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INTEGRATED UNDERSTANDING OF BUSINESS INTELLIGENCE IN TECHNOLOGICAL INNOVATION PROCESSES

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Key words: Business Intelligence, information technology, decision-making, innovation, technology, strategy, information management, knowledge management.

Abstract: Business Intelligence (BI) has become a challenge for the information technology, Industry 4.0, as well as a very important managerial issue. Its importance has been recognised especially in a development of analytically based decision-making capabilities having a reflection in software and computer systems. The main functions of BI-based technologies are data gathering, online analytical processing, analytics, data mining, process mining, text mining, business performance management, benchmarking, predictive analytics, and reporting. Therefore, BI systems are capable of handling large amounts of sometimes unstructured data to help identify, develop, and otherwise create and support new strategic business opportunities. The paper more attentively explores the complexity of the Business Intelligence term on the basis of the literature review and reflects it in the proposed definition. In-depth research and a state of the art analyses enabled the development of the complex architecture that aggregates the Business Intelligence concept within a technological innovation process as not only a software issue, but a sophisticated approach to decision-making in a business environment. This multidimensional attitude to BI enables the transformation of resources into strategic capabilities and supports technology transfer, innovation-decision processes, and innovations management. The paper also presents the business value of BI implementation in an organisation and exemplar case study.

Zintegrowana koncepcja Business Intelligence w procesie generowania innowacji technicznych

Słowa kluczowe: Business Intelligence, informatyka, podejmowanie decyzji, innowacje, strategia, zarządzanie informacją, zarządzanie wiedzą.

Streszczenie: Wpisujące się w koncepcję przemysłu 4.0 systemy klasy Business Intelligence (BI) oraz ich implementacja stały się jednym z wielu wyzwań dla współczesnej informatyki oraz zarządzania strategicznego. Szczególnie podkreśla się znaczący wpływ BI jako zestawu technik komputerowych i oprogramowania na automatyzację oraz wspomaganie procesów decyzyjnych, również w organizacjach o profilu technologicznym. Głównymi funkcjami Business Intelligence są m.in. gromadzenie danych, przetwarzanie analityczne, eksploracja danych, eksploracja procesów, zarządzanie wydajnością biznesową, analizy predykcyjne, prognozowanie i raportowanie. Systemy BI umożliwiają zatem przetwarzanie dużych ilości nieuporządkowanych danych w celu identyfikacji i tworzenia nowych strategicznych możliwości biznesowych oraz skuteczniejszego zarządzania innowacjami. W artykule na podstawie przeglądu literatury przedstawiono złożoność i niejednoznaczność pojęcia Business Intelligence oraz zaproponowano autorską definicję uwzględniającą kompleksowy i wielowymiarowy charakter tego pojęcia. Ponadto zaprojektowano architekturę, która agreguje koncepcję Business Intelligence w ramach procesów organizacyjnych i innowacyjnych w przedsiębiorstwie. Podkreślono, że jedynie wieloaspektowe podejście do implementacji i wykorzystywania BI umożliwi transformację zasobów firmy na strategiczne możliwości oraz wspiera transfer technologii, proces generowania i zarządzania innowacjami. W artykule przedstawiono także wartość biznesową wdrożenia koncepcji BI w organizacji oraz przykładową implementację.

1. Theoretical background of BI

Various research studies have emerged in the academic and practitioner literature, each highlighting various aspects of this concept.

Business Intelligence is often defined as an overarching term for decision support systems that are based on the integration and analysis of organisational data resources toward improving business decision making [1]. In this work, the term *BI systems* is used to describe the technical artefacts that provide multifunctional environment to users.

Sometimes *BI* is used as a catchphrase that has been thrown around in different context of advanced information technologies or modern management issues.

Business Intelligence (Intelligent Systems for Business Support) is also understood in research as the ability of an organisation to transform its potential into knowledge, i.e. data into information, and information into knowledge. Large amounts of information are created as a result that could create new opportunities in managing process of developing new technological solutions. Their identification and a suitable strategy implementation would bring competition-related benefits and long-termed stability of the organisation. The main aim of the *BI* concept is to support decision making processes, intelligent research and analyses, aggregation, and multidimensional analysis of multi-source data (both internal and external) [2].

In studies performed by N. Dedić and C. Stanier, *BI* is considered as a set of strategies, processes, applications, data, technologies, and technical architectures which are used to support the collection, analysis, presentation, and dissemination of business information [3].

