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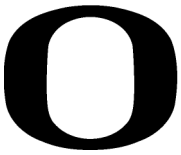

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Identifying Key Components of Business Intelligence Systems and Their Role in Managerial Decision making

CAPSTONE REPORT

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Abstract

Business intelligence systems by definition are used to create knowledge to enable business decision-making (Olszak & Ziemba, 2006). This study examines literature published between 2001 to 2010 and identifies the four most common components of a business intelligence system; ETL tools, data warehouses, OLAP techniques, and data-mining. Functions that each component performs are detailed. How each component is used to facilitate managerial decision-making at three levels of organizational management (operational, tactical and strategic) is described.

Keywords: business intelligence systems, OLAP, ETL, data-mining, data warehouse, decision-making

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Introduction to the Literature Review

Purpose

"Business intelligence is designed to support the process of decision-making" (Arnott, Gibson, & Jagielska, 2004, p. 296). Arnott et al. (2004) define the role of business intelligence "to extract the information deemed central to the business, and to present or manipulate that data into information that is useful for managerial decision support" (p. 296). Negash (2004) notes that business intelligence is "used to understand the capabilities available in the firm; the state of the art, trends, and future directions in the markets, the technologies, and the regulatory environment in which the firm competes; and the actions of competitors and the implications of these actions" (p. 177).

Business intelligence systems combine operational data with analytical tools to present complex and competitive information to planners and decision makers, in order to improve the timeliness and quality of the decision-making process (Negash, 2004). A business intelligence system is a set of tools, technologies and programmed products that are used to collect, integrate, aggregate and make data available (Koronios &Yeoh, 2009). Business intelligence systems provide actionable information delivered at the right time (Negash, 2004) when decisions need to be made.

The beginning point of this study is to identify the key components that are common to all business intelligence systems. Business intelligence systems, as the term is typically used, is often confused with a specific "off the shelf" piece of hardware and with a software solution that businesses can simply purchase, turn on and utilize to create business intelligence to facilitate the decision-making process; but business intelligence systems is really just an umbrella term (Levinson, 2006). In reality, business intelligence systems refers to a vast collection of tools and

techniques that can consist of dozens of hardware solutions with expensive software at one end of the spectrum and as little as one server with specialized software on the other end. While business needs dictate the necessity for different components and complexity for a business intelligence system, all business intelligence systems require, at a minimum, four specific components to produce business intelligence. These components are described throughout the larger literature to the degree that they are now taken-for-granted and they include (a) data warehouses, (b) ETL tools, (c) OLAP techniques and (d) data mining (Olszak & Ziemba, 2006).

Business intelligence system components are used to support a set of managerial decision-making actions (Cella, Golfarelli & Rizzi, 2004). Actions are described as: (a) acquire (e.g. supported by the data warehousing component), (b) gather (e.g. supported by the extract-transform-load component), (c) analyze (e.g., supported by the use of on-line analytical products) and (d) report (e.g., supported by the data-mining component) data that come from different and dispersed sources (Olszak & Ziemba, 2007). The purpose of this study is framed in two stages. Stage One involves identification and description of aspects of each of the four most common components of a BI system. Once aspects are identified and described, they are aligned with the relevant managerial decision-making action of (a) acquiring, (b) searching/gathering, (c) analyzing, and (d) delivery of information. The goal of the study is to propose ways to better facilitate the managerial decision-making process.

Problem

The ability of a corporation to take advantage of all available information through the decision-making process is a critical component for its success (Cody, Kreulen, Krishna & Spangler, 2002). Corporations use business intelligence systems mainly for corporate

management, monitoring of business activities, reporting, planning and decision-making support, as well as optimization of customer relations (Olszak & Ziemba, 2007). More than ever, information supports all critical business decisions (Matei, 2010). Business intelligence seeks to provide the capability to access and analyze information (Matei, 2010), so that massive data from many different sources of a large enterprise can be integrated into a coherent group to provide a 360° view of its business (Koronios & Yeoh, 2009).

Business intelligence is a relatively new term, coined in the early 1990's by Howard Dressner (Watson & Wixom, 2007). Business intelligence can be defined as "a broad collection of software platforms, applications, and technologies that aim to help decision makers perform more effectively and efficiently" (Arnott, Gibson, & Jagielska, 2004, p. 295). At senior managerial levels, business intelligence systems provide the input to strategic and tactical decisions and "at the lower managerial levels... helps individuals do their day-to-day job (operational)" (Negash, 2004, p. 189). On a strategic level business intelligence systems create the information used in the forecasting of future results based on historical results; on the tactical level, they provide a basis for decision making to optimize actions for overall company performance; and on an operational level, business intelligence systems provide just-in-time analysis of departmental performance (Olszak & Ziemba, 2007).

Business intelligence systems can be used to guide and improve decision making at all levels, strategic, tactical and operational (Coman, Duica, Radu, & Stefan, 2010). According to a 2007 Gartner survey of 1,400 CIOs, business intelligence projects were the number one technology priority (Watson & Wixom, 2007), due to their ability to facilitate improved decision making through the delivery of information based on data analysis. A critical component for the success of the modern enterprise is the ability to take advantage of all available information and through the use of analytics such as On-Line Analytical Processing (OLAP) (Cody et al., 2002).

OLAP refers to the techniques of performing complex analysis over the information stored in a data warehouse to transform it into decision information (Shi, Wang, Wu, Xu, & Zeng, 2006).

Although business intelligence systems are widely used in business, research about them is limited (Negash, 2004). It is important for businesses to understand the value of business intelligence systems because such systems support decision making at all levels of management: strategic, tactical and operational through data analysis and delivery (Olszak & Ziemba, 2007).

Significance

According to Arnott et al. (2004), the role of business intelligence is to extract the information deemed central to the business and to present or manipulate that data into information that is useful for the managerial decision support through the use of business intelligence systems. Understanding business intelligence systems enables any organization to implement an analytical approach that transforms data into information, information into knowledge and then knowledge into decisions as illustrated in Figure 1, as shown by Olszak and Ziemba (2007). Factors such as an ever increasing number of very diverse internal and external data sources, the sheer volume of data generated and used in everyday business, complexity of business processes as well as various compliance, privacy and other data related issues, have made cross-organizational data integration and analysis more complex (Marjanovic, 2009).

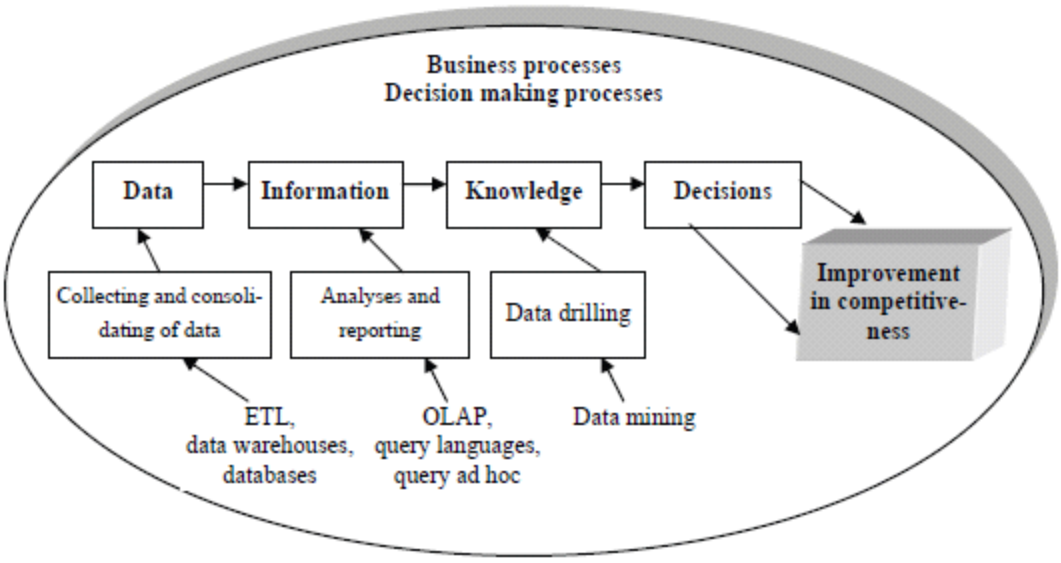

Figure 1. The Role of BI in decision making (Olszak & Ziemba, 2007, Figure 2, p.137)

The use of business intelligence systems has become popular in recent years as an approach to gather and analyze data for business use (Anderson, Fries, & Johansson, 2008). Koronios and Yeoh (2009) believe that this is because business intelligence systems can deliver meaningful data at the right time (when decisions need to be made) to the right location (the area of business that is to be affected) in the right form (the reporting tool that supports the decision being made) (p. 23).

