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VISUALIZATION METHODS IN BUSINESS INTELLIGENCE SYSTEMS – AN OVERVIEW

Abstract: Recently the quick obtainment of critical business information is very significant problem for managers, because executives of many enterprises decide to implement business intelligence (BI) applications. The usefulness of these systems is not decided by the amount of information to receive, but the amount and type of information which is required at the right moment. Visualization of the information or data should be considered as a one of the most important aspects of implementation of BI systems. Decision-makers also pay attention to easy-to-use and to understand visual techniques of data interpretation. In this paper, a solution of visualization information of business intelligence systems is presented. Solutions of visualization used in analytical applications of business intelligence systems are characterized. Basic directions of conducted researches concerning the use of visualization methods in BI systems are indicated.

Keywords: business intelligence, visualization, information visualization, visual data exploration.

1. Introduction

Making the right decision often requires the dynamic monitoring of the company's activity, executing multidimensional data analysis (also coming from many years before) and generating reports on demand. The response to these needs is business intelligence systems. BI applications are used for the analysis of all basic areas of an enterprise's activity, such as, e.g.. finance, production, logistic, marketing, sales, customers. These applications provide many reports containing much information in each statement. Retrieving information needed at the moment from these reports is eased by the use of appropriate forms of its presentation, and of friendly and easy user interface. Nowadays decision-makers want not only to look at static reports or even ad hoc reports, but also to define goals and key performance indicators in an interactive way and to drill through information to identify chances of advancement and threats of breakdown connected with the leading activity. These factors have an impact on quicker adoption of applications by managers. These are basic reasons of

development of applying graphic methods in BI systems. Within the last few years the role of data visualization has increased and become one of the main components of a BI solution (see among others [Wise 2008]). Properly adopted visualization improves the reception of necessary information, which consequently enables to pick up the right decision in shorter time. Implementation of BI systems with right visualization solutions in an enterprise gives many benefits for this company. Decision-makers can easily find needed information and readily understand it.

In this article solutions of using visualization in BI systems are discussed. The elaboration is structured as follows. In the next section concepts of BI are briefly described. Section 3 describes characteristics of visualization of business information. Section 4 contains analysis of using graphical methods in business intelligence systems. A number of examples of visual interpretation are presented and discussed. In section 5 basic areas of research on using visualization in BI systems are briefly described. Finally in the last section a summary of this work is given.

2. Concepts of business intelligence

In both literature and economic practice a variety of interpretations of the term "business intelligence" can be found. Selected BI definitions have been presented in Table 1.

Whilst analyzing the BI definitions, four basic approaches to the concept can be noticed, where it is interpreted as (see also [Dudycz 2008a, pp. 41-42]):

1) a management concept which goal is to assure that the managers obtain information of appropriate quality and in due time,

2) an information technology solution which means dedicated applications allowing an advanced analysis of data (queries, reports, analysis),

3) a system architecture comprising, first of all, data warehouses, query and report tools, online analytical processing, statistical analysis and data mining,

4) a system solution resulting from the close co-operation of information technology and business where BI is not only a tool for data analysis, but also the preparation and conduction of this analysis.

Business intelligence differs from decision support system and executive information system in their wider thematic range, multivariate analysis, semi-structured data originating from different sources and multidimensional data presentation (see [Olszak, Ziemba 2007, p. 137]). The main purpose of BI is to enable decision-makers on all management levels to make better and timelier decisions. It is assumed that BI may support decision-making on all levels of management regardless of the level of their structuralization [Olszak, Ziemba 2007, pp. 137-138].

1. On the strategic level, BI systems make it possible to set objectives precisely and to follow realization of such established objectives. BI allows performing different comparative reports, e.g. historical results, profitability of particular offers, ef-

