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INTELLIGENT DECISION SUPPORT FOR SME MANAGERS – PROJECT INKOM[1]

Abstract: The article presents the architecture and functionality of the Intelligent Dashboard for SME Managers (called InKoM). InKoM can be considered as an advanced Decision Support System integrated with Business Intelligence functions. In the article, the architecture of the system based on TETA BI solutions and functionalities is described. The innovativeness of the InKoM system involves particularly the wide use of representation methods of economic and financial knowledge, techniques and tools for visual data mining, and deep Internet retrieval methods. The system will offer managers, especially from small and medium enterprises, powerful analytical and reasoning functionalities increasing the quality and effectiveness of decision-making processes.

Keywords: dashboard for SME managers, BI systems, representation and usage of financial knowledge, semantic data mining.

1. Introduction

The current economic situation forces the decision-makers of small and medium enterprises (SMEs) to have at their disposal current and appropriate knowledge about the economic situation of the enterprise and its environment. Because of that, decision-makers must have the efficient methods and tools to identify and analyze key performance indicators that have an impact on the operations of the enterprise. Analyzing information in the traditional way becomes very difficult, sometimes even impossible. However, discovering all dependences between various financial ratios is necessary, because they can indicate important trends, and alert one to anomalies and dangers [Olszak 2011, p. 85]. Decision-makers in these enterprises, in comparison to managers of big companies, may not have access to all essential strategic information. Usually financial expertise is either not available or too expensive. Big companies

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have at their disposal strategic consultation and possess standard procedures to solve problems in the case of essential changes in the business environment. For financial and personnel reasons most SMEs cannot afford these types of facilities. It should be noted that SMEs operate in a definitely more uncertain and risky environment than big enterprises, because of a complex and dynamic market that has a much more important impact on SMEs' financial situation than on big companies'. Tolerance of mistakes is narrower (see among others [Gibcus, Vermeulen, Jong 2009, pp. 74–91]). In these circumstances, SMEs' decision-makers often act intuitively and as a result, the rationality of their decisions is significantly weaker. Moreover, SMEs' decision-makers often do not have a solid knowledge of economics and finance.

The currently existing Business Intelligence (BI) and Executive Information Systems (EIS) provide the functionality of data exploration from various databases and data warehouses. However, the usage of data exploration is much reduced to simple data mining algorithms and data aggregation. In order to interpret correctly economic ratios, not only their values are needed, but also knowledge of various relations between them. Decision-makers expect from new ICT solutions that they would interactively provide not only needed and up-to-date information on the financial situation of their companies, but also explanations taking into account the contextual relationships.

The structure of the paper is the following. In the next section the state-of-the-art Business Intelligence systems are presented. The third section describes the architecture and main functions of InKoM. To illustrate the essential parts of InKoM, a few examples of financial ontology and data exploration ontology are described. The last section summarizes the work already carried out and points to further research and development tasks.

2. The state-of-the-art and related works

InKoM can be considered as an advanced Decision Support System integrated with Business Intelligence functions. Today, Business Intelligence seems to be a very common commercial buzz-word used in publications and economic practice. One can notice that there is a variety of definitions and interpretations of the term (see among others [Al-Eisawi, Lycett 2012; Dudycz 2010; Jagielska, Darke, Zagari 2003; Laudon, Laudon 2010; Olszak 2012; Sell et al. 2008; Serban et al. 2012; Vercelis 2009]). Generally, we can say that BI is defined as an integrated set of tools to support the transformation of data into information in order to support decision-making (see also [Sell et al. 2008]). From a technical point of view, the architecture of BI can include: data warehouse, data marts, basic analytical tools(query engine reporting tools, On-Line Analytical Processing tools, data visualization tools), advanced analytical tools (such as statistical tools, data mining) and business applications (tools which provide analysis of specific business functions related to manufacturing, sales, customer relations, financial monitoring, etc.), and corporate portals.

