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A MODEL OF ONTOLOGY SUPPORTING COTS COMPONENT SELECTION PROCESS IN MANAGEMENT INFORMATION SYSTEM DOMAIN

Abstract: The main aim of this article is a proposal of ontology as a solution to support COTS components selection and evaluation in Management Information System (MIS) domain. On the basis of Computer World Report, five ERP systems were selected including their specified characteristics. A proposal of a model of ontology has to provide systematic and repeatable solution for COTS components selection in MIS domain, including individual preferences of an enterprise. The conclusions finish this paper.

Keywords: ontology, COTS software, Management Information System, COTS components selection.

1. Introduction

The choice of appropriate software components from any number of available software solutions is one of the most important issues in selection and development process of enterprise's Information System. The existence of a huge number of diffused information is one of existing inconveniences relative to the selection process. Moreover it could bring the risk increase in the decision-making process. Hence the crucial key is an effective and efficient analysis of given domain which has a great influence on information quality using to perform these activities.

The selection of Information System is a complex process. The methods, techniques, tools and information available on the Web provide different types of system selection and many approaches preferable by decision-makers. The problem is how efficient are these approaches and how the selection process can be ameliorated. Hence the application of a domain ontology brings a systematic approach of COTS components selection and it allows decision-makers to find the most suitable characteristics of components.

This article presents a model of ontology supporting COTS selection process in Management Information Systems. For each of five ERP systems the set of criteria was selected. The main aim of that ontology is to provide a systematic approach for COTS components in Management Information Systems domain.

2. The processes of searching information about COTS components

Nowadays one of existing problems considering modern enterprises is the proper selection of Information System. Many times the Information System is built or developed on the basis of available software components. One of existing constrictions of components selection process is the access to the information about functional characteristics of these components. The set of evaluated components depends on both the knowledge about components that a decision-maker has and the available knowledge about analyzed solutions. The components identification is possible using different methods and techniques.

The process of obtaining information on the basis of Web resources is a very frequent way as well. However, that information is provided by the vendor, hence it could be treated as subjective source or additionally, it could be gathered based on the software documentation (very often not completed) [Morisio, Torchiano 2002]. On the other hand many existing software components placed on the COTS products portals require the application of suitable method supporting solutions selection. The process of data obtaining and analyzing considering a big amount of components is a time-consuming and expensive process. As an effect it does not provide the required knowledge.

Furthermore the process of obtaining the components resources is a taxonomy. The main aim of the taxonomy is to provide a systematic description of available software products. However, the information about software components included in taxonomy is diffused. It encompasses a short and not well-defined description of collected components. Moreover both precision and trustworthiness of collected information are not well-documented [Li 2006]. The different standards of components description do not simplify the whole classification process – very often the different taxonomies present the component functionality in a different way. Additionally, the vendors use different standards of description with a dissimilar specification level. Hence, decision-making process and decision-makers' knowledge about a given component mainly depend on the information provided by a vendor or a producer. The components (described by a wide range of functionalities) have a high position in the classification rank but very often they are not much better products. Information provided by vendors or producers is a subjective knowledge source considering a component because the vendors do not want to publish the weaknesses of solutions in opposite to emphasize the advantages [Torchiano, Morisio 2004].

Similarly, a decision-maker exploits an independent report as a knowledge source about components. The range of that report is based on the information provided by the vendor. Frequently the components' tests are not characterized by a high level of specification, delivering only the general information about every component. Moreover the ranges of reports encompass many domains. The realization of that researches for selected domain requires both the appropriate specification level and the high costs. Hence, very often it is unprofitable activity. In addition, the cyclic character of these researches (very often not encompassing the current situation on the market) is one of the inconveniences.

The utilization of opinions and evaluations based on expert knowledge require providing the information about components as well. The series of tests generate the high costs involving the specialist domain knowledge from an expert. More often than not the results depend on subjective opinion of decision-maker and his knowledge and lessons learned from selected domain.

Some of available testing tools are general solutions that supply only the information about basic functionalities, price or technological requirements. In case of finding a specific functionality these solutions are not sufficient. Moreover particular tests are made on the specified project context. Therefore, some of given results can depend on used requirements in the particular tests.

