
Firstname						X	
Secondname						X	
Title			X	X	X	X	
Abbreviation	X						X
Date	X						
Abstract	X		X				
Place		X					X
ISBN		X					
WWWpage	X	X				X	X
Text				X		X	X

The ontology is then prepared for implementation into ATOM environment and the knowledge base preparation. First are included characteristics of classes, classes are than included and the proper characteristics are assigned to the classes. The last step is implementation of the associations. After ontology definition is immediately possible to prepare the knowledge base, see an example in Fig 3.
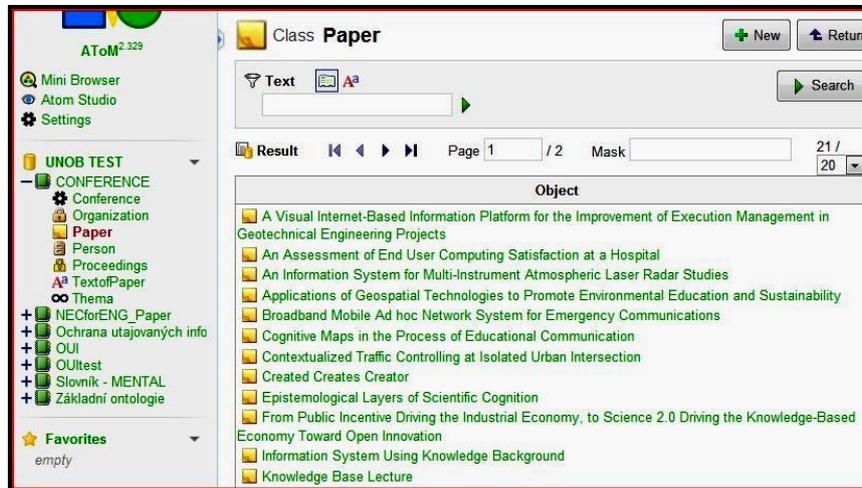
Fig. 3. Ontology and data in the ATOM environment [Source author]

5 Examples of Knowledge Management Systems

The realization team in the last seven years developed several KMS that are as a research results and some of them are implemented in the ACR and used for the analytical purposes. Next chapter describes main characteristics of the KMS created.

5.1 Administration of NEC in ACR

Knowledge management system (KMS) MENTAL contributes to the solution of the problem of knowledge management of the Army of the Czech Republic Network Enabled Capability (ACR NEC). Knowledge system MENTAL is the result of the defense research project and development project of the Department of Communication and Information Systems (CIS), Faculty of Military Technology, University of Defence. MENTAL project was launched in 2008 with the aim of processing the analysis of knowledge-based approach, ontologies and ontology languages, and assessing their suitability for the use in the Army. Emphasis was placed on evaluating of the state of security solutions at ACR NEC, formalizing a NEC strategy and developing conceptual NEC encyclopedia, designing methodology for developing knowledge-based systems in the Army, and developing ontologies of Ground Forcers C2 System (GFCCS), and NEC security.

For the practical implementation of the knowledge system has been selected a product of AION CS Company - MENTAL SW tool ATOM2,. ATOM2 is a set of software tools for the construction, maintenance and presentation of the information and knowledge. ATOM is based on TM principles. ATOM can implement taxonomies, classifications, network keywords, dictionaries, encyclopedias, thesauri,

indexes, catalogs, information collection documents, photo bank, and timeline of events with easy creation of interconnections and clusters.

At the end of 2011 functional model of MENTAL KMS was implemented into Army Staff Information System (SIS) ACR. SIS is designed to support and integrate command and staff operations at the strategic, operational and tactical levels. Then the project finished through review process. Opponent conclusions noted strong potential for implementation of the MENTAL project in the ACR environment. Consequently results of project were implemented in the SIS environment for ACR personnel that can familiarize with KMS environment for their routine work.

5.2 Lessons Learned (LL) from the Military international missions

The main goal of the LL project was to cover documents with the knowledge layer that prepare integrated access to LL information. NATO is paying substantial attention to LL, its Joint Analysis and LL Centre (JALLC) runs the portal [16] and database of the experience from operations. It is a platform to share documents and a tool to connect users with the same interests (Communities of Interest). As a data source for our project we have used documents being pursued at the Institute of Doctrine at the Training Command – Military Academy (TC-MA) in Vyškov. Those documents are translations of selected documents from JALLC portal. During the work we have collected 31 documents published in PDF format, in total about 2000 pages (one typical document consists of 60 to 100 pages).

