Business Intelligence Systems: State-of-the-art Review and Contemporary Applications

Article · January 2009

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BUSINESS INTELLIGENCE SYSTEMS: STATE-OF-THE-ART REVIEW AND CONTEMPORARY APPLICATIONS

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ABSTRACT

Recently business intelligence (BI) applications have been the primary agenda for many CIOs. However, the concept of BI is fairly new and to date there is no commonly agreed definition of BI. This paper explores the nebulous definitions and the various applications of BI through a comprehensive review of academic as well as practitioner's literature. As a result, three main perspectives of BI have been identified, namely the management aspect, the technological aspect, and the product aspect. This categorization gives researchers, practitioners, and BI vendors a better idea of how different parties have approached BI thus far and is valuable in their, design, planning, and implementation of a contemporary BI system in the future. The categorization may even be a first effort towards a commonly agreed definition of BI.

Keywords - Business Intelligence Systems, Review, Evolution, BI Applications

1. INTRODUCTION

The business intelligence (BI) market has recently experienced high growth as vendors continue to report substantial profits [1, 2]. The BI applications have emerged as the top spending priority for many CIOs and remain the most important technologies to be purchased [3, 4, 5]. CIOs realize that data is one of their more valuable assets because data is used to generate information. The increasing needs for prompt decision making leads to the generation of information at an increasing pace. Data analysis, reporting, and query tools in BI systems can help business users wade through a sea of data to generate valuable information from it.

With its rapid growth, business intelligence as a relatively new area in information system [6] warrants academic attention [7]. However, most of the BI literature has come from within the business world, the IT industry, and vendors [8]. Academic research within the information system field is still at an early stage [8, 9, 10] and so there is no commonly agreed definition of BI. Vitt *et al*. acknowledged that the term is multifaceted and is "*used by different pundits and software vendors to characterise a broad range of technologies, software platforms, specific applications, and processes*" [6]. Thus it is a content-free expression and means different things to different people. In view

of this, this paper first presents the various definitions and categories of BI and suggests how the categories can fit into different dimensions of BI.

2. BUSINESS INTELLIGENCE

According to Gibson *et al,* the term *business intelligence* and its key concepts originated with the Gartner Research in 1989 [7]. Howard Dresner of Gartner Research, who is also widely recognised as the father of BI, first coined the term as "*a broad category of software and solutions for gathering, consolidating, analysing and providing access to data in a way that lets enterprise users make better business decisions*" [7]. However, this research found that the term *business intelligence* was used as early as 1958 by Luhn in an IBM journal article entitled "A Business Intelligence System". Using a selective dissemination of information (SDI) technique, Luhn's paper presents a concept which is similar to the modern notion of business intelligence. The following is the original definition from Luhn [11]:

> *"Business is a collection of activities carried on for whatever purpose, be it science, technology, commerce, industry, law, government, defense, et cetera. The communication facility serving the conduct of a business (in the broad sense) may be referred to as an intelligence system. The notion of intelligence is also defined here, in a more general sense, as "the ability to apprehend the interrelationships of presented facts in such a way as to guide action towards a desired goal."*

Since then, leading vendors and prominent authors have used various other definitions used to capture the essence of BI. These definitions are summarized in Table 1. A comparison of the definitions reveals that they generally fall into three main categories, namely the *management (a.k.a. process)* aspect, the *technological* aspect, and the *product* aspect. The management and the technological aspects recognizes the traditional separation between technical and managerial approaches and are in line with Petrini and Pozzebon's observation [12]. Following Chang's suggestion, the third aspect (i.e., product) is added to capture the view of those who see BI from a solution's perspective [13]. Table 2 categorizes existing definitions of BI using the three categories found here.

An interesting finding worth mentioning here is the fact that while some definitions fall strictly into one category, others span two or three categories. This highlights the currently multi-faceted definition of BI, and hence the lack of agreement on how different parties perceive a BI system.

