Knowledge Organization Systems and Their Typology

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Summary:

The term, "Knowledge Organization System" (abbr. KOS) has yet to be included in the Czech specialized terminology (which uses "information retrieval language" instead). However, the term has been used for more than 15 years in international literature and in practice, encapsulating vocabularies, authority lists, subject headings, classifications, thesauri, ontologies and other knowledge organization tools of digital network communication. Today, the tools are represented by Linked Open Data technology. The study presents the provisional results of our research concerning the present state of knowledge organization systems, conducted within the DF13P01OVV013 "Knowledge Base for the Subject Area of Knowledge Organization" project, as a part of the NAKI Program. The methodology of the research is based on empirical analysis of knowledge organization systems, which are registered in the prototype of the designed knowledge base. It also draws on the analysis of proposed or implemented typologies presented in literature or in the operating KOS registries. The study further presents a typology of knowledge organization systems that would help identify the systems in the knowledge base. In addition, we have produced a working definition of the term "knowledge organization system", presenting it to the Czech professional community for further consideration.

Keywords: knowledge organization, knowledge organization system, KOS typology, registries

Introduction

This study presents preliminary results of our examination of the current state of today's Knowledge Organizations Systems (abbreviated as KOS; the text uses a verbatim translation into Czech and the acronym, SOZ; however, neither the term nor the acronym have so far been included in the Czech terminology of information science). The research, conducted within the "Knowledge Base for the Subject Area of Knowledge Organization" project of the NAKI program, puts forth a typology of knowledge organization systems for the purposes of their description and categorization within a knowledge base prototype. Our research methodology is based on empirical analysis of knowledge organization systems registered in the prototype of the proposed knowledge base. The methodology further draws on analyses of already proposed or implemented typologies as presented in specialized literature, or in the operating KOS registries.

The article has three sections. The first section defines the content and scope of the term, *Knowledge Organization System*, and its relevance in the context of the traditional term, *Information Retrieval Language*, used in the Czech environment. The second part presents a comparison of the most significant typologies that are currently used for research activities, and

within the newly operating registries of KOS. In the third section, the authors propose their own typology of knowledge organization systems that draws on the systems' semantic strength.

1. Defining the Concept of "Knowledge Organization System"

Knowledge organization system is a relatively recent[1] term for the tools and other help instruments that are traditionally used under different names for information and knowledge processing in memory institutions, and in social, individual and all other areas that require organized information recording and effective access to information. The meaning of the new term still remains to be clearly defined as evidenced by the fact that, with the exception of the ASIS&T[2] Thesaurus, the term has not been included in any other specialized thesaurus and classification[3]. So far, the term has been vague; moreover, its definition varies from author to author. This is clearly evidenced by the following examples of the definitions of the term that differ from one another by their approaches, and by their formulations. The first example of a KOS definition concentrates on determining its function as follows: „Knowledge Organization Systems/Services (KOS) […] model the underlying semantic structure of a domain. Embodied as Web-based services, they can facilitate resource discovery and retrieval. They act as semantic road maps and make possible a common orientation by indexers and future users (whether human or machine)"[4]. The second example defines the KOS in view of its function, adding typical instances of the KOS: "The term knowledge organization systems is intended to encompass all types of schemes for organizing information and promoting knowledge management. Knowledge organization systems include classification and categorization schemes that organize materials at a general level, subject headings that provide more detailed access, and authority files that control variant versions of key information such as geographic names and personal names. […] also include highly structured vocabularies, such as thesauri, and less traditional schemes, such as semantic networks and ontologies"[5]. The third example, however short, defines the KOS through its function and structure: "We consider KOS as knowledge representation based on concepts and with different degrees of relationships between them"[6].

1 G. Hodge maintains that the term was coined in 1998 at the founding Networked Knowledge Organization Systems Working Group – NKOS WG), that took place on 27. 6. 1998 at the conference, ACM Digital Libraries '98 in Pittsburgh (HODGE, Gail. Systems of knowledge organization for digital libraries: beyond traditional authority files. Washington: The Digital Library Federation, Council on Library and Information Resources, April 2000, p. 3. ISBN 1-933645-06-7 (DLF). Freely available from: http://www.clir.org/pubs/reports/pub91/pub91.pdf).

2 The term, knowledge organization systems, is listed as one of the top terms in the knowledge and information facet.

3 The following thesauri have been inspected: LISA Thesaurus LISS Thesaurus, INSPEC Thesaurus, PASCAL Thesaurus, KO Literature (Classification System for Knowledge Organization Literature [online]. ISKO 2011-2012, last update 2012-04-13 [cit. 2014-08-25]. Available from: http://www.isko.org/scheme.php).

4 TUDHOPE, Douglas, KOCH, Traugott. New applications of knowledge organization systems: introduction to a special issue. In: Journal of digital information [online]. 2004, 4(4) [cit. 2014-08-25]. ISSN 1368-7506. Available from: https://journals.tdl.org/jodi/index.php/jodi/article/view/109/108.

5 HODGE, Gail. Systems of knowledge organization for digital libraries: beyond traditional authority files. Washington: The Digital Library Federation, Council on Library and Information Resources, April 2000, p. 1. ISBN 1-933645-06-7 (DLF). Also available from: http://www.clir.org/pubs/reports/pub91/pub91.pdf.

6 SOUZA, Renato Rocha, TUDHOPE, Douglas, ALMEIDA, Maurício Barcellos. Towards a taxonomy of KOS: dimensions for classifying knowledge organization systems. In: Knowledge organization. 2012, 39(3), 181. ISSN 0943-7444.

For the purposes of this research, we conceive of KOS as a tool designed for the support of the processes of information organization. We define *information organization* as any intentional activity consisting in introducing a structure into an already existing, recorded knowledge with the objective of making its storing and access possible. The *storing activities* affect nearly the entire life cycle of knowledge, from its representation (expression), possible communication or sharing, recording, publishing, processing (identification, description, content analysis, indexing, transformation) to its very storing. In reverse, there is a set of *activities facilitating access* to knowledge, from the expression of knowledge need and the possible formulation of a request to search for or the discovery of new information, the presentation and organization of results obtained from organized collection, or, as the case may be, generation of new knowledge. In both cases, KOS is a tool that has the form of a model of a future structure of an organized set. At the moment, these tools, originally used in the isolated environments of individual institutions, are transforming into digital network communication tools, currently represented via the technology of Linked Open Data (LOD). The high number and diversity of knowledge organization activities analogically reflect in the broadness of the definition of KOS. In addition, there is the diversity of the environments where individual activities may take place – besides the traditional areas of memory institutions, there is a whole range of professional and laic areas. If we accept thus broadly-defined term, we must also accept the fact that it encompasses a highly diverse set of often dramatically different instances whose common characteristics may be difficult to find.

As the above examples demonstrate, and given the range of the extent of the term itself, the very definition of Knowledge Organization System may only be very general. Therefore, the following section of this article shall concretize the term via detailed examination of both the KOS function, and its structure and attributes as defined by prominent experts in the field.

1.1 Function, Structure and Distinctive Attributes of Knowledge Organization Systems

In his work on digital libraries and knowledge organization[7], D. Soergel specifies six areas of functionality of the knowledge organization system, supplying concrete examples as follows: *semantic* function (e.g; semantic map of individual fields and their mutual relationships, clarification of terms by situating them in the context of qualification, dictionaries of data elements, and conceptual bases of knowledge systems), *communication* function (e.g; help with learning and knowledge acquisition, formulating correct questions, understanding a written text, composing an understandable text), *conceptual* function (e.g.; when determining research objectives and during issue clarifying, during consistent data collecting and comparative statistics composing), "*action*" function (support of processes and activities, e.g.; use of classification of diseases in diagnostics), *selection* function (e.g.; information, goods, and services search; knowledge access), *linguistic* function (e.g.; the formation of dictionaries for both humans and machines when working with language).

R. Szostak identifies *words* (*terms*) as the basic building elements of the KOS structure, expressing concepts whose meaning is unambiguously defined in a controlled dictionary, and

7 SOERGEL, Dagobert. Digital libraries and knowledge organization. In: Sebastian Ryszard KRUK, Bill McDANIEL, ed. Semantic digital libraries. Berlin: Springer, 2009, p. 29. ISBN 978-3-540-85433-3 (Print). ISBN 978-3-540-85434-0 (Online). Also commercially available from: (DOI): http://dx.doi.org/10.1007/978-3-540-85434-0_2.

syntactic rules, established for the connecting of the words[8]. In accordance with the current trend of linked data within a semantic web, Szostak finds it useful to conceive the general structure of KOS in terms of the RDF (Resource Description Framework) language, whose core is formed by statements formed by the triples of subject – predicate/property[9] – object. In the KOS, both the subject and the object are represented by shared hierarchy of terms (e.g.; classification classes), representing the things. The predicate, also called in RDF the "property", is either represented as an attribute of a thing, or as a relationship between subject and object (which, from theoretical point of view, represents a specific type of attribute shared by more than one entity). The hierarchies of attributes and the hierarchies of relationships are other structural elements of the KOS. The elements of the three classifications – *things*, *properties of things* and *relationships among things*, or, as the case may be, words (terms) that express those, may be combined at will into RDF triples.

In the Aristotelian tradition, the attributes represent the differentiating qualities (*differentia specifica*) required for the forming of correct definitions. They have been listed and provided with commentary by M. Zeng and M. Žumer in their report on the preparation of Metadata profiling for the registries of KOS vocabularies[10]. The authors argue that knowledge organization systems are specific information resources whose characteristics share the following common features, distinguishing them from other kinds of creative works: *continuity* (continuous actualization and development that mirrors changes in the real word) leading to *micro-level management* (i.e.; version creating, dating, and data-providing on the responsibility and origin of individual notions and terms), *diversity* of the "family" members (shortened, expanded or abridged versions are dynamically derived from the same stem system), *shared authorship* (authorship changes in the course of re-use, mapping, connection-making, and deriving both within the same "family" and among themselves), *complex mutual relationships* (e.g.; among different editions, language versions including different kinds of translations and local revisions, and different printed and electronic formats as seen, for example, in Dewey's decimal system). These attributes clearly show that knowledge organization systems belong to the complex category of integrating information sources, which is difficult to process. The situation is made even more difficult by the fact that oftentimes, rather than functioning as individual units, the KOS are integrated into other resources, typically into online retrieval systems and search applications.

