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Design of Financial Knowledge in Dashboard for SME Managers

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Abstract — The article presents the approach to develop the economic and financial knowledge used for the Intelligent Dashboard for Managers. The content of the knowledge is focused on essential concepts related to the management of micro, small and medium enterprises. Knowledge-based functions, not previously available in commercial systems, increase the quality, effectiveness, and efficiency of the decision making process. The Intelligent Dashboard for Managers contains six ontologies describing areas of Cash Flow at Risk, Comprehensive Risk Measurement, Early Warning Models, Credit Scoring, Financial Market, and General Financial Knowledge. The ontology design process and examples of topic maps and usage in financial data analysis are illustrated and discussed.

I. Introduction

Decision makers of small and medium enterprises (SMEs) using Business Intelligence systems frequently need appropriate knowledge about the economic situation of the enterprise and its environment. Knowledge about key dependences between various financial ratios is essential, because they can indicate important trends and alert one to anomalies and dangers [23, p. 85]. Decision makers in SMEs, in comparison to managers of big companies, may have no access to much essential strategic information. Usually, financial expertise is either not available or too expensive. For financial and personnel reasons most SMEs cannot afford these types of facilities. Furthermore, SMEs operate in a definitely more uncertain and risky environment than big enterprises, because of a complex and dynamic market that has much more important impact on SMEs' financial situation than on big companies'. Tolerance of mistakes is narrower (see among others [12, p. 74-91]). In these conditions, SME's decision makers often act intuitively and as a result, the rationality of their decisions is decidedly smaller. Moreover, the statistics show that SME's decision makers often don't have a solid knowledge of economics and finance.

In general, most existing Business Intelligence (BI) and Executive Information Systems (EIS) provide the functionality of data aggregation and visualization. Many reports and papers in this domain underline that decision makers expect new ICT solutions to interactively provide not only relevant and up-to-date information on the financial situation of their companies, but also explanations taking into account the contextual relationships.

The aim of this article is to present the approach to developing the economic and financial knowledge used in the Intelligent Dashboard for Managers (called further InKoM). The InKoM system has been developed by a consortium consisting of the Wroclaw University of Economics (WUE), which is the leader, and a company UNIT4 TETA BI Center Ltd. (TETA BIC). Credit Agricole Bank Polska S.A. also participates in the project.

Figure 1 presents the main components of the InKoM: a comprehensive description of the TETA BI system with examples of its application is available on the website: [28] (see also [3], [31]). It can be seen that the InKoM uses TETA BI mechanisms for extracting source data from transactional systems (ETL), its data warehouse, and analytical database. However, the available solutions – in particular the standard analyses, reports and analytical statements generated by the system – are complemented by economic and financial knowledge – most importantly ontologies and topic maps – and financial data mining algorithms, including mechanisms for extracting business knowledge from the deep Web. This enables a dynamic, on-line, interactive analysis of key business indicators.

The transactional data obtained from external sources, supplemented with planning data, e.g., budgets, form multidimensional data structures, or cubes, which are stored in a TETA BI Analysis Services database and provide a basis for the on-line, interactive creation of standard analytical queries and/or reports. The InKoM system complements and extends these processes[1]. By providing

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[1] The InKoM architecture and functionalities have been presented in [18]; [19].

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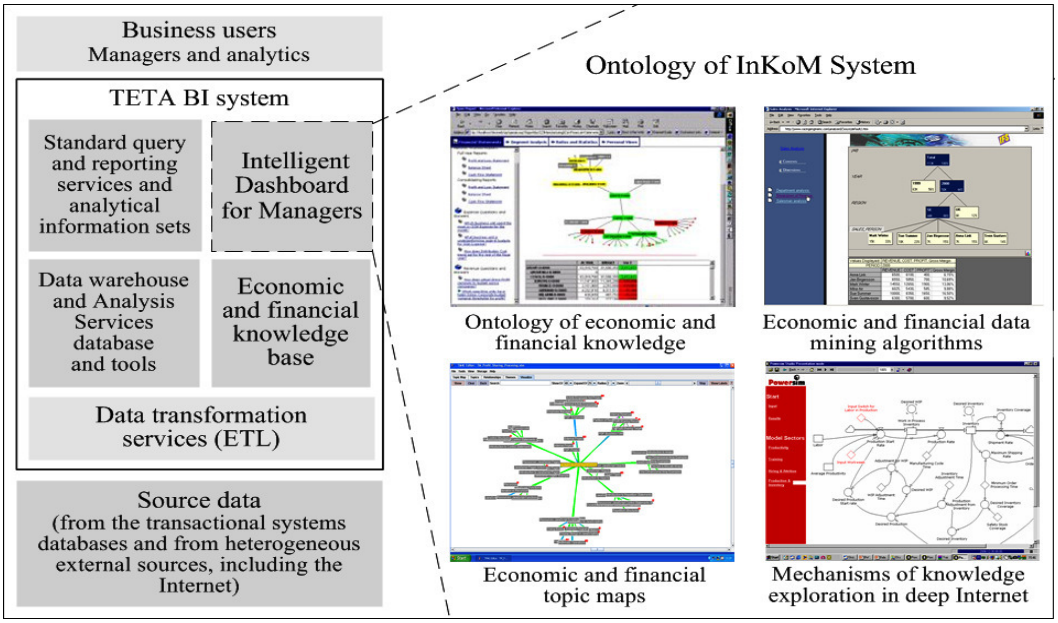

