The article puts emphasis on verification conception of ontology of return on investment (ROI) indicator for topic map application. Research was carried out on two applications created in program TM4L. This study concentrated on visualization of connections between topics in the context of easier obtaining information about algorithm of counting indicators.

Studies will be continued in order to verify ontology of ROI in formal and substantive respect testing created applications in TM4L and Protégé. Future works will involve studying for using topic map for notation ontology of economical ratios will be continued in order to verify usefulness of such application allowing visualizing semantic associations for particular area of economic analysis and use of topic map as a tool of visual exploration of data.

**Keywords:** Ontology, topic map, economical ratios, visualization.

**Introduction**

Economical\(^1\) ratios provide much information concerning functioning of an enterprise. These ratios are essential on condition that they are well calculated and interpreted. Their usefulness depends also on comprehension by decision makers existing between indicators structural and semantic connections. However, existing financial information systems concentrate on providing information reflecting hierarchic connections between indicators.

One of suggested solutions, which allow presenting various associations between economical ratios, is the standard of topic map. This solution is a relatively new form of presentation of knowledge, which puts emphasis on data semantics and ease of finding desired information (e.g. Ahmed et al., 2006; Freese, 2001; Newcomb, 2002). Topic map is an International Organization for Standardization (ISO) standard (ISO/IEC 13250, 2000) used to describe knowledge structures and associate them with information resources (e.g. Pepper, 2000; Grand et al., 2000) and allowing to solve problems related to information retrieval and interpretation through the structuring of information resources according to user requirements (Korczak et al., 2009).

Conception of usage topic map for notation of ontology of knowledge concerning indicators has such advantage that created model of ontology can be relatively easily modified; and simultaneously it becomes possible to use multiple applications based on different ontologies of particular area. This is essential, because there is no single universal system of economical ratios, which would be used in all economic organizations. Many enterprises use many models of assessment of run activity based on analysis of various indicators. Usage of topic map enables also dynamic, interactive visualization of rates and semantic associations, existing between them. Thanks to that decision makers will receive

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tool, use of which can result in easier acquiring of needed information from existing in enterprise databases.

This article is continuation of carried out researches on possibility of adaptation and verification the standard of topic map as method of presenting semantic associations between different economical ratios. Thanks to visualization users can more swiftly notice and understand various structural and semantic relations.

This paper discusses the conception of ontology of indicators return on investment for topic map application. The elaboration is structured as follows. The upcoming section presents the state-of-the-art in ontology, topic map, visual method and ontology of economical ratios. Then, procedure of creating ontology of ROI indicators is described. This is followed by discussion of conceptualization stage of ROI indicator ontology. Further section elaborates researches concerned with verification of conceptualization of ontology of ROI indicator noted in topic map. Finally, in the last section a summary of this work is given and a future research projects are indicated.

Related work

Ontology

In literature many different definition of ontology can be found. A wide review of the issue is presented by Abramowicz (2008), Noy et al. (2005), Smith, 2010. However, there is no universally used one in information technology. Most often general explanation of ontology defined by Gruber (1993, p.907) is quoted: “is an explicit specification of a conceptualization”. Ontology can be defined also as a graph of organized semantic topics, where nodes are distinguished topics, whereas edges denote existing relations between them. During designing ontology for given field following criteria described by Gruber (1993, pp.908-909) should be obeyed: clarity, coherence, extendibility, minimal encoding bias and minimal ontological commitment. Constructing ontology always denotes analysis and organizing knowledge concerning specific field noted in formalized structure.

Initially ontology in IT was developed with a view to data in Internet. Currently its appliance is wider, basing also on possibilities of ontology to represent specific knowledge (inter alia to share it) and to make elastic platform of integrating information and elements from various information systems. In the world studies on noting ontology of chosen field by information tools are carried out. There are already libraries of ontologies in the Internet, for example: library of ontologies Ontolingua (http://www.ksl.stanford.edu/software/ontolingua/), library of ontologies DAML (http://www.daml.org/ontologies), library of program Protégé (http://protegewiki.stanford.edu/index.php/Protege Ontology Library). Pages containing descriptions of ontologies concerning particular field are also created. For example NCBO BioPortal (http://bioportal.bioontology.org) contains about 100 ontologies concerning especially biomedical field. Many publicly available commercial ontologies also exist: e.g. UNSPSC (www.unspsc.org), RosettaNet (www.rosettanet.org), DMOZ (www.dmoz.org).