1.2 Levels (Layers) of Knowledge Organization Systems

Figure 1 combines two perspectives on the knowledge organization system: 1) function-based perspective that conceives the KOS as a tool of knowledge organization and 2) object-based perspective that views the KOS as a specific type of information resource that is equally processable/organizable[11].

8 SZOSTAK, Rick. Classification, ontology, and the Semantic Web. In: Advances in classification research online [online]. 2013, 24(1) [cit. 2014-08-25], pp. 30-37. doi:10.7152/acro.v24i1.14674. ISSN 2324-9773. 24th ASIS SIG/CR Classification Research Workshop. Available from: https://journals.lib.washington.edu/index.php/acro/article/view/14674.

9 Predicate/property in English.

10 ZENG, Marcia Lei, ŽUMER, Maja. A metadata application profile for KOS vocabulary registries. In: Knowledge organization: pushing the boundaries: ISKO UK [3rd] Biennial Conference, 8th - 9th July 2013, London [online]. London: ISKO UK, 2013 [cit. 2014-08-25]. Available from: http://www.iskouk.org/conf2013/papers/ZengPaper.pdf.

11 Despite the abstract nature of the three words that knowledge organization system comprises as a term, the term does not denote any abstraction but rather a concrete artifact (i.e.; a thing created purposefully, with the objective of its use) – a tool for the processes of knowledge organization.

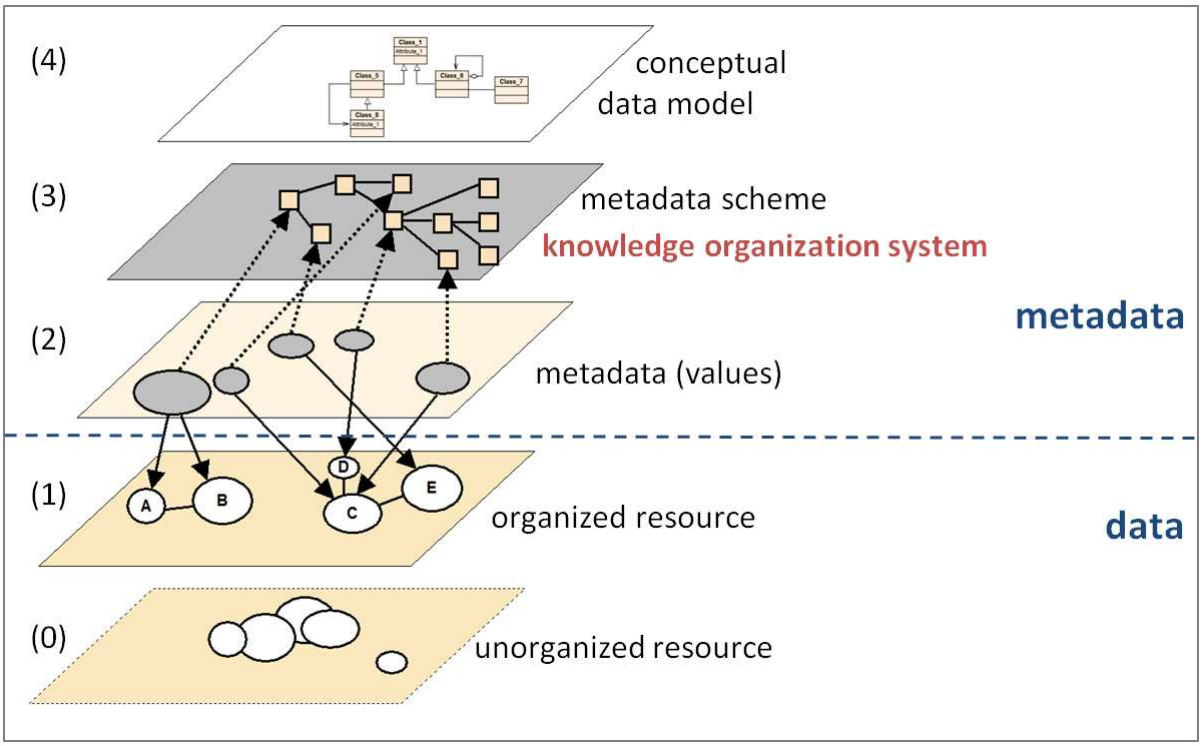


Fig. 1. Knowledge Organization System (levels of knowledge organization)

The individual layers schematically separate important components of the organized source of knowledge: for better clarity, level (0) is given as the lowest one, representing unorganized resources (e.g.; so-far unprocessed estate archives). Level (1) has a structure that came to existence through the grouping of resources pursuant to a criterion (e.g.; archive documents organized into content-based folders). Situated above the levels of unorganized and organized data are the meta-levels: level (2) represents metadata as the typical product of knowledge organization (e.g.; content characteristics, current price, size); metadata may form a physical part of the source (e.g.; imprint, ex libris, metadata in an HTML document), or refer to a source (e.g.; bibliographic citation, Universal Decimal Classification number). While level (1) presents the structure of organized resources, level (3) presents the metadata structure as relatively stable in comparison with the dynamically changing set of metadata. Due to this relatively stable semantic structure, not only metadata values, but also the relationships among the metadata elements, and their possible attributes as defined in the so-called metadata scheme, may be used for work with organized sources. This level is therefore a schematized representation of the structure and function of KOS (e.g.; classification, thesaurus, authority list, nomenclature). Level (4) demonstrates yet another metalevel – the "superstructure" of metadata (e.g.; FRBR, CIDOC CRM). The conceptual models of knowledge organization systems generalize their structures, making theoretical research possible, and, most important, enabling the implementation of knowledge organization systems into the current information infrastructure of the network environment.

The following two examples demonstrate the differences between a function-based and an object-based perspective concerning the knowledge organization system:

Example 1 offers a function-based perspective on KOS, assuming that "classic" primary documents, such as the PDF format of information science journal articles, are represented in the data layer. Level (0) of Figure 1 represents unorganized articles from different publishers; level (1) represents the articles in the database of the field, such as in the aggregated full-text collection of the EBSCO producer; level (2) represents the set of LISS Thesaurus descriptors used for the indexing of the articles; level (3) is the LISS Thesaurus, and level (4) contains the general model of the structure of the Thesaurus pursuant to the ISO 25964-1 standard[12].

Example 2 perceives the KOS as a processed object, assuming that knowledge organization systems are situated within the data layer; for example, a repository of knowledge organization systems, such as the BioPortal[13] that serves as a biomedicine KOS's storage. The level (0) represents the set of so-far unorganized systems; level (1) is the the knowledge organization systems stored in the repository. The metadata of the Dublin Core standard (DC), for example, may be situated in the metalayer: level (2) contains the values of metadata elements of the upcoming Metadata Application Profile for KOS (DC-AP NKOS)[14] vocabularies and the NKOS Vocabularies[15]; level (3) consists of the very profile of DC-AP NKOS. In the metalevel (4), there is the DCMI Abstract Model (DCAM)[16].

1.3 Czech Terminology

Since a relevant article published elsewhere[17] provides a detailed account of the issues of knowledge organization in the Czech Republic, this article only summarizes the main points.

The current system of Czech terminology, prepared by Blahoslav Kovář in the 1970s, is recorded in the Czech Explanatory Terminology Database of Library and Information Science (TDKIV). He uses the term *information retrieval (abbr. IR) languages* ("selekční jazyky" in Czech, literally translated as "selection languages" in English) for knowledge organization systems. The terminology is founded on a process-based perspective on knowledge organization, while the information retrieval language is understood as the tool for the processes of information organizing. Alongside the division of organization into identification- and subject-based, IR languages are also divided into identification- and subject-based, and further divided into subject indexing ("předmětové" in Czech) and systematic languages. Identification-based languages are IR languages focused on the formal attributes of resources; subject-based languages are focused on content attributes. Those IR languages that do not convey any paradigmatic relations among the language elements are called subject indexing languages. The languages that make it possible to express a paradigmatic relationship (especially hierarchy and association) are

12 Scheme available from: http://www.niso.org/schemas/iso25964/Model_2011-06-02.jpg.

13 National Center for Biomedical Ontology (USA). BioPortal [online]. © 2005-2014 [cit. 2014-10-15]. Available from: http://bioportal.bioontology.org/. -- To this date, the portal contains 389 KOSs.

14 Dublin Core Metadata Initiative. NKOS Task Group. NKOS AP Elements. In: DCMI NKOS Task Group [online]. 2013, updates 2014-04-03 final, polished 2014-08-03 [cit. 2014-08-25]. Available from: http://wiki.dublincore.org/index.php/NKOS_AP_Elements.

15 Dublin Core Metadata Initiative. NKOS Task Group. NKOS Vocabularies. In: DCMI NKOS Task Group [online]. 2013, updated 2013-12-16 [cit. 2014-08-25]. Available from: http://wiki.dublincore.org/index.php/NKOS_Vocabularies.

16 Dublin Core Metadata Initiative. DCMI Abstract Model – DCAM [online]. 2007-06-04 [2014-08-25], sect. 2. Available from: http://dublincore.org/documents/abstract-model/#sect-2.

17 KUČEROVÁ, Helena. České termíny pro věcné pořádání informací po 40 letech: příspěvek k terminologické diskusi. In: ProInflow: časopis pro informační vědy [online]. 2013, 5(Speciál), [cit. 2014-02-17], pp. 1-19. ISSN 1804-2406. Available from: http://pro.inflow.cz/sites/default/files/pdfclanky/ProInfow_Kucerova_final_0.pdf.

called systematic. The notions, “identification-based” and “subject-based” and, most importantly, “systematic” and “subject indexing”, form a useful theoretical platform between an abstract notion of the highest level (i.e.; IR language) and concrete names of individual cases of the processes of knowledge organization (e.g.; cataloging, tagging, classifying, categorizing) and their tools (e.g.; UDC, and the VIAF authority file). The basic unit of information organization is the (classical printed) document. Significant duality is used for the division of IR languages – strong borders are run between identification- and subject-based languages, and between systematic and subject indexing languages. The paradigmatic changes of the 1990’s that occurred because of the widely-spreading electronic sources and internet technologies have so far not been reflected in the Czech terminology.

