BUSINESS INTELLIGENCE
State of the Art, Trends, and Open Issues

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Abstract: Business Intelligence (BI) is one emergent area of the Decision Support Systems (DSS) discipline. Over the last years, the evolution in this area has been considerable. An overview of some aspects of the area is presented in this article. The roots of BI and its usual associations with Knowledge Management Systems (KMS), Competitive Intelligence (CI), and Artificial Intelligence (AI) are introduced. From the literature review, it was observed that the definition of an underlying structure on the area is missing. Therefore, a framework for BI is defined. The state of the art of BI research field was made, presenting recent trends and open issues for research.

1 INTRODUCTION

BI can be presented as an architecture, tool, technology or system that gathers and stores data, analyzes it using analytical tools, and delivers information and/or knowledge, facilitating reporting, querying, and, ultimately, allows organizations to improve decision making (Clark *et al.,* 2007; Kudyba & Hoptroff, 2001; Michalewicz *et al.*, 2007; Moss & Shaku, 2003; Negash, 2004; Raisinghani, 2004; Thierauf, 2001; Turban *et al.*, 2008). To put it shortly, Business Intelligence (BI) can be defined as the process that transforms data into information and then into knowledge (Golfarelli *et al.*, 2004). More recently, Michalewicz (Michalewicz *et al.*, 2007) presented the notion of Adaptive Business Intelligence, incorporating Artificial Intelligence (AI) with BI. Owing to the wide variety of concepts presented in the literature, a framework is needed.

Being rooted in the Decision Support Systems (DSS) discipline, BI has suffered a considerable evolution over the last years and is, nowadays, an area of DSS that attracts a great deal of interest from both the industry and researchers (Arnott & Pervan, 2008; Clark *et al.*, 2007; Hannula & Pirttimäki, 2003; Hoffman, 2009; Negash, 2004; Richardson *et al.*, 2008; Richardson *et al.*, 2009). BI has strong associations with Knowledge Management (KM) and Competitive Intelligence (CI) (Clark *et al.,*

2007; Liebowitz, 2006; Negash, 2004; Turban *et al.*, 2008; Zeller, 2008). Despite being treated as independent areas, there is the need to consider looking into the intersections between them.

This paper contributes to the design of a framework for BI. The paper contributes, moreover, to a better understanding of BI roots and connected areas. It also helps to get an insight on research on BI, and on some trends and open issues.

The paper is organized as follows: business intelligence roots and associations are presented in section Two and an overview of research on BI is presented in section Three; in section Four, a framework for Business Intelligent is introduced; in section Five, trends and open issues are pointed out; in section Six, conclusions and future investigation directions are mentioned.

2 BUSINESS INTELLIGENCE ROOTS AND ASSOCIATIONS

The roots for Business Intelligence (BI) can be found in the field of Decision Support Systems (DSS) which "is the area of the information systems (IS) discipline that is focused on supporting and improving managerial decision-making" (Arnott & Pervan, 2008). DSS can also be presented as a computer-based solution that can be used to support
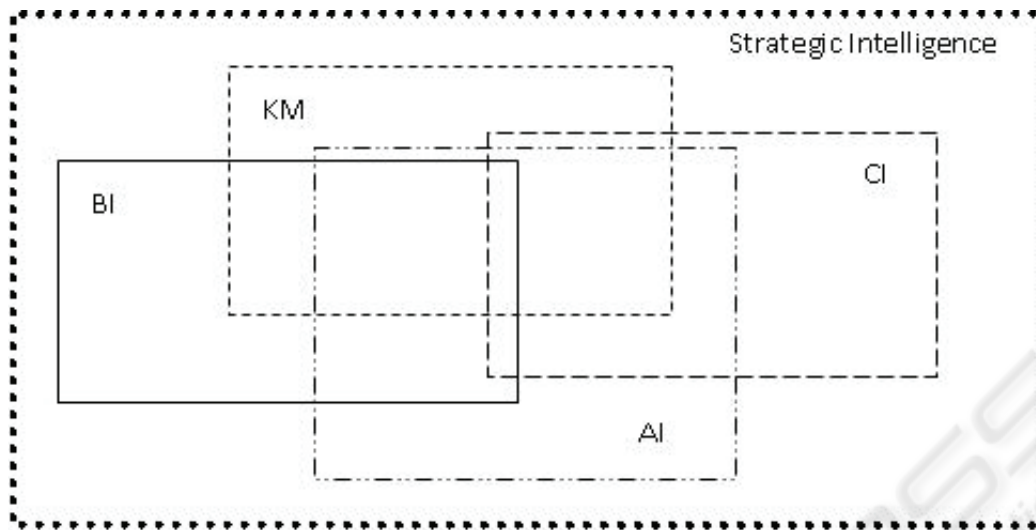
Figure 1: BI Associations.

complex decision making, and solving complex, semi-structured, or ill-structured problems (Nemati *et al.,* 2002; Shim *et al.*, 2002). The term BI has replaced other terms such as executive information systems and management information systems (Negash, 2004; Turban *et al.*, 2008). Nowadays it can be said that BI is an area of DSS that attracts a great deal of interest. BI refers to Information Systems aimed at integrating structured and unstructured data in order to convert it into useful information and knowledge, upon which business managers can make more informed and consequently better decisions.