Fig. 1. Components of the Intelligent Dashboard for Managers and their location in the TETA BI system

economic and financial knowledge stored in ontologies and presented in the form of topic maps to facilitate the perception of concepts, InKoM can make the analysis more comprehensive and simpler. This is particularly important for users who are not specialists in the analysis and interpretation of economics and finance.

Over a dozen methods of building ontologies have been developed. Among methods listed in literature, the following are worth noting (more widely characterized inter alia in [13]; [22]): METHAONTOLOGIA (based on the standard IEEE 1074-1995), the method of Noy and McGuinness, On-To-Knowledge, SENSUS, TOVE (TOronto Virtual Enterprise), UPON (Unified Process for ONtology building) and the method of Ushold and King. Noy and McGuinness emphasized that the best model of ontology is the one that best cooperates with existing information system, accomplishes a set of goals, is intuitive and easy to maintain [Noy, McGuinness 2005]. So far there is no single standard of design because creating an ontology is dependent on its application and the needs of specific users (see [22]). However during last years the standardization activities in terms of information have been undertaken at European level; an example is the SMEST project (see http://www.cencenelec.eu/sme/SMEST/).

The structure of the paper is the following: In the next section the ontological approach to knowledge design is described. The third section presents the ontology structure. The fourth section characterizes the ontology design process in the InKoM. To illustrate the use of the InKoM, a case study of ontology for credit scoring is described. The last section summarizes the work already carried out and points out the further research and development tasks.

II. Ontological Approach to Knowledge Design

The main goal of any BI system is to access the right data at the right time to allow proactive decision-making (see among others [9], [26], [30]). The users of BI systems expect access to useful information through an interface easy to understand and use. However, existing BI solutions are designed primarily for users who are able to understand the business data models (see [25]). BI systems provide simple, personal analytical tools which support the exploration of data sources, retrieval of information based on predefined economic and financial relations, and do not require a priori knowledge about data structures and methods of data accessing (see among others [21], [25], [26]).

Today the development of new BI systems is oriented towards BI 2.0 (using semantic search) and 3.0, Service Oriented Architecture (SOA) and Software as a Service (SaaS) (see [21], [25], [26]). The typical features of the systems include: proactive alerts and notifications, event driven (real time) access to information, advanced and predictive analytics, mobile and ubiquitous access, improved visualization, and semantic search information (see also [21]).

One of the main part of modern BI systems is the ontology (see [21]). Ontology in information technology means „an explicit specification of a conceptualization“ [15, p. 907]. In general, the ontology is used to create the necessary knowledge models for defining functionalities in analytical tools. In the development of InKoM, many new features are integrated, such as domain ontology covering key concepts of corporate finance and economics, knowledge discovery algorithms, semantic search

mechanisms, explanation facilities, and tools for visual navigation in domain knowledge.

In the InKoM project, six ontologies were built. Choosing scopes of created ontologies was a difficult task, because of domain complexity and the necessity to develop numerous links between the theory of finance and the contents of BI system databases. The task needed cooperation in pragmatic way with experts on the analysis of finance, economics and business informatics. Experience of our industrial partner, UNIT 4 TETA BI Center, gained from implementing the TETA BI system in enterprises, was also essential in choosing these areas. The result of this work is six ontologies covering economic and financial areas: Cash Flow at Risk, Comprehensive Risk Measurement, Early Warning Models, Credit Scoring, the Financial Market, and General Financial Knowledge. The ontologies will be detailed in the next section.