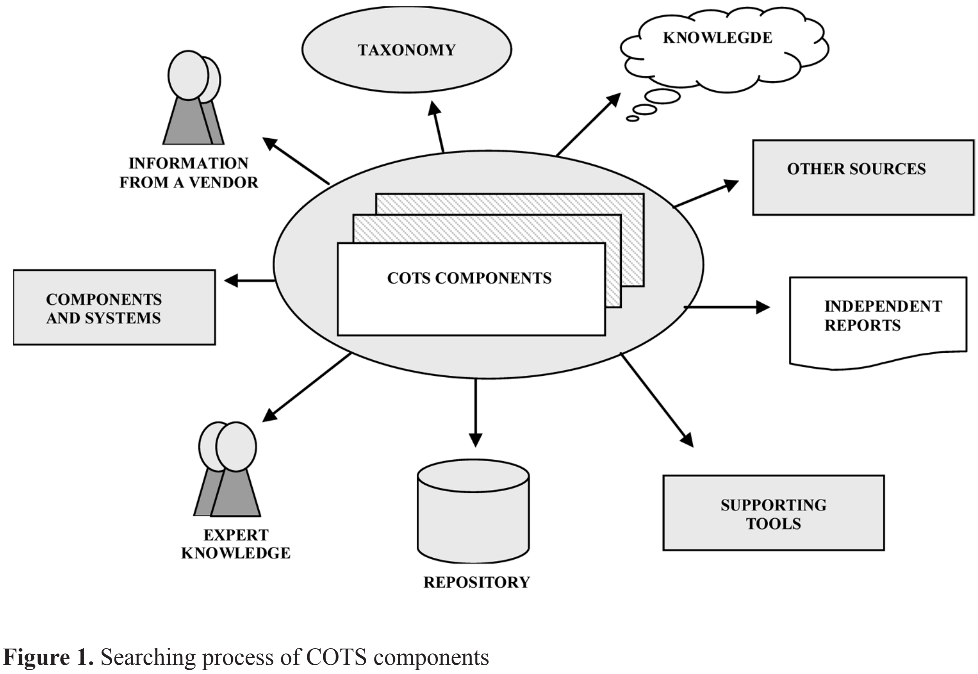

Figure 1. Searching process of COTS components

The process of analysis and evaluation of commonly used approaches for COTS components software selection indicated many existing insufficiencies. Primarily, information supplied by COTS software vendors or producers is incomplete, and very often it presents the strengths of the solution. Moreover COTS software vendors do not provide required knowledge about a lack of particular functionalities or other shortcomings [Morisio, Torchiano 2002]. Moreover, during the components indication process it is quite difficult to find complete and specified information considering components ready to use in a particular domain. Mostly, the high level of specification knowledge from the experts (who evaluate these components) is required [Ayala 2008]. Thus, it is impossible to use only general information. The application of domain ontology can help in the COTS components selection process. It refers only to the one or similar domains, providing very specified and well-defined information about available components.

3. The process of building system from COTS components (on base of repository)

Many researchers emphasize an important role of components repository but it is not required during the efficient reuse process [Rothenberger et al. 2003; Morisio et al. 2002]. COTS components repositories available on the market are the general solutions, ready to use in many domains. Owing to a huge number of COTS components on the market, the general repository application could not cope with the basic demands and requirements derived from decision-makers and functional conditions required by particular domain as well. Nowadays a few number of COTS repositories supporting selection and evaluation process exist on the market but these solutions can be insufficient in terms of the continuous development of COTS marketplace.

The increasing role of COTS components on the software marketplace influences the growth of popularity and possibility relative to the whole system from COTS components [Carvallo 2004]. The COTS market offers a wide range of software components supporting an enterprise functions in different domains. The proper location of available components (and after then the choice of optimal solution) is one of the existing problems for the enterprise.

The main aim of repository is to ensure effective collection and processing of information using the mechanisms which improve this process. The common accessibility of COTS software components on the market has a significant influence on the constrictions in COTS selection process in a very expanded repository. The COTS market is still developing, offering some new COTS systems and reusing existing solutions. Hence, the repository update process is required including new (inchoate) components. However, acquisition of the knowledge about components is time-consuming process, limited by constricted access to the components information and documentation [Clark et al. 2004]. Furthermore, the general level of criteria is insufficient during the selection process – it allows only for initial classification of candidates. Therefore, specified characteristics are demanded in the next steps of selection process.