BI is associated with Competitive Intelligence (CI) and Knowledge Management Systems (KMS) (Clark *et al.,* 2007; March & Hevner, 2007; Negash, 2004; Thierauf, 2001; Turban *et al.*, 2008). Negash (Negash, 2004) presents CI as a branch of BI, and refers to it as "a systematic and ethical program for gathering, analyzing and managing external information that can affect company's plans, decisions and operations" (Negash, 2004). KMS refers to "IT-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application." (Alavi & Leidner, 2001). It can be argued that BI and KMS are not disparate systems, but that they are complementary as they share elements required to support managerial decision making (Clark *et al.,* 2007; Liebowitz, 2006). Moreover, BI, KMS, CI, and AI should be aggregated so as "to provide value-added information and knowledge toward making organizational strategic decisions" (Liebowitz, 2006), in order to achieve Strategic Intelligence for businesses. These associations are depicted in Figure 1.

"*Organizational performance often depends more on an ability to turn knowledge into effective action and less on knowledge itself*" (Alavi & Leidner, 2001). Deeper studies evolving the associations presented could conduct to an understanding of how BI could lead decision makers to attain this ability.

3 RESEARCH ON BUSINESS INTELLIGENCE

Despite wide acceptance that the term BI was coined by Gartner in 1989 (Power, 2007; Turban *et al.*, 2007; Turban *et al.*, 2008; Zeller, 2007), the first reference to Business Intelligence was made by Lunh (Lunh, 1958), and several publications on BI can be found between 1958 and 1989. Lately, the use of the term BI has been growing (Arnott & Pervan, 2008; Hannula & Pirttimäki, 2003), and there can be found a significant number of publications that focus on this subject, as well as professional associations whose main goal is to disseminate the use of BI by organizations. Software vendors have defined positions on the market with diversified BI software packages and open source platforms are also available. As a result, the market tends to stabilize (Richardson *et al.,* 2008; Richardson *et al.*, 2009).

Negash refers, in 2004, that Information Systems research in the BI field is, by that time, scarce (Negash, 2004). Since then, scientific investigation is growing at a significant rate, as can be confirmed
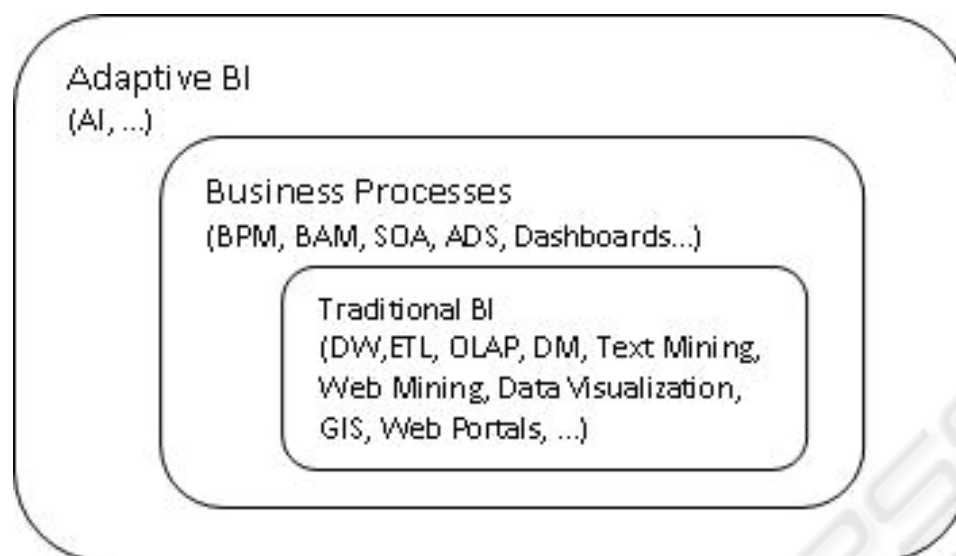
Figure 2: A schematic view of BI approaches.