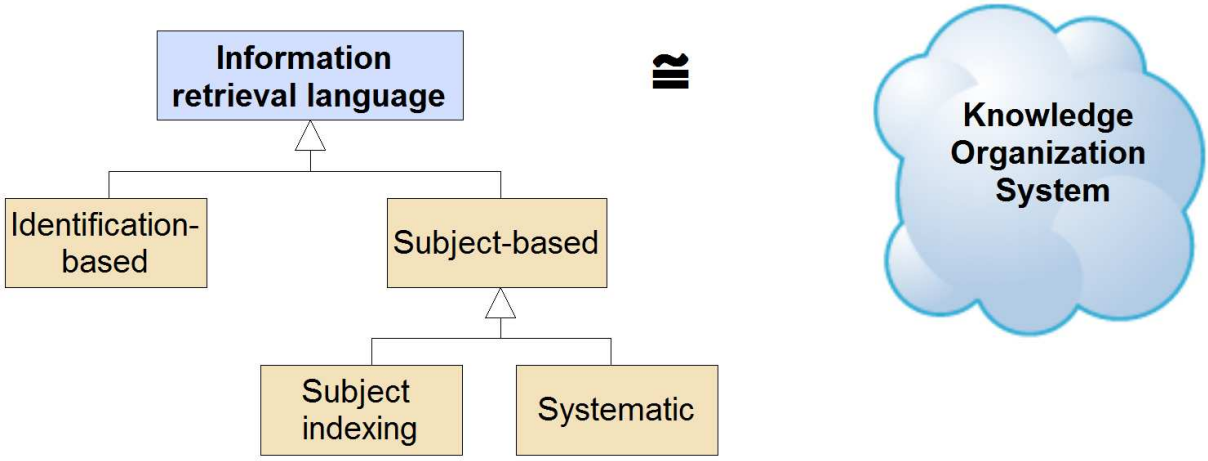


Fig. 2 Czech and worldwide terminology or Knowledge Organization Systems

The above mentioned article on the terminology of subject-based organization domain proposes that the term, “IR language” is replaced with the term, “knowledge organization system,” or, as the case may be, with an analogically extended version, “information and knowledge organization system”. It was concluded that the notions, “IR languages” and “knowledge organization system” may be considered equivalent in terms of their key characteristics – both notions denote both the tool and the product of the information organization process. However, these notions are not truly synonymous; rather, there is partial, though quite extensive, overlapping of their meaning. For example, natural language may be used as IR language; however, it may no longer be called knowledge organization system. On the other hand, there are knowledge organization systems that may not be conceived of as IR languages; e.g.; semantic networks and conceptual schemes. The scheme of Figure 2 shows another difference between the clearly defined typology of IR languages and the so-far heterogeneous and vaguely defined term, Knowledge Organization System (the diversity of the current KOS typologies will be presented in section 2).

At the same time, it was concluded that both notions are ultimately metaphoric; both the metaphor, “language”, and the metaphor, “system”, seem aptly chosen, enjoying the support of distinguished experts in their specialized articles. Besides the “Czech school”, the following

experts have used the metaphor, "language": E. Svenonius (bibliographic language[18]), V. A. Moskovič (information language[19]), and the founding fathers of information science, C. N. Mooers, A.C. Foskett, and D. Soergel (indexing language); the metaphor is also implied in todays's ISO 25964 standard[20] (structured/controlled vocabulary). The explanation of the notion, "ontology", via the term, "vocabulary" as given on the pages of W3C[21] is a good example of how the metaphor of "language" is used and extrapolated onto the broadly understood term, "vocabulary" by the Semantic Web community. This approach is also applied in the Dublin Core scheme. The metadata scheme of classes, attributes, and relationships is called element set vocabulary and the lists of attribute values are called value vocabulary. The metaphor, "system" is used by members of the NKOS[22] community which is at present involved in research and application in the area of knowledge organization systems. The name of SKOS (Simple Knowledge Organization System)[23] is another example of the use of system metaphor.

The metaphors of language and system are mutually complementary, meeting the necessary (though perhaps insufficient) conditions for branding an entity as a knowledge organization system. A system it must be; i.e.; the given entity must be defined via a structure and a function corresponding to the set goal (support of knowledge organization), while at the same time meeting the minimum language characteristics prerequisite. This means that the entity must either have the vocabulary, or the grammar (syntactic rules) or both. While an "overarching" terminological metaphor that encompasses both the language and the system attributes so far does not exist, we propose that the Czech terminology adopts the system metaphor by using the term, "knowledge organization system", which might help international communication.

1.4. Working Definition of Knowledge Organization System

Our working definition of knowledge organization system has been formulated by means of the classical Aristotelian method of definition, using the superordinate genus name and the distinguishing properties of the species. By virtue of this approach, KOS may be conceived as a specific kind of a system that differs from other systems via its distinguishing properties. These specifics are given both by its function, by its structure, and by the attributes characterized in part 1.1.

Our proposal of the following definition has ensued from our analysis of the KOS specifics, supported by our literary research: *A knowledge organization system is a scheme that models a structure (i.e.; elements and mutual relationships) of an organized set of knowledge. Support of*

18 SVENONIUS, Elaine. Bibliographic languages. In: The intellectual foundation of information organization. Cambridge (MA): MIT Press, 2000, chapter 4, pp. 53-55. ISBN 0-262-19433-3.

19 MOSKOVIČ, Vol'f Abramovič. Informacionnyje jazyki. Moskva: Nauka, 1971. 143 p.

20 ISO 25964-1:2011. Information and documentation – Thesauri and interoperability with other vocabularies – Part 1: Thesauri for information retrieval. 1st ed. Geneva: International Organization for Standardization, 2011-08-08. 152 p.

21 World-Wide Web Consortium. Vocabularies. In: World Wide Web Consortium (W3C) [online]. Cambridge (MA): World-Wide Web Consortium, © 2012 [cit. 2014-08-25]. Available from: http://www.w3.org/standards/semanticweb/ontology.

22 LYKKE, Marianne. Networked Knowledge Organization Systems/Services (NKOS). In: Marcia J. BATES, Mary Niles MAACK, ed. Encyclopedia of library and information sciences. 3rd ed. Boca Raton (Florida): CRC Press, © 2010, pp. 3911-3915. doi:10.1081/E-ELIS3-120044732. ISBN 978-0-8493-9712-7 (set, Print). ISBN 978-0-8493-9711-0 (Online). Commercially available from: http://www.tandfonline.com/doi/pdf/10.1081/E-ELIS3-120044732.

23 MILES, Alistair, BECHHOFER, Sean, ed. SKOS Simple Knowledge Organization System Reference [online]. W3C Recommendation 18 August 2009 [version]. Cambridge (MA): World Wide Web Consortium, © 2009. Available from: http://www.w3.org/TR/2009/REC-skos-reference-20090818/.

the processes of knowledge organization and access to knowledge is the basic function of the knowledge organization system. A concept is the basic structural element of the knowledge organization system. A vocabulary, that is, the formal expression of concepts, forms the core of the physical representation of each knowledge organization system. The vocabulary is utilized to express both the semantics and the syntax of the organized whole, or, as the case may be, the rules defining how a structure is to be used.

2. Typologies of Knowledge Organization Systems

In view of the preceding definition of knowledge organization systems (KOS), this section of the article examines the relevant issue of their typology. International discussions about how to categorize the KOSs have been going on for over 15 years. So far, several important models have been produced. This part will present, compare and assess selected KOS typologies as they appear in world literature and in the concrete practice of their registries. The results of this small-scale comparative analysis of select typologies will be used here for our proposal of a provisional KOS typology, which shall be presented in Part 3 of this article. This typology is also important for the design of the knowledge base of the aforementioned NAKI project. The proposed values of the KOS types are moreover necessary for complete metadata descriptions of these systems.

The typologies thus far produced suggest that there is a common core of a sort shared by the KOS types. The typologies have been formed pursuant to the key criteria of structure, function, or, as the case may be, use. Although other sorting criteria may also apply, the main criteria that have so far been applied are constitutive and dominant. The first sub-section of this article will therefore analyze and evaluate the main typologies as documented in literature, including the standards. In addition to the theoretical approach, the second sub-section will provide analyses and assessments of typologies from select practices of "live" KOS registries that feature practical and pragmatic perspectives, as well as an occasional approach of being "above" the issue (only those registries that verifiably involve a KOS typology have been selected). The analyzed typologies are presented in a comparison chart. The chart provides the original KOS names (in English); the text commentaries are Czech translations.

2.1 Typologies of Knowledge Organization Systems in World Literature

In her paper on the definition of the term, *knowledge organization system*, G. Hodge was one of the first authors to provide a typology of the systems[24], accompanied by her commentary. The typology is the result of the author's long-term practice[25]; at the time, she came up with the typology as the key for the application in the evolving digital libraries. Her outline of 11 kinds of then well-known KOS types (see Table 1) was no news. What did matter was the fact that the author defined the KOS types by combining some of their key characteristics: structure, complexity, relationships, and their historical roles. The importance of the above-given characteristics also surfaced in her proposal to divide the given KOS types into three groups. The *Term Lists* group included less structured systems with basic functions, such as *Authority Files* (names), Specialized *Glossaries*, more generally oriented *Dictionaries* and *Gazetteers*, frequently

24 HODGE, Gail. Systems of knowledge organization for digital libraries: beyond traditional authority files. Washington: The Digital Library Federation, Council on Library and Information Resources, April 2000, pp. 4-7.