Integration of these ontologies into the BI systems assures:

- support for the definition of business rules in order to get proactive information and advice in decision-making;
- a semantic layer describing relationships between the concepts and indicators;
- relevant information according to the different kinds of users that can be found in an organization;
- effective usage of existing data sources and data warehouse structure.

The knowledge representation layer is the most critical aspect of a BI system, since it broadly shapes the core understanding of the information displayed on their screen [30]. In InKoM design, the basic assumption of navigation was that managers should be able to view focus and context areas at the same time to present the relevant knowledge structure [27].

Visual exploration in InKoM is based on a standard Topic Map (TM – ISO/IEC 13250:2003). TM enables the representation of complex structures of knowledge bases [4] and the delivery of a useful model of knowledge representation (see [20, p. 174]), where multiple contextual indexing can be used. TM is a relatively new form of the presentation of knowledge, which puts emphasis on data semantics and the ease of finding desired information (see also [1]; [24, p. 30]). The application of topic maps permitted us to separate the data of the enterprise's information system from operational business activities (see among others [17]). Developed topic maps for analysis of economic indicators (see among others [7], [8], [17]) have demonstrated that the system [6]:

- can be easily used for the representation of economic knowledge about economic and financial measures,
- can express the organizational structure,
- can be adapted to new applications and managers' needs,
- can be supportive of the managerial staff by facilitating access to a wide range of relevant data resources,
- can assure a semantic information search and interpretation for non-technically-minded users,
- can visualize different connections between indicators that make possible the discovery of new relations between economic ratios constituting knowledge still unknown in this area,
- can improve the process of data analysis and reporting by facilitating the obtaining of data from different databases in an enterprise, and finally
- can be easily extended by users who are not IT specialists, e.g. by experts in economic analysis (using tools for creating a topic map application).

The preliminary evaluation of ontologies is very encouraging The knowledge of corporate finance is very useful in the interpretation and explanation of data presented in financial reports of BI systems.

III. Ontology Structure

The essential element of the InKoM systems' knowledge is a part containing topic maps for six created ontologies for selected areas called: Cash Flow at Risk, Comprehensive Risk Measurement, Early Warning Models, Credit Scoring, Financial Market, and General Financial Knowledge.

CFaR is considered to be one of the best adjusted ratios for the needs of complex risk measurement in enterprises. According to the newest trends in enterprise management and on companies' economic practice, it was determined that the appropriate ratio for complex risk management in enterprises is Cash Flow at Risk (CFaR) using the RiskMetrics Group rules. The choice of Cash Flow at Risk meets managers' needs in the scope of creating single risk ratio illustrating risk level connected with an enterprise's operating activity. Of course, the prerequisite for the manager being able to use this information is the appropriate knowledge level on CFaR ratio.

The ontology of Comprehensive Risk Measurement involves various variants of the model used to estimate the Cash Flow at Risk ratio. The developed ontology concerns the way of understanding and defining inter alia: risk variables, risk models, risk management process.

The ontology of the Early Warning System contains models of cautionary forecasting in supporting a manager's decision. The developed concept uses a group of tools for early warning model creation, in which mainly data from financial reports are used. By using this data, an objective view of company's situation can be quickly and easily obtained, which is essential in managers' efficient and accurate decision making.

The ontology of Credit Scoring describes the model of the credit procedure carried out by a bank. Credit scoring evaluation is an integral part of bank credit procedures (credit processes) and it is an essential stage in conditioning the granting of credit. It is realized by a bank's

organizational units and supporting infrastructural-system solutions, and the company trying to get credit (potential borrower) is the subject of analysis (quantitative and qualitative). The internal logic and details of credit procedures in a specific bank is its unique know-how and is not usually made public.

In literature many approaches to credit scoring can be found, such as stochastic models (e.g. Bayesian models, regression, Markov chain), artificial intelligence techniques (e.g. expert systems, neural network models, genetic algorithms), data mining methods [5]; [10]; [11]; [16]; [32]. The approach implemented in the InKoM system is based on the rules of thumb generally accepted in the practice of financial institutions. Of course there are still open questions which might be considered: which methodology to choose? what models might work? should one look at the profit on each product in isolation or the total profit over all possible products? In general there is no overall best method of credit scoring. The InKoM system is open to include more advanced models and rules, specific to the particular type of company or financial institution.