with a search in some of the most known scientific sources. A great number of publications on BI appears in diversified publications, but new journals focused specifically on BI are arrising. The literature presents research that explores several aspects of BI. To mention just a few: (Arnott & Pervan, 2008; Clark *et al.*, 2007; March & Hevner, 2007) include in their research references to the role of BI in the DSS and IS disciplines, (Hannula & Pirttimäki, 2003) present an empirical study about BI activities on Finnish Companies, (Pervan & Arnott, 2006) present an analysis on research in data warehousing and BI between 1990 and 2004, (Cheng *et al.,* 2009; Li *et al.*, 2008) develop BI applications to specific managerial problems, (Elbashir *et al.,* 2008; Lin *et al.*, 2009) intend to develop models to evaluate BI systems, (Hobek *et al.,* 2009; Watson, 2009) are concerned about the role that people play on a BI project.

BI presents a vast area of research. Therefore, it is difficult to be comprehensive on the presentation of the research that is being done. Nevertheless, a framework for BI, trends on BI, and several research issues emerge from the literature.

4 A FRAMEWORK FOR BI

As pointed out above, BI refers to information systems aimed at integrating structured and unstructured data in order to convert it into useful information and knowledge, upon which business managers can make more informed and

consequently better decisions. There are different approaches to BI. A schematic view of the main approaches that are presented in the literature is depicted in Figure 2.

The traditional approach of BI is concerned with, data aggregation, business analytics and data visualization (Kudyba & Hoptroff, 2001; Raisinghani, 2004; Turban *et al.*, 2008). According to this approach, BI explores several technological tools, producing reports and forecasts, in order to improve the efficiency of the decision making. Such tools include Data Warehouse (DW), Extract-Transform and Load (ETL), Online Analytical Processing (OLAP), Data Mining (DM), Text Mining, Web Mining, Data Visualization, Geographic Information Systems (GIS), and Web Portals.

On the next level there is a concern with the integration of business processes on BI (Eckerson, 2009; Golfarelli *et al.*, 2004; Turban *et al.*, 2008; Wormus, 2008; Zeller, 2007). According to this approach, "BI is a mechanism to bridge de gap between the business process management to the business strategy" (Zeller, 2008). In addition to all the tools in traditional BI, tools such as Business Performance Management (BPM), Business Activity Monitoring (BAM), Service-Oriented Architecture (SOA), Automatic Decision Systems (ADS), and dashboards, are included.

Adaptive Business Intelligence is concerned with self-learning adaptive systems, that can recommend the best actions, and that could learn with previous decisions, in order to improve continuously

(Michalewicz *et al.*, 2007). Artificial Intelligence is, in this manner, incorporated on BI systems.

5 TRENDS AND OPEN ISSUES

It is difficult to be comprehensive on the coverage of such a vast area hence a choice was made to highlight the trends and research issues considered most relevant.

One trend is Pervasive BI , or BI for the masses (Eckerson, 2008; Lunger, 2008; Negash, 2004). There is a concern on delivering BI to all levels of an organization. Another trend is Real-time BI or Operational BI, which pretends to deliver information based on real time data, as opposed to historical data (Brobst & Pareek, 2009; Klawans, 2008; Negash, 2004). Other point concerns on how to deal with the increasing quantities of data available for BI systems (Klawans, 2008; Strenger, 2008). Emphasis is also being placed on cultural aspects and on the human side of BI (Hobek *et al.,* 2009; Lin *et al.*, 2009; Watson, 2009).

Some research issues that have been identified in the literature in DSS could also be explored in the BI area, namely, integration issues, analysis of usability, assessment, return on investment, and technological issues. A research area could analyze and evaluate technologies that are potentially applicable to analysis and understanding (Nemati *et al.*, 2002). Powerful analytical tools, such as DM, remain too complex and sophisticated for the average consumer, therefore, another area of research could be the development of more effective human-computer interfaces (Clark *et al.,* 2007; March & Hevner, 2007).

6 CONCLUSIONS AND FUTURE WORK

According to the present analysis, BI is an emergent dynamic area. The presented framework can be used as the basis for subsequent research, since it helps to operationalize the actual state of the art. Research could be developed along all the presented levels (Figure 2), since there are open issues on all of them. The associations with knowledge management, competitive intelligence, and artificial intelligence, have a great potential for development, and for research.

Investigation areas on BI could include integration issues, analysis of usability, assessment, return on investment, and technological issues.

As future work the authors will explore the usage of DM tools on BI, considering the Knowledge Discovery on Databases (KDD) process, as presented by (Fayyad *et al.*, 1996). It is their belief that only the full integration of the KDD process on BI can conduct to an effective usage of DM on BI.

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