Table 1. A review of variety definitions of business intelligence

Author/Source	Description
Baltzan P., Phillips A. (2009)	Business intelligence refers to applications and technologies that are used to gather, provide access to, and analyze data and information to support decision-making efforts.
Biere M. (2003)	Business intelligence is the conscious, methodical transformation of data from any and all data sources into new forms to provide information that is business driven and results oriented.
Dodd N. (2007)	Business intelligence systems are interactive computer-based structures and subsystems intended to help decision makers use communication technologies, data, documents, knowledge, and analytical models to identify and solve problems.
Gray P. (2003)	Business intelligence systems combine data gathering, data storage, and knowledge management with analytical tools to present complex corporate and competitive information to planners and decision-makers. The objective is to improve the timeliness and quality of the input to the decision process.
Hashmi N. (2000)	Business intelligence systems describe a set of concepts and methodologies designed to improve decision-making in business through the use of facts and facts-based systems.
Jagielska I., Darke P., Zagari G. (2003)	Business intelligence system is a combination of data and information, processes, tools and technologies that provide decision-makers with business insight or intelligence, and which allow them to develop processes and make strategic decisions in an effort to make their organization more effective and/or profitable.
Moss L., Atre S. (2003)	Business intelligence is an architecture and a collection of integrated operational as well as decision-support applications and databases that provide the business community easy access to business data.
Oracle (2007)	Oracle business intelligence is a portfolio of technology and applications that provides the industry's first integrated, end-to-end Enterprise Performance Management System, including category-leading financial performance management applications, operational business intelligence applications, business intelligence foundation and tools, and data warehousing.
Rossetti L. (2006)	Business intelligence is a broad category of applications and technologies for gathering, storing, analyzing, and providing access to data to help enterprise users make better business decisions.
Savioz P. (2004)	Business intelligence consists of activities of collection, analysis, and application of information describing relevant facts and trends (opportunities and threats) from organization's entire environment used to support the business decision-making process.
Triple Tree (2002)	Business intelligence applications are decision support tools that enable real-time, interactive access to and analysis of mission-critical corporate information. Business intelligence: closing the loop between analysis and action.
Turban E., Aronson J.E. (2001)	Business intelligence is used to describe the new role of the Executive Information System, especially now that data warehouses can provide data in easy-to-use, graphics-intensive query systems capable of slicing and dicing data (Q&R) and providing active multi-dimensional analysis (OLAP).

fectiveness of distribution channels along with carrying out simulations of development or forecasting future results on the basis of some assumptions.

2. On the tactical level, BI systems may provide some basis for decision-making within marketing, sales, finance, capital management, etc. The systems allow optimizing future actions and modifying organizational, financial or technological aspects of company performance appropriately in order to help enterprises realize their strategic objectives more effectively.

3. On the operational level, BI systems are used to perform ad hoc analyses and answer questions related to departments' ongoing operations, up-to-date financial standing, sales and co-operation with suppliers, customers, etc. Operational Intelligence provides near-real-time (or right-time) metric information about business processes, activities and outcomes to support operational decision making.

From a technical point of view, the architecture of BI allows: analytical processing and distributing information. Analytical processing includes solutions for the multidimensional analysis of actual economic facts, the discovery of the dependence between them and also the prediction of events. As a part of this layer the basic analytical tools (traditional query and report tools, On-Line Analytical Processing tools, data visualization tools), advanced analytical tools (statistical tools, data mining) and business applications (tools that provide analysis around a specific business function or a specific vertical that support making various decisions on production, sales, competition monitoring, finance, etc.) can be set apart. Also the essential element in the architecture of BI systems are solutions allowing the distribution of information. Two basic categories of solutions are set apart: the *pull* method (where we have a distribution of results of analysis in corporate portals considered in the context of intranet and extranet) and the *push* method (where we have an automatic distribution of the results of questions by reports in the forms such as: e-mail, text message, fax, automatic prints).

The main goal of any business intelligence system is to access the right data at the right time to allow proactive decision-making (see among others [Wise 2008]). The users of BI systems expect access to more information, easy to understand and use[1] interface and the information presentation, which should be intuitive, interactive and provide context and embedded knowledge [Morris 2009]. Specific attention in BI systems is given to the user interface which should let the user among others: filter, sort and analyze data, formulate ad hoc or predefined reports, generate alternative scenarios, produce drillable charts and graphs. The use of graphic interfaces is a primary characteristic of the new generation of BI applications.

Many BI analytical application use data visualization tools to bring essential business information to organizations. For end users, the presentation layer is the most critical aspect of a BI system, since it broadly shapes their core understanding

[1] In the research carried out by Aberdeen Group it has appeared that the most important factor of rating the system by the users is ease of use (93%) [Hatch 2007].

of the data displayed on their screen [Wise 2008]. The research particularly shows that the information systems, which management stuff valued as bad, presented information only in the form of text and table.[2] The role of data visualization is becoming more important within business intelligence.