Table 1. The characteristics of COTS components repositories

Repository	Application	Evaluation	Access
1	2	3	4
CeBASE COTS Lessons-Learned Repository	CLLR is living repository, common used and developer by users. Users involvement in repository development process allows for knowledge and experiences collection and exchange between the users, involved in COTS system development. The main aim is to create information society based on knowledge and experience. Repository access – online. The repository is based on lessons. The lessons are described by set of attributes – the most important described context in which the lesson was learned (type of system, type of enterprise, COTS type). Other attributes refer to data type, recommended customers, proper lifecycle, etc.	The development process depends directly on repository application/popularity and users needs.	http://fc-md.umd.edu/ll/index.asp
CLARiFi (CLear And Reliable Information For Integration)	Selection technique is based on components broker application, supporting integrators during the components selection process to/for a system. CLARiFi is components broker by supplier interface (to register components) and integrator interface (to select components). CLARiFi allows the integrators components selection and focalize on the system during the requirements definition process and available components characteristics.	The main limitation of supplier taxonomy CLARiFi is an aggregation of different taxonomy components without sufficient rationalism. Many categories overlap, inconsistent terminology and not well-defined tree structure.	Project refunds by European Commission (CLARiFi project, IST-1999-11631).

1	2	3	4
NFR/COTS Components Trading	COTS components description is based on non-functional requirements, integrating them with functional information using a template: COTSXMLSchema. Non-functional requirements are described using NFR approach. The proposal of documentation and COTS components selection is based on XML templates. First of them – COTScomponent supports in documentation of components phase. The second – COTSquery is used for query producers/vendors. These templates can be used by a few types of users (system architects, system designers, system developers or vendors) to export and import components from/to software repositories.	The main shortage is not sufficient/enough compliance of non-functional system requirements and requirements composition into software architecture requirements and individual components requirements.	http://www.cotstrader.com

Source: base on: [Basili 2002; Clark et al. 2004; Iribarne et al. 2001].

Moreover, the general aim of repository is to provide the high level of specification during the components selection process [Dukic 2000]. The problem is how to collect knowledge about components, which is theoretically unavailable in academic books, publications or widespread Web resources (if it exists in the Web, very often this knowledge will be diffused, available in many different sources – it requires long and time-consuming research).

Table 1 presents three selected examples of COTS repositories: CeBase COTS Lessons-Learned Repository [Basili 2002], CLARiFi [Clark et al. 2004] and COTS Components Trading [Iribarne et al. 2001]. These repositories are general solutions and they are not related to any domain (thus, they are very expanded solutions).

Analyzing Table 1, one can see that any of presented repositories is not adequate to use in specified domain because they are too broad. The repository proposed by Basili and Boehm (CeBase COTS Lessons-Learned Repository) requires the user's involvement in repository development process. Moreover the access to the repository data is proceeding online. The drawbacks encompass the difficulties with time estimation for preparing and matching COTS components for tracking system. Another inconvenience refers to risk estimation considering an expert opinion. Hence a huge number of users requires involvement of many experts from different domains [Basili 2002]. Then COTSTrade repository provides a description of COTS software components on the basis of both functional and non-functional requirements. It applies COTSXMLSchema templates. However, the main shortage is not sufficient compliance of non-functional system requirements including requirements composition into software architecture requirements and individual components requirements [Iribarne et al. 2001]. Thereafter CLARiFi repository uses a components broker for COTS selection, which supports integrators during the components selection process. Moreover the main limitation of CLARiFi is an aggregation of different taxonomy components without sufficient rationalism. Furthermore many categories overlap, and also inconsistent terminology and not well-defined tree structure exist [Clark et al. 2004].

Therefore, all of presented repositories are not sufficient to use in COTS components selection process in Management Information Systems domain. However, many researchers emphasize an important role of components repository but it is not required during the efficient reuse process [Rothenberger et al. 2003; Morisio et al. 2002]. Hence, the application of COTS ontology for Management Information System domain can accomplish the insufficiency corresponding with COTS components selection.

4. A model of ontology supporting COTS components selection process in MIS domain

The usage of repository requires the broad knowledge of both the structure and mechanisms inside the repository. Furthermore the new technology development causes the enlargement of existing repositories. Thus, the selection process of COTS components is not expedited and improved. Hence, the process of building repository is much more time-consuming and ineffective. The fully automated mechanism that collects and updates COTS components base is much simpler solution. Thus, a decision-maker is involved in building the knowledge base of COTS components.