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 [Dudycz 2010; Sell et al. 2008; Wise 2008]). The users of BI systems expect access to more information, an interface easy to understand and use, and information presentation functionalities which should be intuitive and interactive and provide contextual and embedded knowledge [Morris 2009]. Specific attention in BI systems is given to the user interface which should allow the user, among others, to filter, sort and analyze data, formulate *ad hoc* or predefined queries and reports, generate alternative scenarios, and produce "drillable" charts and graphs. The recent literature places greater emphasis on the development of BI systems towards BI 2.0 (using semantic search, Service Oriented Architecture (SOA) and Software as a Service (SaaS)) (see [Nelson 2010; Raden 2007; Sell et al. 2008]). These systems usually possess the following features: proactive alerts and notifications, event-driven (real-time) instant access to information, advanced and predictive analytics, mobile and ubiquitous access, improved visualization, and semantic search information (see also [Nelson 2010]).

One of the main artifacts of InKoM is the ontology, in particular, domain ontologies and ontology of data exploration. An ontology in information technology means "an explicit specification of a conceptualization" [Gruber 1993, p. 907], organizing knowledge concerning a specific field noted in formalized structure. Ontologies are used to create the necessary knowledge models for defining functionalities in analytical tools. To visualize knowledge topic maps (TM) are used extensively. A topic map is a "model of knowledge representation, and its main purpose is to organize the information through semantic linkage in the data, concepts, and sources" [Pimentel, Suárez, Caparrini 2009, p. 30]. TM provides a useful model of knowledge representation and enables the methods to describe complex structures of knowledge bases [Arndt, Graubitz, Jacob 2008]. TM is a relatively new form of the presentation of knowledge, which puts an emphasis on data semantics and the ease of finding the desired information (see also [Ahmed, Moore 2006; Pimentel, Suárez, Caparrini 2009, p. 30]). In the design of InKoM, topic maps applications were created for six ontologies for the analysis of economic and financial indicators, and the ontology for semantic data exploration.

There are many advantages of applying semantic technology to the analytical tools, notably (see [Korczak, Dudycz 2009; Pinto, Santos 2009; Sell et al. 2008; Serban et al. 2012]):

- support for the definition of business rules in order to get proactive information and advice in decision-making;
- disposal of semantic layers describing relationships between the concepts and indicators;
- support to present information according to the different groups of users in an organization;
- easy modification of existing data source and data warehouse structure (usually, structure changes demand the work of analysts, system administrators and programmers).

In InKoM, the presentation layer is the most critical aspect of a BI system, since it broadly shapes the core understanding of the data [Wise 2008] and it enables intuitive ways of information retrieval. A good interface contains comprehensive representation (helps users identify interesting sources) and efficient navigation (allows users to access information quickly) [Hunting, Park 2002]. Visual exploration in InKoM is based on a standard Topic Map (TM – ISO/IEC13250:2003). The application of topic maps allows the separation of data of the enterprise information system from operational business activities (see among others [Korczak, Dudycz 2009]). Case studies using TM for analysis of economic indicators (see among others [Dudycz 2011a; Dudycz 2011b; Korczak, Dudycz 2009]) have shown that topic maps [Dudycz 2012] can be easily used for the representation of economic knowledge about economic and financial measures, and can be also supportive of the managerial staff by facilitating access to a wide range of relevant data resources. Additionally, TM can visualize different connections between indicators that make possible the discovery of new relations between economic ratios constituting knowledge still unknown in this area.

To sum up, the results of the analysis of information requirements showed that there is a need not only to provide solutions that make it possible to obtain knowledge from different, scattered sources, but also to analyze and present new knowledge in an interactive way.

3. Main functions of the Intelligent Dashboard for Managers

The InKoM system will be used as a dashboard dedicated to SME decision-makers working also on mobile devices. Therefore, a multimodal interface and, *inter alia*, various forms of information representation, human–computer interaction, and numerous alerts and task notifications will be elaborated on. The essential element of the InKoM system will be a module containing topic maps for six created ontologies for selected areas of the analysis of economic and financial ratios. For instance, they will concern: Earnings at Risk, Cash Flow at Risk, Early Warning System. In order to do that, ontologies for specific fields will be conceptualized. This requires interdisciplinary expert knowledge, both theoretical and applied, in economics and finance. 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 outside consulting is too costly. Reproducing knowledge with the use of a topic map contributes to, *inter alia*, a better understanding of economic concepts and interpretation of specific economic and financial indicators. In addition, in 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.