The topics include the experience from conducting operations of their own units (e.g., 'Mission planning','100 days in an operation', 'Escalation of power', 'Patrol activity', 'Base protection, 'Searching operation', 'Snipers'), the description of adversaries and their combat (such as 'Muslim culture', 'Tactics of insurgent fight', 'Taliban') and evaluating information (for example, 'Experience of the LL', 'Information extraction of resources'). After the initial analysis of documents and the selection of concepts for ontology (classes and occurrences), the splitting of documents into sub-sections (articles) and the creation of the first part of ontology was performed. Then, the ontology was developed by extending the ontology of LL documents; the significant class instances were selected and included into the system. Finally, the knowledge layer was linked with articles. For this step special scripts for automation were created.

The process of document splitting included the conversion into XML format; the major parts are sub-automatically identified (based on headers and paragraphs within text). The final processing depends on human eyes and experience. During the analysis the following concepts were identified: PROCESS (as described in LL), THING (as described in LL, predominantly weapons), RULE (rules and procedures to execute processes), DOCUMENT (referred to in LL, such as a regulation), ORGANIZATIONS (referred to in LL, especially within army), FUNCTION (a described role or a function), PERSON (mentioned as a member of an organization), REGION (part of a country referred to in LL) and TOWN (located in country and region). The automation task consisted of preparation, exploration and import steps. Preparation step includes the preparation of the unstructured data sources and matching ontology terms. During exploration the processing of the data

sources and the finding of the new associations between the objects in ontology and the data sources was performed. Finally, the import step connected the generated associations into the existing knowledge base.

5.3 Portal for Military universities cooperation

The aim of the knowledge system Military Universities (MilUNI) is to provide an explicit platform for the cooperation of military universities in teaching, research and exchange of teachers and students [17]. It is another successful practical example of ATOM SW technology use introduced as the main result of MENTAL scientific project. The system contains information about universities, their structure, and focus at universities members. It includes publications from conferences in full text so that they can be studied or cited by partner universities' academic persons. Main page is shown in Fig. 4.
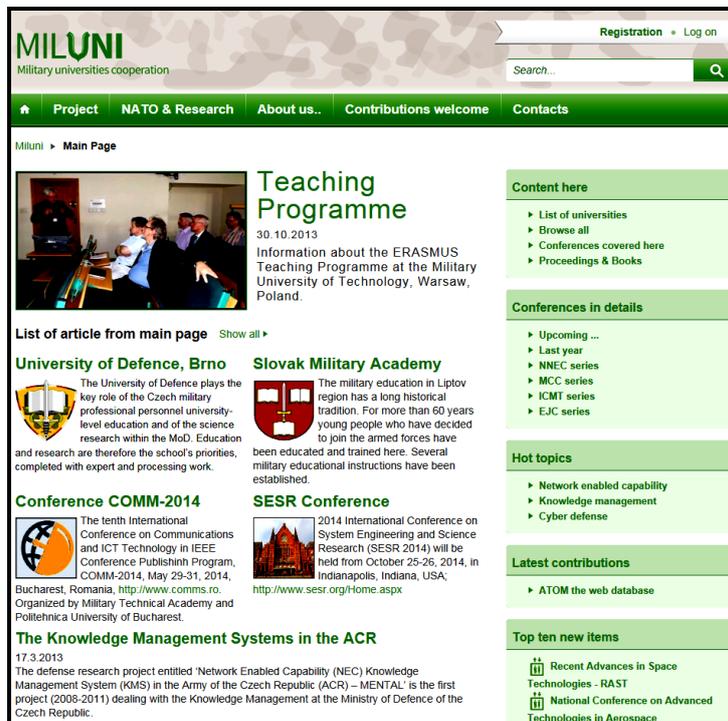

Fig. 4. MilUNI knowledge system main page [Source author]

The MilUNI structure is flexible. It is currently divided into following parts:
- Main Content (list of universities).
- Projects.
- NATO & Research area.
- Conferences area.

This university is involved in many universities' cooperation communities, i.e.:

- Central European Forum on Military Education (CEFME).
- International Military Academic Forum (iMAF).
- LoD7 (Line of Development - initiative for the exchange of young officers).