Over a dozen methodologies of creating ontologies were developed. These are inter alia: Cyc, KBSI, TOVE, EMA, HOLSAPPLE, HCOME, System KACTUS, Methontologie, SENSUS, On-To-Knowledge method, UPON (a wide review of the issue is presented in: Gomez-Perez et al. 2004; Noy et al., 2005). However many authors point out that there is no one right method of designing ontology (Noy et al., 2005). Likewise, there is no single right ontology, therefore for relatively simple fields huge number of competing ontologies can be built (Abramowicz, 2008). Considering of these alternative approaches recommends adjustment to needs of specific users.
Topic map for notation of ontology of return on investment indicator

Topic map for ontology

Topic maps were designed to solve the problem of large quantities of unorganized information, which is not useful if it cannot be found or linked (Freese 2000). A topic map can represent information using topics (representing any concept), associations (which represent the relationships between them), and occurrences (relationships between topics and information resources relevant to them) (e.g. Librelotto, 2009, p.175). Usually a topic map is a semantic graph, that contains definitions of a set of topics and a set of association between topics called ontology of a domain (Korczak et al. 2009, p.86). This structure allows to link information resources. In that way it is possible to build semantic network (e.g. Grand et al., 2000; Rath, 2001), which enables easy navigation on scattered sources of data. Analysis of potential possibilities of use of standard topic map was described among others in works of Ahmed et al. (2006), Korczak et al. (2009), Sanin et al. (2007). Seven basic benefits of creating topic map application for organization of information in existing information in the company can be presented (Đudycz 2009, pp.70-71):

- topic maps are saved as computer files in the open standard, so they are not limited to the concrete form of data presentation;
- topic map is characterized by flexibility, i.e. it can be freely modified by adding new topics and connections between them;
- once the topic maps have been built, a user can easily merge data from one topic map to another;
- topic maps offer the alternative of indexing and searching for topic names, and then using topic occurrences to present links to all content related to the topics found by the search;¹
- the layer of topics is separated from the layer of resources;
- topic maps can be used to combine topic information received from multiple separate sources into a single functioning topic map;²
- a standard like topic maps, is that a larger set of tools from various vendors become available, like query languages, graphic visualization, portal integration, content management, workflow, natural language querying.

Topic maps as the foundation for integrating all sorts of data sources (Ahmed et al., 2006) can support the extraction of information from all relevant subsystems. The ability of topic maps to link resources anywhere and to organize these resources according to a single ontology, will make topic maps a key component knowledge management solutions (Librelotto 2009, p.174).

Topic map as visual method

Visual analysis and visualization techniques have been proven - as said Keim and Schneidewind (2005, p.1767) - “to be of great value in analyzing and exploring such large data sets, since presenting data in an interactive, graphical form often fosters new insights, encouraging the formation and validation of new hypotheses to the end of better problem solving and gaming deeper domain knowledge”. In this interactive visual process, the user is able to subsequently concentrate on the interesting data elements by filtering

¹ Such searching is more efficient than that based on basic hierarchic structure (e.g. Garshol, 2004; Yi, 2008, p.1899). The results of this Yi’s (2008, p.1910) study shows that relationships-based query searches using this topic maps-based information retrieval system resulted in better recall and shorter search times than did those for fact-based query searches.
² In building semantic layers there is no need to modify subsystems or to duplicate content and logic of subsystems. A wide review of the architecture of information system with topic map application is presented in (Korczak et al., 2009, pp.88-89).
uninteresting data, and focusing (zooming in) on the interesting elements, until finally
details are available for an interesting subset of the analyzed elements (e.g. Atzmueller et al., 2005, p.1756). Important stage in this process is use of appropriate solutions, which
allow filtering and zooming in (zoom out).