3. Visualization of business information

Visualization is the process of representing data as a visual image (see [Gray 2003, p. 24]), and is defined as "the use of computer-supported, interactive, visual representations of *abstract data* to amplify cognition" [Burkhard, Meier 2005, p. 477]. In other words, visualization allows decision-makers to use their natural spatial/visual abilities to determine where further exploration should be done. This implies that visualization, when used appropriately, can allow the decision-maker to find the information in the data (see [Tegarden 1999, p. 6]). Visualization techniques may help to solve the problem, because "visualization offers a link between the human eye and the computer, helping to identify patterns and to extract insights from large amounts of information" [Zhu, Chen 2005, p. 139]. Information visualization allows first of all to (see [Dudycz 1998, pp. 26-27; Tegarden 1999, p. 6]):

– exploit the human visual system to extract information from data,
– provide an overview of complex data set,
– assist in identifying exceptions in data and prompt users into action,
– identify structure, patterns, trends, anomalies, and relationships in data,
– assist in identifying the areas of "interest".

Visualization technologies have been used in many areas of business because graphical representation of the data makes analysis easy and aids the user to make informed and quick decisions. Visualization enables to easily identify oddities in detail data, isolate them, and investigate their source much faster than with traditional analytical methods. Business information has been visualized in the form of tables, outlines, pie charts, line graphs, and bar charts for a very long time (see [Dudycz 2008b, p. 61]). Mentioned graphic methods do not meet all expectations of users of BI systems. Firstly, today business information is typically abstract, discrete, multi-dimensional and can be either historical or generated in real-time. Secondly, today's enterprise data is a mix of structured, unstructured, and semi-structured content, whereas users need access to it all. Thirdly, users need semantic information depicting relations between facts.

The reasons mentioned above have impact on methods' development and verification of usage of multidimensional graphics to represent business-related data or information. These are solutions such as: dashboards for performance monitoring, reports, graphs, dials and cubes for operational and performance reporting data, alerts,

[2] The assumptions of this study are more closely presented in [Dudycz 2005, pp. 41-44].

triggers and indicators (that can be delivered by numerous channels like desktops, mails, wireless, etc.), impact diagrams, strategy maps, tree maps, hyperbolic 3D and topic maps. The fundamental properties required for good information visualization applications are [Korczak, Dudycz 2009, p. 87]:

1) interactivity (i.e., they use direct manipulation of a user interface techniques to apply operations such as filtering),

2) efficiency (i.e., the visualization is rendered in real-time),

3) focalization (i.e. visualizations use focus and context techniques such as distortion or dynamic zooming).

The important direction of researches concerning business information is a verification of graphic methods enabling visual data exploration. The basic idea of the visual data exploration is "to present the data in some visual form, allowing the human to get insight into the data, draw conclusions, and directly interact with the data" [Keim 2002, p. 100]. In this interactive process, the user is able to subsequently concentrate on the interesting data elements by filtering uninteresting data, and focusing (zooming in) on the interesting elements, until final details are available for an interesting subset of the analyzed elements (see also [Atzmueller, Puppe 2005, p. 1756]). Important stage in this process is the use of appropriate solutions which allow filtering and zooming in (zooming out).

In conclusion visualization tools allow decision-makers to interact with the information they need in the way that best suits them.

4. Analysis uses graphical methods in business intelligence systems

4.1. Graphical methods on analytical applications of business intelligence systems

The technologies and tools used on the level of analytical processing should meet the needs of different user groups, including people who independently design reports and analysis (e.g. analysts), and people who utilize pre-prepared reports (e.g. board directors, finance directors). In the range of such a group the following solutions can be set apart: basic analytical tools, advanced analytical tools, and analytical applications constituting dedicated solutions.

In analytical applications graphic methods enabling to visualize information essential for decision-makers are used in the form of charts, diagrams, graphs or more advanced visualizations. This type of visual benefit saves people the time and effort of searching through information, accessing drill through or parameter-based reports, and gives people direct access to an overview of all of the information they require [Wise 2008]. The ability to use these visualizations as an output for analytical applications enables decision-makers among others to identify discrepancies and areas that require improvement quickly.