S. Negash defines it as a superordinate to decision support, executive information systems, and management information systems that aims at improving the quality of information used in the decision-making process as a consequence of the simplification of storage, identification, and analysis of information [4].

Some scientific approaches to *Business Intelligence* highlight the process of gathering and analysing internal and external business information [5]. L.T. Moss and S. Atre claim that *BI* is neither a product nor a system, but 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 [6].

BI is also misunderstood as an organised and systematic process by which organisations acquire, analyse, and disseminate information from both internal and external information sources that are significant for their business activities and for decision making [7]. Similarly, research focused on enterprise computing environment presents *Business Intelligence* as a process

of transforming raw data into useful information for more effective strategic, operational insights, and decision-making purposes so that it yields real business benefits [8].

Business Intelligence promises a range of technologies for using information within organisations to ensure compliance to strategic and tactical objectives, as well as government laws and regulations. As a research field, *BI* encompasses data and knowledge management, the modelling of processes and policies, data quality, data privacy and security, data integration, data exchange, data cleaning, inconsistency management, information retrieval, data mining, analytics, and decision support [9], then operations engaged in the process of innovations development.

In a more limited view, *Business Intelligence* is also investigated as a set of applications and technologies implemented in an organisation to exploit, store, analyse, and share data to take better, real-time strategic or operational decisions [10].

However, the ability to collect information does not automatically infer intelligence that is rather the ability to interpret information and make the right decisions. The essential element of *BI* is the understanding of what is happening within an organisation and its business environment, as well as appropriate action-taking for achieving organisational goals [7].

Some of the above-mentioned research perspectives define *BI* as a holistic philosophy, while others approach it from a more technical point of view.

In this article, the concept of *BI* does not relate to a particular piece of information or IT equipment, but it is defined as a systematic process that businesses employ comprised of both technical and cross-organisational elements to improve decision making process at tactical, operational, and strategic level. The overall aim of the *BI* for technology driven organisations is to enrich the technological innovation process with so far uncovered opportunities, data, and facilitate its stages, i.e. basic and applied research, development, engineering, manufacture, marketing, promotion, and continuous improvement (Fig. 1). Therefore, this definition adheres to a broader understanding of the *BI*.

The complexity of the term takes into account also, technical and behavioural capabilities and analytic skills of IT personnel that have an impact on infrastructure capabilities [11] such as *BI* systems. Efficient *BI* process presents its users with information for analysis to enable effective decision making and management support, with the overall purpose of increasing organisational performance.

Only the synergy derived of the combination of strategic management techniques, information technology systems and human resources management brings a real *Business Intelligence* into a company, government unit, or research organisation.