Generally the main aim of some existing repositories is to support components selection process. However, they do not ensure that any of given components will be suitable for the system and other components in the best way. More often than not existing repositories are able to indicate only available solutions based on one-criterion analysis (when the aim of searching in repository is to find only one component) [Ayala, Franch 2007].

The ontology offers a freedom in process of requirements definition. This approach is not limited by any method considering functional or non-functional requirements. The user or decision-maker has a possibility to indicate how preferable requirements the solution should have. On the basis of reasoning mechanisms the automatic selection process of one or more solutions that comply established criteria starts up. The result completely depends on the specification level preferable by decision-maker. The higher level of specification the bigger number of results.

Table 2. The selected characteristics of ERP systems

System		Comarch Egeria	Digitland Enterprise	Epicor	ExactGlobe	IFS Applications
Criterion	Subcriterion					
Enterprise operation	small (limitation to: 3000 transaction per month;3000 indexes; 30 users)	-	yes	-	yes	-
	medium (limitation to: 10000 transaction per month;10000 indexes; 60 users)	yes	yes	yes	yes	yes
	big (more than: 10000 transaction per month; 10000 indexes; 60 users)	yes	yes	yes	-	yes
Types of enterprise	One company	yes	yes	yes	yes	yes
	Multicorporate system	yes	yes	yes	yes	yes
	International coorporation	yes	yes	yes	yes	yes
Financial and economic analysis		yes	yes	yes	yes	yes
BI system		yes	yes	yes	yes	module: IFS Analiza Zarządcza
SCM system		-	-	yes	-	yes
Multilanguage		yes	yes	yes	yes	yes
Payment system	Built-in modificable system	yes	yes	-	-	yes
	Internal system preferable	-	-	iScala Payroll	Datacomp	-
Sales	POS/sales service	-	yes	yes	yes	yes
	Refunds	-	yes	yes	yes	yes
	Sales procedures according to the Polish Law	yes	yes	yes	yes	yes
Electrionic data interchange	Polish version	yes	yes	yes	yes	yes
	Mulitlanguage version	yes	yes	yes	yes	yes
	Built-in access and internet techniques	yes	yes	yes	yes	yes
	Using XML format	yes	yes	yes	yes	yes
System adaptations	Adaptations, modifications and programming possibilities for a user	yes	yes	yes	-	-
	CASE	yes	yes	yes	yes	yes
	Programs modifications	yes	yes	-	yes	yes
	Work flow	yes	yes	yes	yes	yes
Using existing data from other Information Systems - fully automated process		yes	yes	yes	yes	yes

Source: on the basis of Computer World report (http://www.computerworld.pl/centrumERP/).

The general aim is to present an example of ontology for ERP systems on the basis of selected functionalities (Functional Criterion). It focuses not only on the presentation of particular functionalities but also on running the ontology as a tool supporting COTS components selection for ERP systems. In this example the criteria were selected randomly based on Computer World report for ERP systems. Furthermore it is possible to expand, modify or change selected criteria. Additionally the ontology can encompass unlimited systems and criteria as well. However, the best results are made when compared systems belong to the same or similar domain.

The analysis encompasses five selected ERP systems on the basis of *Computer World* report.[1] For each of them the set of criteria was attributed. Moreover for selected criteria the possible values were described. Together 11 criteria were analyzed, therein the higher level of specification was used for 6 of them. Table 2 presents the juxtaposition of ERP systems with described set of criteria.

The term "ontology" very often is referred to philosophy which defines ontology as a science about existence, types and structures of objects, their nature and train of events, processes and relations between them [Gruber 1993; Fridman-Noy, Hafner 1997]. In information science, an ontology is regarded as software (or formal description) of artifacts, designed for specified set of usage and computable environment [Smith 2003].

Referring to COTS products the ontology should help organizing available information of COTS components in MIS domain. It this case the application domain is implied such as specified branch of knowledge [Fensel, Groenboom 1997]. The ontology for COTS components has to provide the definitions of concepts derived from selected domain (MIS) and relations between those concepts including meta-description of COTS software.