Visualization technology draws an immediate picture of trends and relationships by allowing decision-makers to run visual queries. On Figure 1 there is shown an example of using visualization methods in analytical application. With interactive graphs, users can examine information from multiple perspectives and in various forms while incorporating as many variables as they want. Additionally more and more visualization tools of BI analytical applications enable to (see among others [*SAS® Enterprise BI Server* 2007]):

– summarize and present data using a variety of highly customizable charts, including: vertical and horizontal bar, pie, donut, subgrouped pie, star and block charts; allow users to generate scatter, line, area bubble and overlay plots;
– generate static or dynamic interactive charts and graphs;
– provide highly interactive business graphics, including animated bubble plots, 3D scatter plots, trellis plots, summary charts and needle charts;
– visually query and filter data for interactive tabulation and ability to rearrange data at will;
– provide visual analytics, including interactive simulations and optimization and state-of-the-art time series modeling.

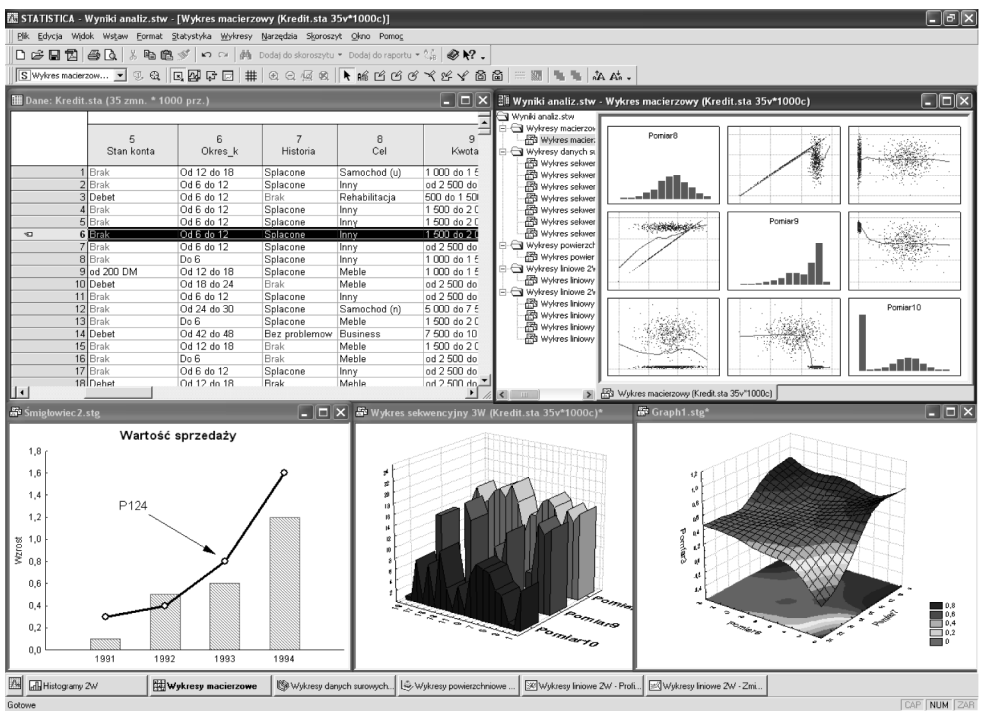

Figure 1. Example of using visualization methods in analytical application

Source: www.statsoft.pl.

In conclusion: most analytical applications BI provide some capabilities of information visualization that allow a user to manipulate the data to obtain the answers to the specific questions.

4.2. Use of dashboard and corporate portals in business intelligence system

Information visualization in the distribution of information is realized by using dashboard and corporate portal, which has become standard business practice over the last decade.

A dashboard is a visual display of the most important information needed to achieve one or more objectives, consolidated and arranged on a single screen so the information can be monitored at a glance (see [Few 2006]). This tool integrates information from multiple components and tailors the information to individual preferences (see [Baltzan, Phillips 2009, p. 52]). The dashboard is a new genre of popular Business Intelligence data visualization and the interesting concoction of the most basic data visualization features with a mix of animation and interactivity, blended with a simulation of speedometers and thermometers (see [Malik 2007a]). The dashboard is a type of display, a form of presentation, not a specific type of information or technology. It involves multiple technologies, processes and methodologies working together to present a complete picture of strategic change in an organization and to provide a consolidated view of the enterprise.

Dashboards are used to generate and deliver the right information, to the right person, at the right time – enabling better decision-making. Effective ones display meaningful analyses and actionable information in an easy-to-read format. Dashboard catalog of analytic templates includes several types of data visualization: speedometer, barometer, thermometer, traffic lights, interactive metric trend, Pareto chart, map, statistical analytics and other forms of graphics (see [Dudycz 2008b, p. 62]). Demonstration dashboard screen is shown on Figure 2. It features several different component types for display and management of key performance indicators. Visualization tools provide a graphical interpretation of a company's data so that it can be analyzed from different perspectives and allow creating advanced dashboard in which large amounts of information are presented on a single screen. Data visualization dashboards can provide a unique and valuable perspective of business.

