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Business Intelligence Trends: A review of Mobile Business Intelligence

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Abstract

The early stages of Decision Support Systems evolved with the technological improvements and availability of massive amounts of data. The concept of Business Intelligence became apparent along with this evolution which incorporates a range of fields and supports decision making in business organizations. Mobile business intelligence is a popular trend in the domain of business intelligence at present. Business organizations employ mobile business intelligence as an extension to the existing business intelligence systems. This study intends to present a review of mobile business intelligence while addressing its benefits, challenges, and limitations. Moreover, this study provides details of several use cases of the applications of mobile business intelligence discovered in the literature.

Keywords: Business intelligence, Mobile Business Intelligence, decision making, Decision Support Systems

1 Introduction

The term Business Intelligence (BI) can be generally defined as computer-based techniques used to collect, store and analyse business data to support management and decision-making. Due to the large volumes of data emerging rapidly, business organisations attempt to gain a competitive advantage by revealing useful patterns and trends through the analysis of these data. BI is an evolving concept which at present applies

artificial intelligence in performing business activities to replace human cognitive intelligence (Ranjan, 2009). In traditional BI, data warehouses are often used to store the business data extracted from source systems. Data integration is performed prior to storage to make the data usable in business functions. Afterwards, tools technologies are applied to data to execute business functions such as reporting, performance analysis, decision-making, and risk assessment (Vizgaitytė and Rimvydas, 2012).

With the expansion of mobile technologies and mobile access to business data exploited the concept of Mobile Business Intelligence (Mobile BI). Mobile BI allows the users to access business data and information irrespective of time and location and supports enhanced decision making.

This study begins with a detailed discussion of BI, including the importance and trends. The next section (2.2) focuses on mobile BI, where section 2.2.1 discusses challenges and limitations. The last section (2.2.2) presents several use cases of mobile BI encountered in the literature. This study concludes with section 3 by providing a comprehensive summarised discussion on the topics.

2 Literature Review

2.1 Business Intelligence

The first computer applications for transaction processing and other scientific activities emerged in the 1960s (Watson, 2009). Yet, the support on decision making from these applications was at the infant stage during that time. In the late 1960s, Michael S. Scott Morton's (1967) doctoral research dissertation presented a system to support the planning of laundry equipment (Power, 2007). Afterwards, the review articles and the book published by Gorry and Scott (1971) influenced the spread of concepts about decision Support Systems (DSS) and suggested the name "management decision systems". Eventually, a wide range of DSS emerged with the combination of multidisciplinary research areas. Two significant concepts were proposed in the meantime, namely, Sprague's DSS Development Framework and Alter's DSS Taxonomy (Watson, 2006). Sprague's framework, introduced in 1989, contains three components: the database, model base, and interaction between the user and system components (Sprague and Watson, 1975). Alter's taxonomy suggested seven categories of DSS, depending on the two initial categories as data-centric and model-centric (Watson, 2009). As time evolved, the primary concept of DSS changed and was enhanced with the emergence of various other applications such as Geographical Information Systems (GIS), Knowledge Management Systems (KMS) and Executive Information Systems (EIS). Data warehouses became popular to store massive

amounts of data and information used in decision making. With the combination of internet technologies, other data (such as web pages and documents) also started to be used in addition to numeric data. With the advancements in technology, significant changes were made to the domain, changing the collection, analysis, and delivery of information. Data visualization techniques and real-time data collecting and processing expanded the performance of these applications. Despite all these changes over time, the fundamental concepts of decision support remain the same. Howard Dresner initially admitted the term "Business intelligence" in 1989, which is now being used to address all the decision support applications (Nylund, 1999).

Since there is no established, commonly accepted definition for BI, various interpretations are available (Ranjan, 2009). In general, business intelligence can be described as an aggregation of applications and processes supported by technologies to collect, store access and analyse data for the benefit of effective decision making. Figure 01 illustrates the overview of a generic BI environment for the enterprise-level proposed by Hugh Watson (Watson, 2009). The fundamental components and concepts of BI will be discussed based on this diagram consequently in this paper.