The Financial Market ontology involves information about the financial market and financial instruments. Knowledge on this topic is an essential element capable of aid manager in making investment decisions and securing from market risk. Financial market may be used by managers to regulate liquidity by using money market instruments.

The ontology of General Financial Knowledge concerns essential economic-financial knowledge which is required to analyze issues of listed ontologies. This ontology includes a set of supplementary topics to other ontologies and will be used in calculating the value of Cash Flow at Risk (the ontology of Cash Flow at Risk), basic economic ratios (the ontology of Early Warning System) and indicators used by banks in the process of credit scoring (the ontology of Credit Scoring).

To sum up, the domain knowledge about relations between economic and financial ratios will make the analysis and interpretation of contextual connections easier. This is very important in the case of SMEs, where a company does not employ experts in economic-financial analysis and using outer consulting is too costly. Reproducing knowledge with the use of a topic map contributes inter alia to better understanding of economic concepts and the interpretation of specific economic and financial indicators.

To navigate in the financial knowledge of InKoM, a semantic search will be applied to avoid difficulties related to decision makers' interpretation of economic and financial information. This gives the opportunity to search data sources taking into account not only structural dependences, but also semantic context.

IV. Ontology Design Process

In the design of the InKoM system five basic stages of creating the ontology were defined. These are:

1. Definition of the goals, scope and constraints of the created ontology. While creating an ontology, assumptions about the created model of knowledge that will apply during its building have to be provided. That requires an answer to the question: what will the created ontology be used for?
2. Conceptualization of the ontology. This is the most important stage in the procedure of ontology development[2]. It includes the identification of all notions, definition of classes and their hierarchic structures (Superclass – Subclass), modeling relations, identification of instances, specification of axioms, and rules of inference.
3. Verification of the ontology's correctness by experts. In this stage the constructed ontology is verified by experts who did not participate in the process of creating it.
4. Coding the ontology in the format compatible with the topic map standard. During this stage the developed ontology is described in the formal language or chosen software. The result of this stage should be the encoded ontology[3].
5. Validation and evaluation of the built ontology. It is the stage during which evaluation of the created ontology meets the needs of the managers.

The important stage in the described procedure of creating an ontology is the conceptualization of the ontology. The process of conceptualization of an ontology is an intellectual activity organizing knowledge from a given field carried out by the person, either an expert or collaborating with an expert, responsible for creating the model of knowledge without the support of automated tools (see inter alia [2, p. 2036]). In this scope, there are few concepts of identification of topics and relations between them within the process of conceptualization. These are the following approaches to carrying out analysis: top-down, bottom-up and middle-out. We used middle-out, because it enables us best to maintain the level of detail control of the created ontology and reduce imprecisions, which translates into reducing iterative work (see [29, p. 21]; see also [2, p. 2036]). Based on literature studies (inter alia [13], [22]), as well as research carried out, the following procedure in conceptualization of the ontology of economic knowledge was used:

1. Identification and definition of all topics.

[2] Independently of the field that is to be modeled by using an ontological approach, it is the most important stage in creating a model based on ontology (see inter alia [2, p. 2036]).

[3] In the InKoM project at first, in order to quickly test developed ontology, it was entered in the program Ontopia. Ultimately it will be realized with the use of software for topic maps developed by the company UNIT 4 TETA BI Center.

A topic, representing any concept, is "a syntactic construct that corresponds to the expression of a real-world in a computer system" [14, p. 60]. In the InKoM project, a topics' list was determined by experts creating ontologies for the given field of economic knowledge. These topics include, beside their names, also their synonyms and descriptions (table 1). The example below illustrates a description of topics related to the case study: Credit Scoring that will be detailed in Section VI.

TABLE 1.
THE EXAMPLE OF TOPICS' LIST

Name	Synonym	Description
Return on Assets	ROA	ROA indicator is a synthetic measure that determines company's assets capability to create profit. It shows the percentage net profit per unit of capital invested in the company.

2. Creating a taxonomy of topics.
Specification of taxonomic relations between distinguished topics and defining classes and subclasses (table 2). This relationship describes the topics generalization. This approach to creating a taxonomy is proposed in METHAONTOLOGIA (see i.e. [13]).