Audience

This study is designed to inform organizational decision makers of the following levels of organizational decision-making: (a) operational, (b) strategic, and (c) tactical. These decision-makers are IT professionals, CIOs and CTOs alike who require the efficient and effective analysis of data "in order to better understand the situation of their business and improv[e] the

decision making process" (Cella, Golfarelli, & Rizzi, 2004, p. 1). According to Watson and Wixom (2007) "business intelligence is currently the top-most priority of many chief information officers" (p. 96).

Outcome

The outcome of this study is structured as a set of set guidelines to enable IT professionals (up to and including CIOs) to better utilize their business intelligence systems. The guide describes the key components of a business intelligence system in three areas: (a) a definition of each of the four most common components (data warehouses, ETL tools, OLAP techniques, and data mining) including identification of detailed aspects; (b) the specific role in the business intelligence system in relation to the relevant managerial decision-making actions, including acquiring/gathering, searching, analyzing, and delivery of information; and (c) how each component can be used to better facilitate business decision making associated with each level of organizations: operational, strategic, and tactical.

Delimitations

Focus. This study details the four most commonly identified components used in business intelligence systems (ETL tools, data warehouses, OLAP techniques, and data mining) that support managerial decision making with a focus in four pre-selected areas: (a) acquiring/gathering (e.g. data warehousing), (b) searching (e.g. extract-transform-load), (c) analyzing (using on-line analytical products) and (d) reporting (data mining) in order to build an understanding of business intelligence systems. This study does not present the best known methods for decision making or detail the different types, brands, or vendors of business intelligence systems as this goes beyond the scope of the purpose of this study.

Time frame. Business intelligence was born within the industrial world in the early 90s and a decade's worth of research has seen naive techniques transform into mature tools (Cella, Golfarelli, & Rizzi, 2004). In order to keep the information relevant to today's business climate and technology only sources published with the last ten years are used in this literature review.

Collection and selection criteria. The sources of literature for this study are primarily derived from academic online databases as well as business journal databases. These databases have a high concentration of peer-reviewed scholarly sources and journal articles that are authored by recognized experts in their respective field of study. Generalized search engines are not used for this study as preliminary searches provided content of little academic value. The one exception to this rule is Google Scholar, a site that searches academic and scholarly databases and provides results with a high degree relevance to the search string provided.

All sources selected for this study are either focused on business intelligence or rooted in the technologies or processes related to the development of information creation for the purpose of business decision making. Preference is given to sources that directly reference business intelligence or business intelligence systems and have a significant portion of the literature detailing the concepts and technologies supporting business intelligence.

Data Analysis Plan Preview

This study is designed as a literature review, "to summarize and evaluate the existing knowledge of [this] topic" (Machi & McEvoy, 2009, p. 4) in order to provide a concise, informed overview of the topic. This overview provides an understanding of the topic that encompasses a large body of literature that is analyzed to produce themes and descriptions of business intelligence system components. The literature used in this study is obtained using both

key words and phrases and evaluated to determine the application and authority of the content. All literature that meets these criteria is evaluated to find similar conceptual frameworks.

This study employs a qualitative research approach to data analysis known as conceptual analysis. A conceptual analysis is a type of analysis that "look[s] at the occurrence of selected terms within a text or texts, [both] implicit as well as explicit" (Busch, De Maret, Flynn, Kellum, Le, Meyers, Saunders, & White, 2010). The analysis is conducted by coding for a low level of generalization as the terms used to find the literature are specific enough to identify and evaluate the commonalities of the text.

Writing Plan Preview

In order to identify the key components of business intelligence systems in an organization, this study assembles, synthesizes and analyzes selected literature to form an understanding of the current knowledge on the topic (Machi & McEvoy, 2009, p. 6). The study is presented in a thematic approach organized around a topic or issue (University of North Carolina, 2010); in this case, the key components of a business intelligence system. The study addresses three related areas, which are the central themes of the inquiry: (1) a definition of each of the four most common components of a business intelligence system (data warehouses, ETL tools, OLAP techniques, and data mining) including identification of detailed aspects; (2) the specific role of each component in the business intelligence system and how; and (3) how each component can be used to better facilitate business decision making associated with each level of management including operational, strategic, and tactical.

Definitions

The terminology used in this literature review is taken from references selected for use in this study. Although many terms used within this review have multiple definitions, the definitions provided here are specific to the field of business intelligence and especially business intelligence systems. Some terms are given further definition in the text of this study.

Acquiring - the automated sequence of collecting heterogenic data from dispersed sources and depositing this acquired data into a common repository such as a data warehouse (Olszak & Ziemba, 2007).

Analyzing - The practice of organizing structured and unstructured data into ordered patterns used to acquire, cleanup and integrate information for business decision making (Negash, 2004).

Business decision making - Actions that define the way a business process is performed at the operational, tactical and strategic level (Hevner & March, 2005).

Business intelligence - "[A]n approach to management that allows an organization to define what information is useful and relevant to its corporate decision making" (Arnott et al., 2004, p. 296).

Business intelligence system - A set of integrated tools, technologies and programmed products used to collect, integrate, analyze, and make data (Koronios & Yeoh, 2010).

Data - Conversations, graphics, images, movies, news items, text, video and web pages used as an input for analysis for the purpose of decision making (Negash, 2004).

Data mining - Tools specifically designed to identify patterns, relationships and rules within the data warehouse (Hevner & March, 2005).

Data warehouse - A subject oriented, collection of data used to support decision making in organizations (Anderson et al., 2008).

Data warehousing - A systematic approach to collecting relevant business in order to organize and validate the data so that it can be analyzed to support business decision making (Cody et al., 2002).

Decision support system (DSS) - A set of tools that analyze data and present it in such a way as to support decisions (Airinei & Homocianu, 2009).

Delivery of information - Task of the presentation component of a business intelligence system. This presentation includes graphics, and multimedia interfaces that allows information to be presented in a comfortable and accessible form (Olszak & Ziemba, 2007).

Extract-Transform-Load (ETL) - Processes and tools used to extract data from legacy systems and external sources then transforming and pre-processing the data into a useful format to load into data ware house structures (Hevner & March, 2005).

Business intelligence hardware - Infrastructure that exists in an organization that is used in decision-making support. This infrastructure includes servers (file and compute), network equipment and workstations (Arnott et al., 2004).

Business intelligence software - Software that is used in an organization for decision-making support. This software includes OLAP, ETL, data-mining and other analytical utilities (Arnott et al. 2004).

On-line analytical processing (OLAP) - Tools that allow analyze multidimensional data known as cubes. Cubes are data that are extracted from the data ware house and used by managers in decision-making situations (Hevner & March, 2005).

Operational decisions - Decisions that are related to and affect the ongoing operations of an organization based on up-to-date financial data, sales and co-operation with suppliers and customers (Olszak & Ziemba, 2007).

Searching - The collection of raw, unprocessed data from a set of source systems and data structures. Data is moved from these sources (internal or external) into a data warehouse through an ETL process to deliver meaning full information for managerial decision support (Watson & Wixom, 2007).

Strategic decisions - Decisions that set objectives and that are made to realize those objectives (e.g. development of future results based on historical results, profitability of offers and the effectiveness of distribution channels) (Olszak & Ziemba, 2007).

Tactical decisions - Decisions related to marketing, sales, finance and capital management. Tactical decisions are often used to support strategic decisions (Olszak & Ziemba, 2007).

Research Parameters

This section details the research design of this study. This section encompasses (a) the research questions used to guide the study, (b) the search report, (c) a list of search terms used to collect the literature references, (d) the evaluation criteria used to determine the relevancy and usability of the references, (e) the detailed approach to documentation used in the research process, (f) the data analysis plan, and concludes with the (g) the writing plan for this literature review.

Research Questions

The research for this study is guided by the following research questions. The questions are designed to deliver a detailed understanding of business intelligence systems as these support four actions in the decision making process:

1. What are the detailed aspects of the most common components of a business intelligence system?

    a. What does each component do?

2. How is each component used in support of four selected managerial decision-making actions?

    1. acquiring/gathering
    2. searching
    3. analyzing
    4. delivery/reporting

Search Strategy Report

The literature for this study is selected from three content areas: (1) key components of business intelligence systems, (2) organizational use of business intelligence systems and (3) the

role of business intelligence system in business decision making. The search strategy is focused on terms used in and associated with the content areas and based on the initial search term *business intelligence*. The initial searches produced hundreds of thousands of results, most of which only referenced business intelligence as a term within the text but did not focus on business intelligence, business intelligence systems or the components of a business intelligence system. Further searches are performed using the *AND* operator and a combination of *business intelligence* and a key term from the list of key terms in this study.

Selected databases and search engines. Searches are performed using the following databases (In alphabetical order).

1. Academic Search Premier
2. Business Source Premier
3. Citeseer
4. Google Scholar
5. Intel Library
6. MetaPress
7. UO Libraries Catalog

Table 1

Database Index Search Results

Database	Amount of time spent searching (rounded in hours)	Results meeting evaluation criteria	Notes
Academic Search Premier	3	7	Searches produced > 10,000 results but relevant results trickled off after the first three pages.