The InKoM system will provide decision-makers with not only methods of information exploration, but also ontology for knowledge extraction from databases [Charest, Delisle 2006; Pinto, Santos 2009]. Data exploration algorithms (such as classification trees, association rules methods, clustering) integrated with topic maps (i.e. semantic search and visual data exploration), will be developed. In general, data mining tools currently available on the market contain many knowledge extraction algorithms, but a lot of them are not applicable for SMEs. Moreover, some of them are too complex and their usage requires costly expert support.

The schema of the InKoM architecture and functionalities were presented in [Korczak, Dudycz, Dyczkowski 2012]. InKoM will be firmly coupled with the TETA Business Intelligent system ([*TETA Business Intelligence*], see also [*Architektura system*… 2011; *We change data*… 2011]).

It can be seen that InKoM uses TETA BI mechanisms for extracting data from transactional systems (ETL), its data warehouse and analytical database. However, the available solutions, in particular standard analyses, reports and analytical statements generated by the system, are complemented by economic and financial knowledge – most important ontologies and topic maps and data exploration ontology, including mechanisms for extracting business knowledge from the deep Web. This enables a dynamic, on-line, interactive analysis of key economic and financial indicators which is of special importance to SMEs' managers.

The flow diagram in Figure 1 illustrates the operation of the Intelligent Dashboard for Managers and its interoperability with TETA BI system. The InKoM components and the processes performed by the system are indicated by shading. The diagram shows that the process of inputting source data to TETA BI and the InKoM data warehouses and databases is implemented through TETA BI ETL tools. The ETL package can extract data from various transactional systems, such as ERP TETA Constellation system databases (a detailed description of ERP TETA Constellation system is available on the website: [*TETA Constellation*] (see also: [Dyczkowski, Korczak 2011, pp. 91–111]) or other UNIT4 TETA business applications, including Navireo and other products from InsERT, as well as other internal sources of economic data of a company.

The possibility of extracting data from systems other than ERP-type solutions is particularly important for SMEs, where they are used (including TETA UNIT4 products) much more frequently than more expensive and more complex integrated business information systems. Mechanisms for extracting knowledge from the deep Internet, which increase the available sources of economic and financial knowledge, complement the standard ETL process.

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.