TABLE 2.
THE EXAMPLE OF TOPICS' TAXONOMY

Superclass	Subclass
Indicators	– Debt indicators – Liquidity indicators – Profitability evaluation indicators – Efficiency assessment indicators
Profitability evaluation indicators	– Net Return of Sale – Return on Assets – Return on Equity

3. Definition of all other types of relations between topics.
In the InKoM project, the basic relationship aggregate of (Aggregate – Member) occurring in all six created ontologies was defined. Moreover within each ontology, additional relations were defined, for example: engagement (Engaging – Accession).
4. The list of all the individual relationships existing in the ontology.
The list includes: the name of the relationship, source topic, and target topic (table 3).

TABLE 3.
THE EXAMPLE OF DESCRIPTION OF THE RELATIONSHIPS

Name of relationship	Source topic	Target topic
Engagement	Profitability evaluation	Net Return on Sale
Engagement	Profitability evaluation	Return on Assets
Engagement	Profitability evaluation	Return on Equity

5. Description of functions and rules.
The following function description, specifies the example of the indicator Return on Assets (ROA), implemented in the InKoM system:

Name:
Indicator Return onAssets (ROA)
Input:
- Result of Net profit (NP)
  type: number, value with balance sheet
- Total Assets (TA)
  type: number, value with balance sheet

Output:
- Return on Assets

Initial conditions:
- available data from balance sheet

Final conditions:
- Message 1: *"Value of indicator ROA"*
- If ROA<5%,
  Then to Message *2: "*Low value of ROA*";*
- If 5% < ROA < 10%,
  Then to Message 3: *"*Average value of ROA*";*
- If ROA > 10%,
  Then to Message 4*: "*High value of ROA*";*

Description/formula:
ROA = NP/ TA

6. Description of usage scenarios.
Usage scenarios, also called use case view, describe demonstration analyses of economic topics occurring in this ontology. For example, if a manager is interested in the opportunity of applying for a bank loan:

1. The manager analyzes the semantic network, from which it follows that the credit score assessment is based on the analysis of indicators belonging to four groups: debt indicators, liquidity indicators, profitability evaluation, and efficiency assessment.
2. From the TETA BI system the manager receives the values of financial indicators that make up the credit score assessment. According to them, the company has bad parameters concerning the profitability evaluation, especially the value of ROA indicator.
3. The manager analyzes the semantic network connected to the data from the TETA BI system on account of semantic connections of the ROA indicator with other indicators. The aim of the action undertaken by the manager is to identify causes of unfavorable values from the ROA indicator.
4. Basing on conclusions from the analysis conducted of economic indicators, the manager can undertake corrective actions which may potentially result in improving the company's condition. Improvement of company's parameter essentials in the score assessment can allow actions to be undertaken concerned with receiving bank loan.

That work has required multi-domain expert knowledge, both theoretical and practical, in economics, finance, and informatics.

In InKoM, a semantic search is provided to avoid difficulties related to decision makers' interpretation of

economic and financial information. This gives the opportunity to search data sources taking into account not only structural dependences, but also the semantic context.

V. CASE STUDY – ONTOLOGY FOR CREDIT SCORING

The case study presented illustrates only a fragment of analysis of the company's financial situation with the use of the ontology of the credit scoring and the databases of TETA Business Intelligence system. Let us assume that the manager is interested in the ROA indicator. The ontology shows that the quantitative financial analysis consists of indicators: debt indicators, liquidity indicators, profitability evaluation indicators, and efficiency assessment indicators (Figure 2). On the Figure 2, solid lines denote taxonomic relations (relation Superclass – Subclasses), whereas broken lines denote all other types of relations between topics.