Business Source Premier	3	12	Similar to other sites this database produces thousands of results but trailed off in relevance after the first 5 pages.
CiteSeer	4	21	This site was second only to Google scholar on relevance and ease of use. This search engine produces very fast results.
Google Scholar	6	34	Google Scholar was the easiest to navigate but provided too many sources that didn't provide a full text. The article titles and abstracts are promising a researcher can leverage other sites through this site.
Intel Library	1	0	Articles not in electronic form and many are too specific to the field of semiconductors
MetaPress	1.5	1	Produced many results with promising titles and abstracts but produces limited full text articles
UO Libraries Catalog	2.5	1	Relevance in search results is low and the spectrum of results are the widest of all search engines

Search Terms

Key terms are taken from the initial search of *business intelligence* as a search term as this term produced more relevant sources for business intelligence systems than *business intelligence system*. Each article, based on a key term, is examined for additional key terms and builds the literature search. The following are the key terms used to gather the preliminary search results:

- Business intelligence

- On-line analytical processing (OLAP)
- Extract-transform-load (ETL)
- Data warehouse
- Data warehousing
- Data mining
- Structured data
- Unstructured data
- Business decision making

Evaluation Criteria

The goal of the preliminary search is to define a baseline of literature to ensure that the topic is well researched and that the literature can support the topic. All search results are evaluated for credibility based on the following criteria: (a) is the literature relevant to the topic and focus of the study, (b) is the literature published within the last 10 years, (c) is the literature peer-reviewed, and (d) is the literature authored by an authority in the respective field (Bell & Smith, 2007). Several viable articles are not used due to the inability to provide a permanent link to the article.

Documentation Approach

This study is designed as a literature review, "to summarize and evaluate the existing knowledge of [this] topic" (Machi & McEvoy, 2009, p. 4) in order to provide a concise, informed overview of the topic. This overview provides an understanding of the topic that encompasses a large body of literature that is analyzed to produce themes and descriptions of business intelligence system components. The literature used in this study is obtained using both key words and phrases and evaluated to determine the application and authority of the content.

All literature that meets the criteria detailed in the evaluation criteria section is analyzed to find similar concepts and foundational information with respect to business intelligence system components.

The references produced from the searches are evaluated based on the evaluation criteria and those that are deemed usable are noted and electronically tagged in an Excel spreadsheet. The spreadsheet contains the date, title, search site used to obtain it, and a link to the full length article. The key words/ key terms used in the study are noted as well and used in subsequent literature searches. The key words are also used in the coding process where articles are binned together based on the commonalities of the key words.

First pass searches are performed on the full text in PDF format. This is done prior to a formal coding process. If the first pass of the literature yields results that can support this study then the reference is added to a rolling list of citable references that are kept in full APA format. Once the references are fully vetted then references are printed in paper form and read in full. The text is marked and notes are made that facilitate the coding of information. The references are coded based on the concept that the literature is describing and divided into the four content areas described in this research report. As each reference is cited in this study the literature is added to the annotated bibliography portion of this study if it is a reviewed article as well as added to the reference list.

Data Analysis Plan

References in this study are analyzed using a qualitative research approach known as conceptual analysis. A conceptual analysis is a type of analysis that "look[s] at the occurrence of selected terms within a text or texts, [both] implicit as well as explicit" (Busch et al., 2010). The

analysis is conducted by coding for a high level of generalization as the terms used to find the literature are specific enough to identify and evaluate the commonalities of the text.

This study is based on literature that is selected specific to the topic; this is the first stage of coding performed against the references. The result includes the pre-selection of a way to define and describe the four most common components of a business intelligence system. Further coding is conducted in order to identify detailed aspects of four relevant managerial decision-making actions of (a) acquiring/gathering, (b) searching, (c) analyzing, and (d) delivery of information. Aspects are revealed through application of a conceptual analysis process, which includes an eight step coding procedure, used to analyze selected references and note the occurrence of terms that reside in text and groupings of texts (Busch et al., 2005). The 8 steps used for coding are (Busch et al., 2005):

1. Level of analysis- In this study, the coding is conducted manually for both single words and phrases. The words and phrases used are: data warehouses, ETL, OLAP, data mining, operational decisions, tactical decisions and strategic decisions. The references are searched using these terms and the relevance is very high with high repetition of these terms within the text.

2. Number of concepts to code for- The concepts that are coded for in this study are the four pre-selected most common core components within business intelligence systems: (a) data warehouses, (b) ETL tools, (c) OLAP techniques and (d) data mining and three relevant managerial decision actions: (a) acquiring/gathering, (b) searching, (c) analyzing, and (d) delivery of information).

3. Coding for existence or frequency of a concept- The existence of each concept is coded for versus the mere frequency of the phrase. During the initial review it is observed

that terms used as keywords within the studies are used sparingly and those studies had little relevance to this literature review.

4. Distinguish among concepts- In several references, terms appear both fully written out and in acronym form while still others rephrased terms into general phrases (i.e. *analytical tools* used in place of ETL and OLAP).

5. Developing rules for coding- As a rule this study uses a high level of generalization with respect to coding of concepts and terms, with interpretation also based in contextual analysis. Conceptual and textual analysis treats synonymous meanings equally.

6. Dealing with irrelevant text- Information that is not within the context of grounded theory or purely the opinion of the author are disregarded for this study and not recorded in the coding process.

7. Coding the texts- Coding for this study is performed by hand versus through automated programs.

8. Analyzing the results- Information derived through the seven coding steps described above is analyzed and presented in a manner described in the writing plan.

Writing Plan

The purpose of this study is to identify and describe the aspects of each of the four most common components of a BI system. Once aspects are identified and described, they are aligned with the relevant managerial decision-making action of (a) acquiring/gathering; (b) searching; (c) analyzing; and (d) delivery of information. The goal of the study is to propose ways to better facilitate the managerial decision-making process. In order to do that, this study assembles, synthesizes and analyzes selected literature to form an understanding of the current knowledge on the topic (Machi & McEvoy, 2009, p. 6). After the analysis is completed based on the coding

process detailed in the data analysis of this study, the data is organized using a thematic approach. A thematic approach organizes literature around a topic or issue (University of North Carolina, 2010). Preliminary themes are related to the main areas of inquiry concerning business intelligence and business intelligence systems; they are (a) the four main key components of a business intelligence system; (b) the role that each of the four main components plays in business intelligence particularly in the areas of managerial decision making actions (acquiring/gathering data, searching data, analyzing data, and delivering information); and (c) how each of the four main components can be used to better facilitate business decisions in each of the three main areas of management (operational, strategic and tactical).

The goal of this thematic approach to is to align each component of a business intelligence system with actions that facilitate decision making and then apply them to each of the three main areas of management. This goal is accomplished by creating an outline of the themes identified through the analysis of the references. Below is the outline used to frame the writing approach of this study.

The study is framed using this thematic outline:

Theme one: The four most common components of a business intelligence system.

(a) A definition of each component

(b) Identification of detailed aspects

Theme two: The specific role of each component in the business intelligence system.

(a) How each component is used in selected managerial decision-making actions

1. Acquiring/gathering information

2. Searching information

3. Analyzing information and

4. Delivery of information

Theme three: How each component can be used to better facilitate business decision making at each level of management.

(a) Operational

(b) Strategic

(c) Tactical

Annotated Bibliography

This section contains the references deemed most relevant in the support of understanding business intelligence systems, their most common components and how each of the most common components is used in managerial decision making. The following annotated bibliography contains 20 entries; each entry includes bibliographic information, a summarization, an assessment of credibility and a reflection on how each reference is used in support of this study (Bisignani & Brizee, 2010). All references listed in this annotated bibliography are coded based on the detailed data analysis plan to extract the relevant information used in this literature review.

Airinei, D., & Homocianu, D. (2009). DSS vs. business intelligence.

> **Abstract**. During last forty years, the terminology used for different kinds of information systems has changed, like from Management Information Systems to Decision Support Systems and Executive Information Systems or like from the last ones to Business Intelligence Systems. But much more has happened than just this change of terms, partly because the technology has significantly evolved from internally developed graphical user interfaces to packaged applications that provide users with easy access to data for analysis.
>
> **Comment.** This article summarizes the differences between the decision support systems and business intelligence and business intelligence systems. Aspects gleaned for this study include the definition of business intelligence, what makes business intelligence unique, and the components of a business intelligence system. This article

is deemed credible because it is published in a peer reviewed journal, both authors are PhDs in the field of information systems and the lead author is a professor at the University of Lasi, in Romania.