25 Gail Hodge has worked in the USA in the area of information industry with focus on bibliographic databases (e.g.; BIOSIS and others) and in the area of standardization of information systems.

used in Anglo-Saxon countries. The *Classification and Categories* group contained more structured KOSs that produce subject-oriented organized files. The author included both *Subject Headings Schemes* with shallower structure and limited hierarchies, and *Classification Schemes*, *Taxonomies* and *Categorization Schemes* which are in practice often treated as interchangeable. The third group, called *Relationship Lists*, contains highly structured or complex systems typified by their connections among concepts. The most frequent KOSs, *Thesauri*, functioning on the basis of concepts and the richness of their interrelationships, belong to this group. Hodge has recently added some brand-new KOS types into the group, such as *Semantic Networks.* Hodge argues that the systems structure the concepts not so much into hierarchies, but into networks or webs with numerous specific relationships. *Ontologies* also belong to the group, she argues, because they are specific concept models, representing a complex of relationships among objects, including rules and axioms.

Hodge's typology was adopted and further developed by the NKOS Task Group (Networked Knowledge Organization Systems)[26]. The lead figure of the group, Marcia Zeng of Kent State University, where she teaches Knowledge Organization, published a work-in-progress version of a typology on the NKOS[27] website in June of 2000. A modified version of her KOS typology was also published in 2008, in a large analytical study dedicated exclusively to KOSs[28]. Zeng presented the total of 14 types of KOSs in her typology (three more than Hodge – see Table 1. However, there are two key criteria she uses to define the KOS types that seem crucial: the structure and the function of the system. Within those, she divides the KOS types into four groups (the group elements are organized from the simplest to the most complex structure, and from the lowest to the highest function). M. Zeng's study also contains a two-dimensional graph[29] that illustrates her typology (which is often quoted). As with Hodge, the first group is called *Term Lists.* Simple-structure and minimum-function systems (literal meaning and control of synonyms in particular) belong to the group, such as simple *Lists* (of select terms), *Dictionaries*, *Glossaries* and, newly, *Synonym Rings*. The author includes higher-structure systems and added-functions systems (e.g.; establishment of simple hierarchies) in the second group, called Metadata-like Models. *Authority Files* (names), *Directories* with lists of names and associated contact information, and *Gazetteers* belong to this group. The third group, called *Classification and Categories*, includes systems of higher and highest levels of hierarchies. The author places the traditional *Subject Heading Schemes* as well as *Categorization Schemes*, *Taxonomies*, and *Classification Schemes* here. Like Hodge, Zeng places Thesauri, which import accentuated and important association relationships, in the first place of the fourth group, called *Relationship Models*. *Semantic Networks* and, most importantly, the growing *Ontologies* with their broad range of associative and other relationships among concepts, and defined rules and axioms, also belong to the group.

26 The group presentations and activities results are accessible at the group's webpage: http://nkos.slis.kent.edu/.

27 ZENG, Marcia Lei. Taxonomy of knowledge organization sources / systems. In: Networked Knowledge Organization Systems/Services: NKOS [online]. Kent: School of Library and Information Science, Kent State University, Draft June 7, 2000, revised July 31, 2000 [cit. 2014-08-25]. Available from: http://nkos.slis.kent.edu/KOS_taxonomy.htm.

28 ZENG, Marcia Lei. Knowledge Organization Systems (KOS). In: Knowledge organization. 2008, 35(2-3), 160-182. ISSN 0943-7444.

29 ZENG, Ref. no. 28, p. 161, Fig. 1.

The KOS typology of M. Zeng, or, as the case may be, the NKOS Task Group, became the point of departure for the official typology of KOSs, called *KOS Types Vocabulary*[30], which is being prepared within the Metadata Application Profile for the registries of KOS vocabularies by a new DCMI-NKOS Task Group[31]. The typology has to be established because the KOS element – an element of DCMI <dct:format> Metadata terms – must have a value. The term, "vocabulary," which is frequently used in IT, appears in the title of the typology so that the terminology abides by the DCMI initiative standards. It is a purely alphabetical list (see Table1) of 16 KOS types ("vocabularies") providing brief definitions of the original system types (in this case, a singular is used). There is no KOS types hierarchy. Compared with the original typology by Zeng, the type, Directories, was excluded; on the other hand, three new types were added, while the names of others were slightly modified. The following types figure on the list: 1. *Categorization Scheme*, 2. *Classification Scheme*, 3. *Dictionary*, 4. *Gazetteer*, 5. *Glossary*, 6. *List* (of terms), 7. *Name Authority List* (a Zeng type modified by adding "Name"), 8. *Ontology*, 9. *Schema* (a newly-added type that is significant for data model schemas, such as for Taxonomies and Ontologies), 10. *Semantic Network,* 11. *Subject Heading Scheme (*a Zeng type modified by adding "Scheme"*),* 12. *Synonym Rings*, 13. *Taxonomy*, 14. *Terminology* (a newly-added type of a system that contains concepts and their explanation in a specialized field), 15. *Thesaurus*, 16. *Vocabulary* (a newly-added system type for a simple or complex file of special-purpose "terms" in the IT area, e.g.; in the area of semantic web and Linked Open Data). The last type is problematic, because it is also used for other system types (see the title of the typology). It is a bridging term that is also synonymous with the term, "knowledge organization system." In the Czech context, moreover, there is a problem with the English words, "dictionary/vocabulary" because there is only one word in the Czech language that encapsulates both meanings.

The main (core) types of KOSs (see Table 1) listed by the DCMI-NKOS Task Group and their definitions are also codified in the new International Standard ISO 25964-2:2013[32] concerning the interoperability of thesauri with other "vocabularies" (the norm exclusively uses this term, or, as the case may be, "controlled vocabulary"). The KOS typology is not directly represented in the standard, but in the context of fact-finding as regards thesauri, the typology presents other, related "vocabularies" (chapters 17-24). Definitions of several types are missing even from the introductory list of terms (Categorization, Dictionary, Gazetteer, List, and Semantic Network). On the other hand, "controlled vocabulary" and "structured vocabulary" are shortly defined in the list – both types are provisionally listed in Table1 on the same line as the type, "vocabulary" from the typology of DCMI-NKOS, even though their definitions differ), and "data model" (this type is listed as "schema" in the DCMI-NKOS typology). The standard and the list of DCMI-NKOS as given here were more or less parallel (moreover, the norm was co-authored by several experts from the DCMI-NKOS group, including M. Zeng), and so the terms and definitions in particular were, among others, adopted in the definitions given in the DCMI-NKOS Task Group.

30 Dublin Core Metadata Initiative. NKOS Task Group. NKOS Vocabularies. 2., KOS Types Vocabulary. In: DCMI NKOS Task Group [online]. 2013, updated 2013-12-16. Available from: http://wiki.dublincore.org/index.php/NKOS_Vocabularies#KOS_Types_Vocabulary.

31 Dublin Core Metadata Initiative. NKOS Task Group. NKOS AP Elements. In: DCMI NKOS Task Group [online]. 2013, updates 2014-04-03 final, polished 2014-08-03 [cit. 2014-08-25]. Available from: http://wiki.dublincore.org/index.php/NKOS_AP_Elements.

32 ISO 25964-2:2013. Information and documentation – Thesauri and interoperability with other vocabularies – Part 2: Interoperability with other vocabularies. 1st ed. Geneva: International Organization for Standardization, 2013-03-04. 99 p.

Table 1 demonstrates that R. Souza, D. Tudhope and M. Almeida[33] have produced the most extensive KOS typology so far. They have prepared another, interesting KOS typology (also in the form of topic maps) based on their analyses and assessment of thus far important knowledge organization systems, as published in current literature and in their own articles. The presented types are organized hierarchically, on more than one level; this organization is, once again, contingent on the structure of the systems, their functions, and the types of the communities using the KOS. The first group, called *Unstructured Texts* contains unstructured text systems, such as *Abstracts*, and other *Surrogates* (substitutes of entire texts). A greater number of types is given in the second group, called *Term and/or Concept Lists* and dominated by *Authority Files* (lists of authors' names, titles of works, codes of countries, languages, etc.); *Dictionaries*, *Glossaries*, *Gazetteers*, and *Synonym Rings* are also listed. In addition, *Folksonomies*, Tag Lists, and *Concordance Lines* are also in the group. The last type listed is *Controlled Vocabularies* which, however, also belongs to the third group, called *Concepts and Relationships Structures*. This group has *Classification Schemes*, *Categorization Schemes*, *Subject Headings*, *Taxonomies* (of different partial types), *Thesauri*, *Semantic Networks* and *Ontologies*; *Information Retrieval Indexes* (within a databases), *Data Dictionaries* and *Frames*. The last group, called *Concept, Relationship and Layout Structures* contains KOS-specific models. *Mind Maps*, *Argument Maps*, *Concept Maps* and *Rich Pictures*, *Data Models* (e.g.; *Enterprise Data Models*), *Entity-Relationships Models* (e.g.; *Conceptual Data Schemas* etc.) and other partial types of Reference Models (e.g.; *Business Reference Models*, *Technical Reference Models*, and combinations with the preceding type, *Data Reference Model*). The analytical study concludes by proposing an interesting new "taxonomy" of all the dimensions (criteria) of KOS categorization.

33 SOUZA, Renato Rocha, TUDHOPE, Douglas, ALMEIDA, Maurício Barcellos. Towards a taxonomy of KOS: dimensions for classifying knowledge organization systems. In: Knowledge organization. 2012, 39(3), 179-192. ISSN 0943-7444.

Table 1. Overview of select KOS typologies (items are given in their original language and listed alphabetically in accordance with the first column; a legend to the colored fields is provided in the concluding part 2.3.).