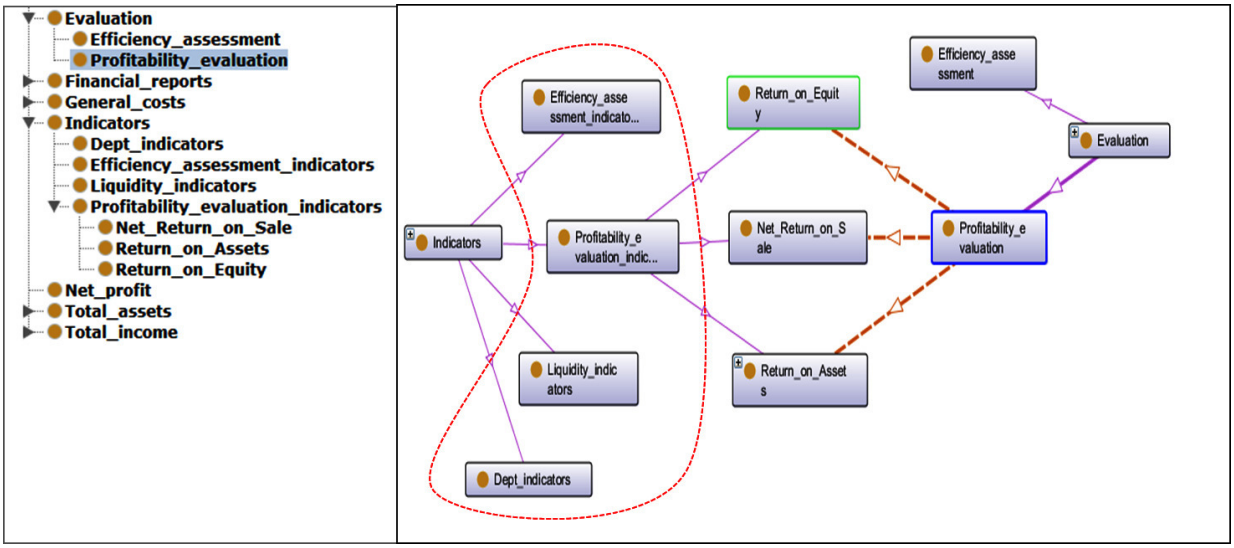

Figure 2. Example of topic map including the quantitative financial indicators

Returning to the ROA, it is known that the more effectively a company manages its assets, the higher the value of this indicator. It is assumed that its value should be greater than 5%. The ROA indicator is calculated on data from the balance report, that is Net profit (NP) and Total Assets (TA) (Figure 3):

$$ROA = NP / TA$$

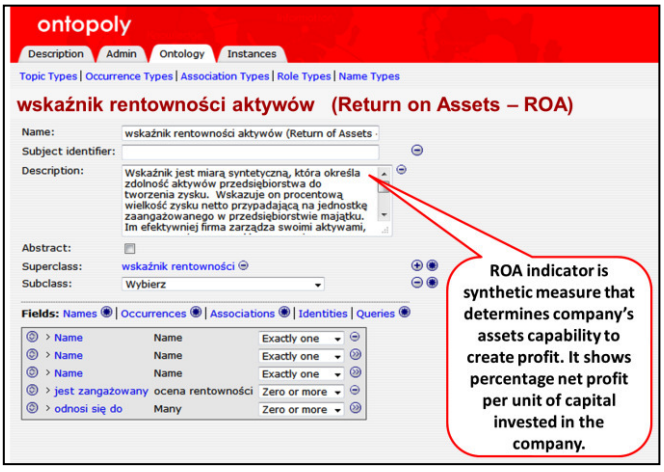

Figure 3. Topic definition – ROA

in year 2011 is equal to 12 908,00, and in the year 2012 equals 14 169,00, whereas the value of Total Assets in the year 2011 equals 184 400,00 and in the year 2012 354 000,00. Based on this data, the ROA indicator in 2011

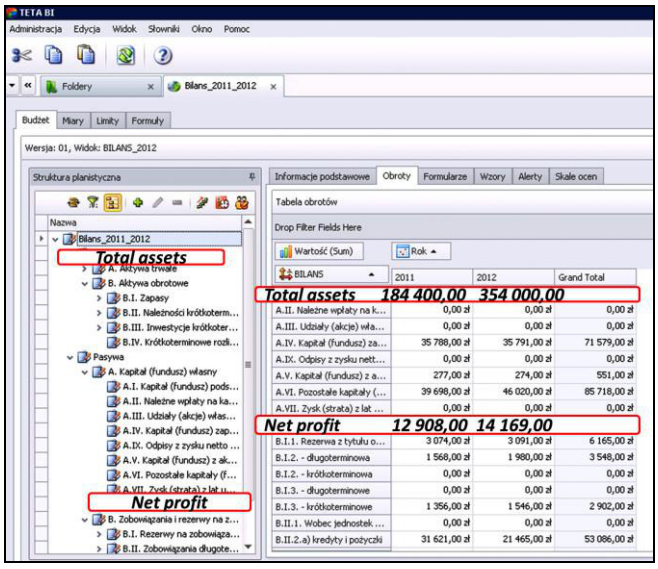

Figure 4. Example of balance sheet extracted from the TETA BI system

On figure 4 is presented an example of a balance report for the years 2011 and 2012 extracted from the TETA BI system. For the analyzed company, the value of Net Profit is equal to 7%, and in 2012 is equal to 4%. This means that the company's condition in 2012 is bad. In order to improve this situation, the manager needs to identify the cause of