Arnott, D., Gibson, M., & Jagielska I. (2004). Evaluating the intangible benefits of business intelligence: review & research agenda. *The IFIP TC8/WG8.3 International Conference.* 1-11

Abstract. A Business Intelligence (BI) system is a technology that provides significant business value by improving the effectiveness of managerial decision-making. In an uncertain and highly competitive business environment, the value of strategic information systems such as these is easily recognized. High adoption rates and investment in BI software and services suggest that these systems are a principal provider of decision support in the current marketplace. Most business investments are screened using some form of evaluation process or technique. The benefits of BI are such that traditional evaluation techniques have difficulty in identifying the soft, intangible benefits often provided by BI. This paper, forming the first part of a larger research project, aims to review current evaluation techniques that address intangible benefits, presents issues relating to the evaluation of BI in industry, and suggests a research agenda to advance what is presently a limited body of knowledge relating to the evaluation of BI intangible benefits.

Comment. This article summarizes the effects of business intelligence systems on managerial decision making. The information taken from this reference is used in this study to summarize the managerial decisions supported by business information systems. The authors for this study are faculty of the information technology

department for Monash University and credibility is further established because this article is published in a peer reviewed journal.

Bontcheva, K., Funk, A., Maynard, D., & Saggion, H. (2007) Ontology-based information extraction for business intelligence. *6th international semantic web conference.*

Abstract. Abstract. Business Intelligence (BI) requires the acquisition and aggregation of key pieces of knowledge from multiple sources in order to provide valuable information to customers or feed statistical BI models and tools. The massive amount of information available to business analysts makes information extraction and other natural language processing tools key enablers for the acquisition and use of that semantic information. We describe the application of ontology-based extraction and merging in the context of a practical e-business application for the EU MUSING Project where the goal is to gather international company intelligence and country/region information. The results of our experiments so far are very promising and we are now in the process of building a complete end-to-end solution.

Comment. This article summarizes the application of extraction tools used in a business intelligence system and how these extraction tools directly affect decision making. The information taken from this paper is used in this study to define and relate extraction tools to managerial decision making. This paper is deemed credible as it was presented at the proceedings of the 6th International Semantic Web Conference and the authors are researchers in the computer science department of the University of Sheffield.

Castellanos, M., Dayal, U., Simitsis, A., & Wilkinson, K. (2009). Data integration flows for business intelligence. *Proceedings of the 12th International Conference on Extending Database Technology: Advances in Database Technology,* 1-11.

Abstract. Business Intelligence (BI) refers to technologies, tools, and practices for collecting, integrating, analyzing, and presenting large volumes of information to enable better decision making. Today's BI architecture typically consists of a data warehouse (or one or more data marts), which consolidates data from several operational databases, and serves a variety of front-end querying, reporting, and analytic tools. The back-end of the architecture is a data integration pipeline for populating the data warehouse by extracting data from distributed and usually heterogeneous operational sources; cleansing, integrating and transforming the data; and loading it into the data warehouse. Since BI systems have been used primarily for off-line, strategic decision making, the traditional data integration pipeline is a one way, batch process, usually implemented by extract-transform load (ETL) tools. The design and implementation of the ETL pipeline is largely a labor-intensive activity, and typically consumes a large fraction of the effort in data warehousing projects. Increasingly, as enterprises become more automated, data driven, and real-time, the BI architecture is evolving to support operational decision making. This imposes additional requirements and tradeoffs, resulting in even more complexity in the design of data integration flows. These include reducing the latency so that near real-time data can be delivered to the data warehouse, extracting information from a wider variety of data sources, extending the rigidly serial ETL pipeline to more general data flows, and considering alternative physical implementations. We describe the requirements for

data integration flows in this next generation of operational BI system, the limitations of current technologies, the research challenges in meeting these requirements, and a framework for addressing these challenges. The goal is to facilitate the design and implementation of optimal flows to meet business requirements.

Comment. This article is relevant to this study as it presents a strong foundation of business intelligence systems, their common components and how they function from a technical standpoint. This article is deemed credible as it is published in a peer reviewed conference proceeding and authored by researchers from the HP labs in Palo Alto California.

Cody, W.F., Kreulen, J.T., Krishna, V., & Spangler, W.S. (2002). The integration of business intelligence and knowledge management. *IBM Systems Journal, 41*(4), 697-713.

Abstract. Enterprise executives understand that timely, accurate knowledge can mean improved business performance. Two technologies have been central in improving the quantitative and qualitative value of the knowledge available to decision makers: business intelligence and knowledge management. Business intelligence has applied the functionality, scalability, and reliability of modern database management systems to build ever-larger data warehouses, and to utilize data mining techniques to extract business advantage from the vast amount of available enterprise data. Knowledge management technologies, while less mature than business intelligence technologies, are now capable of combining today's content management systems and the Web with vastly improved searching and text mining capabilities to derive more value from the explosion of textual information. We believe that these systems will blend over time, borrowing techniques from each other and inspiring new approaches that can analyze

data and text together, seamlessly. We call this blended technology BIKM. In this paper, we describe some of the current business problems that require analysis of both text and data, and some of the technical challenges posed by these problems. We describe a particular approach based on an OLAP (on-line analytical processing) model enhanced with text analysis, and describe two tools that we have developed to explore this approach—eClassifier performs text analysis, and Sapient integrates data and text through an OLAP-style interaction model. Finally, we discuss some new research that we are pursuing to enhance this approach.

Comment. This article is relevant to this study as it details OLAP and data-mining within a business intelligence systems and how managerial actions are influenced by the information generated from these systems. This article is deemed credible as it is published in a peer reviewed business journal; two of the four researchers hold doctorates in computer engineering while two hold doctorates in mathematics.

Esat, F., Hart, M., Khatieb, Z., & Rocha, M. (2007). Introducing students to business intelligence: Acceptance and perceptions of OLAP software. *Informing Science and Information Technology, 4,* 105-123.

Abstract. This research concerns a practical on-line analytic processing (OLAP) project given to 2nd year information systems major students. They were required to analyze two sets of sales data with two different OLAP software tools, and report both on their findings and on their experiences of working with the two products. Students then completed a validated instrument with questions about each OLAP tool, and data was analyzed to assess whether proposed relationships in an adapted technology acceptance model (TAM) were supported. For each OLAP product the cognitive

instrumental factors of result demonstrability, output quality, job relevance and perceived ease of use were found to be positively related to perceived usefulness. This supported local and international studies of business users. Facilitating conditions affected perceived ease of use, but anxiety played no significant role. Qualitative student experiences and perceptions are briefly commented on, and suggestions made about future OLAP projects.

Comment. This article is relevant to this study as it focuses on the usage of OLAP techniques within business intelligence systems. This article is deemed credible as it is published in a peer reviewed journal and the research was led by a faculty member of the information systems department of the University of Cape Town.

Hevner, A.R., & March, S.T. (2005). Integrated decision support systems: A data warehouse perspective. *Decision Support Systems, 43,* 1031– 1043.

Abstract. Successfully supporting managerial decision-making is critically dependent upon the availability of integrated, high quality information organized and presented in a timely and easily understood manner. Data warehouses have emerged to meet this need. They serve as an integrated repository for internal and external data—intelligence critical to understanding and evaluating the business within its environmental context. With the addition of models, analytic tools, and user interfaces, they have the potential to provide actionable information resources—business intelligence that supports effective problem and opportunity identification, critical decision-making, and strategy formulation, implementation, and evaluation. Four themes frame our analysis: integration, implementation, intelligence, and innovation.

Comment. This article is relevant to this study as it focuses on the role of data warehouses within business intelligence systems and how data warehouses provide information that supports managerial decision making. This article is deemed credible as it is published in a peer reviewed journal, both authors are PhD's and faculty members of their respective university's school of business.

Hwang, M.I., & Xu, H. (2007). The effect of implementation factors on data warehousing success: An exploratory study. *Journal of Information, Information Technology, and Organizations, 2,* 1-14.

Abstract. Data warehousing is an important area of practice and research, yet few studies have assessed its practices in general and critical success factors in particular. Although plenty of guidelines for implementation exist, few have been subjected to empirical testing. In order to better understand implementation factors and their effect on data warehousing success, perceptions of data warehousing professionals are examined in a cross sectional survey. Best subsets regression is used to identify the specific factors that are important to each success variable. Since different companies may have different objectives or emphases in their data warehousing endeavors, the results are useful in identifying the exact factors that need attention and in providing a basis for prioritizing those factors. The results also suggest several promising directions for continued research on data warehousing success.

Comment. This article is relevant to this study as it presents a practical implementation of a data warehouse within a business intelligence system and the usage within the system. The article is deemed credible as it is published in a peer reviewed journal and

the authors are both professors at Central Michigan University and are PhDs in their respective fields of information systems.

Jaklic, J., Popovic, A., & Turk, T. (2010). Conceptual model of business value of business intelligence systems. *Management: Journal of Contemporary Management Issues, 15*(1) 5-30.

