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State-of-the-art Mobile Business Intelligence

A study based on evaluating three BI vendors

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Abstract - Mobile BI has become popular in today's business since technology and devices have evolved to make mobile BI cost-efficient and it is accepted as one of the most promising software areas in the near future. In this paper we introduce the-state-of-the-art mobile business intelligence (BI). It is a qualitative study that gives an insight of three BI vendors and their future adaptations. Quality attributes are used as a software quality metric to make the assessment as to whether quality requirements defined in this study are being met and going to be met in the close future. We aimed to create an overall picture of the quality requirements of mobile BI by exposing its challenges, and evaluate the upcoming improvements in mobile devices to understand future state of the mobile BI. Findings from the study demonstrate that quality requirements of mobile BI defined in this study are essential to satisfy the needs of customers. BI vendors examined in this study develop similar solutions to adapt their system to those requirements and achieve desired combination of those requirements.

Keywords: mobile business intelligence, mobile BI requirements, quality requirements of mobile BI, future state of mobile BI, future directions in mobile devices.

1. Introduction

With the contributions to development of data creation, storage, and access (Airinei and Homocianu, 2010), information has become one of the most important resource for the enterprises (Sajjad, et al., 2009). However, deriving information from multiple sources became difficult for decision makers. A new set of tools using computer based techniques was required in order to extract data from enormous database and facilitate the decision making process (Sajjad et, al., 2009); hence the born of business intelligence (BI).

Rapid technological development in the last decade has changed the capabilities of the mobile phones enormously. Today, they are actually fairly powerful computers (Stipic and Bronzin, 2011). The need of data access and technological development of the mobile devices let IT professionals to develop an extension of BI called mobile BI. Stipic and Bronzin (2011) describes Mobile BI as a procedure which lets users to access different types of data anytime and anywhere by using the appropriate applications and devices. Such procedure allows users to make fast and accurate decisions (Stipic and Bronzin, 2011) and increases their responsiveness (Airinei and Homocianu, 2010) without a need of their office computers (Eckerson, 2011).

There are obstacles limiting the deployment of mobile BI systems such as limited data storage, CPU power and lack of accurate connection. Architectural solutions developed are still inadequate to overcome those limitations (Yamakami, 2008). Thus, it is important to concretize and prioritize the requirements in order to elicit most important ones. Besides, today's business environment considers the mobile BI solutions as one of most promising areas in the close future (Dresner Advisory Services, 2011) as useful and necessary to distribute intelligent business data (Stipic and Bronzin, 2011). In order to realize the future state of mobile BI, we determine the future directions in mobile devices that may have impact on the quality attributes of mobile BI systems such as improvements on hardware, software and architecture (Stipic and Bronzin, 2011). This study aims to create a rich picture of the quality requirements of mobile BI and expose the forthcoming technological improvements in order to evaluate the mobile BI systems in the present and future.

Within this study we will report on the software requirements of mobile BI, and evaluate those with respect to existing mobile BI systems and future directions in mobile devices. Report uses three mobile BI systems developed by major BI vendors; IBM Cognos Mobile, SAP BusinessObjects Mobile and Jaspersoft Mobile.

This research is intended to contribute to body of knowledge on mobile BI and its quality requirements.

In section 2, paper presents an overview of related research in the field of mobile BI, its software requirements, and upcoming technological improvement in the mobile devices. Related research is followed by research approach in section 3 where the method being used dilated. Data collected is presented in section 4 and general implications of the findings are elaborated in section 5. Finally, section 6 presents a conclusion has drawn from analysis, and suggests some future work.

2. Related Research

In this section, paper summarizes the related research in the mobile BI area. The related research contains a brief review of mobile BI systems, software requirements, mobile BI challenges where quality attributes of mobile BI is identified and future direction in mobile devices respectively.

2.1. Mobile BI

Mobile BI refers to taking front end view of BI onto mobile devices (Sajjad, et al., 2009). Mobile BI therefore aims to fulfill main requirements of BI systems. According to Wu, et al. (2007), there are three main objectives that architects should consider when creating a BI architecture solution; (a) provide always correct data across the organization, (b) provide simplified system implementation-deployment-administration, (c) deliver operational needed/necessary knowledge to perform an action. These main objectives combined with characteristics of mobile devices create the main quality requirements of mobile BI presented in the section; “Challenges”.