The dashboard software must provide a user-friendly and intuitive interface for all levels of users (strategic, tactical, and operational), therefore strategic dashboard contents tending to be enterprise-wide, tactical dashboard contents tending to be localized and self-contained within a department or group and operational dashboard contents tracking operational processes and typically display more real-time data can be set apart [Blahunka 2007; Malik 2007b].

Visualization tools such as dashboards provide a useful way to view data and information. Dashboard supports organization-wide analysis and integrated decision-making as well as provides decision-makers with a graphical view of performance

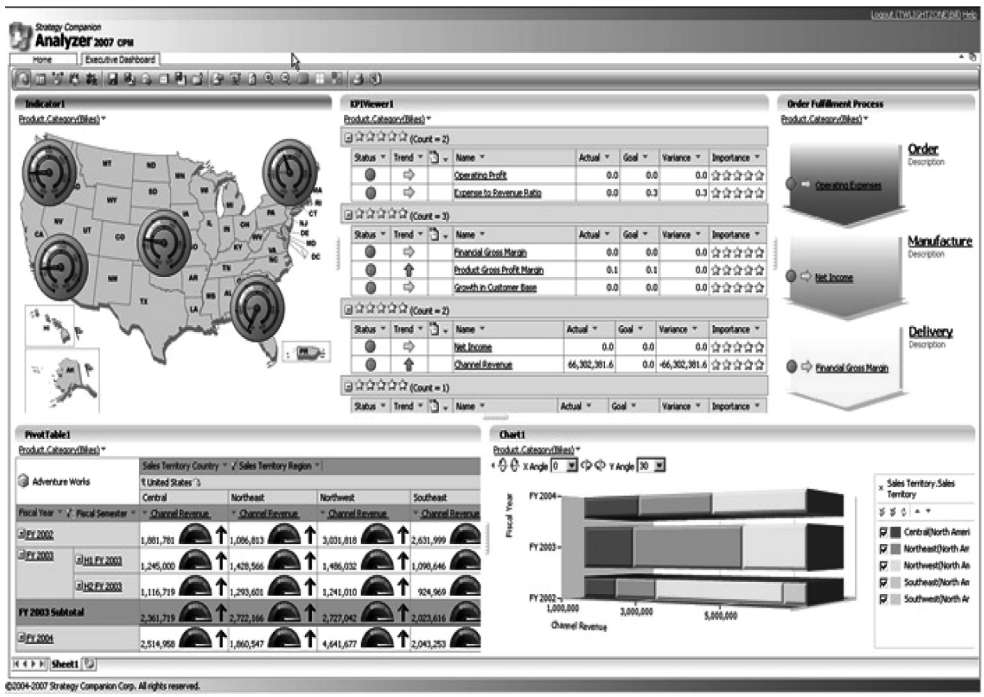

Figure 2. Example of using visualization methods in dashboard

Source: www.strategycompanion.com.

to help to identify opportunity and challenges quickly, because it enables to [Dudycz 2008b; Swoyer 2007; Wheeler 2009]:

a) support at least three simultaneous activities (monitoring, reporting/analysis and management) – dashboards can consist of sets of related functionalities built on top of information infrastructure and graphical data make it easy for users to monitor key performance metrics quickly, summarized dimensional data help users to analyze the root causes of problems, and detailed operational data help identify the areas on which decision-makers should concentrate at the moment,

b) monitor strategies in business units – dashboards enable to monitor activity in the whole company,

c) communicate strategy effectively – dashboards support business strategy by expressing important information, key drivers, performance expectations, and the results – to make strategy relevant to everyone,

d) monitor performance against targets – dashboards inform quickly on critical performance measures in real time,

e) analyze trends and variances – dashboards enable to revise a forecast almost immediately, and then see it updated back in the dashboard in near real time,

f) communicate complex information quickly – dashboards translate corporate data into a rich, graphical presentation using gauges, maps, charts, and other graphics to show multiple results together,

g) personalize screen's look – dashboards can be personalized for individual users or groups of users.