Abstract. With advances in the business intelligence area, there is an increasing interest for the introduction of business intelligence systems into organizations. Although the opinion about business intelligence and its creation of business value is generally accepted, economic justification of investments into business intelligence systems is not always clear. Measuring the business value of business intelligence in practice is often not carried out due to the lack of measurement methods and resources. Even though the perceived benefits from business intelligence systems, in terms of better information quality or achievement of information quality improvement goals, are far from being neglected, these are only indirect business benefits or the business value of such systems. The true business value of business intelligence systems hides in improved business processes and thus in improved business performance. The aim of the paper is to propose a conceptual model to assess business value of business intelligence systems that was developed on extensive literature review, in-depth interviews, and case study analysis for researching business intelligence systems' absorbability capabilities or key factors facilitating usage of quality information provided by such systems respectively.

Comment. This article details the benefits of a business intelligence system within a business, specifically benefits related to managerial decision making. This article is

deemed credible as it is published in a peer reviewed business journal authored by three associate professors from the University of Ljubljana. All three authors hold doctorates.

Koronios, A., & Yeoh, W. (2010). Critical success factors for business intelligence systems. *Journal of Computer Information Systems,* 23-32.

Abstract. The implementation of a business intelligence (BI) system is a complex undertaking requiring considerable resources. Yet there is a limited authoritative set of critical success factors (CSFs) for management reference because the BI market has been driven mainly by the IT industry and vendors. This research seeks to bridge the gap that exists between academia and practitioners by investigating the CSFs influencing BI systems success. The study followed a two-stage qualitative approach. Firstly, the authors utilized the Delphi method to conduct three rounds of studies. The study develops a CSFs framework crucial for BI systems implementation. Next, the framework and the associated CSFs are delineated through a series of case studies. The empirical findings substantiate the construct and applicability of the framework. More significantly, the research further reveals that those organizations which address the CSFs from a business orientation approach will be more likely to achieve better results.

Comment. This article is relevant to this study as it details the purpose of a business intelligence system and how to measure the success of such a system. This article is deemed credible as it is published in a peer reviewed journal by researchers from the University of South Australia.

Marques A., Pinto, F., & Santos, M.F. (2009). Ontology based data mining – a contribution to business intelligence. *Proceedings of the 10th WSEAS international conference on mathematics and computers in business and economics.* 210-216.

Abstract. Marketing departments handles with a great volume of data which are normally task or marketing activity dependent. This requires the use of certain, and perhaps unique, specific knowledge background and framework. This article aims to introduce an almost unexplored research at marketing field: the ontological approach to the Database Marketing process. We propose a generic framework supported by ontologies and knowledge extraction from databases techniques. Therefore this paper has two purposes: to integrate ontological approach in Database Marketing and to create domain ontology with a knowledge base that will enhance the entire process at both levels: marketing and knowledge extraction techniques. Our work is based in the Action Research methodology. At the end of this research we use ontology's to pre-generalize the Database Marketing knowledge through a knowledge base.

Comment. This article is relevant to this study because it details the managerial decision-making actions affected by business intelligence systems. This article is deemed credible as it is published in a peer reviewed conference proceeding and authored by researchers from three cooperating Universities.

Matei, G. (2010). A collaborative approach of business intelligence systems. *Journal of Applied Collaborative Systems, 2*(2), 91-101.

Abstract. To succeed in the context of a global and dynamic economic environment, companies must use all the information they have as efficiently as possible, in order to gain competitive advantages and to consolidate their position on the market. To achieve these goals, the companies must use modern informatics technologies for data acquiring, storing, accessing and analyzing. These technologies are to be integrated into innovative solutions, such as Business Intelligence systems, which can help managers

to better control the business practices and processes, to improve the company's performance and to conserve it's competitive advantages. This paper presents Business Intelligence systems and emphasizes their collaborative feature.

Comment. This article is relevant to this study as it details the many different components of a business intelligence system and how they function together and how they enable managers to make better decisions. This article is deemed credible as it is published in a peer reviewed journal, and written by a PhD in information systems.

Negash, S. (2004). Business intelligence. *Communications of the Association for Information Systems, 13*, 177-195.

Abstract. Business intelligence systems combine operational data with analytical tools to present complex and competitive information to planners and decision makers. The objective is to improve the timeliness and quality of inputs to the decision process. Business Intelligence is used to understand the capabilities available in the firm; the state of the art, trends, and future directions in the markets, the technologies, and the regulatory environment in which the firm competes; and the actions of competitors and the implications of these actions. The emergence of the data warehouse as a repository, advances in data cleansing, increased capabilities of hardware and software, and the emergence of the web architecture all combine to create a richer business intelligence environment than was available previously. Although business intelligence systems are widely used in industry, research about them is limited. This paper, in addition to being a tutorial, proposes a BI framework and potential research topics. The framework highlights the importance of unstructured data and discusses the need to develop BI tools for its acquisition, integration, cleanup, search, analysis, and delivery. In addition,

this paper explores a matrix for BI data types (structured vs. unstructured) and data sources (internal and external) to guide research.

Comment. This article is relevant to this study as it details business intelligence system components and how they are used within an organization's managerial ranks. This article is deemed credible as it is published in a peer reviewed journal and written by a PhD in management information systems.

Olszak, C.M., & Ziemba, E. (2003). Business intelligence as a key to management of an enterprise. *Informing Science and Technology.* 855-863.

Abstract. The paper focuses on the Business Intelligence systems. At the beginning, knowledge as an important and strategic asset that determines a success of an enterprise is presented. Next, some characteristics of the Business Intelligence systems are discussed and their architecture is described. Purposefulness of applying such solutions in an enterprise is highlighted. An integrated approach to build and implement business intelligence systems is offered. The systems are shown in four dimensions: business, functional, technological and organizational

Comment. This article is relevant to this study as it directly ties the managerial decision-making actions of an organization to the use of business intelligence systems. The article is deemed credible as it is published in a peer reviewed journal and authored by two professors of business information systems who each hold a PhD in economics.

Olszak, C.M. & Ziemba, E. (2006). Business intelligence systems in the holistic infrastructure development supporting decision-making in organizations. *Interdisciplinary Journal of Information, Knowledge and Management, 1*, 47- 58.

Abstract. The paper aims at analyzing Business Intelligence Systems (BI) in the context of opportunities for improving decision-making in a contemporary organization. The authors – taking specifics of a decision-making process together with heterogeneity and dispersion of information sources into consideration – present Business Intelligence Systems as some holistic infrastructure of decision-making. It has been shown that the BI concept may contribute towards improving quality of decision-making in any organization, better customer service and some increase in customers' loyalty. The paper is focused on three fundamental components of the BI systems, i.e. key information technologies (including ETL tools and data warehouses), potential of key information technologies (OLAP techniques and data mining) and BI applications that support making different decisions in an organization. A major part of the paper is devoted to discussing basic business analyses that are not only offered by the BI systems but also applied frequently in business practice.

Comment. This article is relevant to this study as it focuses on using business intelligence systems to create better decision-making within an organization. The article is deemed credible as it is published in a peer reviewed journal and authored by two professors of business information systems who each hold a PhD in economics.

Olszak, C.M. & Ziemba, E. (2007). Approach to building and implementing business intelligence systems. *Interdisciplinary Journal of Information, Knowledge and Management, 2*, 135-148.

Abstract. The article aims at describing processes of building Business Intelligence (BI) systems. Taking the BI systems specifics into consideration, the authors present a suggested methodology of the systems creation and implementation in organizations.

The considerations are focused on objectives and functional areas of the BI in organizations. Hence, in this context the approach to be used while building and implementing the BI involves two major stages that are of interactive nature, i.e. BI creation and BI "consumption". A large part of the article is devoted to presenting objectives and tasks that are realized while building and implementing BI.

Comment. This article is relevant to this study as it focuses on organizational usage of business intelligence systems and the effects on business outcome. The article is deemed credible as it is published in a peer reviewed journal and authored by two professors of business information systems who each hold a PhD in economics.

Rodrigues, L.C. (2002). Business intelligence: the management information system next step. *Third International Conference on Management Information Systems Incorporating GIS & Remote Sensing, 1,* 269-278.

Abstract. Currently, information technology assumes a major role in business, because of it pivotal role in building business intelligence in enterprises. Here we discuss the premises those business intelligence results from the sophistication of a management information system towards the combination of the concept of intelligence and the concept of competitiveness, as organizational tools to give market leadership to enterprises. To do this, we propose and discuss a model to elaborate on business intelligence extended concept. It involves internal and external information to be incorporated as innovation platforms helping enterprises find unique solutions. Competitive intelligence, as gathering, processing and distributing key information to key people, can evolve to a business intelligence as an extended concept of business systems effectiveness and strategy. This extended concept comprehends also knowledge management, that aligns organizational competencies, building on cognitive bases, to position businesses strategically in the market.

Comment. This article is relevant to this study as it focuses on how managers use business intelligence generated from business intelligence systems and how this intelligence influences decision making. This article is deemed credible as it is published in a peer reviewed conference proceeding and authored by a researcher from the Regional University of Blumenau's department of administration.

Schink, H. (2009). Current state and future challenges of real-time ETL. *Proceedings 2nd student conference on software engineering and database systems.* 6-10.