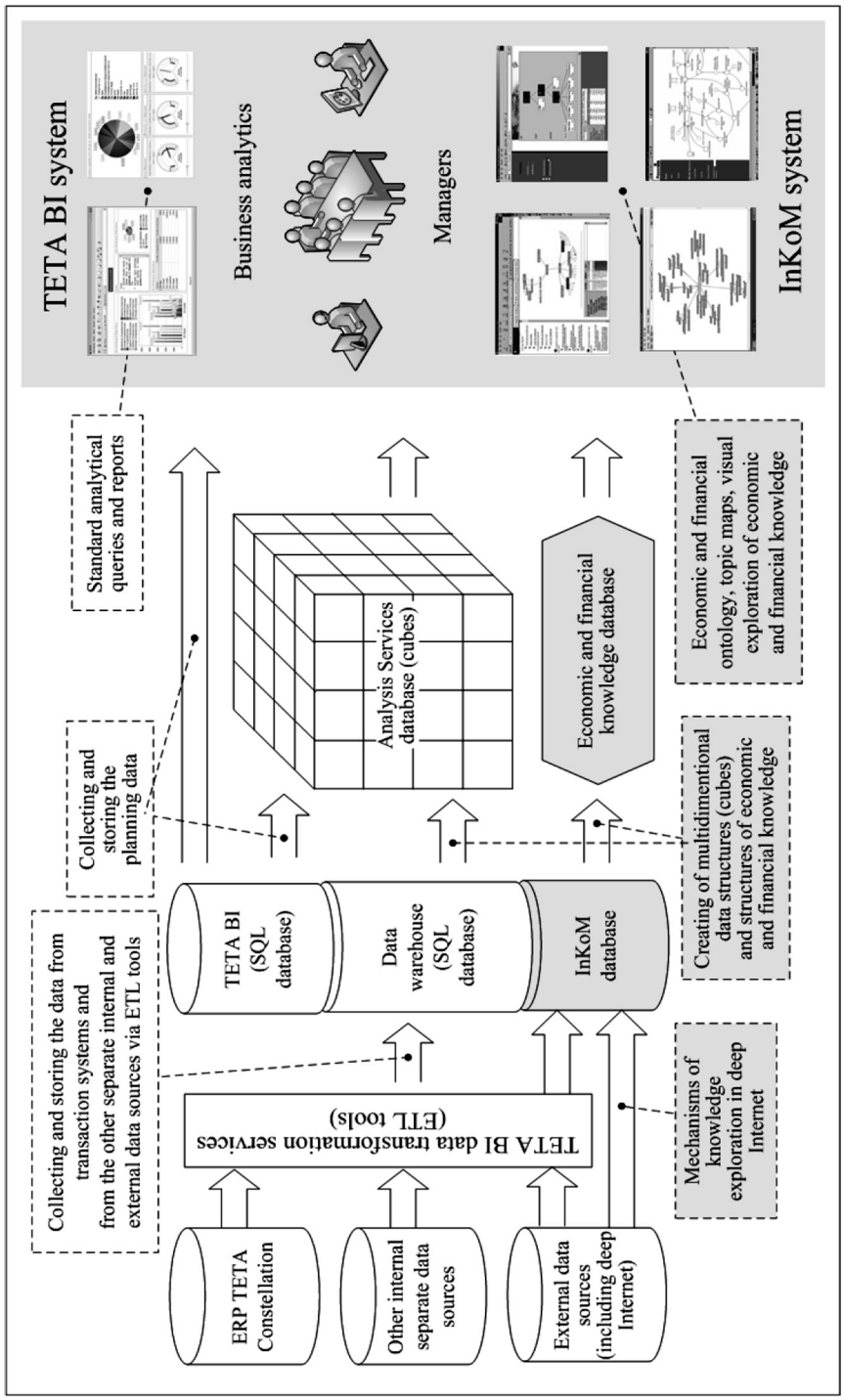

Figure 1. Flow diagram illustrating the operation of the Intelligent Dashboard for Managers and its interoperability with the TETA BI system

Source: own elaboration.

The key task of InKoM is to develop topic maps for the ontologies of economic and financial indicators. In the process of conceptualization, ontology experts from this field will attend, not only to agree on vocabulary and semantic structure, but also to represent their tacit knowledge, which is their experience [Sanin, Szczerbicki, Toro 2007]. In project InKoM experts will build the ontology for selected field of analysis of indicators such as: (1) early warning system, (2) market risks analysis (currency risk, interest rate risk, risk of price volatility), (3) estimation of Cash Flow at Risk, (4) credit rating, (5) financial markets and (6) global view of economic and financial knowledge.

Between the economic and financial indicators there are various hierarchic and semantic connections. Analysis of semantic relations often has an essential impact on formulating accurate conclusions from the carried out economic analysis assessing the functioning of an enterprise. An ontology can be defined also as a graph of organized semantic topics, where nodes are a distinguished topic, whereas edges denote the existing relations between them. Figure 2 shows an example of ontology to analyze economic indicators. Among them there is the *Profit margin* indicator. This is the quotient of *Net profit* divided by *Total income*. Semantic analysis of the relationship indicates that the value of the *Profit margin* indicator depends on the sales of the three products (*Product A*, *Product B* and *Product C*). However, sales of products depend on the properties of these products (*Market demand*, *Price* and *Quality*). Such analysis of indicators can potentially ease and shorten the time needed, *inter alia*, to identify chances of advancement and threats of breakdown connected with leading activity.

By providing economic and financial knowledge stored in ontologies and presented in the form of topic maps to facilitate the perception of concepts, one can make the processes under consideration more comprehensive and simpler. This is particularly important for users who are not specialists in the analysis and interpretation of economic and financial indicators, or users with a limited knowledge of relationships between different financial and economic ratios.