The ERP COTS ontology can be defined as two sets (O and L) from a formal and rigorous way. The O set defines a structure of the ontology, when L set describes the ontology vocabulary [Bassara 2005; Gliński 2004; Maedche, Staab 2001]. Referring to COTS components the formal description includes the structure of the ontology (O) on base of available COTS ERP components, whereas L set provides meta-description of COTS components. Furthermore O set depicts the conceptual structure of COTS components and shows the relationships between them. Moreover L set determines how the concepts (COTS components) and the relationships between these components should be considered, providing the meta-description of COTS components.

The formal representation of the ontology supporting COTS components selection is presented below. The terminology proposed below describes the concepts and defines the relationships between them. T concept includes all the entities from a particular domain (MIS). Then, ^ concept is an empty concept. Axiom MIS $\equiv$ T informs that every entity in the ontology is a Management Information System (MIS). Furthermore the axiom $\cup$ informs that both FunctionalCriterion and TechnologicalCriterion belong to the whole set of elements. Another axiom determines an intersection FunctionalCriterion and TechnologicalCriterion as an empty axiom (that symbol describes the intersection between concepts – $\cap$). Moreover axiom ERPsystem $\subseteq$ System presents that every entity which belongs to ERPsystem also belongs to System [Goczyła, Grabowska 2005]. Similarly, the criteria and sub-criteria are divided and depicted in the same way.

[1] *Raport Computer World – Systemy ERP*, http://www.computerworld.pl/centrumERP/.

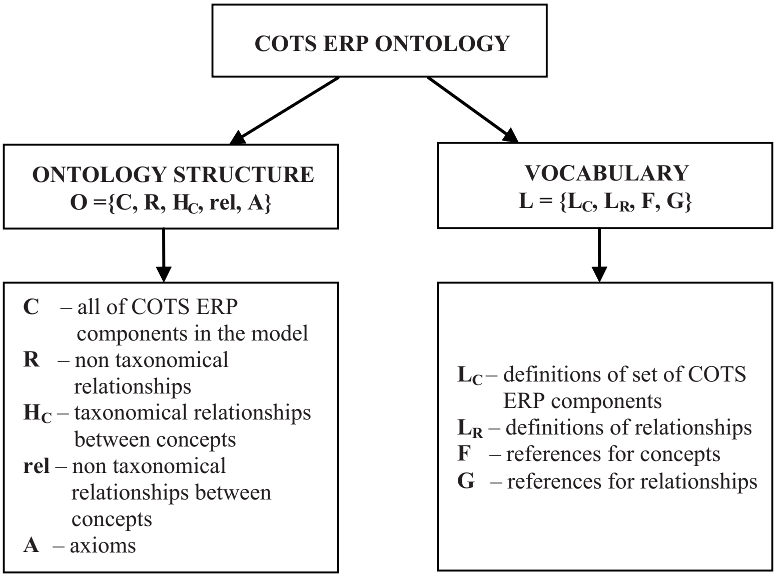

Figure 2. General model of ontology definition for COTS components

Source: on the basis of: [Gliński 2004].

Table 3. A formal knowledge representation of ontology for COTS ERP systems

MIS

MIS ≡ T

FunctionalCriterion ∪ TechnologicalCriterion ≡ T

ERPsystem ⊆ System

FunctionalCriterion ∩ TechnologicalCriterion ≡ ^

has FunctionalCriterion.T ⊆ System

hasTechnologicalCriterion.T ⊆ System

ERPsystem ≡ ComarchEgeria ∪ DigitlandEnterprise ∪ Epicor ∪ ExactGlobe ∪ IFSapplications

FunctionalCriterion ≡ BIsystem ∪ EconomicFinancialAnalysis ∪ ElectronicDataInterchange ∪ EnterpriseOperation ∪ Multilanguage ∪ PaymentSystem ∪ SCMsystem ∪ Sales ∪ SystemAdaptation ∪ TypesOfEnterprises ∪ UsingExistingDataFromIS

ElectronicDataInterchange ≡ AccessUsageOfInternetTechnology ∪ MultilanguageVersion ∪ PolishVersion ∪ UsingXMLFormat