DCMI-NKOS, 2013-	ISO 25964-2, 2013	Souza, Tudhope aj., 2012	Zeng, 2008	Hodge, 2000	BARTOC, 2013-	VEST (AIMS), 2012-	TaxoBank, 2009-
		Abstracts					
		Argument Maps					
categorization scheme		Categorization schemes	Categorization Schemes	Categorization Schemes			
classification scheme	classification scheme	Classification systems	Classification Schemes	Classification Schemes	Classification	Classification Scheme / System	classification system
		Concept Maps					concept map
		Concordance Lines					
		Data Dictionaries					
dictionary		Dictionaries	Dictionaries	Dictionaries		Dictionary	
			Directories				
						Encyclopedia	
		Entity-Relationship Models					
		Folksonomies					
		Frames					
gazetteer		Gazetteers	Gazetteers	Gazetteers			gazetteer
glossary		Glossaries	Glossaries	Glossaries		Glossary	glossary
		IR Indexes					
						Lexical database	
list			Lists (Pick lists)				
		Mind Maps					
name authority list	name authority list	Authority files (Aut.,Titl.,Codes)	Authority Files	Authority Files		Authority file / list	
ontology	ontology	Ontologies	Ontologies	Ontologies	Ontology	Ontology	ontology
		Reference Models					
		Rich Pictures					
schema	data model	Data Models					
semantic network		Semantic networks	Semantic Networks	Semantic Networks			
subject heading scheme	subject heading scheme	Subject headings	Subject Headings	Subject Headings		Subject Headings	subject headings
		Surrogates					
synonym ring	synonym ring	Synonym rings	Synonym Rings				
		Tag Lists					
taxonomy	taxonomy	Taxonomies	Taxonomies	Taxonomies	Taxonomy	Taxonomy	taxonomy
terminology	terminology					Terminology database	
thesaurus	thesaurus	Thesauri	Thesauri	Thesauri	Thesaurus	Thesaurus	thesaurus
		Topic maps					
						Topic Tree	
vocabulary	controlled vocabulary structured vocabulary	Controlled vocabularies			Controlled Vocabulary		controlled vocabulary

2.2 Online Registries Containing KOS Typologies

For reasons of comparison, this part engages in analytical commentary on the KOS typologies, as prepared in "live" accessible databases of the systems' registries. Practical and pragmatic approaches of their creators are examined here as regards questions concerning KOS typology versus categorization. Three registries have been selected (see Table 1); they came to existence in the years of 2009-2013 and they continue developing. One is specific to a field, the other two are more generic.

The *VEST* Registration System (*Vocabularies, mEtadata Sets and Tools*)[34] is a new online registry of systems for complex management and control of agriculture and other field-related information, including KOS (used in the registry in the context of the given technologies, as is the term, "vocabulary"). The registry has been created and is managed by a specialized group of the world organization, FAO (Food and Agriculture Organization of the United Nations); it is accessible via the portal of AIMS (Agricultural Information Management Standards). In August 2014, the registry contained approximately 180 entries. The registry is unique because, in addition to Vocabularies (136 entries), it also separately registers metadata sets (61 entries) and information management tools (62 entries). All of the registered "vocabularies" are typified according to their type and subject area (these are also the search fields). The typology of the "vocabularies" is relatively rich, with the total of the following 12 types (current statistics and commentary are included): 1. *Authority File/List* (15 entries, including authority name data, and lists of language and country codes on the one hand, and certain taxonomy databases of organisms and subject categorization schemes, e.g.; the AGRIS (Agricultural Information System) subject-based categorization), 2. *Classification Scheme/System* (10 entries), 3. *Dictionary* (7 entries; besides different dictionaries, the type contains some synonym rings and even the well-known UMLS (Unified Medical Language System) ontology system, 4. *Encyclopedia* (Encyclopedia of Life, http://eol.org has so far been the only one registered), 5. *Glossary* (16 entries), 6. *Lexical Database* (with no entry so far), 7. *Ontology* (18 entries of the best ontologies on the field), 8. *Subject Headings* (2 entries thus far), 9. *Taxonomy* (14 entries of important taxonomic systems in the field), 10. *Terminology Database* (containing 10 entries of different lexical dictionaries of specialized terms, also featuring, for example, the *Geonames* database), 11. *Thesaurus* (with 40 entries, this is the largest type on the registry; some less-related thesauri are included, e.g.; the ERIC Thesaurus (Education Resources Information Center), while the more important ones, such as the NAL Thesaurus (National Agricultural Library), are yet to be included, 12. *Topic Tree* (the registry uniquely includes this type which, however, has no entry so far).

Taxobank[35], a universally profiled KOS registry, is showing promising features. Since 2000, the registry has been maintained by a specialized team of "taxonomists" of the US company, *Access Innovations*, specializing in software applications with focus on the linguistic aspects of data stored in databases (data harmonization, etc.). The registry contains detailed and well-structured data on "controlled vocabularies" (using this term, rather than "knowledge organization system"). For now, the database contains 240 registered systems. In the *Taxobank* registry, there are 9 types of "vocabulary types" listed so far (see Table 1), as follows (bracketed are

34 Food and Agriculture Organization of the United Nations. Agricultural Information Management Registry of Vocabularies, mEtadata Sets and Tools. VEST Registry. Vocabularies [online]. Rome: FAO, Office of Knowledge, Exchange, Research and Extension, © 2012 [cit. 2014-08-25]. Freely available from the AIMS portal: http://aims.fao.org/vest-registry.

35 Access Innovations. TaxoBank Terminology Registry: TaxoBank [online]. Albuquerque (New Mexico, USA): Access Innovations, 2009- [cit. 2014-08-25]. Available from: http://www.taxobank.org/.

abbreviations of the described types, followed by statistics and notes): 1. *Classification System* (clssys, 9 entries so far, known schemes and others, such as "Taxonomy of NCBI Organisms.") 2. *Concept Map* (concmp, 2 entries only), 3. *Controlled Vocabulary* (contrvoc, 29 entries as the second largest type; however, the name coincides with all included types; upon close examination, one also finds different thesauri, e.g.; DTIC Thesaurus (Defense Technical Information Center), subject headings lists, specialized terminology glossaries, some classifications, e.g.; INSPEC Classification (INformation Service in Physics, Electrical & Electronic, and Computer Control), or a bibliographic Anthropology Database), 4. *Gazetteer* (gaz, only 2 entries), 5. *Glossary* (glos, 3 entries) 6. *Ontology* (ont, 3 entries, e.g.; "DBpedia Ontology," 7. *Subject Headings* (subjh, 6 entries), 8. *Taxonomy* (taxon, a small group of 15 better-and less-known taxonomies), 9. *Thesaurus* (thes, the strongest group of approx. 140 entries of better-and less-known thesauri). Entries are added to the *TaxoBank* registry on an irregular basis; it is mostly internet users who send in their registration suggestions. The system lacks an effective search interface (e.g.; it is not possible to do a search by using vocabulary types). However, the registry has well-structured record, rich in data; one of its best features is the presence of substantial information on types of data display in abbreviated forms (e.g.; hier = hierarchic; alp = alphabetical; perm = permuted; other = other), or the very useful information on relationship types (abbreviated values are used, e.g.; eq_pri_eq = equivalence; eq_lang = language equivalence; hier_bn genus-species hierarchy; hier_inst = class of instance; rel_t = association; othr = others).

The BARTOC (*BAsel Register of Thesauri, Ontologies & Classifications*)[36] system is the latest representative of the KOS registries. The registry has been up and running since 2013, maintained by the Basel University Library server. In August 2014, there were as many as 667 entries of registered systems, largely owing to the active managing of the database (A. Ledl). This registry also calls its registered units "controlled and structured vocabularies" or simply, "vocabularies." However, this is problematic, because a single partial type may still be titled "controlled vocabulary". The BARTOC service has pragmatically designated only five types of knowledge organization systems (vocabularies). The first four are well-know and widely-used, main types of these systems (thesauri, classifications, ontologies and taxonomies); the already mentioned "controlled vocabularies" belong to the fifth type (e.g.; the German authority file, GND (Gemeinsame Normdatei) and the DCMES metadata specification). However, the service features no other types of KOS (e.g.; subject headings schemes); therefore, important subject headings (MeSH, LCSH, etc.), are simply joined together with thesauri. The majority of entries have only one category; in some cases, another type may be given. The current statistics reveals that the most systems (approx. 360) belong to the *Thesauri* group. *Classifications* (approx. 185 systems) take the second place. *Ontologies* (approx. 65 systems) are in the third place, *"Controlled Vocabularies"* are in the fourth place (approx. 33 systems), and *Taxonomies* are in the fifth place (approx. 22 systems). The public access to the registry via the search interface has yet to offer greater possibilities of exact and detailed search of the KOS records (e.g.; the very "vocabulary" type search is missing). The records contain a relatively sufficient amount of metadata; it is the system's advantage that it specializes in supplementing Dewey's decimal classification terms (up to the third hierarchic level), which is frequently used in German-speaking countries, as well as providing the multilingual EUROVOC thesaurus descriptors.

36 Universitätsbibliothek Basel. BARTOC.org: BAsel Register of Thesauri, Ontologies & Classifications [online]. Projektleiter Andreas LEDL. Basel: Universitätsbibliothek Basel, 2013- [cit. 2014-08-25]. Freely available from the Baseluniversität server: http://www.bartoc.org/.

2.3 Results of KOS Typologies Comparison

Our comparison of five KOS typologies selected from specialized literature and standards, and three select typologies applied in the real-life operations of the new KOS registries – and upon years of debates – has shown that there is a certain broader core of the types, surrounded by specific KOS types which emerge individually, and tend to be questionable. The orange fields of our comparative chart (see Table 1) feature the types of KOSs that have been agreed on both by theoreticians and practice professionals; that is, they have appeared in all of the eight typologies (five theoretical + three practical). This is the smallest core of the following well-known and recognized KOS types (we have used the titles used by the DCM-NKOS group, which are to be approved as standard): *Classification schemes*, *Ontologies*, *Taxonomies*, *Thesauri*. Other types can be joined to this group; these form a broader core of the KOS types (having appeared three to seven times). They are the yellow field systems in our comparative chart: *Subject Heading Schemes* (7 showings, i.e.; 5 theoretical and 2 practical); *Authority Name Lists* (6 showings, i.e.; 5+1); *Glossaries* (6 showings, i.e; 5+1); *Gazetteers* (5 showings, i.e; 4+1); *Dictionaries* (5 showings, i.e; 4+1); *Vocabularies/Controlled Vocabularies/Structured Vocabularies* (5 showings, i.e; 3+2); *Categorization Schemes* (4 showings, i.e; 4+0); *Synonym Rings* (4 showings, i.e; 4+0), *Semantic Networks* (4 showings, i.e; 4+0); *Schemas/Data Models* (3 showings, i.e; 3+0); and *Terminologies* (3 showings, i.e; 2+1). The following KOS types with two showings (in the light green field) may be, upon consideration, added to the core: *Concept Maps* (1+1), and *Lists* (2+0). Other KOS types with one showing may be considered marginal for now.