One of the key features of InKoM is integration data exploration methods with intelligent assistance in the exploration processes. This idea has been already successfully introduced in a few recent research projects in order to enhance the methodological support missing in most data mining tools and reduce the lack of background data mining knowledge of users as well ([Data Mining Portal…; Nigro, Cisaro, Xodo (Eds.) 2007; Hilario et al. 2011; Kietz et al. 2010; Pinto, Santos 2009; Serban et al. 2012]). In InKoM the method of knowledge discovery can be qualified as semantic data exploration due to the use of domain ontologies, notably economic and financial as domain ontology, and data exploration as knowledge discovery process ontology (see Figure 3). Functionally, to carry out the knowledge discovery process, the manager can be guided by the ontology of data exploration. On the other hand, the manager can execute data exploration algorithms to generalize or specialize concepts or rules already defined in the financial ontology, using attributes referenced in the corporate databases.

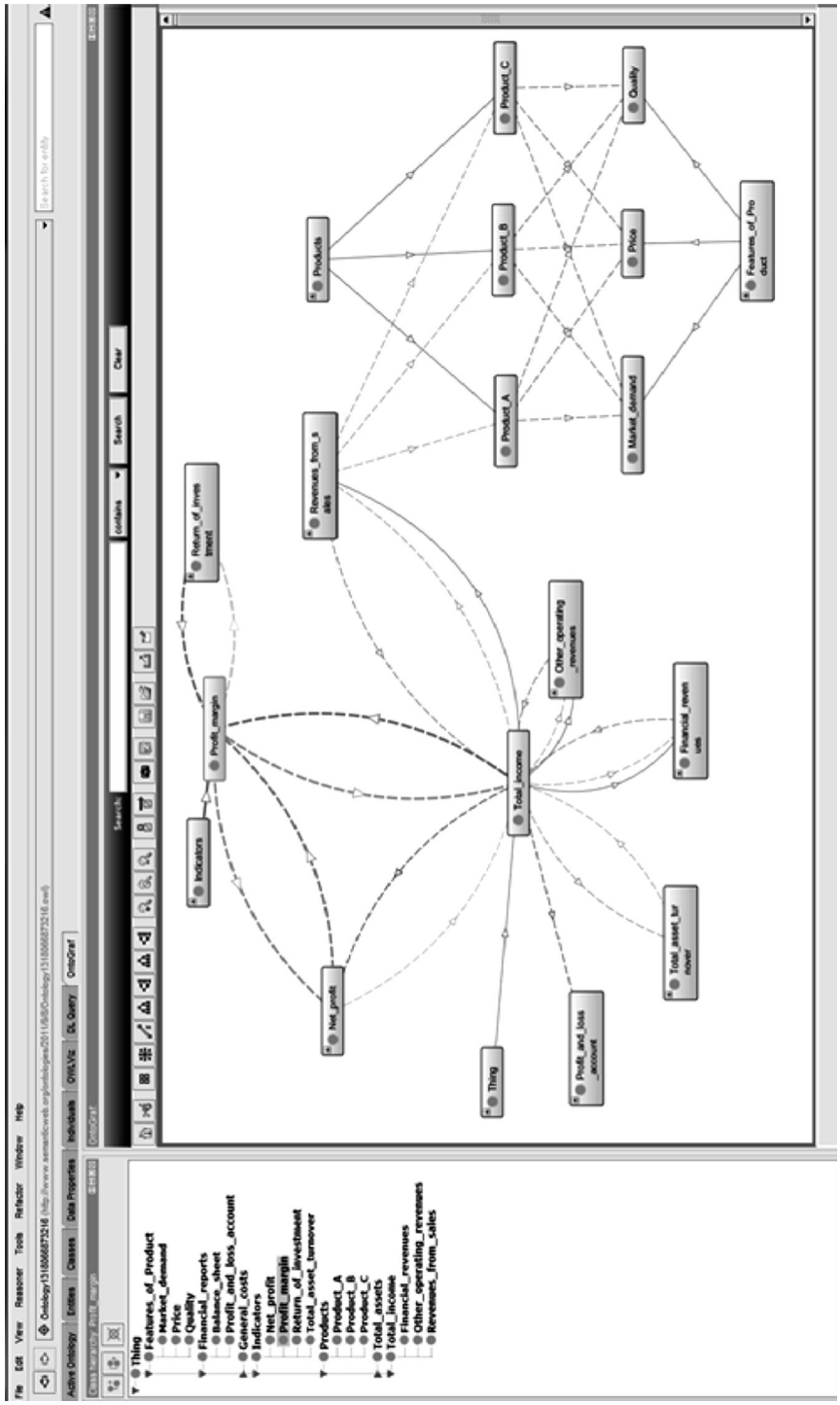

Figure 2. An example of ontology visualization system to analyze economic indicators

Source: own elaboration.