EnterpriseOperation ≡ Big ∪ Small ∪ Medium

PaymentSystem ≡ BuiltInModificableSystem ∪ InternalSystemPreferable

Sales ≡ POS ∪ ProceduresSalesAccordingToPolishLawSystem ∪ Refunds

SystemAdaptation ≡ CASE ∪ ProgrammingAdaptationModificationByUser ∪ ProgramsModification ∪ WorkFlow

TypesOfEnterprises ≡ InternationalCorporation ∪ MultiCorporateSystem ∪ OneCompany

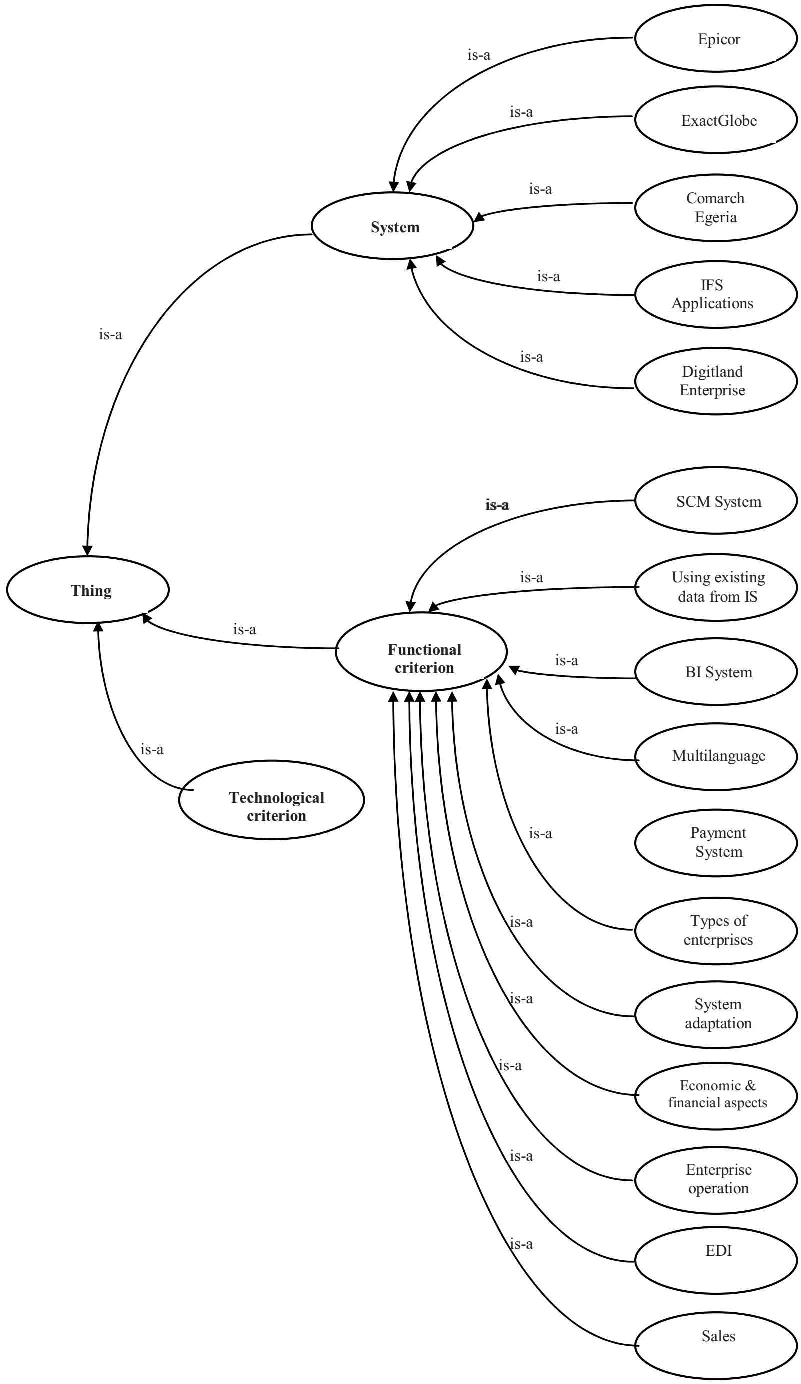

Figure 3. Selected functional criteria of ERP systems

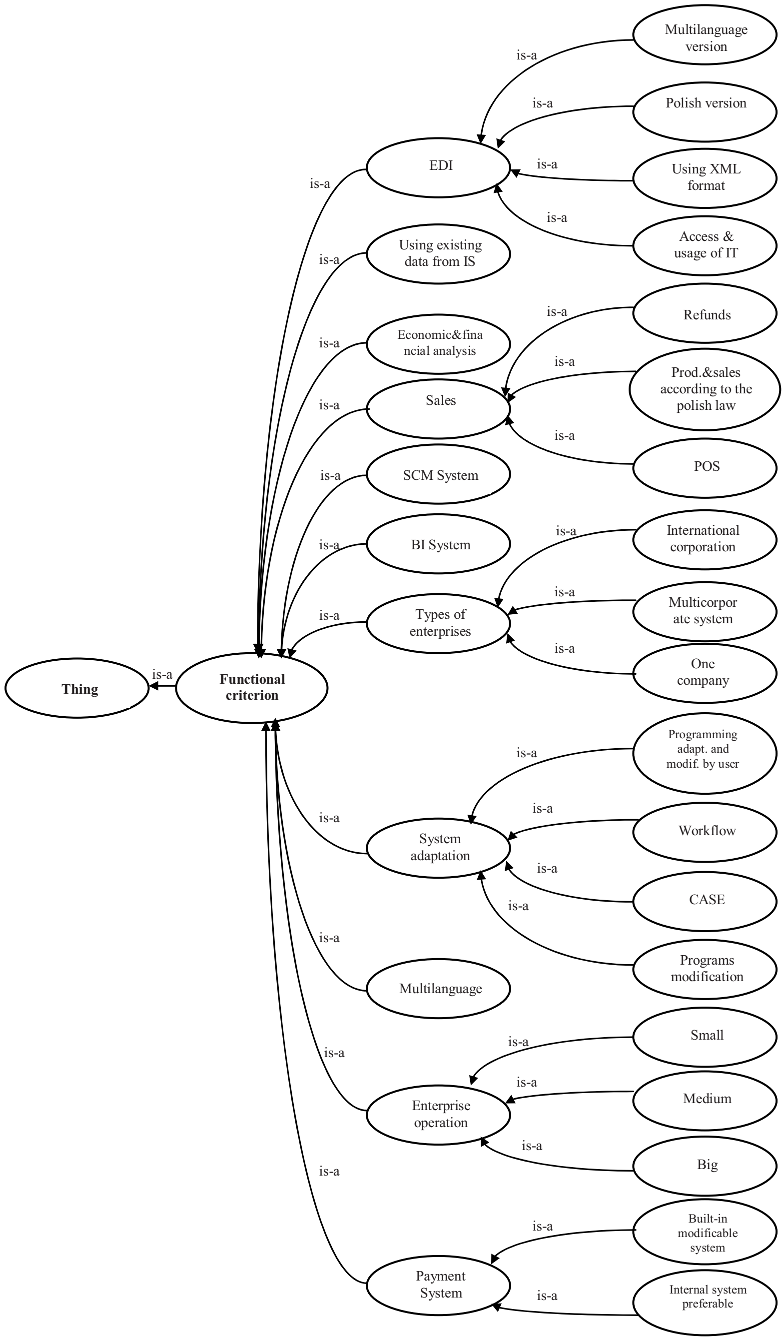

Figure 4. Selected functional criteria and subcriteria of ERP systems

The ontology was built using Protégé 4.1 program. The language supports building the ontology is OWL (Ontology Web Language). It provides both the possibility for description of concepts and new additional functions for describing possible relationships. Each group of criteria is referred to subclasses with a higher level of specification. The whole ontology is based on the structure of tree. The developed ontologies with a huge number of classes and complex inheritance almost always require the tree class hierarchy [*A Practical Guide*… 2009].

The using of OWL language [*Web Ontology*…] allows for presenting existing relationships of given objects (*Object Properties*) that join the entities between them. The following types of relations were indicated:

isFunctionalCriterion,
isTechnologicalCriterion,
hasFunctionalCriterion,
hasTechnologicalCriterion,
hasCriterion (transitive),
isCriterion (transitive),
hasCriterionSCMsystem(functional),
hasCriterionPaymentSystem (functional),
hasCriterionSales (functional).