Our comparative analysis of the KOS typologies has shown that there is a problem with certain names of the KOS types because they are not unified; they are used differently in different fields and user communities (library, computing, etc.). The analysis also points out certain incoherences in understanding the names within one typology, as outlined in our short commentaries in Part 1 of the article. Our analysis has shown that from a certain perspective, the term, “knowledge organization system” is synonymous with “vocabulary”. The interchangeability of the terms “vocabulary” and “controlled vocabulary” – as the names for a group containing more than one partial KOS type – with the term used for the title of a singular type of a certain typology, presents the greatest problem. Some of the working KOS registries also show real examples of incorrect or problematic placement of certain KOS into unfitting types.

3. Proposal of a Typology of Knowledge Organization System

In order for a typology to be usable, the entire entity must be clearly defined before it is organized. As regards the KOS definition, we have decided to take into consideration the necessary conditions as given in Part 1: the entity must be an intentionally created organization tool whose structure corresponds to the characteristics of the language, and where “concept” is the basic structure unit. By virtue of this, we have eliminated marginal and problematic types, such as: files of randomly created keywords and tags, fulltext indexes, lists of morphologic parts, language dictionaries, abstracts, encyclopedias, data and concept models, concept maps, and “mere” languages (e.g.; RDF). We have then proposed our own typology for the remaining systems which have complied with all the necessary conditions, and which we have identified as the core.

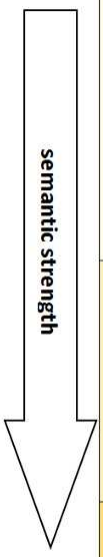
Part 1.1 states that the KOS are very complicated information resources. Therefore, there is a large number of division criteria usable for the construction of a typology: *organization unit* (document, science field, person, institution, product, service, place, process, concept…);

semantic strength, i.e.; the ability of a KOS structure to represent meaning and complexity; *domain*, which may be universal or polythematic, also encompassing special themes; *knowledge representation* (enumerative of facet-based, pre- or post-coordinated); *type of vocabulary/dictionary* (controlled, uncontrolled, single- or multilingual); *openness/closeness* (the so-called presumption of opened or closed world); *granularity* (specificity); *format, purpose*, (functionality, user-destination, e.g.; categorization is better suited for browsing and viewing, thesauri for searching).

Of all the above criteria, the first two, *organization unit* and *semantic strength*, seem particularly important. An organization unit expresses that which is organized. According to this criterion, a KOS may become the organizing tool of things, concepts and terms. The group of concepts to be organized is particularly interesting as it may be further divided into a sub-group organizing "pure knowledge," such as in science classification or biology taxonomy, and a sub-group that traditionally belongs to information science, focusing on the so-called *aboutness*, i.e.; concepts that express the results of the content analysis of information resources.

We have used the criterion of semantic strength as key for our proposal of a KOS typology. Our typology is based on the analyses of current important typologies as listed in the preceding parts of this study, and on our experience with entering data concerning knowledge organization systems into our knowledge base prototype, which was created as a part of our research project. We expect that the typology may be used for the following: 1) categorization of registered units in the knowledge base, 2) terminology platform for expert discussions and further research.

A range that currently comprises 16 types will be useful for the former, above-mentioned case of re*source categorization* in the knowledge base. Table 2 shows the different types, ranked according to their "complexity," or, as the case may be, semantic strength. The overview begins with the simplest type – word lists, and concludes with ontologies – tools that make it possible to represent the richest structure of contents and their relationships. A somewhat simplified way to outline the relationships of the gradual growth of complexity among groups represented by letters is as follows: group A = word lists; group B = A + definition of meaning of words; group C = B + grouping of words with similar meaning (equivalence); group D = C + definition of preferred terms; group E = D + definition of hierarchic relationships; group F = E + definition of associative relationships; group G = F + inference. Table 2 further shows that groups A – C focus on organization of words (terms), groups D – G organize on the level of concepts. The KOS types numbered 10 –16 roughly correspond to the set called "subject authorities" in the Czech context. We assume that with each increase of the expressive potential of an organization system, the level of precision and recall of search performed via the system also increases. At the same time, however, the construction difficulty and laboriousness increase as well.



category			type (in Czech)	English		
vocabularies linear structure	organization of terms	1	nabídkový seznam (menu)	*pick list*	A	list of words
		2	negativní slovník (stop slova, zakázaná slova)	*stopwords, exclusion list*		
		3	(řízený) slovník	*(controlled) vocabulary, dictionary*		
		4	číselník (nomenklatura, seznam, kódovník)	*list, code list*	B	A + definition
		5	(výkladový) slovník, glosář	*glossary*		
		6	terminologický slovník	*terminology*		
		7	seznam synonym	*synonym ring, synset*	C	B + equivalence
classification hierarchic structure	organization of concepts	8	slovník zeměpisných názvů	*gazetteer*	D	C + preferred terms
		9	seznam jmenných autorit	*name authority list/file*		
		10	předmětový heslář	*subject heading scheme*		
		11	kategorizace, kategorizační schéma / systém	*categorization scheme*	E	D + hierarchies
		12	taxonomie (biologie)	*taxonomy*		
		13	klasifikace / klasifikační schéma / systém	*classification scheme*		
concept networks network structure		14	tezaurus	*thesaurus*	F	E + associations
		15	sémantická síť	*semantic network*		
		16	ontologie	*ontology*	G	F + inference

Table 2. Typology of knowledge organization systems pursuant to their semantic strength

In the latter case, *terminology system* for expert discussions and research, dichotomies proved to be useful in practice, the limit of the number of categories (presented elements) for these purposes apparently being the psychological border of 7±2[37] of the presented elements. That is why we have sought another perspective on the KOS to organize the types of our scale into larger groups. The above-mentioned article on the KOS terminology points out that the ”subject indexing–systematic” dichotomy is unsustainable because it no longer reflects the current real world. However, we clearly need an “intermediate” level of KOS perspective. For now, we have therefore chosen the following, slightly modified categories of G. Hodge based on structure and relationships typology: Vocabularies with simple, linear structure; the hierarchically structured Classifications, and Concept Networks.

Our experience so far shows that the existing typology does not warrant any unified approach. The authors of the editorial to the monothematic issue of *Applied Ontology* magazine on the relationship of ontologies and terminologies[38] illustrated the problems relating to the placement of individual instances into given type categories. The authors performed an extensive literary research, showing the current lack of unity of identification on the example of seven concrete KOSs as they appeared in specialized texts. As regards the *WordNet* system, they identified 10 cases of KOS placement into the lexical database category: 12x as (linguistic) ontology, 1x as folksonomy, 2x as other categories. The *Foundational Model of Anatomy* (FMA) system was

37 MILLER, George Armitage. The magical number seven, plus or minus two: some limits on our capacity for processing information. In: Psychological review. 1956, 63(2), pp. 81-97. ISSN 0033-295X (Print). ISSN 1939-1471 (Online).

38 GRABAR, Natalia, HAMON, Thierry, BODENREIDER, Olivier. Ontologies and terminologies: continuum or dichotomy? In: Applied ontology. 2012, 7(4), 375-386. ISSN 1570-5838 (Print). ISSN 1875-8533 (Online).

identified as follows: 7x as ontology, and 2x as terminology. The *Medical Subject Headings* (MeSH) system was identified as follows: 6x as terminology or thesaurus, 6x as ontology, 5x as ontology but described as thesaurus or controlled vocabulary. AGROVOC system: 8x as thesaurus or controlled vocabulary, 3x as ontology, 1x as thesaurus refactored into ontology. NCI Thesaurus: 2x as terminology or thesaurus, 6x as ontology and 4x simultaneously as thesaurus and ontology. UMLS (Unified Medical Language System): 9x as metathesaurus or domain-specific terminology system, 5x as ontology, 3x as both. In order to clarify our typology of individual KOS types, the following are their brief characteristics (the serial numbers correspond to the numbers in Table 2), and examples of their instances.

1. Pick List (*list box* or *combo box* in terms of the user interface) is contained in nearly every online web system, such as *Documentart* offered in the advanced search interface by the new BASE metadata service (http://www.base-search.net/Search/Advanced), *Sources* – a list of search collections of the NARCIS system (National Academic Research and Collaborations Information System, http://www. narcis.nl), or a number of partial offers of search data within the advanced search in the NASA digital archive (http://ntrs.nasa.gov/advSearch.jsp).

2. Exclusion List (aka negative vocabulary) contains a list of words excluded from a certain kind of processing (typically from searches). Some examples are: the *Stopwords* vocabulary of the Web of Science system 2009 (http://images.webknowledge.com/WOK46) or the stopwords vocabulary of the Ranks NL Webmaster Tools NL system (http://www.ranks.nl/stopwords/czech).

3. Controlled Vocabulary has a pre-defined scope (usually determined by the enumeration of the terms), and a defined content of terms to ensure there is consistency in the naming of concepts; for example, the first part of the license agreement (Definition) of the *Creative Commons* webpage (http://creativecommons.org/licenses/by-nc-sa/3.0/cz/legalcode), or lists of terms concerning visual images, such as “Key Words” (enhancement terms) for Digital Newsphoto Archives (http://biblio.org/slanews/archiving/terms/photowords/htm) prepared by the working group for the newspaper photograph-archiving section of the US Special Libraries Association (SLA). Similar vocabularies for graphic programs are available commercially (e.g.; Controlled Vocabulary Keyword Catalog (CVKC), http://controlledvocabulary.com/products).