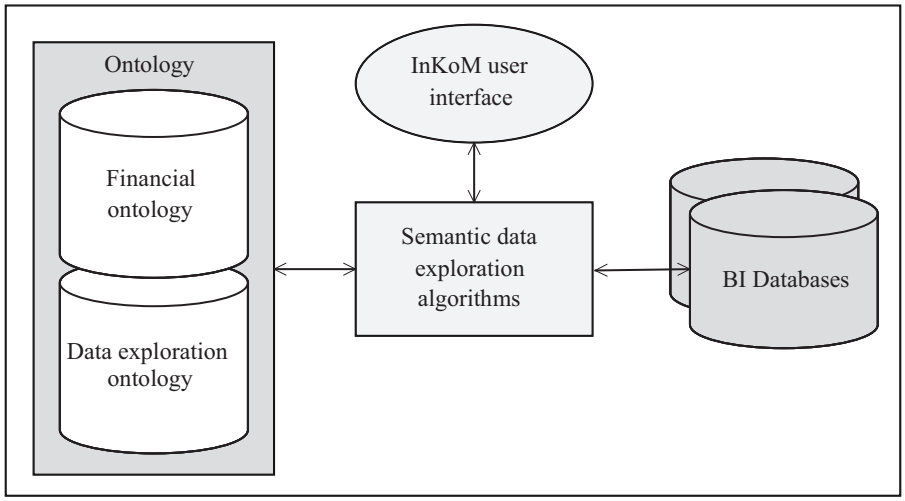

Figure 3. Schema of architecture of semantic data exploration

Source: own elaboration.

As presented in Figure 3, the InKoM ontology is composed of two parts: financial ontology (the example has been given previously) and data exploration ontology. The data exploration ontology contains the concepts and relationships related to the data exploration processes (see Figure 4). The ontology will be served to govern the data exploration tasks, suggest appropriate algorithms, set up parameters, indicate the semantics and sources of data. The ontology will be also applied to support the manager with algorithms evaluation methods and financial ontology updating. In all these knowledge discovery tasks, the manager will be assisted by the data exploration ontology. For example, to discover new knowledge about products, InKoM will provide information about data resources and recommend a set of exploration algorithms to apply. If the manager selects, for instance, the clustering function of products by K-means algorithm, then InKoM will perform the computation using the specific data and propose resulting clusters of customers where each cluster may be described by a collection of rules. The rules may describe a cluster of "good products" in terms of profit, market demand, number of positive comments of customers, etc. After semantic validation, the discovered rules may be inserted into the ontology and extend through concept specialization the existing knowledge about the customers.

The new financial knowledge may be also used to drive and improve future data exploration activities. Contrary to most data mining tools where the user is "abandoned" to solve the problem, InKoM's semantic data exploration guides the manager in the choice and parameterization of algorithms, data sets assignment, data preprocessing, result evaluation and financial ontology updating. InKoM, based on strong steps interdependencies, assures that the process of data exploration is carried out correctly avoiding mistakes and omissions.