One of these visualization methods enabling visual data exploration is the topic map
application. It allows displaying the whole semantic network (topics and associations)
efficiently, as it is essential to select the relevant information. Fundamental factors for
good visualization interface of application of topic map are: the overview of the structure
for the global understanding of the structure and of the relationships within the hierarchy;
the ability to zoom and to select some nodes; and dynamic requests in order to filter data
in real time (Grand et al., 2000).

The topic maps can be easily used to represent financial knowledge about financial
measures, where graphical expressions can assure semantic information search and
interpretation for non-technically-minded users. As empirical researches carried out by
Falconer (2009, p.136) show visualization increases comprehension of ontology, causing
that “users performed better on the conceptual task of actually understanding and
describing the semantics of a given concept”.

Topic map is a relatively new visualization form of the presentation of knowledge, which
puts emphasis on data semantics and ease of finding desired information.

**Ontology of economical ratios**

Noy and McGuiness (2005) pay attention, that during creating ontology of economical
ratios it is necessary of being aware, that: „There is no single correct ontology for any
domain. Ontology design is a creative process and no two ontologies designed by different
people would be the same”. However, Smith (2004) notes, that “information systems
ontologists have thus far not been able to develop an algorithm for the automatic
conversion of income statements and balance sheets prepared on the basis of the two sets
of standards”. Despite these problems, it is necessary to undertake studies connected with
building ontology of economical ratios in order to create topic map application for them.

In literature attention is paid on such drawbacks of analysis of rates as: lack of indicating
reasons of appearing disadvantageous phenomena and possibility of wrong interpreting
indicators (e.g. Rutkowski 2007, pp.102-103). Searching reasons of appearing undesirable
phenomena and noticing positive factors can facilitate examining source data through
analysis semantic associations between economical ratios. These tasks can be streamlined
by visualization these various connections. Initial researches one use of topic map to
visualize semantic associations between different indicators, which have impact on
calculating the profit sharing indicators (Korczak et al., 2009), points out possibility of
using this standard for notation of ontology for any area of economic analysis. Such
solution can also serve to integrate data that are located in many information systems
functioning in enterprise.

**Procedure of creating ontology of ROI indicators**

There are many methods describing procedure of creating ontology for information
solutions. But so far, there is no single recommended approach to its creating. Based on
analysis of existing methodologies (a wide review of the issue is presented in: Gomez-
Perez et al. 2004; Noy et al., 2005) and analysis of determinants linked with creating of
ontology of ROI a procedure of creating ontology of economical ratios was proposed. In
this procedure following stages were distinguished:

1. Determine the domain and scope of the ontology;

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1 Analysis of potential possibilities of use of standard topic map for representation of financial knowledge was
described in: (Korczak et al., 2009).
2. Consider reusing existing ontologies;
3. Conceptualization of ontology;
4. Entering ontology;
5. Evaluation and verification of created ontology.

Presented procedure requires further works verifying its usefulness in creating ontology of economical ratios.

The conceptualization of ROI indicator

One of stages of creating ontology of ROI indicator is conceptualization stage. This stage adopts occurring of enumeration of important terms in the ontology, defining the classes and the class hierarchy, modeling of associations and indicating occurrence. It is not only important, but also difficult stage for constructing topic map application for ontology of ROI indicator.

During creating ontology of ROI approach middle-out was used1. Firstly, most detailed terms, and then general terms were identified. At the end by repeated iteration terms acting as subclasses were assigned. Among identified terms following classes were set apart: total assets, fixed assets, current assets, general costs, total income and indicators. In order to create hierarchic relationships between terms it is necessary to analyze them to identify associations between them. In created ontology the following taxonomic relations were identified2:
- Subclass-Of for class: Indicators,
- Partition for classes: Total assets, fixed assets, current assets, general costs and total income.