A conducted market study published by Dresner Advisory Services (2011) on mobile BI indicates the importance of mobile BI that over %65 organizations accepted such solutions as “very important” (%45) and “critically important” (%23) in 2011 versus %52 (%35 and %17 respectively) in 2010. This study as well shows that companies accepted mobile BI as unimportant in 2010 declined from 11% to only 2% in 2011 (Dresner Advisory Services, 2011) even though the field being examined is fairly new (Stipic and Bronzin, 2011); hence, mobile BI solutions are one of most promising areas in the near future.

2.2. Software Requirements

Evaluating a software system is equivalent to defining quality attributes of that system. According to IEEE Std 1061 (1998), “Software quality is the degree to which software possesses a desired combination of attributes”. Paper exposes software requirements in order to define those attributes of mobile BI.

Software requirements are the needs of customers for a system which provides the services and constraints on it (Sommerville, 2011). They are used as software metrics to

evaluate the software systems. They are divided as functional and non-functional (quality) requirements.

Functional requirements define the functionality of the system; what system should do. The latter is defined as constraints on the functionalities of the system; how system should be (Sommerville, 2011). There is not a strict distinction between them according to Sommerville (2011); “A user requirement concerned with security, such as limiting access to authorized users, may appear to be a non-functional requirement. However, when developed in more detail, this requirement may generate other requirements that are clearly functional, such as need to include user authentication facilities in the system.” This emphasize that they may be dependent each other and one can generate or constraint another. Thus, paper exposes functional and quality requirements of mobile BI together. They are analyzed in order to concretize and then prioritize the quality requirements of mobile BI.

2.3. Challenges

Mobile BI architecture differs from BI architecture design because of the characteristics of mobile devices. Those characteristics give challenges for software engineers have to cope with. Yamakami (2008) depicts those challenges in three categories; Constraints, diversity, and changes. First, there are constraints that mobile devices require to overcome such as limited storage and battery, inadequate capabilities of input, CPU power and so forth (Yamakami, 2008). The latter is diversity that mobile computing environment has to overcome such as hardware, software, basic networks and so forth. Execution environments and main application platforms on computers are differ than mobiles. That is challenge for software engineering in terms of coding and testing (Yamakami, 2008). Finally, changes should be updated in mobile computing. Due to rapid changes in hardware, software and networking in between, it is difficult to design architecture (Yamakami, 2008).

Mobile BI architecture is complex and involves many design tradeoffs because of those challenges. Without undertaking a formal analysis process involving stakeholders (Safeer and Zafar, 2011), it is difficult to ensure that the architectural decisions made—those which make constraint on the achievement of quality attribute such as performance and security—are appropriate ones that eliminates the risks (Kazman, et al., 2000). Kazman, et al. (2000) argues that an evaluation method done early in the project can be used to verify that design is appropriate for the problems. Architecture Trade-offs Analysis Method (ATAM) is a technique for analyzing software architectures and aims to understand the consequences of architectural decisions with respect to the quality requirements of the systems (Kazman, et al., 2000). Such method evaluating the mobile BI systems should also carry out the mobile devices as main platform in the process.

There are three phases in ATAM divided based on to achieve different goals; paper focuses on particular phase of ATAM (phase 0) preparing prerequisites materials in order to concretize the mobile BI system requirements (Kazman, et al., 2000).

Prerequisites materials: There are three prerequisites of ATAM presented by Kazman, et al. (2000);

- Known business drivers (system background)
- Defined quality attribute scenarios
- A draft architecture

Purpose of using ATAM in this study is to define quality attributes of mobile BI; thus draft architecture is out of scope. In order to get appropriate requirements of mobile BI, the users, functionalities and business drivers of the mobile BI systems will be identified (Kazman, et al., 2000).

2.3.1. Users of Mobile BI

Users of mobile BI can be defined in general as corporate workers who require relevant and real-time business data (Sajjad et al., 2009) when they are out of office (Eckerson, 2011). While retailers for example, require to access data in real time even when they are on visiting the stores (Airinei and Homocianu, 2010), executives might need Key Performance Indicators (KPIs) even when they travel between work locations (Eckerson, 2011). Mobile BI system offers users functionalities of BI but including more;

- Supports decision making, data mining, documenting, and online processing (Sajjad, et al., 2009).
- Allows users to work effectively when they are outside of office, (Sajjad, et al., 2009).
- Keeps business processes running anywhere and anytime (Sajjad, et al., 2009).
- Improves information flow through organization (Eckerson, 2011).
- Allows users to view and interact with dashboards and reports when they are on the road (Airinei and Homocianu, 2010).
- Alerts users to rapid corrective actions (Stipic and Bronzin 2011).