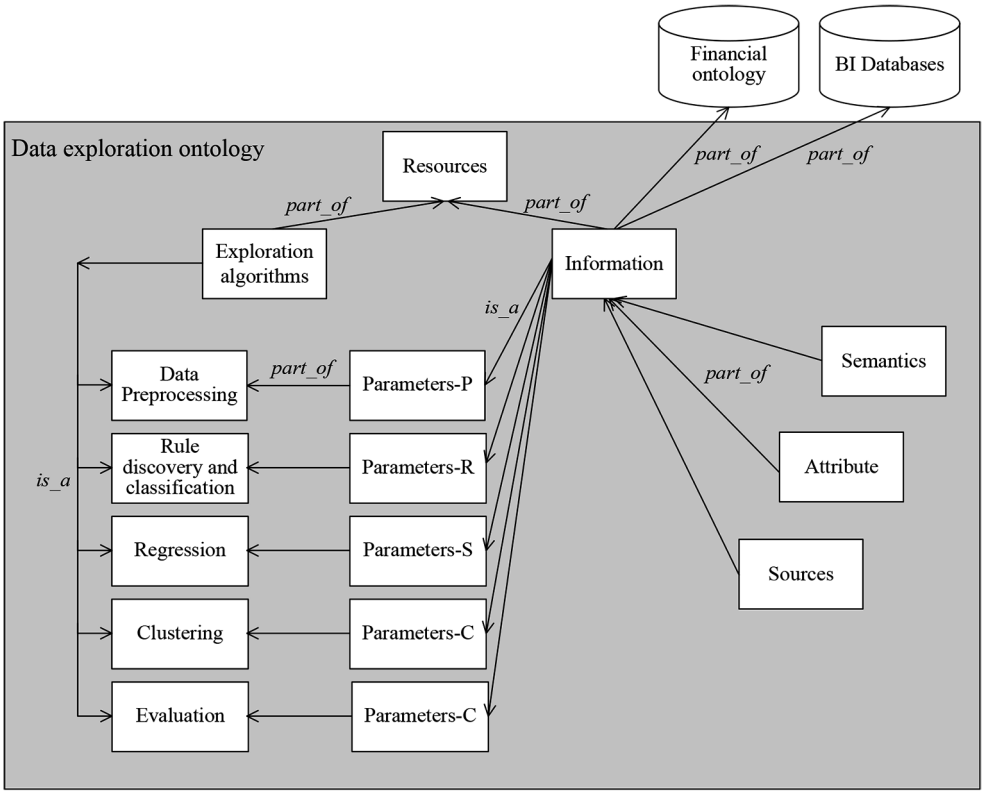

Figure 4. Data exploration ontology

Source: own elaboration.

We do hope that the synergy of integration of financial and data exploration ontologies can significantly empower the manager in knowledge discovery activities.

4. Summary and future work

In this paper, the InKoM project has been presented, with its main components as well as the tasks related to the implementation of the InKoM system. One of these tasks will be developing ontology for six selected fields of analysis of indicators. The example of ontology to analyze the economic indicator *Profit margin* was briefly described. The ontology of data exploration has been presented with the basic algorithms and data structures. Currently the work on this topic is in progress.

The effectiveness of the final system will be examined and assessed in the course of the development of the InKoM system. The studies will be conducted on several levels: on the one hand, taking into account possible versions of the InKoM system

and, on the other hand, from the perspective of the main beneficiary of the project, i.e. UNIT4 TETA BI Center, as well as that of SMEs that are intended to use the system. Further studies will be also conducted on, among others, financial methods, such as NPV, IRR, TCO, and methods to assist SME managers in data exploration processes and information retrieval.

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INTELIGENTNE WSPOMAGANIE DECYZJI MENEDŻERÓW MŚP – PROJEKT INKOM

Streszczenie: W artykule przedstawiono główne założenia projektu InKoM, którego celem jest realizacja i wdrożenie Inteligentnego Kokpitu dla Menedżerów MSP. Innowacyjność systemu InKoM polega przede wszystkim na zastosowaniu nowych metod reprezentacji wiedzy ekonomicznej i finansowej oraz technik i narzędzi wizualnej eksploracji danych. Omówiono główne funkcje tworzonego systemu. Wskazano realizowane aplikacje mapy pojęć dla sześciu obszarów systemów analizy wskaźników ekonomicznych i finansowych. Krótko omówiono integrację metod eksploracji danych w celu uzyskania inteligentnego procesu eksploracji danych. Przedstawiono schemat architektury semantycznej eksploracji danych.

Słowa kluczowe: reprezentacja wiedzy ekonomiczno-finansowej, wizualna eksploracja danych, systemy BI, kokpit dla menedżerów.