Next stage of creating ontology is identification of semantic associations. Thirteen different types of associations are identified. Six of them are feedback relations. In the end occurrences of terms are defined. Individual results of conceptualization stages of ontology of ROI were consulted with financial expert. Furthermore, after finishing whole process of conceptualization created ontology was submitted to evaluation to independent financial expert. The evaluation was to take a stance on correctness of identification of topics in analysis of ROI indicator by Du Pont model (system of financial control), semantic associations and occurrence. Suggestions of the expert concerning associations were considered in created ontology of ROI.

Verification of topic map for ontology of ROI indicator

Reasons of modification of associations

To carry out researches concerning verification of the standard of topic map as method of presenting semantic associations between different economical ratios use of two programs (TM4L and Protégé) was planned. After entering ontology of ROI indicator in program TM4L it turned out that visualization of ontology of ROI defined this way can be unintelligible for users and even make it harder to understand existing connections between indicators.

It was noticed, that the problem is connected with overlapping of different associations between the same topics. Identified associations were once again analyzed, which were then classified into three groups. The first group consists of four relations (e.g. sum of

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1 Conceptualization stage of ontology of ROI indicator is wider described by Dudycz (2010).
2 In literature following four possible to occur taxonomic relations are described: subclass-of, disjoint-decomposition, exhaustive-decomposition and partition (e.g. Gomez-Perez et al., 2004).
3 For designed ontology class Indicator includes those terms, which value can be taken neither from profit and loss account or balance.
rates) that can be identified when examining relations between terms, conducting analysis in Du Pont model using top-down pyramid that is starting with ROI indicator. The second group consists of six relations (e.g. element of sum of rates) that can be identified by conducting analysis in Du Pont model using bottom-up approach. Associations from this group are feedback relations of connections listed in the first group. Relations belonging to these groups show existing arithmetic relations between topics. They illustrate the way of counting given indicator. The third group consists of three relations (e.g. potential growth), that are not pointed in graphic Du Pont model. These are relations showing logical associations between topics. Identification of these relations resulted from opinions of experts, both during creating conceptualization of ontology of ROI and after finishing it.

Looking for reasons having influence on obtained value of ROI indicator the analysis of relations top-down is essential. But analysis of indicators in Du Pont model is rarely being carried out beginning from indicators at the bottom of this pyramid. During creating topic map program for ontology of ROI indicator it was assumed that detail of created ontology should match the purposes of its use and be more intuitive for user. According to this assumption modification of associations between topics was carried out.

**Modification of associations**

Analysis of identified connections in created ontology, considering needs of users, showed that relations within the first group can be left, changing some of them from binary to n-ary relations. Following relations were defined:

1. Sum of rates - binary relation containing two roles: sum and element;
2. Difference of rates - ternary relation containing three roles: difference, minuend and subtrahend;
3. Product of rates - binary relation containing two roles: product and factor;

Three relations belonging to the third group remained unchanged. These are:

1. Potential growth, i.e. growth of value of first rate should be accompanied by increasing values of second rate;
2. Proportional growth, i.e. growth of value of first rate should be accompanied by proportional increasing value of second rate;
3. Proportional positive/negative change, i.e. growth or decrease of value of first rate causes proportional respectively increase or decrease of second rate.

Modified ontology of ROI indicator was entered in program TM4L.

**Testing two programs of ontology ROI**

Initial researches of two applications for ontology of ROI created in program TM4L were carried out again. These studies concerned verification of usefulness of topic map in understanding existing connections between indicators. Assuming intuitiveness of program and clarity of visualization as criterion we will analyze differences between these two applications running it in TM4L Editor and M4L Viewer.

We will show benefits obtained from modification of associations in created ontology of ROI on example of analysis of indicator Total asset turnover. On Figure 1 and Figure 2 visualization of ontology of ROI in TM4L Editor is shown with extended number of associations, and on Figure 3 after modification of associations. Effect of visualization these two applications (where criterion is number of topic and associations) is similar. Problem for user appears, when he starts analyzing connections, pointing the cursor at edges e.g. between Total asset turnover and Total assets. In case of first application two
relations are interchangeably shown: either one (Figure 1) or the other (Figure 2). Both relations send the same information to the user: indicator Total assets is divisor of quotient which is Total asset turnover. After modification of associations identical information is displayed only as one relation (Figure 3).