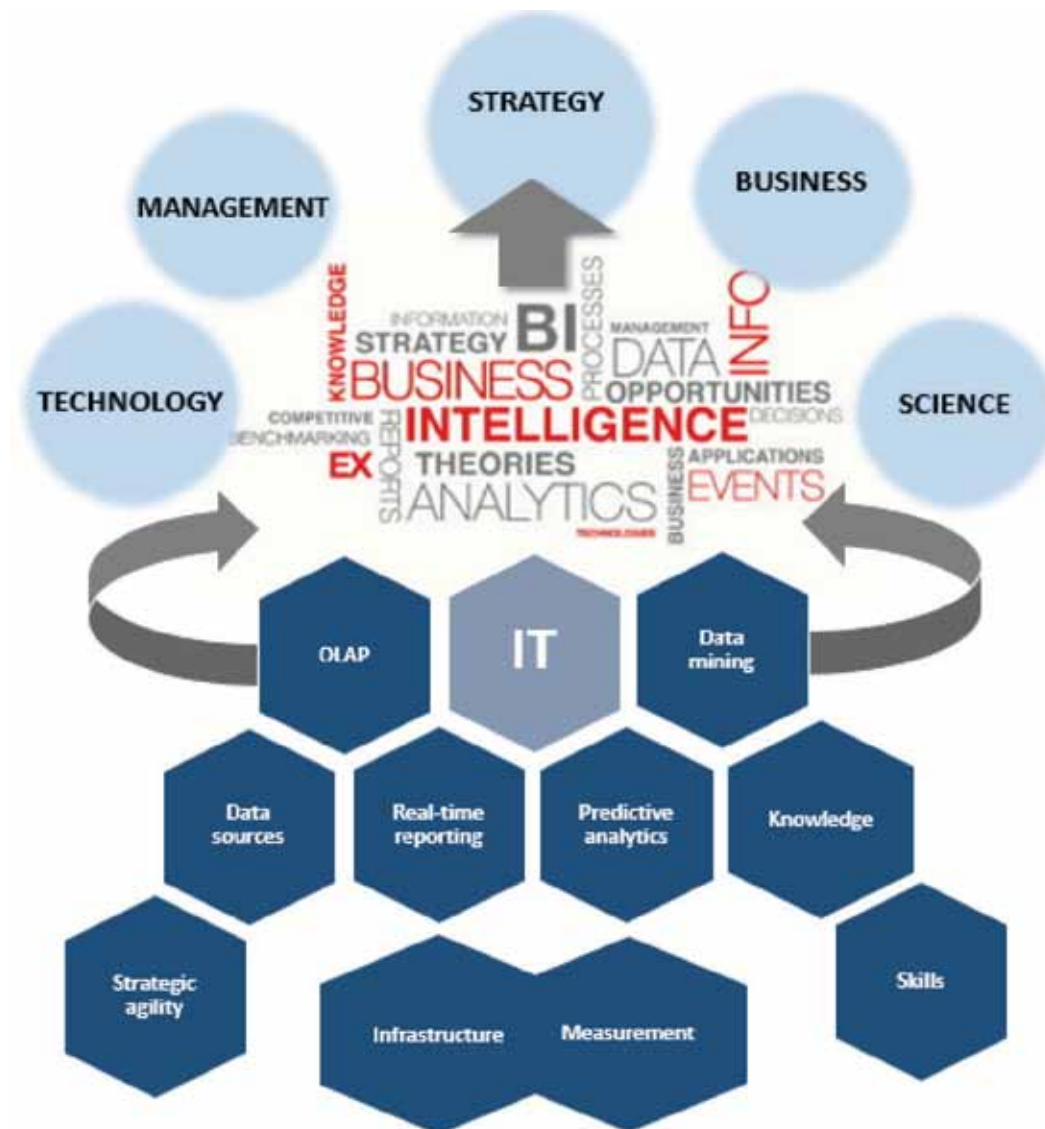


Fig. 1. The complex understanding of the *Business Intelligence* concept

2. Business Intelligence Architecture

The Business Intelligence architecture is comprised of different unique components to collect, transform, analyse, and present the structured and unstructured raw data in simple formats to assist decision makers in making timely decisions [12]. The BI architecture is a framework for organising the data, information management, and technology components that are used to build advanced systems for reporting and data analytics that are necessary in developing advanced technological systems.

The components of a BI-based system tend to differ based on the industry and organisation, but at a macro level, all BI landscapes have the same format. Several existing BI architectures that differ in their components, layers, processes, and data flow were found, e.g., [4, 12–20].

The typical Business Intelligence system consists of four basic functional layers:

- 1) **Acquisition** – a tool layer used to extract, transform and load data (ETL) from ERP (*Enterprise Resource Planning*), MRP (*Material Requirements Planning*), CRM (*Customer Relationship Management*) [16] transaction systems or other data sources;
- 2) **Integration** – a storage layer consisting of data repositories, data warehouses that integrates data into one coherent model that contains data of high quality;
- 3) **Collaboration** – an analytical layer including applications for online analytical processing (i.e. OLAP), decision support applications, data mining, queries and reports that allow access, analysis and sharing of data in the repository;
- 4) **Information delivery** – a presentation layer responsible for providing an access to data by

business-friendly reporting and analytical tools that present information in the form of interrelated, transparent and interactive reports and analyses, e.g. dashboards.

However, the Business Intelligence architecture provides a set of computer-based techniques that can be used to create high quality data for reporting and analysis and supports cross-organisational, operational processes, such as developing, managing and delivering products and services, managing customer service, management and support processes (e.g., human resource management, information technology management, financial management, knowledge improvement), and

strategy management (strategy formulation, business planning, governance and compliance). Due to the presented complex understanding of the BI, an adequate BI architecture for technology organisation was designed (Fig. 2).