University of Defence was set up to create web Portal to cover all these activities as basic communication and information tool. The knowledge system Military Universities (MilUNI) will serve as a basis for the common web portal enabling easy, well arranged and user-friendly tool for universities' communication.

5.4   Portal for CEFME group

The goal of the CEFME group is to support the education and training military professionals and cooperation of the participating universities in teaching, research, exchange of teachers and students; increase mutual awareness and facilitate the organization of joint events. Information for portal was accessed from the open sources; nevertheless, wherever possible, the information was evaluated and confirmed by using different sources on the Web or from official papers. The main feature is to provide user friendly access to the information about the structure of the university, its main educational areas, program of the faculties' education, list of departments, research and conference activities, etc.

The Portal CEFME is derived from the MilUNI, but it is adapted to the needs of the ten CEFME universities, see Fig. 5. The ontology consists of the same MilUNI classes: university, university-part, organization, product, person, collection, conference, article, and activity (program, project, and product). The KMS is linked to the CIA FactBook [18] in order to use information about countries. The new classes are meeting, action, workgroup, and function.

6   Experiences from Implementation

In this chapter the team summarized experience in the KMS implementation.

6.1   Project MENTAL Implementation

Preparation of implementation took place in cooperation with AION CS Company and 34 (currently known as CIS Agency). CIS base, Prague. Basic installation requirements have been prepared in the "Installation of knowledge management MENTAL – KMS ACR NEC to SIS", which took place on the basis of cooperative meeting. Knowledge system was installed to the SIS (Staff Information System) ACR for the administration of Network Enabled Capability - MENTAL, as a result of defense research project (2008 - 2011).

To the SIS ACR has been implemented results of MENTAL – ACR NEC KMS, NEC Glossary, Legislature concerning "Laws for the people".
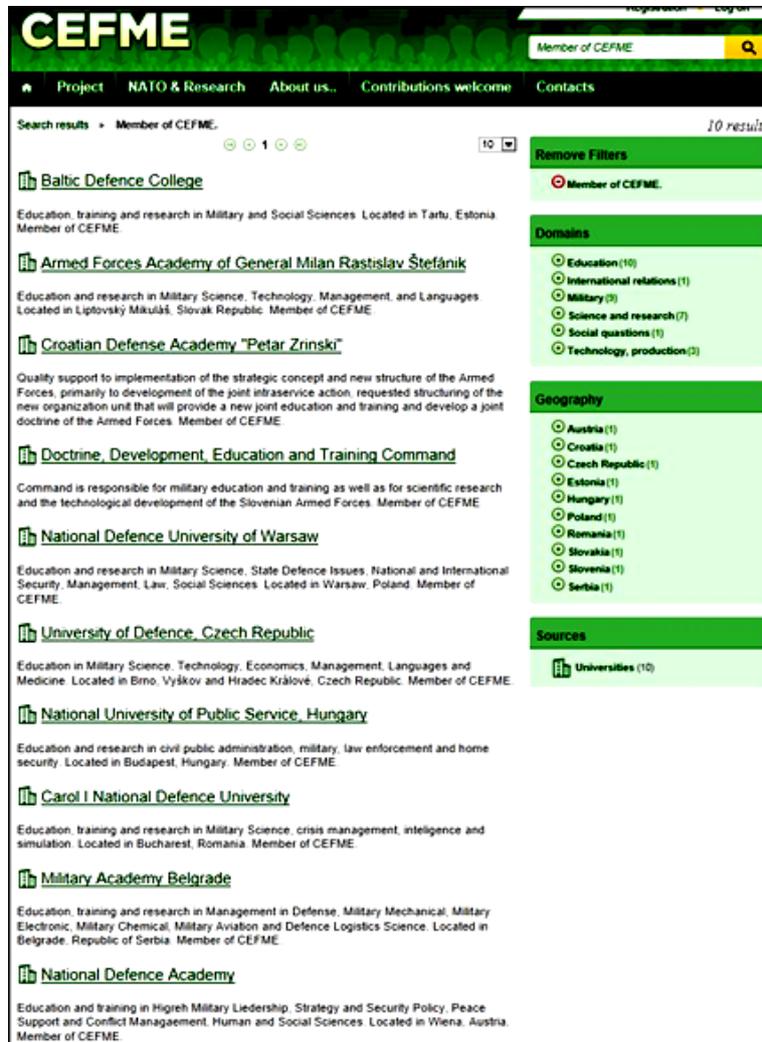
Fig. 5. Portal – Result List of the CEFME universities [Source author]

To the installed systems were also attached documents:
- Functional model of MENTAL.
- The methodology for creating KMS.
- User documentation for ATOM SW.