Abstract. Business becomes faster every day, i.e. Business opportunities and problems appear and pass frequently. A competitive business has to react on these as they arise. To react as fast as possible decision makers make usage of sophisticated business intelligence (BI) tools. These tools use of obtained data by monitoring the business process itself. Usually data warehouses (DWH) store and provide this data. To support fast and profound business decisions DWHs have to provide data that is as up-to-date as possible. The operation which fills the DWH with the newest data is called extraction, transformation and loading (ETL). That is why speeding up the ETL process to provide real-time ETL is an important issue. This paper will give an overview of the current state and future challenges of real-time ETL. This includes a short introduction of ETL and of problems arising with real-time ETL. A presentation of recent work on real-time ETL is following. The paper ends with an discussion on further problems and future challenges for the work on real-time ETL as well as suggestions for future investigations.

Comment. This article is relevant to this study as it focuses on managerial decision making through the use of business intelligence systems specifically focused on ETL

tools. This article is deemed credible as it is published in a peer reviewed conference proceeding and authored by a researcher from Otto-von-Guericke University.

Shi, Z., Wang, M., Wu, W., Xu, L., & Zeng, L. (2006). Techniques, process, and enterprise solutions of business intelligence. *Systems, Man and Cybernetics. IEEE International Conference.* 4722-4726.

Abstract. Business Intelligence (BI) has been viewed as sets of powerful tools and approaches to improving business executive decision-making, business operations, and increasing the value of the enterprise. The technology categories of BI mainly encompass Data Warehousing, OLAP, and Data Mining. This article reviews the concept of Business Intelligence and provides a survey, from a comprehensive point of view, on the BI technical framework, process, and enterprise solutions. In addition, the conclusions point out the possible reasons for the difficulties of broad deployment of enterprise BI, and the proposals of constructing a better BI system.

Comment. This article is relevant to this study as it details the main components of a business intelligence system and details how these components are used to influence business decision making. This article is deemed credible as it is published in a peer reviewed conference proceeding and authored by a researchers from the Chinese Academy of Science, Beijing.

Watson, H.J. & Wixom, B.H. (2007). The current state of business intelligence. *Computer 40,* (9), 96-99.

Abstract. Business intelligence (BI) is now widely used, especially in the world of practice, to describe analytic applications. BI is currently the top-most priority of many chief information officers. BI has become a strategic initiative and is now recognized

by CIOs and business leaders as instrumental in driving business effectiveness and innovation. BI is a process that includes two primary activities: getting data in and getting data out. Getting data in, traditionally referred to as data warehousing, involves moving data from a set of source systems into an integrated data warehouse. Getting data in delivers limited value to an enterprise; only when users and applications access the data and use it to make decisions does the organization realize the full value from its data warehouse. Thus, getting data out receives most attention from organizations. This second activity, which is commonly referred to as BI, consists of business users and applications accessing data from the data warehouse to perform enterprise reporting, OLAP, querying, and predictive analytics.

Comment. This article is relevant to this study as it related evidence of business dependence on business intelligence systems and the different technologies used within business intelligence systems. This article is deemed credible as it is published in a peer reviewed journal and authored by a professor from the University of Georgia and a professor from the University of Virginia.

Review of Literature

A systematic search of online databases and research indices provide a large body of literature detailing business intelligence systems and the impact they have on business decision making. The selected literature has been analyzed and coded to present the most relevant data related to three themes. The first details the four most common components of a business intelligence system, which are Data Warehousing, ETL tools, OLAP techniques, and Data Mining. The second examines how each of the four most common components relates to the managerial decision making actions as described by Olszak and Ziemba (2003). Actions are acquiring/gathering information, searching information, analyzing information, and reporting information. The third examines how business intelligence systems can be employed at each of the three levels of management: operational, tactical and strategic.

The term *business intelligence system* is a generic umbrella concept that groups a multitude of like architected information systems, derived from business and information fields. These systems are used to transform data into information, information into decisions, and decisions into successful actions (Matei, 2010). The term *business intelligence system* lacks a generally accepted definition. Table 2 (see below) shows nine, which at first glance appear to be similar but vary in focus and detail. The lack of clarity in the understanding and use of the term can lead to difficulty when studying the field of business intelligence systems; in fact one research team proclaims that business information systems are neither a single product nor a single system (Jaklic et al., 2010). In reality, business intelligence systems are better described as a grouping of products and systems.

Table 2

Definitions of Business Intelligence Systems

Author	Definition
Airinei & Homocianu, (2009)	"Information systems used for decision making" (p.7) … composed of ad-hoc querying, often using data or exploiting a database / data warehouse respectively helping managers solve less structured or non-structured problems.
Arnott et al., (2004)	"An approach to management that allows an organization to define what information is useful and relevant to its corporate decision making" (p. 296).
Castellanos et al., (2009)	"Technologies, tools, and practices for collecting, integrating, analyzing and presenting large volumes of information to enable better decision making" (p. 1).
Esat et al., (2007)	"An organized and systematic process by which organizations acquire, analyze, and disseminate information from both internal and external information sources significant for their business activities and for decision making" (p. 106).
Kronos & Yeoh, (2010)	"[An] integrated set of tools and technologies and programmed products that are used to collect, integrate, analyze and make data available" (p.23).
Negash, (2004)	"Operational data and analytical tools to present complex and competitive information to planners and decision makers" (p. 177).
Olszak & Ziemba, (2003)	"Set of concepts, methods and processes that aim at not only improving business decisions but also at supporting realization of an enterprise's strategy" (p. 856).
Shi et al., (2006)	"Tools, techniques and solutions designed for end users to efficiently extract useful business information from oceans of data" (p. 4722).
Watson & Wixom, (2007)	Two phase process of getting data into and out of a data warehouse.

The definition of business intelligence system used for this literature review is: *A set of integrated tools, technologies and programmed products used to collect, integrate, analyze, and transform data into information (Koronios & Yeoh, 2010). This information is then used to enable effective business decision making.*

Definitions of the Four Most Common Components of a Business Intelligence System

Business intelligence systems are used for intelligent exploration, integration, aggregation, and a multidimensional analysis of data originating from various information resources… data is treated as a highly valuable corporate resource (Kronos & Yeoh, 2010). And although definitions vary, and business needs dictate the necessity for different components and complexity for a business intelligence system, all business intelligence systems require, at a minimum, four specific components to produce business intelligence. These components are described throughout the larger literature to the degree that they are now taken-for-granted and they include (a) data warehouses, (b) ETL tools, (c) OLAP techniques and (d) data mining (Olszak & Ziemba, 2006). This section defines and details the functioning aspects of each of these four components.

Data warehouses. A data warehouse is a collection of relevant business data that is organized and validated (Cody et al. 2002) so that it can be analyzed to support business decision making. Data warehouses are populated with data that has been extracted from distributed databases, often heterogeneous and, in some cases, external to the organization which is using it. Data warehouses are subject oriented databases that are integrated into an information system. They are time relevant, meaning that they are snapshots of a point of time within the information

system and they are not updatable so as to maintain the integrity of the historical point in which the snapshot of data is taken.

Data warehouses are offline, meaning that they reside on a different system than that of the data of which they are storing a snapshot. New data warehouses are constantly being loaded with business critical data to ensure that up to the minute data is available for decision making. The criticality of that data is predetermined by the organization using the data warehouse. The data is historical, a summary of prior transactions that when analyzed can provide a wealth of knowledge in which managerial decisions can be made. These decisions are based on the history of the business that a data warehouse is holding (Schink, 2009).

The data warehouse is considered the core component of a business intelligence system (Negash, 2004). This collection of data is used to support the management decision-making process (Hevner & March, 2005). In addition to providing the snapshot of historical data, a data warehouse also provides room for the thematic storing of aggregated information, data that has been analyzed by an ETL tool then loaded into the appropriate data warehouse (Olszak & Ziemba, 2003). A well implemented data warehouse is easy to use, allows for quick information recovery, stores more information, improves productivity, allows for better decisions, increases an organization's competitive advantage (Hwang & Xu, 2007). Hevner and March (2005) conclude that the key role of a data warehouse is to provide an understanding of business problems, opportunities, and performance based on compelling business intelligence facilitating decision making.

ETL tools. ETL tools and processes are responsible for the extraction of data from one or many source systems, as they transform data from many different formats into a common format and then load that data into a data warehouse (Schink, 2009). ETL tools are tasked with

extracting information deemed central to the business. They manipulate and present that data into information that is then used for managerial decision making (Arnott et al., 2004). Castellanos et al. (2009) suggest that early in the history of business intelligence systems, ETL design and implementation was considered a supporting task for the data warehouse and thus was not viewed as a piece of the business intelligence puzzle but as a subset of the data warehousing problem.

ETL solutions are divided into three distinct stages that find and convert data from various sources and inserts the resulting product into a data warehouse. The three stages of ETL are:

1.The *extraction* stage: This stage involves obtaining access to data originating from different, often heterogeneous sources. These sources are often distributed across multiple platforms and can be part of a customer's information system (Schink, 2009).