Table 1: Summary of varied BI definitions (Source: Developed for this research)

BI Vendor / Author	Definition of BI
Turban *et al.* (2007)	An umbrella term that encompasses tools, architectures, databases, data warehouses, performance management, methodologies, and so forth, all of which are integrated into a unified software suite.
Moss and Atre (2003)	It 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.
Chang (2006)	The accurate, timely, critical data, information and knowledge that supports strategic and operational decision making and risk assessment in uncertain and dynamic business environments. The source of the data, information and knowledge are both internal organisationally collected as well as externally supplied by partners, customers or third parties as a result of their own choice.
Gangadharan and Swami (2004)	The result of in-depth analysis of detailed business data, including database and application technologies, as well as analysis practice.
Kulkarni and King (1997)	A product of analysing business data using business intelligence tools. It emerges as a result of this analysis.
Moss and Hoberman (2004)	The processes, technologies, and tools needed to turn data into information, information into knowledge and knowledge into plans that drive profitable business action. BI encompasses data warehousing, business analytics tools and content/knowledge management.
Adelman and Moss (2000)	A term encompasses a broad range of analytical software and solutions for gathering, consolidating, analysing and providing access to information in a way that is supposed to let an enterprise's users make better business decision.
Gartner Research (Hostmann 2007)	An umbrella term that includes the analytic applications, the infrastructure and platforms, as well as the best practices.
IBM (Whitehorn & Whitehorn 1999)	An umbrella term that broadly covering the processes involved in extracting valuable business information from the mass of data that exists within a typical enterprise.
Business Objects (Business Objects 2007)	The use of an organisation's disparate data to provide meaningful information and analysis to employees, customers, suppliers, and partners for more effective decision making.
Cognos (Cognos 2007)	Business intelligence brings people and data together, offering a variety of ways to see the information that backs fact-based decision-making.
SAS Institute (Ing 2007)	Delivering the right information to the right people at the right time to support better decision making and to gain competitive advantage.
Oracle (Oracle 2007)	A portfolio of technology and applications that provides an integrated, end-to-end Enterprise Performance Management System, including financial performance management applications, operational BI applications, BI foundation and tools, and data warehousing.
Informatica, Teradata, MicroStrategy (Markarian, Brobst & Bedell 2007)	An interactive process for exploring and analysing structured, domain-specific information (often stored in a data warehouse) to discern trends or patterns, thereby deriving insights and drawing conclusions.

Table 2: Three approaches to the definition of BI (Source: Adapted from [12], [13])

Approach	Managerial/Process	Technological	Product
Definition	Focus on the process of gathering data from internal and external sources and of analysing them in order to generate relevant information for improved decision making.	Focus on the tools and technologies that allow the recording, recovery, manipulation and analysis of information.	Describe BI as the emerging result/product of in-depth analysis of detailed business data as well as analysis practices using BI tools.
Author	Whitehorn & Whitehorn (1999); Business Objects (2007); Cognos (2004); SAS Institute (2007); Moss & Hoberman (2005); Hostmann (2007); Oracle (2007); Turban *et al*. (2007); Markarian, Brobst & Bedell (2007)	Moss & Atre (2003); Moss & Hoberman (2004); Adelman & Moss (2000); Turban *et al*. (2007); Oracle (2007); Hostmann (2007) * Note: The definition of Hostmann (2007) and Moss & Hoberman (2005) spans across both process and technological approaches.	Chang (2006); Gangadharan & Swami (2004); Kulkarni & King, (1997); Turban *et al*. (2007) * Note: The definition of Turban *et al*. (2007) spans across all three approaches.

3. ADDRESSING THE MULTI-FACETED DEFINTION OF BUSINESS INTELLIGENCE

From the *technological* standpoint, BI is considered as a broad category of tools, software, solutions, and technologies that enables decision-makers to find, accumulate, organize, and access a wider range of information from disparate data sources [15, 18, 19, 25]. In this context, the emphasis of BI is not on the process itself, but on the technologies that support the gathering, storage, consolidation, analysis, and mining of corporate data. The desired output is the unveiling of 'insights' that might be deeply embedded in the data, if there is a right mix of data warehousing and data mining [27].