4. Code List is a non-hierarchic organized list of verbal descriptions of things and events with numerical or alphabetical codes, for example, the CZSO Nomenclature of Countries (CZEM, http://www.czso.cz/csu/klasifik.nsf/i/ciselnik_zemi_(czem)); language codes as given in the ISO 3166-3:2013, Codes for the Representation of Names of Countries and Their Subdivisions – Part 2: Code for formerly used names of countries (2nd ed., 2013) commercially available online from http//:www.iso.org/iso/home/standards/country_codes.htm – free samples are included.

5. Glossary contains a list of words, and explanation of their meaning, for example, *Linked Data Glossary* (Hyland, B., Atemezing, G., Pendleton M., Srivastava, B., ed. W3C, 2013, available from http://www.w3.org/TR/ld-glossary) and *Glossary of European Judicial Network* (http://ec.europa.eu/civiljustice/glossary/glossary_cs.htm).

6. Terminology is a dictionary of field-related terms, for example, the TDKIV Czech online database (http://aleph.nkp.cz/F/?func+file&file_name+find-a&local_base=ktd) or the online dictionary, ODLIS: *Online Dictionary for Library and Information Science* (REITZ, J.M. Santa Barbara, ABC-CLIO, 2014, available from http://abc-clio.com/ODLIS_A.aspx).

7. Synonym Ring represents sets of synonymous terms, each of which may be used to define a certain concept[39], such as *Czech Language Thesaurus: Dictionary of Czech Synonymous, Cognate and Related Words and Phrases* (Klégr, A., Praha: Lidové noviny, 2007, ISBN 978-80-7106-920-1), WordNet system (http://wordnet.princeton.edu) or a list of grammatical synonyms of Web of Science (http://images.webofknowledge.com/WOKRS57B4/help/WOS/hs_spelling_terms.html).

8. Gazetteer is an organized collection of information about geographic entities, for example the well-known *Getty Thesaurus of Geographic Names© Online* (http://getty.edu/research/tools/vocabularies/tgn/) or the collection of national geographic authorities produced cooperatively (http://autority.nkp.cz/vecne-autority/soubor-geografickych autorit-1).

9. Name Authority List is a controlled vocabulary ensuring unified naming of a determined group of entities within a given context[40], for example, the collection of *Name Authority Headings* of Library of Congress, accessible online from the portal of all authorities (http://authorities.loc.gov/); its MARC 21 format version (Authorities) is commercially available from CDS LC (http://classificationweb.net/) and in the form of linked open data, available from URI: http://id.loc.gov/authorities/names. The VIAF (http://viaf.org/), also available in the form of linked open data (http://viaf.org/viaf/data/) is the most significant international file of name authorities. The important and extensive, commercially available code of chemical elements, materials and substances of the US Chemical Abstract Services (CAS Registry Numbers; its derivate is available from the service, "Common Chemistry," http:www.commonchemistry.org), may also be placed here.

10. Subject Heading Scheme is a structured vocabulary containing terms for object-based indexing plus rules for their combining in pre-coordinated chains of terms when necessary[41], such as the French national subject system, RAMEAU (accessible in various formats from the main site, http://rameau.bnf.fr/, or the linked open data structure, http://data.bnf.fr/liste-rameau) or the Czech *Polythematic Structured Subject Heading Scheme* produced by NTK (National Technical Library, http://www.techlib.cz/cs/82897-polytematicky-strukturovany-heslar).

11. Categorization Scheme is a list of categories (groups, classes) for the grouping of organized entities on the basis of their belonging to a category. Typical examples are the following: categorizations of domain fields, *Web Science of Categories* of Thomson Reuters used in the *Web of Science* system (its latest version commercially available from http://apps.webofknowledge.com/), or in an older, 2012 version as partial vocabularies with commentaries on SCIE files, http://ip-science.thomsonreuters.com/mji/scope/scope_scie/SSCI, http://ip-science.thomsonreuters.com/mjl/scope/scope_sci/ and AHCI, http://thomsonreuters.com/mjl/scope_ahci/)

12. Taxonomy is a hierarchic enumerative classification used mainly in natural sciences (biology, zoology), such as the *Integrated Taxonomic Information System* (http://www.itis.gov/index.html). The term has lately been used for classification of digital objects, such as webpages. The Drupal system uses taxonomy in this sense in its *Taxonomy* model (https://www.drupal.org/node/774892).

13. Classification Scheme is a list of concepts and pre-coordinated combinations of concepts

39 Explanation adopted from ISO 25964-2, Ref. no. 32, pp. 13, art. 3.79.

40 Explanation adopted from ISO 25964-2, Ref. no. 32. p. 8, art. 3.50.

41 Explanation adopted from ISO 2596-1, Ref. no. 20, p. 11, art. 2.57.

organized in classes[42]. Most often, it comprises a hierarchic structure with a smaller number of top (root) classes and a higher number of hierarchic structures, such as the first, printed edition of DDC (Dewey, M. *A Classification and Subject Index for Cataloguing and Arranging the Books and Pamphlets of a Library*, Amherst, Hampshire County, Mass., 1876) which is also accessible in a digital form (http://archive.org/details/classificationan00dewerich, http://catalog.hathitrust.org/Record/001163285), or its latest electronic form, *Dewey-Info* (http://dewey.info/) also providing data in the form of linked open data. The Russian Rubricator, VINITI, freely accessible online, is another example (http://scs.viniti.ru/rubtree/main.aspx?tree=RV).

14. Thesaurus is a controlled and structured dictionary where concepts are represented by terms, organized in such a way that relationships of hierarchy and association among concepts are explicitly expressed, while preferred terms are accompanied by references to synonyms and quasi-synonyms[43], such as the *ERIC Thesaurus* (freely accessible from ERIC database, http:/eric.ed.gov) or the *AGROVOC Thesaurus* (http://aims.fao.org/standards/agrovoc/linked-open-data).

15. Semantic Network is a graphic representation of semantic relationships among concepts, such as *OpenStreetMap Semantic Network* (http://wiki.openstreetmap.org/wiki_OSM_Semantic_network) or the semantic network, *UMLS Semantic Network* (semanticnetwork.nlm.nih.gov) for biomedical terms and their relationships.

16. Ontology is a shared and reusable conceptual representation of a particular domain, usually equipped with axioms and ontological commitments; besides organization and retrieval, it serves for communication, reuse of knowledge, and automatic deriving of new knowledge. Some examples of general ontologies are as follows: *DBPedia Ontology* (http://wiki.dbpedia.org/Ontology?v=zj4) or BFO – *Basic Formal Ontology* (http://ifomis.uni-saarland.de/bfo/), or YSO – *General Finnish Ontology* (http://finto.fi/yso/en/); the following is an example of a domain-specific ontology: GO—*Gene Ontology* (http://geneontology.org).

Conclusion

Our examination of knowledge organization systems, performed as a part of the NAKI project, "Knowledge Base for the Subject Area of Knowledge Organization," has produced our working definition of the term, *knowledge organization system*, and our proposal of a KOS typology as a basis on which to include the term into the Czech specialized terminology. In our proposed KOS typology, we have synthesized the approaches detected via our analysis, using the unifying criterion of *semantic strength* to ensure that the typology is consistent. Neither our definition nor our proposed typology are definite; rather, they have been conceptualized as suggestions for further discussion. Rather than answers, the results of our research have generated further questions.

The fact that the conceptual and terminological bases of the KOS are not unified has generated issues which are detectable both on the interdisciplinary level (e.g.; there is a significant difference between the information science community and computer science), and within each field, which unfortunately concerns information science, too. It is obvious that the call for the unification of terminology, made at the end of the 20th century, has not yet been heard. The complaint of B. Weinberg about "a serious lack of vocabulary control in the literature on

42 Explanation adopted from ISO 2596-1, Ref. no. 20, p. 2, art. 2.6.

43 Explanation adopted from ISO 25964-1, Ref. no. 20, p. 12, art. 2.62.

controlled vocabulary"[44] has not lost its appeal. This situation might, on the one hand, provoke skepticism as regards the tools and the vision of a Semantic Web with (semantically) linked data. On the other hand, we might ask whether the detected lack of unity in the understanding of knowledge organization systems and their types is truly a problem rather than an adequate reflection of the diversified and constantly changing world of knowledge. Even the current knowledge organization systems are in motion – the key motion being the integration of originally distinctive features that used to separate classifications from subject headings schemes, for example – towards coexisting within one concrete system (e.g.; MESH, LCSH, AAT, DDC Relative Index, UDC facetization).

Part 1 of this article has demonstrated the broad scope of meaning that KOS encompasses. We argue that a term of this kind may only be defined very generally, and that determining a category of this type may prove impossible, because there is no set of common characteristics to build on. This issue has re-emerged – with varying intensity – when defining the KOS categories for our typology. Relatively stable categories, such as thesauri, with their consensually accepted ISO 25964 standard, are exceptions to the rule. We are aware that the "justification" of each type included in the typology ought to be grounded in the presence of distinct features rather than in differences in the naming. The results of our comparison of existing typologies seem to suggest that linguistic analysis is not conducive to unified approach to new conceptual base of KOS. Therefore, we have attempted to produce a classical definition of KOS and its types via their common features; however, only a few, very abstract features have been detected so far. For this reason, focus on "non-Aristotelian" principles of categorization might prove more successful in future research. The following alternative approaches to categorization as listed by G. Lakoff[45] appear promising: *family resemblances* (the principle was thus named by L. Wittgenstein; Lakoff defines it as a mutual relationship of familiarity among a category members, generated by a series of family resemblances without the existence of a set of their common features); *centrality/prototypes* (some members are better representatives of a category than others are); *degree of membership* (we have adopted this approach to some extent when defining the "core" of the KOS types); *base category* (the so-called middle-out method: neither the lower-level of concreteness nor the upper-level of abstraction members represent the starting point; rather, it is the most important representatives that act as the starting point from which to proceed up and down); metonymy used as "*pars pro toto*" ("part standing for the whole" or the naming of the whole by its part, which currently applies to the way the terms, "vocabulary" and "ontology" are used for KOS). In his article on the KOS systematics[46], J. Tennis offers yet another perspective, arguing that focusing exclusively on the core, traditionally viewed as document retrieval systems, may not be the key to determining the fundamentals of KOS, but that other marginal types facilitating access to knowledge about the creation and implementation of systems, outside the area of information science, must also be taken into consideration. By virtue of their analysis, traditional "core" KOSs may be newly "illuminated".