After the MENTAL installation to the SIS ACR environment army staff is given the first systematic possibility of familiarization with knowledge system, which was implemented by using commercial software ATOM2 from AION CS Company. Possibility to access to the knowledge portal MENTAL was supported by SIS from the end of 2012. KMS associates the information in the context of any form of

documents (text, image, and diagram). In particular, important is information context, in case of link from information to the other, if they have some connection. It is very useful for military personnel if they need to process relevant ACR documents. They do not have to search in sets of documents concerning all problems, but they can faster finish their searching by simple navigation using ontology.

The documentation includes "Ministry of Defence knowledge systems methodology", approved by MoD/CIS department. The final methodology is also a result of the MENTAL project and projects for the development organization of the Department of CIS, Faculty of Military Technology, UoD. The installation was carried out jointly by AION CS and management of department SIS 34.CIS base. Installed software was prepared in the form of a virtualized system, which includes Windows Server 2008 R2, database server MS SQL 2008 and SW ATOM with knowledge systems. SW license lent the CIS department of the UoD. During installation there was no problem. Additionally, there have not been reported any problems during testing period and whatever necessity of servicing. This argument is essential for awards cooperation with the supplier of software company AION CS, which proved to be a strong, technically proficient contractor operated technology and reliable partner of the research team and ACR.

6.2 MENTAL access measurement

One of the tasks of the project was to analyze user access of SIS to information stated in the MENTAL. The emphasis was placed on evaluating of terms with the highest number of visitors. The collection and evaluation of approach was carried out month by month from January 2012 to today. It is possible to say that SIS users are very satisfied with MENTAL pages and the most visited terms are following:

The most searched term was The Promise and Code of Ethics of a Professional Soldier, which discussed the implementation of the Concept of the professional ACR and the mobilization of the armed forces of the Czech Republic.

The second most searched term was Ground Forces C2 System. GFCCS is an extensive project that brings not only the introduction of new technical features and technologies, but also a means for the necessary change in the style and content of work activities of commanders and their staffs, and consequently a means to optimize their organizational structures. The user's attention was completely focused on both the GFCCS of Ground and Air Forces.

Further was detected interest of users to Manuals of the GFCCS of Ground Forces, and a common view of the situation in an integrated environment NEC and project SOANEC (Service Oriented Architecture NEC).

The third term with the highest number of visits was NEC that is understood as a coherent integration of sensors, commanders and staffs, weapon systems, developing the army's ability to act flexibly and efficiently. In an integrated environment, commanders will be better informed about the situation on the battlefield. At the event will be able to adequately respond using voice and data communications.

NEC is a long-term transformation program, it will take many more years before communication and information systems, operational procedures and knowledge will be connected with result of a significant improvement of military operations.

7 Father Works

Father works in the KMS area are oriented to the security of information area. The security management of every organization is responsible for the design and implementation of qualified access to information. It is necessary to know which dimensions must be determined in information handling. The dimensions of the needs can be processed by developing the taxonomy, which determines what we want to solve. In our case we decided to design seven dimensions, see Fig. 6.
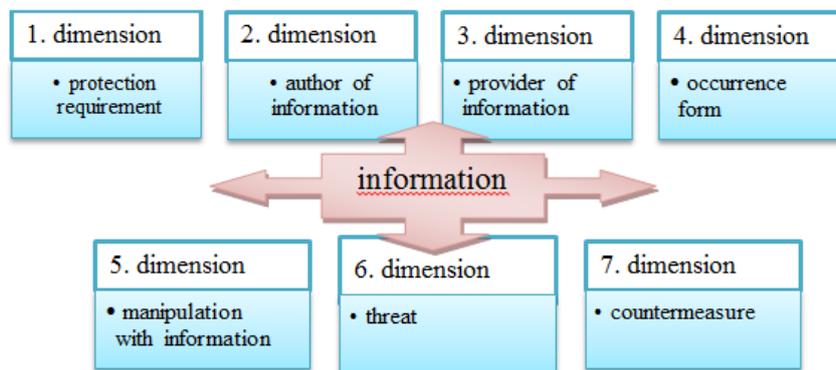

Fig. 6. Taxonomy of information [Source author]

When processing taxonomy we realize which aspects need to be taken into account in our decision. Security management decides exactly how the access to information will be set up. This approach must respect the legal requirements regarding data protection. Based on the analysis of available resources we have selected 32 main documents, which deal the problem of information handling.