The *managerial* approach presents BI as a *process* in which data from both internal and external sources are integrated so as to generate actionable information for improved decision support, and to realise the benefits of the deployment of integrated transaction processing systems and enterprise applications [18, 20, 22, 23, 24]. So, the primary focus is on the coordination and management of the process by which different information sources from diverse operational and transactional systems (both inside and outside the company) can be integrated and analysed coherently to support the decision making process [12].

From the perspective of the *product* approach, BI is deemed to be a product (i.e., a result) emerging from advanced processing of high-quality data, information and knowledge, and analytical practices that support decision-making and performance assessment [13]. In this regard, various analytical and mining tools from BI vendors such as Cognos, Business Objects, and the SAS Institute are applied. The sources of data include those supplied from operational, transactional and legacy systems within the organisation and from suppliers, business partners, customers or third parties such as government agencies, industry benchmarks, and information service providers [13].

In order to clearly define the meaning of the term *business intelligence* in the light of these three interpretations, this study suggests that the *technological* aspect of BI to be considered as a *BI System*, whereas the *process* perspective is regarded as the *implementation* of BI systems. The product perspective is the *result (i.e. actionable information)* of analysis of business data which originated from various sources. The characteristics of *actionable information* are described in Table 3.

Table 3: Characteristics of BI from the product perspective (Source: Adapted from [28])

Characteristics	Descriptions
Integrated	Must have a single, enterprise-wide view
Data integrity	Information must be accurate and must conform to business rules
Accessible	Easily accessible with intuitive access paths, and responsive for analysis
Credible	Every business factor must have one and only one value
Timely	Information must be available within the stipulated time frame

4. BUSINESS INTELLIGENCE SYSTEMS

According to Reinschmidt and Francoise, a BI system is "*an integrated set of tools, technologies and programmed products that are used to collect, integrate, analyse and make data available*" [29]. Negash states that a BI system "*combines data gathering, data storage, and knowledge management with analytical tools to present complex and competitive information to planners and decision makers*" [10]. The objectives are to enable business managers and analysts of all levels to readily access any data in the organisation and to conduct appropriate manipulation and analysis [17]. Implicit in this definition is the notion that a BI system can improve the timeliness and quality of the input to the decision making process [10], and thus corporate data is transformed from *quantity to quality* [16]. However, the idea is not new and fifty years ago Luhn of IBM wrote that [11]:

> "*Information is now being generated and utilised at an ever-increasing rate because of the accelerated pace and scope of human activities. At the same time the growth of organizations and increased specialization and divisionalization have created new barriers to the flow of information*". Intrinsically, he notes that "*a comprehensive system may be assembled to accommodate all information problems of an organisation. We call this a Business Intelligence System.*"

In other words, a BI system can be viewed as enterprise architecture for an integrated collection of operational and decision support applications and databases [15], which provides various business stakeholders with easy access to the required information. Moreover, it facilitates the analysis and sharing of information and helps with the making of informed business decisions [16]. Negash and Gray argue that a BI system is not revolutionary technology, but rather a "*natural outgrowth of a series of previous systems designed to support decision making*" [9].

In terms of its key components, Fisher *et al.* assert that a BI system is composed of a set of three complementary data management technologies, namely data warehousing, online analytical processing (OLAP), and knowledge discovery which is predominantly aided by data mining techniques [30]. More specifically, Olszak and Ziemba posit that a BI system is composed of the following essential components [31]:

- ETL (Extraction-Transformation-Load) tools that are responsible for data transfer from operational or transaction systems to data warehouses;
- data warehouses to provide some room for thematic storing of aggregated and analysed data;
- OLAP tools which allow users access and which analyse and model business problems and share information that is stored in data warehouses;
- data mining tools for determining patterns, generalisations, regularities and rules in data resources;
- reporting and ad hoc inquiry tools for creating and utilising different synthetic reports; and
- presentation layers that include customised graphical and multimedia interfaces to provide users with information in a comfortable and accessible form.