44 „There is a serious lack of vocabulary control in the literature on controlled vocabulary". WEINBERG, Bella Hass. ASIS'97: the classification research workshop. In: Key words. 1998, 6(2), 21-22. ISSN 1064-1211.

45 LAKOFF, George. Ženy, oheň a nebezpečné věci: co kategorie vypovídají o naší mysli. 1. vyd. Praha: Triáda, 2006, pp. 25-26. ISBN 978-80-86138-78-7 (hardcover).

46 TENNIS, Joseph T. Fringe types and KOS systematics: examining the limits of the population perspective of knowledge organization systems. In: Advances in classification research online [online]. 2009, 20(1) [cit. 2013-08-23], [14 p.]. doi:10.7152/acro.v20i1.12885. ISSN 2324-9773. -- 20th ASIS SIG/CR Classification Research Workshop (Vancouver, Canada, 2009).

Although the current fast changes prevent us from fixing the outlines and the components of a dynamically developing phenomenon, we may certainly express our hopes that future progress and the parallel research of knowledge organization systems will, upon a certain stabilization, facilitate a clearer perspective on their essential and differing features, making themselves a base on which to build a typology for both theoretical and practical use.

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Works Cited

Access Innovations. *TaxoBank Terminology Registry: TaxoBank* [online]. Albuquerque (New Mexico, USA): Access Innovations, 2009- [cit. 2014-08-25]. Available from: http://www.taxobank.org/.

Dublin Core Metadata Initiative. NKOS Task Group. NKOS AP Elements. In: *DCMI NKOS Task Group* [online]. 2013, updates 2014-04-03 final, polished 2014-08-03 [cit. 2014-08-25]. Available from: http://wiki.dublincore.org/index.php/NKOS_AP_Elements.

Dublin Core Metadata Initiative. NKOS Task Group. NKOS Vocabularies. In: *DCMI NKOS Task Group* [online]. 2013, updated 2013-12-16 [cit. 2014-08-25]. Available from: http://wiki.dublincore.org/index.php/NKOS_Vocabularies.

Dublin Core Metadata Initiative. NKOS Task Group. NKOS Vocabularies. 2., KOS Types Vocabulary. In: *DCMI NKOS Task Group* [online]. 2013, updated 2013-12-16 [cit. 2014-08-25]. Available from: http://wiki.dublincore.org/index.php/NKOS_Vocabularies#KOS_Types_Vocabulary.

Food and Agriculture Organization of the United Nations. *Agricultural Information Management Registry of Vocabularies, mEtadata Sets and Tools. VEST Registry. Vocabularies* [online]. Rome: FAO, Office of Knowledge, Exchange, Research and Extension, © 2012 [cit. 2014-08-25]. Freely available from AIMS Portal: http://aims.fao.org/vest-registry.

GOLUB, Koraljka, TUDHOPE, Douglas, ZENG, Marcia Lei, ŽUMER, Maja. Terminology Registries for Knowledge Organization Systems: Functionality, Use, and Attributes. In: *Journal of the American Society for Information Science and Technology*. September 2014, 65(9), pp. 903-912. doi:10.1002/asi.23090. ISSN 1532-2882 (Print). ISSN 1532-2890 (Online). Also commercially available from Wiley Online Library (DOI): http://dx.doi.org/10.1002/asi.23090.

GRABAR, Natalia, HAMON, Thierry, BODENREIDER, Olivier. Ontologies and terminologies: continuum or dichotomy? In: *Applied ontology*. 2012, 7(4), 375-386. ISSN 1570-5838 (Print). ISSN 1875-8533 (Online). Also commercially available from IOS Press (DOI): http://dx.doi.org/10.3233/AO-2012-0119.

HODGE, Gail. *Systems of knowledge organization for digital libraries: beyond traditional authority files*. Washington: The Digital Library Federation, Council on Library and Information Resources, April 2000. vi, 37 p. ISBN 1-933645-06-7 (DLF). ISBN 1-887334-76-9 (CLIR, erroneous). Also freely available from publisher’s web: http://www.clir.org/pubs/reports/pub91/pub91.pdf.

ISO 25964-1:2011. *Information and documentation – Thesauri and interoperability with other vocabularies – Part 1: Thesauri for information retrieval*. 1st ed. Geneva: International Organization for Standardization, 2011-08-08. 152 p.

ISO 25964-2:2013. *Information and documentation – Thesauri and interoperability with other vocabularies – Part 2: Interoperability with other vocabularies*. 1st ed. Geneva: International Organization for Standardization, 2013-03-04. 99 p.

KUČEROVÁ, Helena. České termíny pro věcné pořádání informací po 40 letech: příspěvek k terminologické diskusi. In: *ProInflow: časopis pro informační vědy* [online]. 2013, 5(Speciál) [cit. 2014-02-17], pp. 1-19. ISSN 1804-2406. Available from: http://pro.inflow.cz/sites/default/files/pdfclanky/ProInfow_Kucerova_final_0.pdf.

LYKKE, Marianne. Networked Knowledge Organization Systems/Services (NKOS). In: Marcia J. BATES, Mary Niles MAACK, ed. *Encyclopedia of library and information sciences*. 3rd ed. Boca Raton (Florida): CRC Press, © 2010, pp. 3911-3915. doi:10.1081/E-ELIS3-120044732. ISBN 978-0-8493-9712-7 (set, Print). ISBN 978-0-8493-9711-0 (Online). Also commercially available from: http://www.tandfonline.com/doi/pdf/10.1081/E-ELIS3-120044732.

MILES, Alistair, BECHHOFER, Sean, ed. *SKOS Simple Knowledge Organization System Reference* [online]. W3C Recommendation 18 August 2009 [version]. Cambridge (MA): World-Wide Web Consortium, © 2009. Available from: http://www.w3.org/TR/2009/REC-skos-reference-20090818/.

MOSKOVIČ, Vol'f Abramovič. *Informacionnyje jazyki*. Moskva: Nauka, 1971. 143 p.

SOERGEL, Dagobert. Digital libraries and knowledge organization. In: Sebastian R. KRUK, Bill McDANIEL, ed. *Semantic digital libraries*. Berlin: Springer, 2009, pp. 9-39. ISBN 978-3-540-85433-3 (Print). ISBN 978-3-540-85434-0 (Online). Also commercially available from (DOI): http://dx.doi.org/10.1007/978-3-540-85434-0_2.

SOUZA, Renato Rocha, TUDHOPE, Douglas, ALMEIDA, Maurício Barcellos. Towards a taxonomy of KOS: dimensions for classifying knowledge organization systems. In: *Knowledge organization*. 2012, 39(3), pp. 179-192. ISSN 0943-7444. Also commercially available from EBSCOhost (LISS): http://search.ebscohost.com/.

SVENONIUS, Elaine. Bibliographic languages. In: *The intellectual foundation of information organization*. Cambridge (Mass): MIT Press, 2000, chapter 4, pp. 53-55. ISBN 0-262-19433-3.

SZOSTAK, Rick. Classification, ontology, and the Semantic Web. In: *Advances in classification research online* [online]. 2013, 24(1) [cit. 2014-08-25], pp. 30-37. doi:10.7152/acro.v24i1.14674. ISSN 2324-9773. 24th ASIS SIG/CR Classification Research Workshop. Available freely from: https://journals.lib.washington.edu/index.php/acro/article/view/14674.

TENNIS, Joseph T. Fringe types and KOS systematics: examining the limits of the population perspective of knowledge organization systems. In: *Advances in classification research online* [online]. 2009, 20(1) [cit. 2014-08-25], [14 p.]. doi:10.7152/acro.v20i1.12885. ISSN 2324-9773. 20th ASIS SIG/CR Classification Research Workshop. Freely available from: https://journals.lib.washington.edu /index.php/acro/article/view/12885/11381.

TUDHOPE, Douglas, KOCH, Traugott. New applications of knowledge organization systems: introduction to a special issue. In: *Journal of digital information* [online]. 2004, 4(4) [cit. 2014-08-25]. ISSN 1368-7506. Available from: https://journals.tdl.org/jodi/index.php/jodi/article/view/109/108.

Universitätsbibliothek Basel. *BARTOC.org: BAsel Register of Thesauri, Ontologies & Classifications* [online]. Projektleiter Andreas Ledl. Basel: Universitätsbibliothek Basel, 2013- [cit. 2014-08-25]. Available free from Baseluniversität server: http://www.bartoc.org/.

World-Wide Web Consortium. Vocabularies. In: *World Wide Web Consortium (W3C)* [online]. Cambridge (MA): World-Wide Web Consortium, © 2012 [cit. 2014-08-25]. Available from: http://www.w3.org/standards/semanticweb/ontology.

WEINBERG, Bella Hass. ASIS'97: the classification research workshop. In: *Key words*. 1998, 6(2), pp. 21-22. ISSN 1064-1211. Also commercially available from EBSCO (LISS): http://search.ebscohost.com.

ZENG, Marcia Lei. Knowledge Organization Systems (KOS). In: *Knowledge organization*. 2008, 35(2-3), pp. 160-182. ISSN 0943-7444.

ZENG, Marcia Lei. Taxonomy of knowledge organization sources / systems. In: *Networked Knowledge Organization Systems/Services: NKOS* [online]. Kent: School of Library and Information Science, Kent State University, Draft June 7, 2000, revised July 31, 2000 [cit. 2014-08-25]. Available from: http://nkos.slis.kent.edu/KOS_taxonomy.htm.

ZENG, Marcia Lei, ŽUMER, Maja. A metadata application profile for KOS vocabulary registries. In: *Knowledge organization: pushing the boundaries: ISKO UK [3rd] Biennial Conference, 8th - 9th July 2013, London* [online]. London: ISKO UK, 2013 [cit. 2014-08-25]. Available from: http://www.iskouk.org/conf2013/papers/ZengPaper.pdf.