Modern dashboards are often a part of an enterprise portal which is also known as an enterprise information portal (EIP) or corporate portal. The enterprise portal is a solution integrating and distributing fragmented information sources and applications existing in enterprise considering needs of individual decision makers. It is characterized by uniformed graphic interface of web browser. Corporate in a way act as a filter letting in only information essential for a given user and allows and eases faster distribution of information intended especially for decision-makers.

The use of visual information in corporate portals is a solution supporting analyzing and presenting essential information for decision-makers. Graphic methods are widely used especially in realization alert solution concerning early warning about possible threats connected with activity conducted by an enterprise (Figure 3). Visualization tools used in corporate portal will bring expected profits on condition that both appropriate graphic methods are clear for decision-makers and suitable information technology tools with friendly user interface.

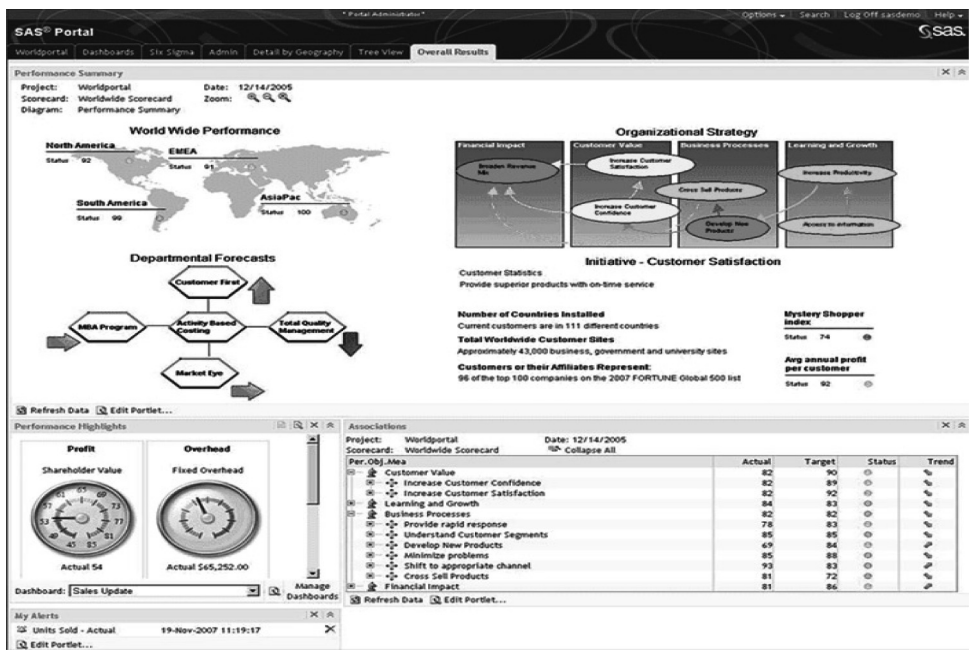

Figure 3. Example of using visualization methods in corporate portal

Source: www.sas.com.

In conclusion, dashboards and corporate portals are essential solutions in BI systems, which deliver the right information to the right person at the right time. However, their potential visualization possibilities are determined by integrated with them visualization tools and analytical applications.

5. Conducted researches concerning visualization in business intelligence systems

Nowadays decision-makers want to be able to access and manipulate the way they analyze data using the intuitive interface, because users of BI systems need to have the freedom and flexibility in exploring. Managers want to understand what the alternatives of making decision are, because they need new ways to drill down and explore deeper. Executives want widespread access to information including semantic information depicting relations between facts. They need to explore different ways of looking at the data and of presenting them. Decision-makers want to have possibility to analyze information about organization anywhere. Mentioned needs of decision-makers induce to carry out further researches connected with the use of visualization methods in BI systems. In this paper we will concentrate on three areas, i.e. visual data exploration, dashboards and visualization in mobile BI application.

One of the areas of researches is the verification of graphic methods which allow visual data exploration. The use of graphic methods in the data mining process makes possible to include manager expertise or feedback in data mining, leading to more effective data exploration (see [Zhu, Chen 2005, p. 146; Keim, Schneidewind 2005, p. 1767]). It is important in BI systems, because visual mining methods enable to overcome major problems of automatic data mining methods, e.g., lack of acceptance of the discovered findings or limited confidence in these (see [Atzmueller, Puppe 2005, p. 1752]). Visual analysis and visualization techniques have been proven – as said Keim and Schneidewind – "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" (see [Keim, Schneidewind 2005, p. 1767]). The aim of these researches is:

– to identify solutions which allow better, faster and more intuitive exploration of very large data resources (including database management and data warehouse systems),
– to identify solutions which allow to visualize the semantic relationships between economical indicators, in order to make interpretation of indicators easier and more correct.[3]

[3] Business data contain a lot of hidden relationships and dependencies that make their usage difficult.