5. COMTEMPORARY APPLICATIONS OF BI SYSTEMS

To date, BI systems have been applied in various industries such as transportation, banking, health care, retail, manufacturing, and pharmaceuticals. Table 4 depicts the contemporary applications of BI systems in various areas.

Table 4: Contemporary applications of BI systems
(Source: Adapted from [32], [33], [34], [35], [36])

BI Applications	Benefits
Transportation Industry • Generally, transportation service providers utilize several tools and platforms provided by Business Intelligence (BI) vendors which enabling the delivery of information to decision makers such as Query Tools Standard, Reporting Tools, Online Analytical Processing (OLAP) tools, Data Visualization Tools, and Data Mining Tools. • Airline industry uses text mining to automatically extract useful information from different written resources such as incident reports.	• The direct benefits of the usage of a BI solution in transportation industry are reduction in the turnaround time for preparation of reports, direct and faster access to the data needed to support decision-making, analyze the flow of businesses across services, regions, clients, pricing, currencies, and market factors in time etc. • The huge databases maintained by airlines have limited human interpretation and the terminology appears different to a computer. Thus, discovery of new, previously unknown knowledge can be found in a timely manner by using text mining.

	• An incident report is prepared whenever an event occurs that might lead to a problem. Text mining of airline incident reports can identify potential dilemma. Text mining can be used with this large set of incident data reported to validate predetermined theories and to cull new patterns of knowledge.
Banking Industry • Banking industry relies on the BI platform to make more effective decisions in a few areas such as Customer Analysis, Operations & Financial Analysis, Sales & Marketing Analysis, Promotion Analysis, and Risk & Fraud Analysis.	• BI applications help management to improve operational and strategic decisions based on better and timely information. • Potential customers are identified through the analysis of purchasing data. Cross-selling opportunities will be recognized via analysis of customer behavior.
Health Care Industry • The implementation of BI in health care industry has enabled data to be delivered beyond administrative offices and directly to clinical staffs who can make the most use of it. • In order to foster a broader adoption, interactive and user-friendly interfaces have been designed to provide users with simple and relevant data like the number of patients, treatments needed, and their hospitalization period.	• Business decision making process has become more effective where users can access any type of information with a fast and consistent response time, independent of the data volumes analyzed or questions asked. • The inter-operability application in BI reduces the operation cost in health care industry by eliminating expensive custom-integration in the computing system.
Retail Industry • BI is implemented for demand forecasting in the retail industry by generating reliable estimates for both short term and long term demand based on the available customer data. • Apart from demand forecasting, BI is also used to monitor customer loyalty by evaluating which customers are loyal and which are likely to leave.	• When reliable estimates of customer demand are generated, service and product distribution plans of a company would always be in place to meet its customer expectations. • By monitoring customer loyalty, factors that influence their decisions to stay or go could be determined in order to devise better strategies to retain them.
Manufacturing Industry • BI systems allow manufacturers to track their inventory usage across location and time by using alerts for instant notification of low inventory levels. • Besides this, BI systems allow manufacturers to analyze data from multiple sources in order to set performance goals and create sophisticated profitability and financial models.	• With the functionality of inventory monitoring, manufacturers can reduce over-capacity and ensure sufficient supplies for their production. • Apart from this, BI systems also help manufacturers in financial management by identifying areas where they can increase profits and improve efficiency.
Pharmaceuticals Industry • BI systems help pharmaceuticals companies to identify which products are most profitable and monitor customer behavior in purchasing products.	• By closely tracking sales performance and consumer behavior, pharmaceuticals companies are able to set better marketing strategies and ensure proper allocation of marketing funds.