2.3.2. Business Drivers of Mobile BI

Business drivers of a system consist of its business requirements and constraints on functionalities (Kazman, et al., 2000). Mobile BI system addresses business requirements that includes;

- The system should allow users access relevant and up-to-date business information (Stipic and Bronzin 2011).
- The system should allow users to work online and offline (Eckerson, 2011).

- The system should work all the time regardless of location (Eckerson, 2011).
- Information must go to right person to secure the corporate confidential information (Bass, et al., 2005).
- Users can continue working outside of office (Sajjad, et al., 2009).
- System should respond quickly to change (Yamakami, 2008).
- Users can update information and take actions from mobile devices (Eckerson, 2011).

Constraints for the system included;

- Interoperable system which should work no matter what hardware technology is being used (Yamakami, 2008).
- Secure system concerns in mobile BI limit the exposing information which might damage the effectiveness of mobile BI (Dresner Advisory Services, 2011).
- Allowing mobile devices to get access to network of companies might cause security and privacy problems (Dresner Advisory Services, 2011).
- Loss of mobile device damages the security control that critical business information must be compromised (Dresner Advisory Services, 2011).

2.3.3. Quality Attributes of Mobile BI

Based on the business drivers of mobile BI systems identified above, user stories are identified as high priority;

- Mobile BI system should work no matter what hardware and software technology is being used.
- Mobile BI system should provide relevant information based on real-time.
- Mobile BI should provide its services when and wherever needed.
- Mobile BI system should work independent of the Internet connectivity.
- Mobile BI system should ensure that corporate business information is conserved.
- Mobile BI system should ensure data is not corrupted.
- Mobile BI system should be flexible to change (add/remove/update of services) at short notice.

Based on stories identified as high priority, paper addresses following quality attributes as priority to be exposed in order to evaluate the current and future state of mobile BI; (1) **interoperability** (Sajjad, et al., 2009; Yamakami, 2008), (2) **reliability**, (3) **availability** (Eckerson, 2011; Sajjad, et al., 2009; Stipic and Bronzin 2011), (4) **security** (Airinei and Homocianu, 2010; Eckerson, 2011) and (5) **modifiability** (Airinei and Homocianu, 2010; Yamakami, 2008).

Paper addresses availability and reliability under same topic since they point similar scenarios in mobile BI.

Interoperability refers to universal accessibility and allows exchanging data among internal components and outside of the world (Qian, et al., 2010). Interoperable mobile BI work no matter what hardware and software technology is being used (Yamakami, 2008). Components of mobile BI should interoperate with all other components independently (Sajjad, et al., 2009). Thus, assessment of interoperability degree in this paper is in which mobile BI processes a desired combination of hardware and software independence. For instance, web-based, native and hybrid solutions are developed working on varied mobile devices such as smart phones, PDAs and pocket PCs, and operating systems Android, Symbian and Windows Mobile operating systems to increase interoperability in other words, hardware and software independency of mobile BI. According to Sajjad, et al. (2009), high interoperable mobile BI should provide BI content on varied mobile devices and operating systems.

Availability refers to the degree of accessibility of the modules or components. For example, a set of services required to meet the requirements of the system should be available or services to be used should be available when needed (Bass, et al., 2005). Sajjad, et al. (2009) argues that users of mobile BI systems require such functionality to access the information anytime and anywhere. **Reliability** of mobile BI is also considered as crucial (Eckerson, 2011). It refers to the failure frequency of the system (Qian, et al., 2010) in which mobile BI should keep operating over time (Sajjad, et al., 2009), the accuracy of output (Qian, et al., 2010) in which users of mobile BI require reliable delivery of business information (Stipic and Bronzin 2011). Bass, et al. (2005) draw attention to another problem of reliability; “Services are often made available over a network with possibly unreliable communication channels. Connections break and messages fail to get delivered or are delivered more than once or in the wrong sequence. Although techniques for ensuring the reliable delivery of messages are reasonably well understood and available in some messaging middleware products today, messaging reliability is still a problem. If reliability is addressed by service developers who are incorporating reliability techniques directly into the services and application, there is no guarantee that they will make consistent choices about what approach to adopt. The outcome might not guarantee end-to-end reliable messaging.” As Bass, et al. (2005) mentioned that reliability of a system is connected to availability of it and paper addresses reliability and availability as one attribute in relation to following scenario; Users of mobile BI require access to relevant and up-to-date business information to facilitate decision making. By doing that, mobile BI system should work online and offline regardless of time and location.