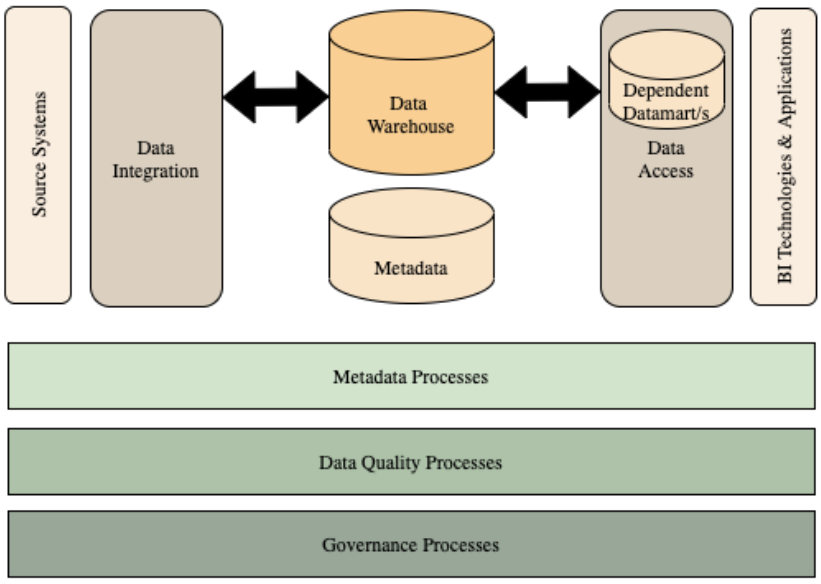

Figure 1: An overview of a generic BI environment

- **Source Systems:** These systems reside outside of the BI environment. Yet, it is a crucial component and basis of the BI solutions since these systems are the sources that provide data (Bălăceanu, 2007). Various applications are considered source systems, such as Enterprise Resource Planning Systems, web services, data from third parties and other operational systems. A technique named "Data

Profiling" is used prior to storing data in warehouses to eliminate the issues due to incomplete or incorrect data. Software tools can be used to perform profiling, and these tools provide a better understanding of the data.

- **Data Integration:** This process is also known as ETL (Extract, Transform and Load). First, the data is extracted from source systems using manually written codes or commercial software tools. Then related business rules are applied to the extracted data to make them more useful. Finally, they are loaded into the data warehouse (Lloyd, 2011).

- **Data warehouse and storing the data:** Data warehouse is subject-oriented central storage of data, which follows different data and architecture models during storage.

- **Users and technologies:** Potential users of BI include customers, suppliers, executives and managers, developers, analysts and workers. These users interact with the data warehouse variety of tools and techniques (Dashboards/scorecards, data mining, data visualization, SQL queries).

- **Metadata:** Metadata is significant in data warehousing since it stores key features (field sizes, ranges, definitions, etc.) about the data. Therefore it is also important in data migration (Watson and Wixom, 2007).

2.1.1 Importance of Business Intelligence

In general, BI supports better decision making within an organization. Improved decision-making will empower the organization by boosting the key value drivers (financial, productivity, risk, and trust value) (Loshin, 2012). With the initial incorporation with BI, the organization will reduce its costs for IT infrastructure. Storage of data within the data warehouse will eliminate the cost of repetitive data extraction. Also, it saves time for users of data by providing efficient access (Watson and Wixom, 2007). Customer satisfaction can be improved by personalization, plus the revenue will be increased due to accessing the target market. A proper analysis of data can be employed towards business process improvement. Furthermore, strategic business objectives can be achieved by convenient decision making. Figure 02 below is an illustration designed by Hung et al. indicating the benefits of BI (Watson and Wixom, 2007).