2. The *transformation* stage: This stage transforms the extracted data and is considered the most complex stage of the ETL process. The transformation stage converts the data into the same schema of the data warehouse to which it is to be loaded. The transformation phase is usually performed by means of traditional programming languages, script languages or the SQL language (Olszak & Ziemba, 2006).

3. The *load* stage: The load stage *pushes* the transformed data and loads the data warehouses with data that are aggregated and filtered (Olszak & Ziemba, 2007).

The requirement of a business intelligence system to be able to extract data in different formats from disperse sources, transform them into like formats, and then load them into the appropriate data warehouse has traditionally made the ETL process the most expensive aspect of

a business intelligence system (Hevner & March, 2005). In some cases a business intelligence system may have a dedicated but separate data warehouse that acts as a staging area.

The ETL process can do low level analysis and transformation in this data warehouse prior to loading it into the enterprise data warehouses (Castellanos et al., 2009). ETL tools can be written to have more emphasis on one particular aspect of the ETL process over the other. Generally there are four categories that ETL tools fall under (Olszak & Ziemba, 2006):

1. EtL: tools that address the extraction and loading aspects of the ETL process.
2. ETl: tools that provide a preference for the data type and format to be extracted and loaded.
3. ETL: tools that offer a balance across all tool functions; the lack of emphasis may cause this aspect to result in poorer handling of a large volume of data formats.
4. eTL: tools that emphasize the integration of data into data warehouses.

OLAP techniques. The origins of On-Line Analytical Processing are rooted in the difficulties encountered when performing data analysis on databases that are constantly being updated during transactions via other information systems (Airinei & Homocianu, 2009). OLAP attempts to analyze complex data in real time on a database that is constantly updated with transactional data. The OLAP optimizes the searching of huge data files by means of automatic generation of SQL queries (Olszak & Ziemba, 2006).

OLAP allows user access, analysis and modeling of business problems and sharing of information that is stored in data warehouses (Olszak & Ziemba, 2007). As noted by Olszak and Ziemba (2007), OLAP offers techniques for data analysis and drilling data and the tools are mainly used for interactive report generations. Matei (20010) states that OLAP tools use data mining techniques and statistical methods to create readable, fast report generation that is used

for forecasting that can further assist in strategic decision making. These reports are generated based on a manager's pre-defined criteria (dimensions).

OLAP is an improvement to earlier single dimensional analysis tools that allowed managers to analyze data from only one perspective at a time. By providing managers with a multi-dimensional tool, OLAP enables managers to analyze data from multiple perspectives and explore it in order to discover hidden information (Matei, 2010).

Data mining. Data mining techniques are designed to identify relationships and rules within a data warehouse, then create a report of these relationships and rules (Hevner & March, 2005). The data mining process involves discovering various patterns, generalizations, regularities and rules in data resources. Knowledge from data mining may be used to predict an outcome of a decision and can also describe reality. The *predictions* generated by data mining use known variables to predict the outcome of a situation, while *reality* is measured by graphing, tabling, and creating formulas based on the existing data (Olszak & Ziemba, 2007).

There are several basic strategies for data mining. The most common are: *classification, estimation, prediction, time series analysis, and market basket analysis* (Shi et al. 2006). These strategies can be aligned with the needs of an organization and help decision making by discovering various patterns, generalizations, regularities and rules in data resources. Examples of these strategies in business include using *market basket analysis* to model retail sales or *classification* to classify unstructured data, such as email, as spam or a legitimate piece of correspondence, such as business or personal information.

The Specific Role of Each Component in a Business Intelligence System

Airinei and Homocianu (2009) describe business intelligence systems as a means to exploit information in order to help managers solve their structured and unstructured problems. Each component of a business intelligence system can be used to exploit information in one or more of these selected managerial decision-making actions: (a) acquiring information; (b) searching/gathering information; (c) analyzing information; and (d) delivery of information (Olszak & Ziemba, 2007).

By analyzing historical data, business intelligence systems strive to eliminate communication barriers that exist at the different organizational levels within a company. These barriers are considered *noise* during the decision-making process. By allowing decisions to be made using consistent information (Matei, 2010), this method of analysis enables managers to evaluate former activities and direct future actions.

The managerial decision-making action a particular component of a business intelligence system can support varies based on many factors. These factors include the type of organization using the business intelligence system, the sector a business operates in, and the maturity of the business intelligence system (Rodrigues, 2002). Olszak and Ziemba (2003) present a framework for the actions a manager takes in order to make business decisions. The alignment among actions and their corresponding business intelligence components is summarized in Table 3. Although different components appear to exhibit crossover functions, it is the level of detail and outcome that are very different. A detailed discussion is provided below.

Table 3

BI System Components Aligned with Managerial Decision-Making Actions

Business Intelligence System Component	Managerial Information Actions
ETL Tools	Acquiring/gathering, Searching
Data Warehouses	Acquiring/gathering
OLAP Techniques	Analyzing, Delivery
Data Mining	Analyzing, Delivery

Acquiring/gathering information. Acquiring information has become increasingly more difficult as modern organizations adopt more distributed information systems in which to store their business critical data (Hevner & March, 2007).This action is used to find the business issue. As Olszak and Ziemba (2006) point out, this action utilizes ETL tools, directing the processes to find what information is needed and into which data warehouse to deposit that information (Shi et al., 2006).

Searching information. After the data are extracted from operational databases (Castellanos et al., 2009), the newly loaded high quality data are mined using data mining techniques and processes. This action is performed at different levels of data quality. Lower quality data are searched by utilizing ETL tools. The more refined or mature an ETL tool, the higher the data quality of the data being loaded into a data warehouse (Schink, 2009).

Analyzing information. Managers need to create data models to understand and address business issues. Through data preprocessing and applying OLAP and data mining techniques managers can analyze information from multiple dimension at varying degrees of granularity, and tasked with a different level of analysis (Shi et al., 2006). For example, information derived through analysis directly affects decisions related to promotional campaigns, forecasting sales and financial results and, in some cases, can be used in fraud detection (Olszak & Ziemba, 2007).

OLAP summarizes data and makes forecasts based on historical data. Data mining discovers hidden patterns in data. Data mining operates at a detail level instead of a summary level. In other words, data mining predicts, while OLAP forecasts.

Data mining and OLAP can be used to analyze:

(a) financial data: analyzing and reporting on costs, revenue and profitability

(b) marketing data: analyzing sales receipts, sales profitability, sales target, actions taken by competitors

(c) customer data: analyzing time of contact, customer profitability, customer behavior, customer satisfaction, and customer loyalty

(d) production data: analyzing production *bottle necks,* delayed orders, in-process materials, tool up-time

(e) logistical data: analyzing relationships in a supply chain and delivery partnerships

(f) wage related data: analyzing wage types, payroll surcharges, payroll collections, employee contributions, and average wages

(g) personal data: analyzing employee turnover, employee type, presentation of information related to individual data

Delivery of information. Data mining is also used in the delivery of information within an organization. In business intelligence systems, data mining can not only interpret, and evaluate results generated from the analysis performed on data stored in a data warehouse, but it can also display reports enabling decision makers to discover various patterns, generalizations, and regularities (Olszak & Ziemba, 2007). In the same way, OLAP creates ad hoc report generation using simpler data mining techniques by summarizing data without the pattern matching that is unique to the data mining process (Matei, 2010). As Olszak and Ziemba (2003)

point out, data mining provides a detail-oriented report while OLAP provides a generic summary of information. Without well defined delivery, management may get extensive reports that are not only inappropriate for the decisions being made at that time but the reports may contain too much information that may cause managers to overlook critical data (Jaklic et al., 2010).

How Business Intelligence Systems can be used to Better Facilitate Business Decision Making at Each Level of Management

Shi et al. (2006) assert that by utilizing business intelligence systems organizations are collecting, treating and diffusing information with the objective of reducing uncertainty in the making of decisions. These decisions are often made under pressure, almost always at critical times in which businesses need real-time data.

A business intelligence system allows managers to make decisions using real time data by monitoring competition, carrying out constant analysis of numerous data and considering different variants of organization performance (Olszak & Ziemba, 2007). As figure 2 shows, data is extracted from operational databases, customer databases, and from data collected pertaining to the competition. The business intelligence system extracts this data from these various data sources, transforms it into specified formats, and then loads the newly formatted data into specially designated data warehouses that are available to all three levels of decision making within the organization: operational, strategic, and tactical (Negash, 2004).