Security is associated with different requests such as information confidentiality, information integrity and information availability (Wang and Jiang, 2009). According to Bass, et al. (2005), information confidentiality refers to access to data is only possible by authorization to ensure that business information is conserved and business information must go to right person to secure the corporate confidential information. The latter, data integrity ensures that data is not corrupted. Finally, information availability is that information is available over time (Bass, et al., 2005). In order to satisfy the security principles, information should be accessible with authorization and there is a need for authentication among users. Hence, access to functionality of mobile BI can be based on an authorization mechanism (Wang and Jiang, 2009). Besides, different users of mobile BI system could access different information through different security levels (Wang and Jiang, 2009). For example, wireless networks are considered as insecure and require additional security service provided by the server (Airinei and Homocianu, 2010). Finally, in case of lost or stolen devices, mobile BI should conserve the confidential data (Eckerson, 2011). Paper addresses security as to whether or not confidential enterprise information is conserved and data that exchange between the services is not corrupted.

Modifiability refers to an ability to make quick changes in cost-efficient way. Loose coupling between modules created brings that ability (Bass, et al., 2005); ease of software system change (Qian, et al., 2010). There is a rapid change in mobile computing and it is defined as challenge in mobile BI that BI vendors have to respond to change in timely manner (Yamakami, 2008). Paper encompasses modifiability as flexibility and reusability; the degree in how easy a system or component can be modified for use in mobile BIs on varied mobile devices and mobile operating systems. Airinei and Homocianu (2010) addresses different architecture solutions designed such as web-based, native and hybrid in order to increase flexibility of mobile BI. They also argue on reusability of BI services that simplify implementation on varied mobile devices and mobile operating systems.

There is another quality attribute identified by using other quality attribute stories which address usability of mobile BI—paper does not focus on usability of mobile BI due to the limitation of data collection regarding user involvement—; Mobile BI system should support to drill-down from report to detailed information and enable user interaction (Airinei and Homocianu, 2010).

2.4. Future Directions in Mobile Devices

Along with contributions to development of functionalities and capabilities of mobile devices such as accessing different networks (Wang and Jiang, 2009), information processing, storing mass, and intermodal user interface (Ryhänen, 2009), they are expected to be trusted platforms for mobile BIs (Ryhänen, 2009). This section exposes the improvements in mobile devices that have done over last decade and expected contributions over time in order to understand what direction the mobile devices verge on. It contributes to understand future state of mobile BI; hence their quality requirements. Paper presents technological improvements in mobile devices as to whether main quality attributes of mobile BI are going to be met or changed in the close future.

Expected contributions and new capabilities are categorized in four main fields by Stipic and Bronzin (2011): Hardware and communications, users experience, software and architecture. Research approach limits data collection regarding human interaction and user experience of mobile BI systems. Users experience so is not covered in this study.

2.4.1. Hardware & communications

“Usage of GPS in mobile BI”

Almost all of the new mobile devices are equipped with GPS capability. Although the GPS and business intelligence technologies exist for years, location based business intelligence is becoming vital component of mobile BI with the rise of the mobile BI (Dignan, 2007). The location based business intelligence lets you make more effective decisions based on who you are and where you are. The mobile business intelligence system creates only necessary reports based on location and simplifies data with the focus of the location (Dignan, 2007).

“Tablets with larger screens will prove themselves to be much more usable devices than mobile phones”

There is a change in trend with mobile devices from small screens to significantly larger screens (Apple iPad, Samsung Galaxy Tab, Windows Slate and so on). This shift enables to place more information and promote better user interaction for mobile BI. Besides, high quality touch-screen will be supported in future mobiles (Stipic and Bronzin, 2011). IDC analyst Stephen Drake claims that mobile devices which have better resolution and screen capabilities make easier data analysis on mobile devices (Fitzgerld, 2010).