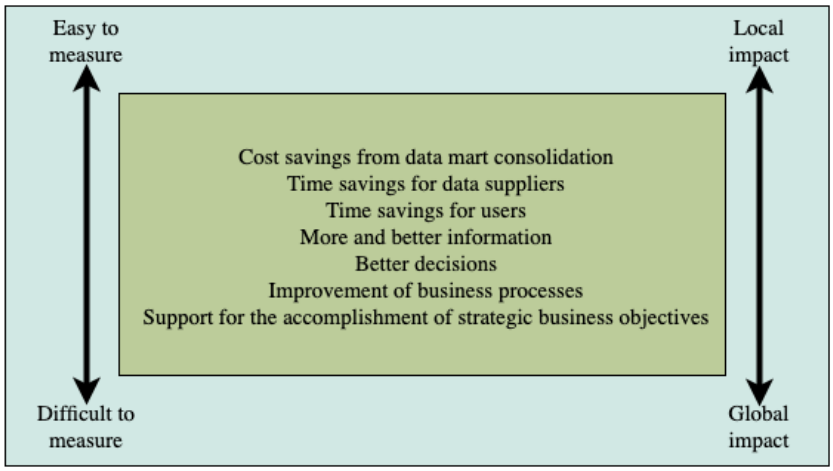

Figure 2: Benefits of BI indicating the impact and difficulty of measurement.

2.1.2 BI Trends

As a result of changes in technology, BI is often subject to changes. Some of the changes are triggered by emerging business requirements. Some of the current trends of BI and technological changes that influence BI will be discussed below.

- **Big Data:** There is no clear boundary to distinguish big data from data. Often massive amounts of unstructured or semi-structured data created by organizations are referred to as big data. Dealing with big data on relational databases requires plenty of time and computational cost. Nonetheless, analysis of big data is beneficial since it can detect repetitive patterns. Therefore big data is generally used with cloud computing to reduce time and cost (Vizgaitytė and Rimvydas, 2012).

- **Software as a Service (SaaS):** SaaS can be described as a delivery method of BI, which is also known as "On demand BI" or "Cloud BI". The applications are hosted at a separate location outside of the company and accessed through a protected connection. Unlike the typical software applications provided by vendors upon subscriptions, SaaS promotes a pay-as-you-go model (Konchev, 2013).

- **Location Intelligence (LI):** This incorporates the fundamental concepts of BI with Geographical Information Systems (GIS) concepts and thereby facilitates location data analysis. Geotagged data are being used to provide more insight for end users (Vizgaitytė and Rimvydas, 2012).

- **Self-Service BI:** In self-service BI the users (often business people) themselves perform the analysis and reporting with the infrastructure provided by IT experts. It promotes user independence and

supports individual users to perform more personalized tasks. (Janoschek, 2021).

- **Predictive Analysis:** Predictive analysis is a data mining technique that can predict future possibilities related to business organizations. It is an important trend for businesses since it can be utilized to maintain market competition (Janoschek, 2021). Business risk can be forecasted and effectively managed by applying predictive analysis.

- **Mobile BI:** This can be referred to as accessing information through mobile devices to perform business intelligence-related activities. This includes both technical and organizational components to support the growth of a firm. Since this study's primary objective is to explore mobile business intelligence, further details will be discussed during the next sections.

2.2 Mobile Business Intelligence

Usage of mobile devices is pervasive at present due to the accelerated evolution of mobile technologies. In 1985 analogue mobile devices were invented, and the GSM devices became available in 1993 (Harper, 2003). During the early stages of mobile phones, only light-weighted software applications (address book, notepad) were available apart from the communication. With the advancements in internet technologies, the capabilities of mobile devices rapidly increased. Nowadays, most mobile devices comprise features similar to desktop computers despite being used differently. The increasing use of mobile devices in day to day activities made the pathway for business managers and researchers to explore more possibilities of mobile business. The desire of making faster responses to critical issues and progress in delivering sophisticated applications on mobile devices by vendors also promoted the progression of mobile BI (Airinei and Homocianu, 2010).

Mobile BI can be interpreted as an extension to the traditional BI where the success of the decision making depends on the mobile devices. In mobile BI, data is extracted from mobile devices, including smartphones, Personal Digital Assistants (PDAs), wearables and tablets and used to perform BI-related activities. The information is delivered to the end-users under three categories. The pull/scheduled reporting category provides user-specific reports regularly, and the users can access the required data to perform their tasks regardless of the time. In the exceptions and alerts category, correlated users will receive alerts upon the occurrence of unexpected incidents. The last category is sharing, which distributes insights for authorized users of the business organization (Phoobane and Kotzé, 2018).