these values. Therefore, following the topic map, the manager notes that the value of Net Profit in 2012 was higher than in 2011, so the disadvantageous ROA indicator results from value of Total Assets. To identify the sources of the ensuing situation, the manager has to examine the semantic relations between Total Assets and other financial topics. Exemplary decomposition of the chosen topic is presented on the Figure 5. The screenshot shows the expansion of the selected topic: Total Assets. On the diagram it is the area encircled by a dashed line, with new topics being a subclass of topic Total Assets.

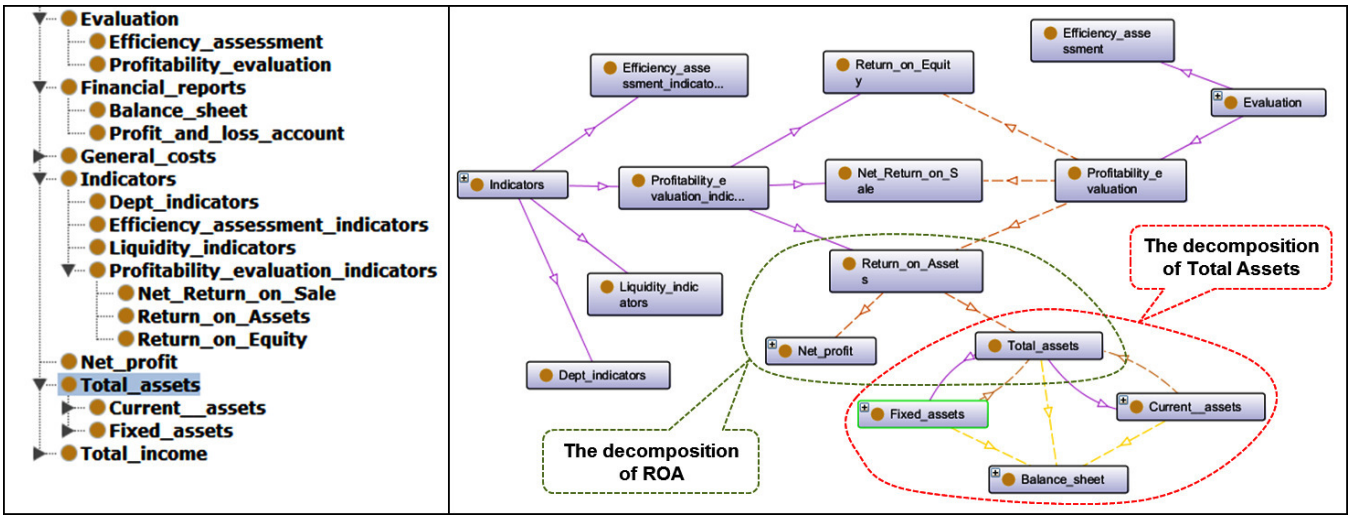

Figure 5. Example of topic map including Total Assets

In the InKoM system the manager can use the topic map application which allows relations between analyzed topics to be shown. This approach can be very useful for managers, because it is difficult a priori to identify causes that show by using only the balance sheet or other financial reports.

To interpret financial reports correctly, many measures and ratios need to be examined that either directly or indirectly influence the final result. Visualizing the relationships explicitly not only it makes the interpretation of indicators easier, but also contributes to finding out explanations of the current values of indicators. The topic map provides a user-friendly interface which allows managers to navigate easily from topic to topic in an interactive manner. Therefore various types of associations are visualized in different ways. For example, the lines which have the same relation have the same color. This enables an easy overview of concepts, visualisations and navigation of hierarchical structures, whilst also providing short definitions on each topic. The visualization is highly interactive: interesting nodes can be put in the foreground with zooms, translations, and rotations. Managers can delete non relevant branches of the graph or expand interesting ones.

VI. Summary And Future Work

In this paper, the approach to developing the ontology of InKoM was presented. The created ontologies are currently integrated in the TETA BI system and will be soon available in beta version. In the next step of the project, the effectiveness of the final system will be examined and assessed by SME managers. Further studies will be conducted on, among others, representation and interpretation of financial indicators, such as NPV and IRR, and methods specific to IT investment, such as TCO.

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