The example of ontology supporting COTS selection and evaluation for MIS domain presented below (Figures 3 and 4) includes ERP systems. Each of the examples describes the relationships and properties existing between instances (individuals) and the inversions between them. First of them (Figure 3) presents the functional criteria in a general level. The next image (Figure 4) depicts the higher level of specification.

The class Thing is the class that represents the set of containing all individuals. Because of this all classes are subclasses of Thing. All of instances of ERP systems are the instances of Management Information Systems and Thing class. The usage of the Reasoner tool (available in Protégé 4.1 application) allowed to identify these systems which accomplish such functions as: sales system or supply chain management system including the specified values attributed to the selected criteria.

5. Quality assessment of ontology supporting COTS selection process in MIS domain

The process of quality assessment of ontology supporting COTS selection process in MIS domain can require the application of semantic techniques. The general aim of semantic technologies is to provide a systematic and repeatable approaches that support COTS components process in MIS domain and help in quality assessment of an ontology.

The selected methods are based on the quality assessment of an ontology, clustering and arranging particular ontologies, adapting the ontology to a given project, evaluating the knowledge representation for a selected ontology and reliability of the ontology for a given domain. Additionally they provides automatic or semi-automatic mechanisms for an ontology evaluation process. The main aim of application of these tools is to deliver relevant information about applying the ontology for both a particular project and domain.

There exist many approaches and tools that support COTS selection process (for example SymOntoX, Ontomanager, Hierarchical Agglomerative Clustering (HAC), PLIB, INSEAS, RASCAL – Users Web Mining, Sema-SC (Semantic Component Selection), Semantic-Based Technique, NFR and MoreCOTS) [Stojanovic et al. 2003; Missikoff, Taglino 2003; Nacim et al. 2006; Nanni 2005; Leukel et al. 2006; Anandha Mala, Uma 2006]. Hence, for the assessment of the quality of the process of presented ontology in this paper the Ontomanager approach was selected.

The general aim of Ontomanager application is to provide a tool for assessment of the quality and truthfulness of an ontology with respect to its problem domain. It provides the answer to the question how a given ontology reflects both a piece of reality and a users' needs in a proper way. Generally, it helps to indicate the weak points in a particular ontology, especially including the users' requirements. Moreover it assures that the created reccomendations enhance the ontology and reflect the users' needs [Stojanovic et al. 2003].

The Ontomanager consists of three modules: Data Integration Module, Visualization Module and Analyzing Module. The first of them (Data Integration Module) connects, transforms and correlates the used data. The Visualization Module creates integrated, used data applied by the users more efficiently using the visualization. The Analyzing Module provides a specified instructions for ontology adaptation including the users' needs [Stojanovic et al. 2003]. Additionally it helps to enhance the quality of ontology. In this way Ontomanager delivers easy to use system for ontology management and quality assessment of the solution with respect to the users' needs as well. Furthermore it copes with implicit changes discovered from the user's behaviour and additionally it allows for the incessant adaptation of an application to the changes in the user's needs.

6. Conclusions

The main aim of this paper is to present an example of ontology supporting COTS selection process in MIS domain. The ontology encompasses the selected solutions of ERP systems. The characteristics of each system are based on *Computer World* Report. The main aim of that ontology is to provide a systematic and repeatable solution for COTS components selection process in MIS domain. Furthermore, using the ontology is not necessary for a decision-maker to have a broad knowledge about specified values of criteria characterizing the system and even so he can make a reasonable choice. Building a repository for COTS components allows to systematize the available information and formalize it by using the ontology.

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MODEL ONTOLOGII WSPOMAGAJĄCEJ PROCES WYBORU SKŁADNIKÓW COTS W DZIEDZINIE SYSTEMÓW INFORMATYCZNYCH ZARZĄDZANIA

Streszczenie: Celem niniejszego artykułu jest przedstawienie ontologii jako propozycji rozwiązania wpierającego wybór i ocenę składników COTS w obszarze Systemów Informatycznych Zarządzania (SIZ). Na podstawie raportu Computer World zostało wybranych 5 systemów klasy ERP wraz ze szczegółową ich specyfikacją. Budowa przykładowego modelu ontologii ma na celu dostarczenie systematycznego i powtarzalnego podejścia wspomagającego dobór składników COTS do indywidualnych potrzeb przedsiębiorstwa w obszarze SIZ. Całość kończą wnioski z przeprowadzonych badań.