6. CONCLUSION

This paper has reviewed the nebulous definitions and applications of business intelligence systems. It first addressed the multi-faceted definitions of BI by categorizing them into three main perspectives, namely technological, managerial, and product aspects. Then it outlined the key components of a typical BI system. It is noted that a BI system is not regarded as a completely new system, but an evolutionary, integrated product of a variety of tools and computing techniques. These include but are not limited to data warehousing, online analytical processing, visualization techniques, data mining, data quality, and web technologies. Also, the literature review has demonstrated that applications of BI systems are really broad and can be tailored to various industrial needs. Due to the unique business nature of every industry, organizations have different requirements in their business intelligence systems. As illustrated in Table 4 above, a banking company has significantly different applications of BI systems as compared to a transportation enterprise. Consequently, to ensure a successful BI system implementation, BI stakeholders have to take into account not only the core business needs, but also the substantial benefits a BI system could bring into their organisations rather than the diverse features as trumpeted by BI vendors.

REFERENCES

[1] Gartner Research 2006, Gartner Says Business Intelligence Software Market to Reach $3 Billion in 2009, Press Release, viewed 08 July 2007, <http://www.gartner.com/ press_releases/asset_144782_11.html>.

[2] IDC 2007, Top Ranked Business Intelligence Tools Vendors Maintain Positions, viewed 03 Jul 2007, <http://www.idc.com/getdoc.jsp?containerId= prUS20767807>.

[3] Gartner Research 2007, "Gartner EXP Survey of More than 1,400 CIOs Shows CIOs Must Create Leverage to Remain Relevant to the Business." Retrieved 01/04/2009, from <http://www.gartner.com/it/page.jsp?id=501189>.

[4] Gartner Research 2008, "Gartner EXP Worldwide Survey of 1,500 CIOs Shows 85 Percent of CIOs Expect "Significant Change" Over Next Three Years." Retrieved 01/04/2009, from <http://www.gartner.com/it/page.jsp?id=587309>.

[5] Gartner Research 2009, "Gartner EXP Worldwide Survey of More than 1,500 CIOs Shows IT Spending to Be Flat in 2009." Retrieved 01/04/2009, from <http://www.gartner.com/it/page.jsp?id=855612>.

[6] Vitt, E, Luckevich, M & Misner, S 2002, *Business Intelligence, Making Better Decisions Faster*, Microsoft Press.

[7] Gibson, M, Arnott, D, Jagielska, I & Melbourne, A 2004, 'Evaluating the Intangible Benefits of Business Intelligence: Review & Research Agenda', *Proceedings of the 2004 IFIP International Conference on Decision Support Systems (DSS2004): Decision Support in an Uncertain and Complex World*, pp. 295-305.

[8] Jagielska, I, Darke, P & Zagari, G 2003, 'Business Intelligence Systems for Decision Support: Concepts, Processes and Practice', paper presented at the 7th International Conference of the International Society for Decision Support Systems.

[9] Negash, S & Gray, P 2003, 'Business Intelligence', paper presented at the Proceedings of the Ninth Americas Conference on Information Systems (AMCIS), Tampa, Florida.

[10] Negash, S 2004, 'Business Intelligence', *Communications of the Association for Information Systems,* vol. 13, pp. 177-195.

[11] Luhn, HP 1958, 'A Business Intelligence System', *IBM Journal of Research and Development,* vol. 2, no. 4, pp. 314-319.

[12] Petrini, M & Pozzebon, M 2004, 'What Role Is "Business Intelligence" Playing in Developing Countries? A Picture of Brazilian Companies', *Cahier du GReSI,* vol. 4, p. 16.

[13] Chang, E 2006, 'Advanced BI Technologies, Trust, Reputation and Recommendation Systems', presented at the 7th Business Intelligence Conference (Organised by Marcus Evans), Sydney, Australia.

[14] Turban, E, Sharda, R, Aronson, J & King, D 2007, *Business Intelligence*, Prentice Hall; 1 edition, New Jersey.