The presented Business Intelligence landscape reflects the complex system which data goes through in order to get processed into information within an organisation environment and on-going cross-organisational processes. The data components of the BI architecture include the data sources that corporate executives and other end users need to access and analyse to meet their business requirements and develop

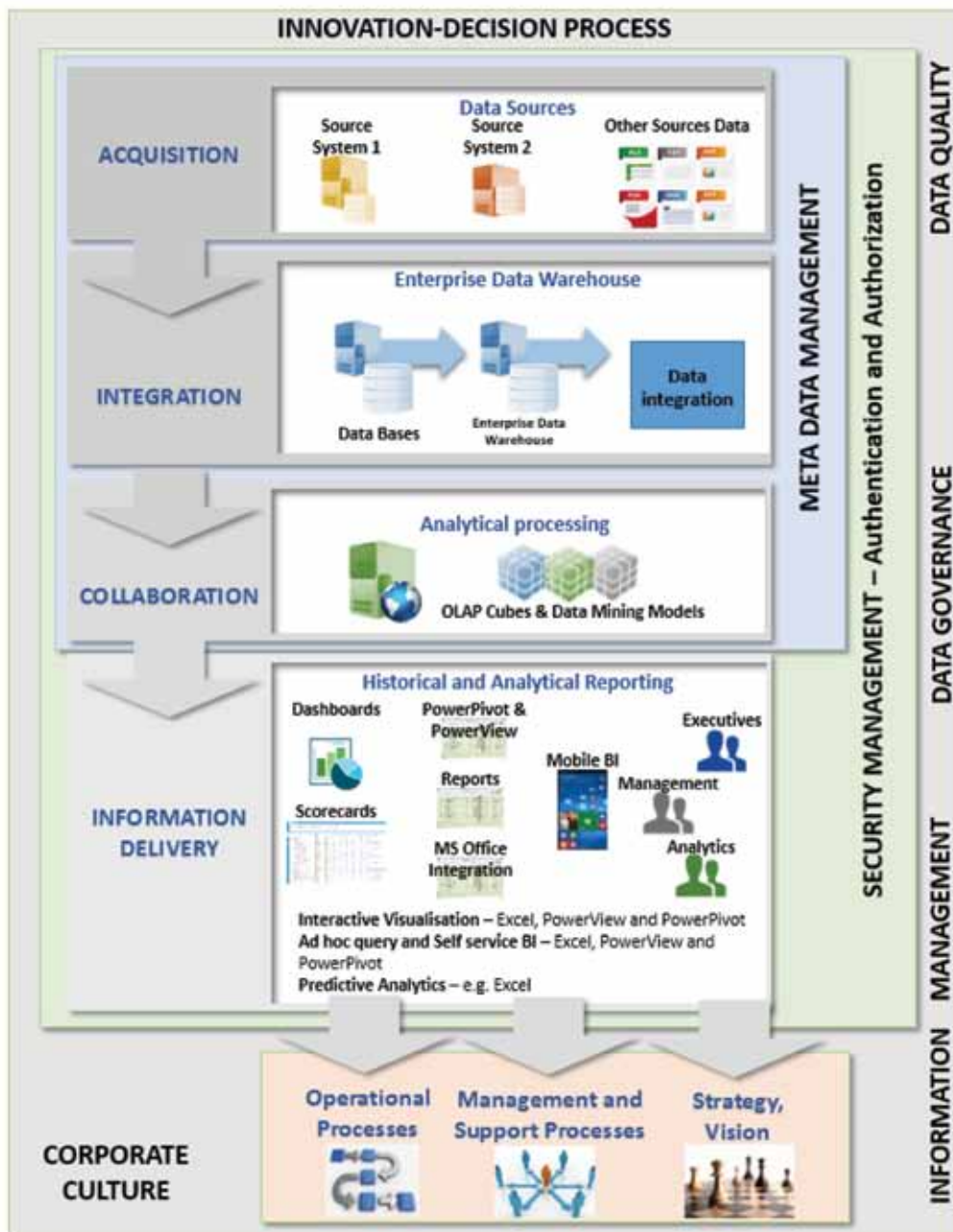


Fig. 2. The conceptual diagram of the Business Intelligence architecture

innovations. The availability of quality information is crucial to making quick, rational business decisions. Therefore, the BI process integrated within an organisation's environment not only provides a structured means of understanding the available information and ensuring its quality, consistency, and relevance, but also improves every-day operations, creates inter-correlations between business functions and eventually brings long-range profitability and competitiveness.

It is important to highlight that a key issue is to correctly introduce and use BI. Critical success factors are also appropriate organisational structure and culture, as well as its process orientation. There is an intense discussion among researchers and practitioners about an efficient model of BI implementation, i.e. Service Oriented Business Intelligence Maturity Model [21], TDWI's Business Intelligence Maturity Model [22], BI Maturity Model [23], AMR Research's Business Intelligence/Performance Management Maturity Model [24], or Gartner's Maturity Model for Business Intelligence and Performance Management [25].

3. Business value of Business Intelligence

Based on the literature review, significant benefits have been identified out of the implementation of the Business Intelligence into business.