We will analyze Total asset turnover by running these two applications in TM4L Viewer. On Figure 4 visualization of Total asset turnover is presented with extended number of associations, and on Figure 5 after modification of associations. There the same conclusion as by analyzing fragment of Du Pont model in TM4L Editor, that is on Figure 4 there is too much lines duplicating the same information. Additionally visualization of algorithm counting indicator Total asset turnover was found less clear. There were no such remarks in case of the second application (Figure 5).

In both applications clicking the topic Indicator resulted in getting the same visualizations (Figure 6 and Figure 7). It is the consequence that was not defined in conceptualization of ontology of ROI between topic Indicator and displayed ratios feedback relation.

Carrying the analysis further and clicking indicator Return on investment results in appearing two screens (Figure 8 and Figure 9) where the same problem appears as earlier: too much excess of information (i.e. associations) towards needs of users caused that the first application was not found user-friendly.

Aim of this stage of research was to create program for ontology of ROI in order to receive application with clear visualization of economical ratios analyzed in Du Pont model. Program with modified associations will be tested by users basing on information financial system.

**Conclusion and future work**

In this article emphasis was put on presenting conception of using topic map for ontology of return on investment indicator. Procedure of creating ontology of economical ratios was proposed. Conceptualization stage of ontology of ROI indicator was briefly described. Reasons of modification to created ontology of ROI were presented. Modified connections between topics were described. Research on two applications of topic map for ontology of ROI indicator was carried out. Initial study showed that during creating ontology for economical ratios significance of existing associations between indicators should be very thoroughly examined. It concerns especially identification of feedback relations.

Studies will be continued in order to verify ontology of ROI in formal and substantive respect testing created applications in TM4L and Protégé. Future works will involve studying for using topic map for notation ontology of economical ratios will be continued in order to verify usefulness of such application allowing visualizing semantic associations for particular area of economic analysis and use of topic map as a tool of visual exploration of data.

**References**


Appendix

FIGURE 1. VISUALIZATION OF ONTOLOGY OF ROI WITH EXTENDED NUMBER OF ASSOCIATIONS
(RELATION: DIVISOR OF QUOTIENT OF RATES)

Source: Own presentation based on TM4L Editor.
FIGURE 2. VISUALIZATION OF ONTOLOGY OF ROI WITH EXTENDED NUMBER OF ASSOCIATIONS (RELATION: QUOTIENT OF RATES)

Source: Own presentation based on TM4L Editor.
FIGURE 3. VISUALIZATION OF ONTOLOGY OF ROI AFTER MODIFICATION OF ASSOCIATIONS (RELATION: QUOTIENT OF RATES)

Source: Own presentation based on TM4L Editor.

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**FIGURE 4. VISUALIZATION OF TOTAL ASSET TURNOVER IS PRESENTED WITH EXTENDED NUMBER OF ASSOCIATIONS**

Source: Own presentation based on TM4L Viewer.

**FIGURE 5. VISUALIZATION OF TOTAL ASSET TURNOVER AFTER MODIFICATION OF ASSOCIATIONS**

Source: Own presentation based on TM4L Viewer.
**Figure 6. Visualization of indicator is presented with extended number of associations**

![Image of visualization with extended associations](image1)

Source: Own presentation based on TM4L Viewer.

**Figure 7. Visualization of indicator is presented after modification of associations**

![Image of visualization with modified associations](image2)

Source: Own presentation based on TM4L Viewer.
FIGURE 8. VISUALIZATION OF RETURN ON INVESTMENT IS PRESENTED WITH EXTENDED NUMBER OF ASSOCIATIONS

Source: own presentation based on TM4L Viewer.

FIGURE 9. VISUALIZATION OF RETURN ON INVESTMENT AFTER MODIFICATION OF ASSOCIATIONS

Source: own presentation based on TM4L Viewer.