Each level of the organization will utilize different OLAP techniques and data mining process to analyze data and report information that is most relevant to them. The information generated from the business intelligence system will be used in all decision-making processes. At the strategic level, decisions set objectives and push the decision direction to the tactical level of the organization. At the tactical level information is mined from the business intelligence system

to develop tactics to realize the strategic objectives and, in-turn, will push a decision down to the operational level of the organization. Both the tactical and operational levels of management are reactive to the strategic decisions of the organization (Cella et al., 2004). Figure 2 shows how data and decisions flow in an organization:

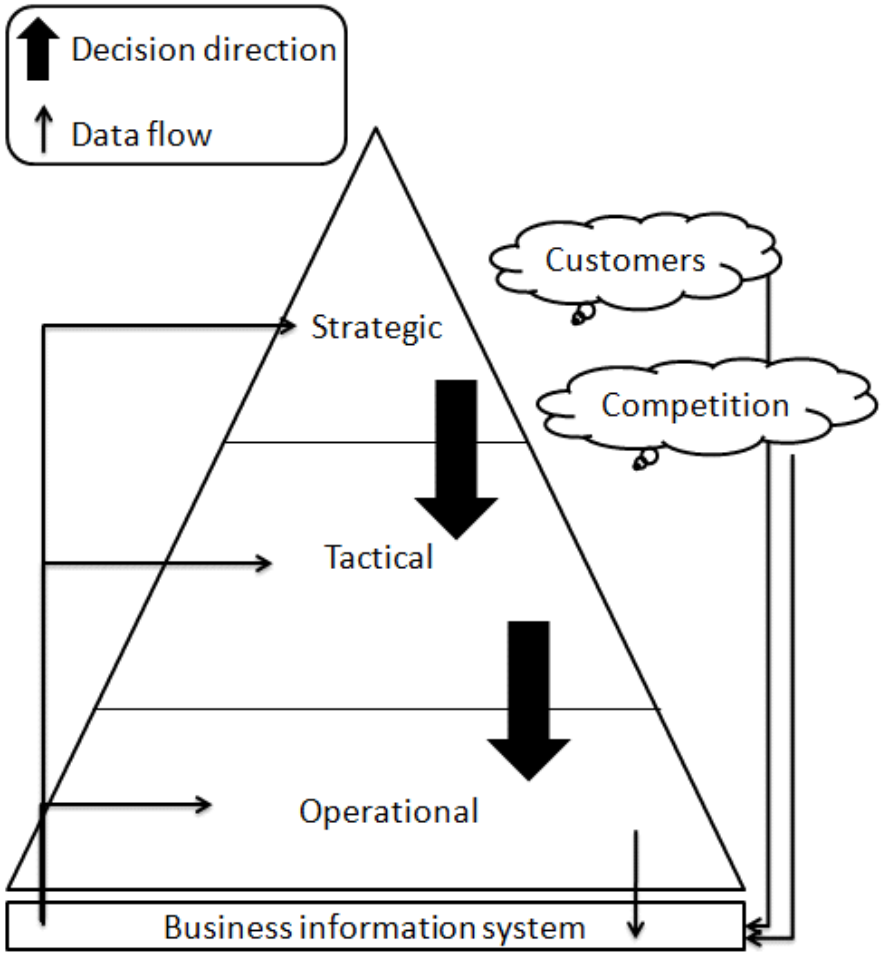

Figure 2. Organizational decision flow overview

Even with a shared objective, different levels of the organization will utilize information for different purposes. At strategic and tactical levels, information provides input to senior

managers; at the operational levels, information provides input to lower level managers (Negash, 2003).

Operational level decisions. At the operational level, decisions affect or are related to the ongoing operations of an organization. These decisions are generally based on up-to-date financial data, sales and co-operation with suppliers and customers (Olszak & Ziemba, 2007). Data are the life blood of daily operations in an organization and business intelligence takes that data and presents it to decision makers in the form of information (Barone, Jiang, Mylopoulus, Won, & Yu, 2010). Business intelligence systems provide information used at the operational level of an organization to address the following specific actions (Olszak & Ziemba, 2006):

1. identify problems and 'bottlenecks'
2. provide analysis of "the best" and "the worst"
3. provide analysis of products
4. provide analysis of employees
5. provide analysis of regions (using measurable metrics such as sales, costs or quantifiable results)
6. perform ad-hoc analysis and answer questions related to departments ongoing operations, up to date financial standing and sales.

Operational level decisions are noted as being the decisions that allow an organization to run its day-to-day activities (Esat et al., 2007). The information provided by the business intelligence system is at a summary level and the data feed into the business intelligence system from the operational level of an organization is analyzed and combined with other external information to create direction and allow for strategic planning to occur.

Tactical level decisions. Decisions made at the tactical level are related to planning and rely on real-time data and forecasting to direct the future actions of marketing, sales, finance and capital management. Tactical decisions are often used to support strategic decisions (Olszak & Ziemba, 2007). The literature details these related tactical decision-making activities as being supported by business intelligence systems:

1. analyses of deviations from the realization of plans for particular organizational units, individuals or indicators
2. decisions related to the direction of marketing, sales, finance and capital management
3. forecasting of demand for a given product or service

The information derived through these activities allows for optimizing future actions and for modifying organizational aspects of the company's performance.

Strategic level decisions. Strategic level decisions set objectives as well as ensure that those objectives are realized. Business intelligence systems provide information in support of strategic decision related to the development of future results based on historical results, profitability of offers (made or received) and the effectiveness of distribution channels (Olszak & Ziemba, 2007). Negash (2004) asserts strategic decisions use business information systems to create forecasts based on historical data from the past, combining it with current performance and then to estimate how conditions will play out in the future. Based on the literature, information provided by business intelligence systems inform these kinds of decisions made at the strategic level:

1. whether to enter new markets
2. the possibility of changing a company's orientation from product-centric to customer-centric

3. the launch of a new product (Watson & Wixom, 2007, p.97)

4. what objectives to set and to follow through on the realization of such established objectives (Olszak & Ziemba, 2007)

Conclusions

This goal of this study is to present a guide to enable IT professionals, managers and executives to identify the key components of a business intelligence system. The guide describes the key components of a business intelligence system by: (a) defining each of the four most common components (data warehouses, ETL tools, OLAP techniques, and data mining) including identification of detailed aspects; (b) associating the specific role in the business intelligence system in relation to the relevant managerial decision-making actions (acquiring/gathering, searching, analyzing, and delivery of information); and (c) detailing how each component can be used to better facilitate business decision making associated with each level of an organization: operational, tactical, and strategic.

This guide provides an understanding of business intelligence systems that encompasses a large body of literature. The literature is analyzed and synthesized, producing themes and descriptions of business intelligence system components, how they enable managerial decision making actions and facilitate decision-making at the three managerial levels of an organization.

This guide is presented in three parts, presented in the Review of the Literature section of this document. The first section describes the importance of business intelligence systems, which includes a set of key definitions of the concept (see Table 2). The second section identifies the most commonly identified components of a business intelligence system and how they are used to enable decision-making within an organization (see Table 3). The third section describes the factors to ensure the effective use of business intelligence systems at each level of management (see Figure 2).

As Olszak and Ziemba (2007) point out, the importance of a business intelligence system is unique to individual organizations based on needs and level of organizational maturity.

Different organizations will require a more or less robust solution based on their needs. A good understanding of an organization's needs will enable the effective use of a business intelligence system. Though the literature details the key components, several authors point out that business intelligence systems will vary based on many factors, including (Cody et al., 2002):

1. number of diverse data types within an operational database
2. diversity among the systems within an organization
3. maturity of analysis capabilities
4. personnel/knowledge workers

The larger body of literature shows that organizations realize the value of business intelligence and the systems used to create this intelligence. Many authors point out that even during economic down turns businesses continue to invest in business intelligence systems because "they recognize the provision of quality information as being the key to gaining competitive advantage" (Arnott et al., 2004, p. 296). And while the traditional customers of information generated by a business intelligence systems are knowledge workers (Negash, 2004), To summarize Castellanos et al., (2009), there is a growing realization that business intelligence systems must be integrated into business operations to enable knowledge workers to make better and timelier decisions.

Olszak and Ziemba (2006) echo the larger body of literature when they describe the deficiencies of management tools and their effect on decision makers: "dispersion of data sources and decentralization... result in insufficient decision making" (p.55). Integrating an environment with a business intelligence system allows for valuable analysis of business data (Olszak & Ziemba, 2003). Table 4 lists the four business intelligence system components and summarizes how they enable and assist in the business decision-making process.

Table 4

BI System component utilization within the decision-making process

Business Intelligence System Component	How Used in Decision-Making
ETL Tools	Used to obtain, adjust and load data from both operational databases and dispersed data sources allowing for the collection of volumes of data (Schink, 2009) which allows for: • near real-time information access • uniform data type in which to analyze
Data Warehouses	Used as repository for all data relevant to an organization to support the decision-making process (Matei, 2010) by: • gathering relevant and context aware data • providing multiple dimensions to data
OLAP Techniques	Used to analyze and report data from huge data sources (Olszak & Ziemba, 2006) by: • providing user access to data warehouses • creating data models
Data Mining	Used to identify patterns and relationships within a data warehouse and creates detailed reports (Hevner & March, 2005) allowing for: • predictions based on historical data • graphing and calculating to create formulas to analyze data

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