Although BI applications are intended to run on different types of mobile devices, the technological aspects should be customized to make them suited for particular devices. As a result, various technologies are being

used to implement content on these devices. HTML5, proprietary technologies such as Flash, catering PDF documents in mobile devices are some techniques prevalent in the market at present (Janoschek, 2021). Primarily, there are two approaches to mobile BI infrastructure. Namely, native applications and browser-based applications (Dubravac and Bevanda, 2015). In addition to these two infrastructures, hybrid applications (a combination of native and browser-based applications) and cloud technologies are also evolving to provide more capabilities. Among these infrastructures, browser-based applications perform well regardless of the platform but with limited functionalities. Native applications are customized according to the operating system and need to be installed into the devices. Even though native applications are comparatively expensive to implement, they provide enhanced features for visualizations and analytics. Hence, native applications are more interactive with users than browser-based applications.

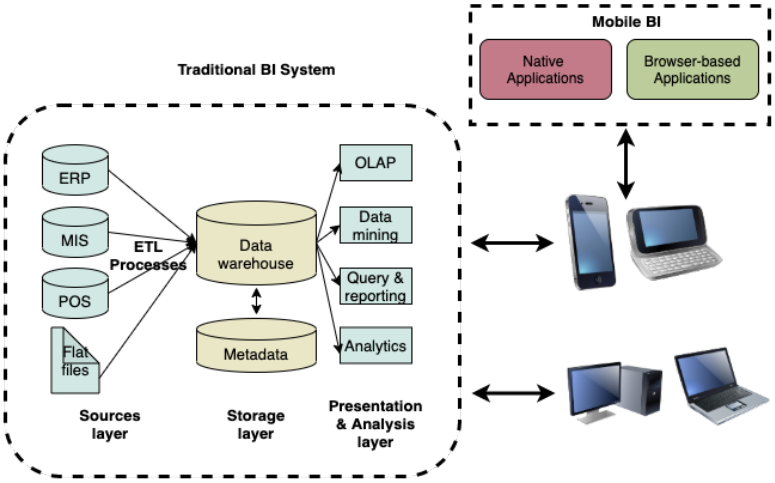

Figure 3: Illustration of the MBI architecture with two primary infrastructures (Native applications and Browser-based applications) (Dubravac and Bevanda, 2015).

In addition to the advantages of BI mentioned above, mobile BI allows users to access real-time data from anywhere at any time. This facilitates responding to the dynamic business environment and critical situations. The overall productivity of the organization will be increased due to faster and precise decision making (Phoobane and Kotzé, 2018).

2.2.1 Challenges and Limitations of Mobile BI

Since mobile BI is consistently associated with mobile devices, limitations are interlinked with the capabilities of these devices. The dominant limitation is the variations of the screen sizes of different devices. For

instance, tablets possess more space on the screen to display reports, analytics and KPIs (Key Performance Indicators), unlike mobile phones. Another limitation is the low memory capacity of the mobile devices which also affects mobile BI. Compared with traditional BI, mobile BI is constrained due to the low processing power of mobile devices (Airinei and Homocianu, 2010). A significant challenge in developing mobile BI applications is ensuring user acceptance by implementing user-friendly interfaces. Sensitive business data and information should be protected by implementing proper security configurations. Unlike the other devices, mobile devices can be lost or stolen due to mobility. This leads to the breach of confidential business information, which might increase the risk of business organizations. Deployment of mobile BI applications requires a considerable cost (especially on the development of native applications). Therefore the business organizations need to bear the time for return on investment. Last but not least, the dynamic behaviour of the business environment and behavioural changes of the mobile device users will also impact mobile BI (Dubravac and Bevanda, 2015).

2.2.2 Use Cases

This section of the study will discuss three use cases of mobile BI found in the literature. The first example will discuss the mobile business intelligence assistance (m-BELA), developed for higher education executives (Afandi et al., 2019). The next example is focused on a framework to deploy mobile BI within small and medium enterprises in developing countries (Kalema, 2018). The third use case represents an open-source service-oriented tool for mobile BI (Sajjad et al., 2009) proposed by Sajjad et al.