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 (Figure 4). 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 (see [Grand, Soto 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.[4] 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.

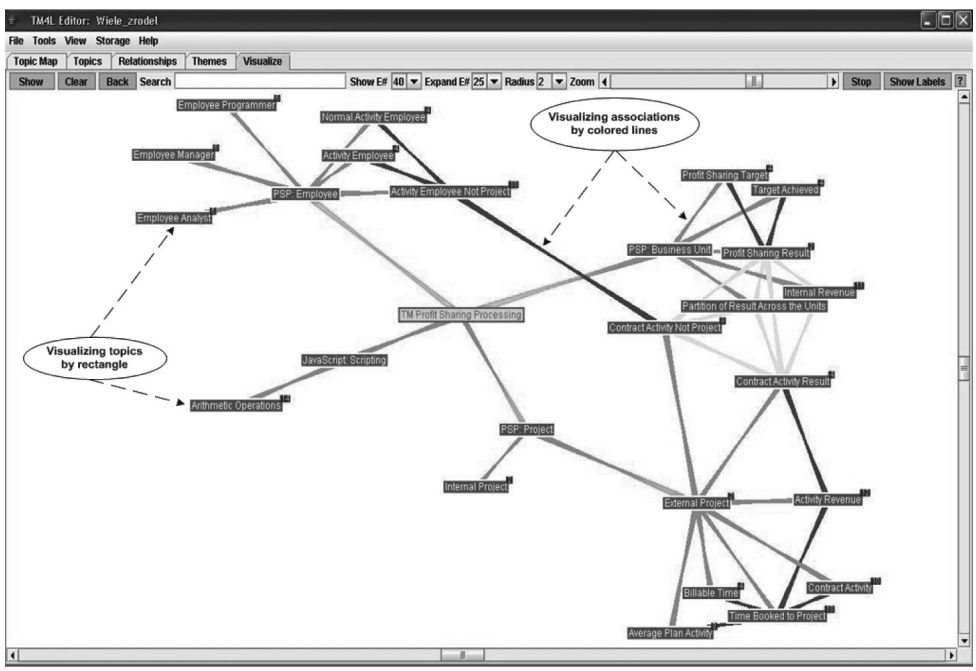

Figure 4. Example of visualization of topic map

Source: own presentation based on TM4L Editor.

The next area of researches is the verification of graphic methods allowing visual intelligence in dashboard of BI systems. Visual intelligence is defined "as the capability of software to provide better insight through intelligently highlighting

[4] Analysis of potential possibilities of use of standard topic map for representation of financial knowledge was described in: [Korczak, Dudycz 2009].

relevant areas and values on the dashboard in response to a user's cursor movement" (see [Malik 2007b]). Such a visualization is to streamline the user's ability to extract information from data and to help the user to avoid the sensation of information overload. In this area the researches will concentrate on showing the best solutions of visualization of alerts, that is, indicators displayed when a measure exceeds the certain threshold.

The last distinguished area of researches is the verification of graphic methods used in mobile applications of BI system. Current applications are fully interactive in order to perform BI functions. Mobile BI applications enable to analyze data anywhere, creating reports and charts as needed. Because of the limited user interface and area of displaying graphs, researches concentrate on verification of graphic methods, which on relatively small screen will present information most clearly. One of the graphic methods useful for the visualization of information in mobile BI applications is sparkline. It is a type of graphic method characterized by small size and large data density. This method very well fits with present trends and variations associated with some measurement in a simple and condensed way such as stock market activity. On Figure 5 there are shown examples of using sparkline in executive dashboard on the mobile application BI.