These documents are arranged hierarchically and represent 820 pages of text. This enormous number of included requirements must be analyzed and presented to all the people within the organization. The form of the presentation must be acceptable for all personnel. There must be easy to find out more details on this issue and must be easy to determine the relation between different areas.

Handling of information within and outside the organization is very sensitive activity. Wrong decisions can have disastrous consequences. Security management must accurately assess every particular situation or state change and then decide to allow or deny access to information. For decision-making process of the security management is necessary to develop ontology. This ontology must capture the real issue being addressed.

To understand the topic and context, it is necessary to design ontology understandable to personnel responsible for the protection of information. The design of ontology proposes the classes, see in Fig. 7. The next step will be precious description of each class and implementation in ATOM SW for creating "Security of information KMS portal".

All files have to be converted to the same file format and portioned into separate paragraphs, tagged and interconnected according to the previously defined ontology.

Process of choosing the proper particularity of connections is the biggest issue that makes crucial difference between helpful and complicated system. Future objectives of this work aiming to finish the back end of the KMS and put it into operation for the users.
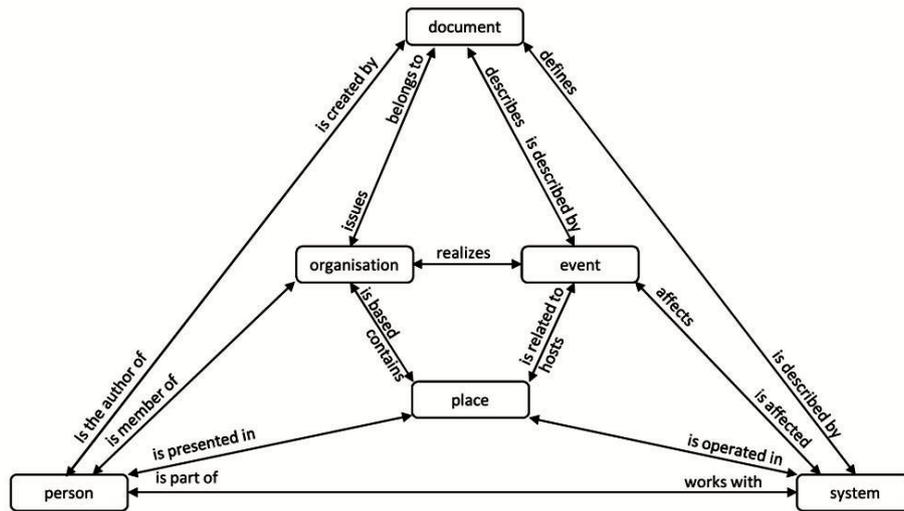

Fig. 7. Ontology for security of information [Source author]

One of the problem we dealt with is the mutual dependence of different legal standards. That gives the link between documents, which are defined just by the ontology. It is complicated to build formal context when one document or term changes or regulates meaning of some other. The final front end application realized by additional web server is intended as the extension based online tool for end users to help them navigate through different types of content. No need of the special skills for the end users is the main purpose. Searching, comparing and studying the included documents will be realized through the combination of keywords and hypertext links in the KMS system.

8 Conclusions

The article presents the results of the research projects MENTAL and MilUNI. The current project is PRO209 [19] that follows in the analysis, development, implementation KMS, and using them in ACR and teaching at the University of Defence, Faculty of Military Technology, Department of Communication and Information Systems.

The enrichment of the KMS for the ACR NEC by further successful applications extends the view on the ATOM software for creating knowledge systems and information management. The KMS developed by the team are implemented "step by

step" in ACR environment and in the international context (MilUNI and CEFME), too. The team ambition is not only developing of KMS in research process, but to implement it into the everyday use.

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