“Higher speeds will allow larger data flows in both directions”

The speed of communication increased from 4800 bit/sec to 3000000 bits/sec in 10 years time between 1998 and 2008. Besides, there are improvements on data transfer rate from 2G (e-mail) to 3G (access to internet, web browsers

and complex applications) to 4G (video streaming) respectively. It is expected that contributions to increasing speed of communication, data transfer rate, and device options will be main reasons of steady growth on mobile devices in near future (Stipic and Bronzin, 2011). Besides, mobile device which supports better internet connectivity make easier data analysis on mobile devices (Fitzgerld, 2010).

2.4.2. Software

“HTML 5.0”

With the development of HTML5 and its capabilities in a browser allow the BI vendors to develop one mobile BI application that runs regardless of platform (Tunvall, 2012). Therefore, when there is a need for adding functionality to existing mobile BI application, it will be more flexible and less time consuming to modify one version of an application that runs every platform (Tunvall, 2012). Moreover, HTML5 brings a solution; In case of mobile cloud application it is possible that a cloud keeps working even connectivity is interrupted (Qureshi, et al., 2011).

“Extensive use of WEB services”

The Internet and networking will enable information in a global platform and mobile devices are expected to have new capabilities as Ryhänen (2009) argues; “they will perform as server for global and local services and as client for global internet services”. Besides, mobile devices will be connected to the local environment and the Internet as gateway without interruption (Ryhänen, 2009).

2.4.3. Architecture

“SaaS (Software as a Service)”

Obstacles limiting rapid and cost-efficient maintenance and increased scalability (Candan, et al., 2009) have led to a movement where an application functions through a network (Anerousis and Mohindra, 2006); Software as a Service is a cloud based delivery model for software applications which are accessible through the Internet. Enterprise Resource Planning (ERP), customer relationship management (CRM), accounting and management information systems (MIS) are four of the most common business environments using SaaS applications (Cloud Taxonomy, 2010). Numbers of SaaS users and preparing to be SaaS users have increasing over the time. It is due to the benefits of SaaS applications as Anerousis and Mohindra (2006) described; multi-tenancy design allows multiple users to perform one instance of application. Besides, there is no installation or maintaining of SaaS application required for the users since provider of the system carries on all needed. At last but not least, any mobile device with continuous connectivity can execute the application with a simple browser (Anerousis and Mohindra, 2006).

"Mobile BI in the CLOUD"

The idea behind the cloud computing is to distribute data and process it (Song and Su, 2011) using computers and servers interconnected together (Qureshi, et al., 2011). Therefore a group of computers and servers manage the computing problem divided into small tasks. There is an extension of cloud computing to mobile devices providing real-time network resources (Song and Su, 2011); in case of mobile BI systems it is to provide relevant and real-time business information anytime and anywhere. It functions as data storage and processing so that mobile applications are independent then type of mobile devices or operating systems (Qureshi, et al., 2011) as well as CPU power and storage capacity of mobile devices are not limiting the deploying mobile BI applications.

3. Method

In this section, the description of research approach used in this paper is presented. It contains following areas; research setting and process, vendor selection, limitations of study and finally analysis method.

3.1. Research Setting

This study is qualitative study to introduce state-of-the-art mobile BI and its requirements. Our research was conducted at Department of Computer Science and Engineering which is located at Campus Lindholmen and part of in University of Gothenburg and Chalmers University of Technology.

We chose the quality attributes as software metric to evaluate the benefits of mobile BI systems. The evaluation process had three major components which are divided into minor parts later; determining the quality requirements of mobile BI system, exposing future directions in mobile devices, and choosing three mobile BI systems among all products. Quality requirements were defined using first phase of Architecture Trade-off Analysis Method (ATAM). We exposed future directions in mobile devices in order to understand the future state of mobile BI as to whether defined requirements will be met or changed in the near future. Three major mobile BI products are selected and examined to pose the question of how industry fulfills those requirements in the present and future.

3.2. Research Process

First step of the research process was brainstorming with our supervisor to gain better knowledge and understanding of problem domain. The process proceeded with literature review from related resources as follows; books from library of Chalmers and Gothenburg Universities, academic articles from IEEE Xplore digital library and Google scholar, journals from Chalmers library database and existing reports and documents from companies selected.