Some studies have emphasised that the introduction of BI systems into an organisation implies both technological enhancement and a revolutionary way of performing and managing business activities and decision-making processes [26]. Business intelligence systems pull information from many different sources, such as data warehouses, online-data processing, customer relationship management, and enterprise resource planning, and they convert the data into useful information [4]. Such systems allow full integration across all functionalities of an organisation and increase overall productivity and efficiency. With the abundance of information available that are now made available to the entity, management can use business intelligence systems to finding hidden patterns useful for *what if* analysis, assessing and monitoring performance analysis, ad-hoc reporting, acceleration of innovation-decision process [27–28]. Quantitative analyses show that, through the use of BI systems, the time spent on data collection can be reduced by 3.5 times; and, as a result, the employees can spend more time on analysis and decision-making [29].

BI systems also make it possible to reach unambiguous decisions in the right time and minimise the costs, and they also provide the opportunity to verify and correlate the decisions with the entire enterprise's strategy, and integrate and analyse the data coming from different sources. As a result, they make it easier to reach decisions [30].

Research conducted by D. Bara and N. D. Knezevic proved that Business Intelligence provides its users with increased understanding of complex information, which puts them in the position of making faster and better business decisions and thereby effectively achieving business goals [31]. Furthermore, BI is useful in reducing data and analysis latency that primarily depends on technical solutions (Fig. 3). J. Davis claims that reducing latency at one or more points in the decision-making time continuum can dramatically increase the business value of the decision.

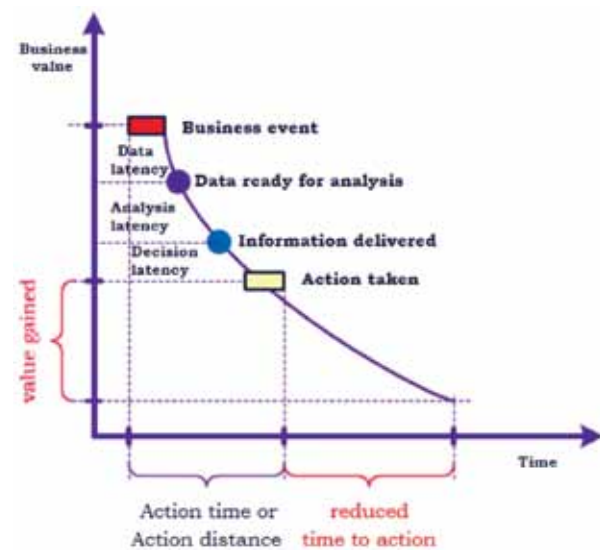


Fig. 3. Benefits resulting from latency reduction

Source: [32] as cited in [31]

Research increasingly suggests that BI is becoming a separate capability that can be leveraged to successfully compete in the marketplace [33]. With the right capabilities, BI can help an organisation predict changes in product demand or detect an increase in a competitor's new product market share and respond quickly by introducing a competing product or new technology [34]. Further benefits of BI systems include cost and time savings, improved information and business processes, better decisions, and superior strategic performance, on a continuum that ranges from local impacts on specific business processes to global impacts on the entire organisation [35].

As adaptability and resilience are crucial competences for thriving in a dynamic global economy, applying BI as new science principle to organisations provides a powerful framework to systems thinking and become proficient at skills, support infrastructure, and foster innovations [36].

Moreover, empirical studies [37–38] are consistent with abovementioned research and confirm a positive impact of BI systems on supplier operations, market segmentation, and sales activities.

4. Case study

The application of the Business Intelligence to decision and innovation support is investigated on the example from a research institute. The author focuses on the problem of information acquisition, integration, and delivery connected with a technological innovation management process in the Institute for Sustainable Technologies – National Research Institute performing in Mazovian District in Poland. The Institute deals with enhancing the innovation performance in the areas of machine construction and maintenance, and technical and environmental safety through design, development, and production of unique systems, technologies, test and research apparatus, and devices for the industry and R&D sector.

According to the institute experts, the main information sources were stored in many traditional and distributed individual computer systems. Depending on the need, the distributive information regarding research, publications, projects, finances was incorporated from various data sources and formats. Therefore, the BI-based computer platform was introduced in order to support the Institute in efficient exchange, diffusion, and transfer of knowledge and innovations. The functionalities of the platform, based on the Business Intelligence software *Metabase* providing big data insights and visualisations, were presented in work [39], and it has been extended since then.