[15] Moss, L & Atre, S 2003, *Business IntelligenceRoadmap: The Complete Lifecycle for Decision-Support Applications*, Addison-Wesley, Boston, MA.

[16] Gangadharan, GR & Swami, SN 2004, 'Business Intelligence Systems: Design and Implementation Strategies', paper presented at the 26th International Conference Information Technology Interfaces ITI.

[17] Kulkarni, J & King, R 1997, *Business Intelligence Systems and Data Mining*, SAS Institute.

[18] Moss, L & Hoberman, S 2004, *The Importance of Data Modeling as a Foundation for Business Insight*, Teradata.

[19] Adelman, S & Moss, L 2000, *Data Warehouse Project Management*, Addison-Wesley, Upper Saddle River, NJ.

[20] Whitehorn, M & Whitehorn, M 1999, *Business Intelligence: The IBM Solution Datawarehousing and OLAP,* Springer-Verlag, NY.

[21] Business Objects, 2007, *About Business Intelligence,* viewed 12 Nov 2007, <http://www.businessobjects.com/ businessintelligence/default.asp?intcmp=ip_company2>.

[22] Cognos 2007, *Cognos 8 Business Intelligence: What Is Business Intelligence?*, Cognos Corporation, viewed 08 July 2007, <http://www.cognos.com/products/cognos8business intelligence/business-value/what-is-business-intelligence.html>.

[23] Ing, S 2007, *A Strategic Approach to Intelligence*, SAScom Magazine, viewed 08 July 2007, <http://www.sas.com/news/sascom/2007q3/column_ nextpractices.html>.

[24] Oracle 2007, *Oracle Business Intelligence and Enterprise Performance Management*, viewed 12 Nov 2007, <http://www.oracle.com/solutions/business_ intelligence/index.html>.

[25] Markarian, J, Brobst, S & Bedell, J 2007, *Critical Success Factors Deploying Pervasive BI (Joint white paper)*, Informatica, Teradata, MicroStrategy, USA. viewed 10 July 2008, http://www.teradata.com/t/pdf.aspx?a=83673 &b=174325

[26] Hostmann, B 2007, 'Business Intelligence Scenario', paper presented at the Gartner Business Intelligence Summit, London.

[27] Marakas, GM 2003, *Modern Data Warehousing, Mining, and Visualization: Core Concepts*, Prentice Hall.

[28] Ponniah, P 2001, *Data Warehousing Fundamentals*, Wiley-Interscience, New York, USA.

[29] Reinschmidt, J & Francoise, A 2000, *Business Intelligence Certification Guide*, IBM, International Technical Support Organization, San Jose, CA.

[30] Fisher, CW, Lauria, E, Chengalur-Smith, I & Wang, RY 2006, *Introduction to Information Quality*, MITIQ Press, Cambridge, MA.

[31] Olszak, C & Ziemba, E 2007, 'Approach to Building and Implementing Business Intelligence Systems', *Interdisciplinary Journal of Information, Knowledge, and Management,* vol. 2, pp. 135-148.

[32] Mohamed Sheriff, n.d., *Application of Business Intelligence in Transportation for a Transportation Service Provider*, Business Analyst, Satyam Computer Services Ltd, viewed 14 July 2009, <http://whitepapers.zdnet.com/abstract.aspx?docid =386490

[33] MicroStrategy, Inc 2009, *MicroStrategy Business Intelligence Solutions – Banking Solutions*, viewed 14 July 2009, <http://www.microstrategy.com/Solution/ ByIndustry/Banking.asp>

[34] Tapscott D, Business Intelligence for the Health Care Industry: Actionable Insights for Business Decision Makers. Information Builders, Everyone Sells: The Value of Business Intelligence in Retail.

[35] MicroStrategy, Business Intelligence and Manufacturing: Major Applications of Business Intelligence Software in The Manufacturing Industry.

[36] MicroStrategy, Business Intelligence and Pharmaceuticals: Major Applications of Business Intelligence Software in the Pharmacy.