Once the field of mobile BI has reviewed, we performed first phase of ATAM. Therefore, we defined functionalities which mobile BI offers for its users, and exposed business requirements of mobile BI and constraints on functionalities. By doing that, we obtained the concretized quality requirements of problem domain. Second, we exposed future directions in mobile devices in terms of promising features that may support or change the quality attributes of mobile BI in the close future. Finally, those requirements are evaluated in the present and future by getting an insight of the existing products and their future adaptations.

3.3. Vendor Selection

There are three mobile BI products exposed in order to understand industrial solutions on mobile BI. We chose those considering their popularities in the market and license agreements; proprietary and open source software. IBM Cognos and SAP BusinessObjects are chosen as a perspective of market leaders and proprietary license agreement, when Jaspersoft is chosen as a perspective of niche player in the market and open source license agreement (Sallam, et al, 2011).

3.3.1. Open source vs. Proprietary software

Open source software (OSS) is licensed to grant the users of software to use, study, modify and redistribute source code where as proprietary software forbids it with copyrights over the software (Heffan, 1997). OSS has advantage of its rapid development by volunteer contributions (DiBona, et al. eds, 1999) while proprietary software retains the source code that only licensee can use the software under the conditions (Heffan, 1997). IBM Cognos and SAP BusinessObjects Mobile are proprietary software that restricted to inspect, modify and redistribute source code. On the other hand, Jaspersoft Mobile is commercial open source software that offers its basic applications for free and extra functionalities can be purchased for a reasonable price (DiBona, et al. eds, 1999). Due to OSS development philosophy (DiBona, et al. eds, 1999), contributions to development of Jaspersoft mobile are more rapid.

3.3.2. IBM Cognos Mobile

Cognos software offer wide range of services designed to facilitate decision-making in your organization; from business intelligence to financial performance and strategy management to analytics applications (IBM Cognos, 2012). IBM Cognos Mobile enables users to access BI content anywhere and anytime by extending Cognos Business Intelligence to mobile devices (IBM Cognos Mobile, 2012). It provides a flexible and proven platform to ensure mobile decision-making is simple, reliable and secure for users who require to view, analyze and share IBM Cognos BI content on varied mobile devices whether they are on the road or at the office, and online or offline without interruption (IBM Cognos Mobile, 2012).

3.3.3. SAP BusinessObjects Mobile

SAP AG is a software corporation to manage business operations and customer relations of enterprises. SAP BusinessObjects BI provides BI solutions; supports making fact-based decisions throughout your organization, allows users to access relevant information and helps achieving quick, confident, and ultimate remarkable results (SAP Business Intelligence, 2012). SAP BusinessObjects extends its BI solutions to any mobile devices when and wherever needed. SAP Mobile BI delivers real-time visibility into your organization with a secure mobile experience. Users have immediate access to online and offline information (SAP BusinessObjects, 2011).

3.3.4. Jaspersoft Mobile

Jaspersoft offers extensive BI capabilities with flexible, cost effective and widely deployed business intelligence software to enable better decision making. It provides a web-based BI solution with commercial open source software (COSS) which benefits from continuous contributions from its active community (Jaspersoft Mobile, 2012). Jaspersoft mobile extends functionalities of Jaspersoft BI solutions to mobile devices with modern design, flexible architecture and affordable licensing to increase usability and flexibility, and reduce cost respectively (Jaspersoft Evaluation Center, 2012).

3.4. Limitations of study

Limitations in this study are as follows:

- Vendor selection is done based on only popularities of their products in the market and software license agreements used.
- Future state of mobile BI is evaluated based on only upcoming technologic improvement on mobile devices.
- Study does not probe for trade-offs among the quality requirements of mobile BI defined in this study.
- Data collection is done based on the documentation of companies published and accessible through the Internet.
- There is another quality attribute defined in this study as primary which has remarkable impact on mobile BI systems; Usability. Due to the method used for data collection which excludes user experience of mobile BI, usability is out of scope.

3.5. Analysis Method

Collected data analyzed with the focus on functional and non-functional software requirements of mobile BI. Data collected from BI vendors is reviewed as to whether industry meets the quality attributes of mobile BI defined in the present. Data collected from published articles regarding future direction on mobile devices analyzed to understand the future directions in mobile BI.