Irwan et al. proposed a mobile application to understand users' voice commands and acknowledge accordingly by providing required data or information for the given command. The application uses both internal and external data sources and displays the results as graphs and reports. HTML5 and javascript have been used as the technologies during the implementation of the m-BELA application. Although this paper has given the implementation details of a native application, there is no evidence of evaluation of the application. Also, the authors have not assessed the impact of this application on higher education executives.

Samuel et al. proposed a framework to deploy mobile BI within small and medium enterprises (SME) in developing countries. They have identified that the SMEs are not using the mobile BI applications due to difficulties in implementation. The reason for this is the unavailability of a convenient framework for implementing mobile Bi applications. The authors have studied various approaches such as textual analysis, principal component analysis, and structural equation modelling. They determined multiple factors (financial resources, top management support, management expectations, etc.) under different categories that affect

mobile BI in SMEs. These factors were then analyzed against their frequencies during textual analysis. Finally, the conceptual framework has been designed by further analysis of the identified factors. A significant step taken by the authors was, evaluating the developed framework using AMOS statistical software and also against the hypothesis (Kalema, 2018).

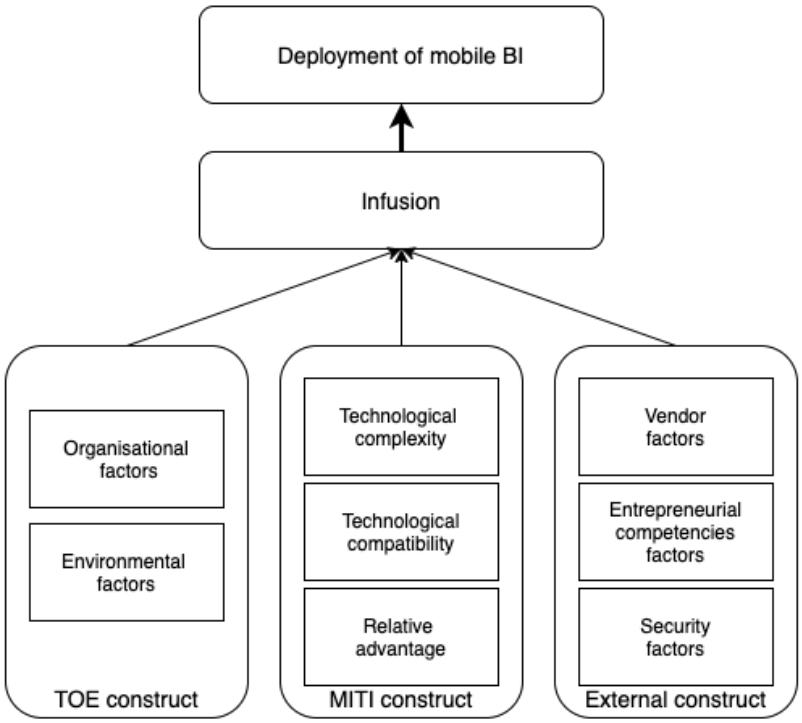

Figure 4: Framework proposed by Samuel et al. for deployment of mobile BI.

Sajjad et al. have developed an open-source service-oriented tool for mobile BI (MBIT). They have used a service-oriented architecture to make the application platform-independent. This study addressed the limitations of the existing mobile BI applications through the proposed application and enabled the end-users to customize the features according to their requirements.MBIT application supports business executives in making faster decisions in critical situations and comprises Web 2.0 compliant in the front end. The application has been tested on the intranet against two other back-end systems (Sajjad et al., 2009). Since all the web services have been tested only on the intranet, the issues related to deployment on the internet cannot be foreseen. Even though the authors claim that the application has been tested, the testing and evaluation results are not presented within the paper.

3 Conclusions

Despite the numerous research conducted in the area of business intelligence, significantly less amount of research work has been carried out in the area of mobile BI. However, research on this concept mainly intends to focus on the user interface design, advancements of mobile technologies and security aspects. Although there are a few limitations and challenges, the immense advantages expand the interest of business organisations towards mobile BI. The burden of the low processing power of mobile devices could be worked out by using cloud computing. The processing phase can be performed on the cloud while limiting only the data visualisations on mobile devices. Since the expectations of mobile BI increase with the changing business environment, further attention and effort should be taken in this research domain.

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