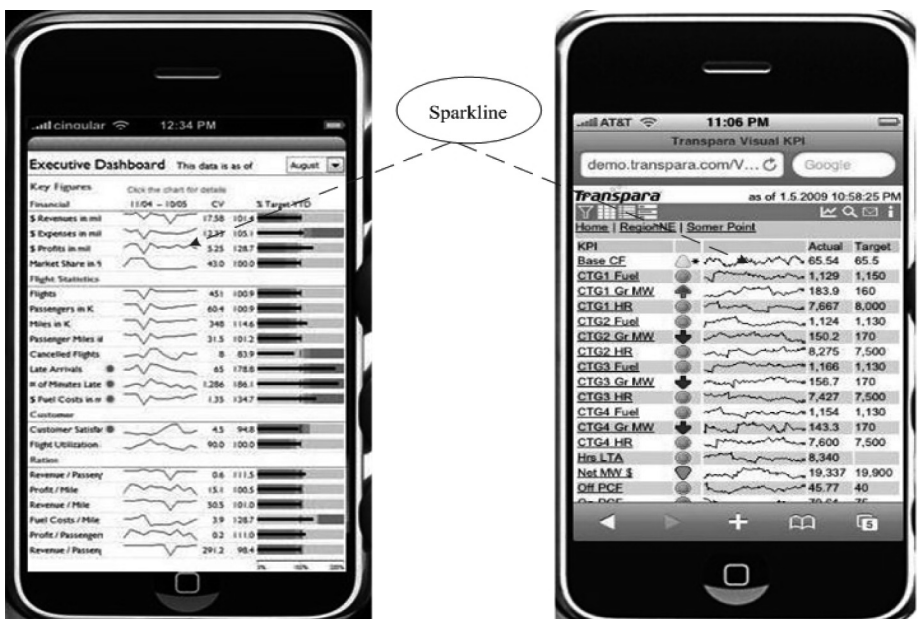

Figure 5. Examples of using sparkline on the mobile application business intelligence

Source: own presentation based on [www.enterprise-dashboard.com/img/sparkline-dashboard-on-iphone.jpg; www.edwardtufte.com/bboard/images/0003MT-8810.jpg].

In conclusion: in practice the areas of researches shown above complement each other. Verified graphic methods, allowing visual data exploration, can be used in dashboards. They will enable to effectively extract information from data. Results of these researches, concerning using in dashboards graphic methods, which are based on minimum number of graphic elements allowing to present only essential and needed information, will find appliance in mobile BI applications.

6. Conclusions

The issues shown in the article are related to the use of visualization methods in business intelligence systems. Possibilities of supporting decision-making on all levels of management by BI applications are presented. Properties of visualization methods used to present business information are elaborated. It is shown that good visualization can be the difference between information overload and information insight. Usage of graphical methods in analytical applications, dashboards and corporate portals of BI systems is presented. At the end the author indicated basic directions of researches connected with the use of visualization in BI systems.

The use of appropriate graphic methods in analytical applications which are suitably selected for conducted analyses of data and considering in this range needs of managers allows minimizing time needed to retrieve needed information at the moment. The use of inappropriate visualization solutions may also cause information overload. That is why there is still need to conduct researches on the effective use of graphic methods in analytical applications considering also predispositions of decision-makers, that is perceptual abilities of human, experience and knowledge in interpreting graphic images. Predispositions of decision-makers should also be taken into account during creating dashboards and corporate portals. Though dashboards appear to be deceptively simple, they are not easy to build. Whilst projecting dashboard, it is important to identify the proper metrics and key performance indicators to control activity of the enterprise, and select the right visualizations methods and tools. Dashboards can provide an unique and powerful tool to present information, however, it is good solution only as much as it really effectively supports managers in making decisions.

The future research will be focused on studying methods of visual data exploration, especially using topic maps for complex structures of economical measure, as efficient visualization method of concepts and associations existing in business information systems.

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METODY WIZUALIZACJI W SYSTEMACH *BUSINESS INTELLIGENCE* – PRZEGLĄD ROZWIĄZAŃ

Streszczenie: konieczność pozyskiwania przez kadrę kierowniczą istotnych informacji, pochodzących z wielu źródeł, stała się jedną z przyczyn wdrażania systemów *business intelligence* (BI). O ich przydatności decyduje nie ilość informacji dostarczanej w różnorodnych raportach, ale jej adekwatność do zaistniałego problemu i odpowiednia szczegółowość oraz sposób jej prezentacji. Istotnym elementem aplikacji BI jest wizualizacja, nie tylko stanowiąca graficzną formę przekazu, ale będąca również narzędziem wyszukiwania potrzebnych informacji. W niniejszym artykule skoncentrowano się na przeglądzie wykorzystania wizualizacji informacji w systemach BI. Przeprowadzono analizę zastosowania metod graficznych w aplikacjach analitycznych BI oraz wskazano i krótko omówiono trzy podstawowe obszary badań, prowadzonych nad wykorzystaniem wizualizacji w systemach BI.