The platform consists of a scientific information system and knowledge bases containing information related to innovativeness (i.e. complex assessment of technological products, Business Intelligence, innovation financing, the economy innovativeness) and computer applications intended for interdisciplinary research (GeneratInn), remote communication (TrueConf), enterprise resource planning (ERP), the management of scientific journals (JUMS), the management of client relations (CRM), and web interviewing (I-Survey) (Fig. 4).

The BI-based tool implemented in the Institute supports technological innovation processes and encourages the transfer of research results into business practice. Moreover, the platform enables multi-criteria report generation, historical and analytical reporting data sharing, and knowledge dissemination. The problems that often occur in decision making process, such as incomplete or implicit information, the lack of an integrated IT system, or inappropriate heuristics are restricted through the use of the platform.

Conclusions

The ability of a company to learn and adapt to its competitive environment is attained through the acquisition of a Business Intelligence-based process that involves many separable components, and it integrates data across the entire organisation to increase overall

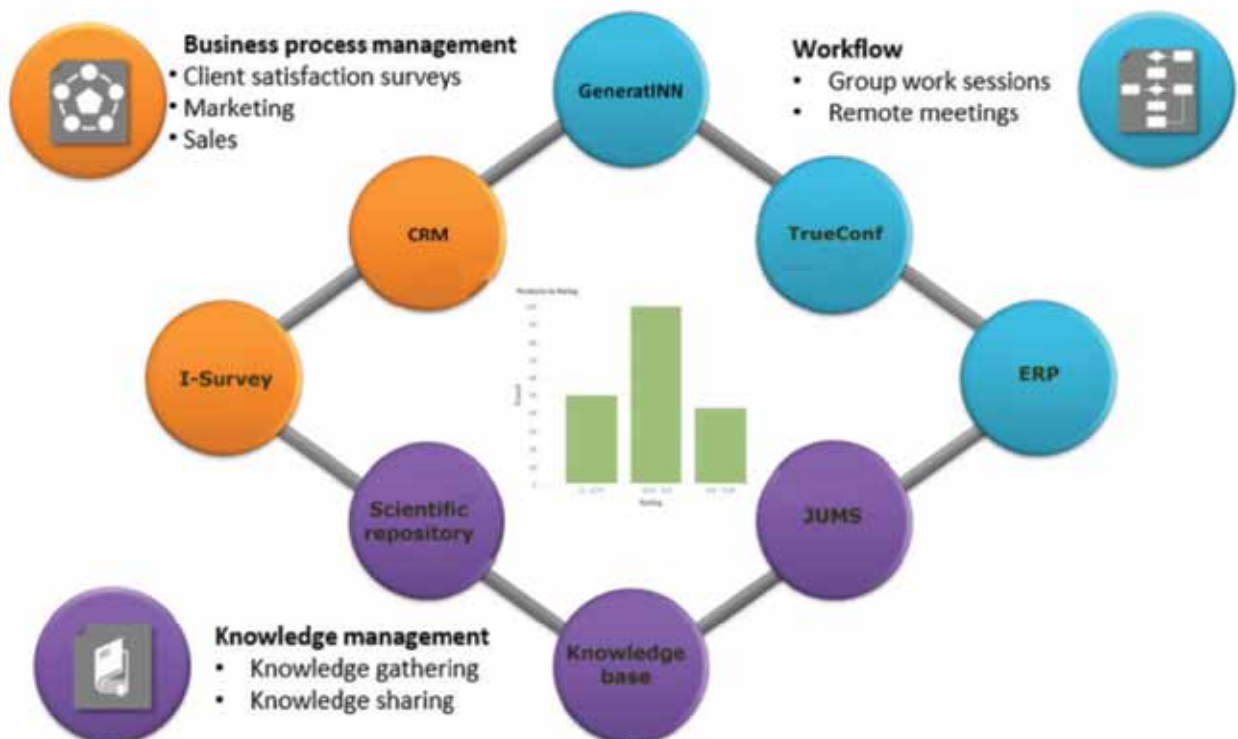


Fig. 4. Structure of BI-based information system

efficiency and improve innovation development. The Business Intelligence process implemented within an organisation deals with information overload and inadequate, incorrect, inconsistent, and misleading information and enables one to efficiently support evidence-based decision making.

However, sometimes shallow understanding of the BI concept might lead to its failure in implementation in real business environment. Therefore, it is important to stress that only the synergy derived of the combination of strategic management knowledge, computer science, and HR management brings a real Business Intelligence into a technological organisation and brings business value measured in revenue growth and innovativeness.

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