4. Data Collection

In this section, we have collected the data from the available reports and documents of three major mobile BI vendors. The data collection is structured based mobile BI and its quality requirements in the present and future.

4.1. The Present

Interoperability: IBM Cognos Mobile has wide support for the leading mobile devices and operating systems with the options of native and web access applications. Cognos Mobile supports BlackBerry phones and PlayBook, Apple iPhone and iPad, Google Android operating system, Nokia devices using Symbian operating system and Windows Mobile operating system (IBM Cognos Mobile, 2012).

SAP BusinessObject also developed varied options which provide BI content on different platforms. SAP BusinessObjects mobile has support for Windows mobile and Symbian platforms since SAP BusinessObjects Mobile BI XI 3.1 version (SAP BusinessObjects, 2011). According to announcement in early 2012, SAP BusinessObjects mobile will support two other main platforms, including Android and RIM by year 2012 (Lucas, 2012).

Jaspersoft mobile has similar strategy as IBM Cognos and SAP BusinessObjects to increase interoperability of mobile BI. It is designed with support of both native and web-based architectural solutions (Jaspersoft Mobile, 2012). It also provides mobile SDK for iOS. Application developers have flexibility of development with the access of the new APIs and client tools (Business Intelligence News, 2011).

Availability and Reliability: IBM Cognos mobile offers high availability to access data. User can reach to reports or other BI contents even when the device is offline. Cognos mobile also provides most up to date, location aware intelligence (only BlackBerry support for now) which gives more reliable BI data (IBM Cognos Mobile, 2012).

SAP BusinessObjects mobile enables users to use their existing security methodologies. Ability of using existing security methodologies gives the trust and reliability of the SAP BusinessObjects BI to the mobile platform level. Thus, it makes centrally hosted and managed mobile content 24/7 available (SAP Business Objects, 2011). Another feature of BusinessObjects is ability to save documents locally which gives availability to any connection interruptions (SAP BusinessObjects User Guide, 2012).

Jaspersoft mobile is developed with open source methodology. Enabling developers to reach the source code and accessing to Jaspersoft and iOS APIs gives flexibility of strengthen the abilities in availability and reliability perspective of the system (Jaspersoft Mobile, 2012).

Security: IBM Cognos Mobile provides security built into both device and Cognos Business Intelligence level which

secures against lost or stolen device and unauthorized access. The security applies in both online and offline mode (IBM Cognos Mobile, 2012).

SAP BusinessObjects Mobile provides security with encrypted data both in device level with device specific encryption and in server level with standard-based encryption. The data is being compressed first before any encryption being applied (SAP BusinessObjects, 2011).

Jaspersoft mobile provides security in central repository level. Central repository secures reports, dashboards or any type of representation of data (Jaspersoft BI Platform, 2012). Security integration in Jaspersoft designed with flexibility in mind. Jaspersoft uses built-in Spring Acegi (Java/JavaEE framework that provides authentication, authorization and other security features) based authentication and authorization with the ability of integrating external security systems such as Windows Active Directory Service (Jaspersoft BI Suite, 2007).

Modifiability: Jaspersoft mobile is created with flexibility in mind. The nature of the open source development enables developers to modify mobile BI system and fit to their needs. Jaspersoft mobile BI increases the modifiability with enabling the developers to access Jaspersoft and iOS APIs to fulfill the needs more efficient or to embed Jaspersoft mobile BI to another existing BI system (Jaspersoft Mobile, 2012). Due to nature of closed-source software development, IBM Cognos mobile and SAP BusinessObjects mobile are not evaluated by developer's aspect of modifiability.

IBM Cognos mobile has both native and web based architectural solutions (IBM Cognos Mobile, 2012). Thus, increases the flexibility when to choose the right implementation according to company needs. IBM Cognos mobile provides capabilities in mobile apps to implement needed and reusable BI content in any device (IBM Mobile Apps, 2012).

SAP BusinessObjects mobile gives opportunity to use existing BI resources. The reusability of existing BI content keeps the user up to date and enables fast first running. The user is able to see the reports which are created with SAP Business Web Intelligence and SAP Crystal Reports which decreases the report development time (SAP BusinessObjects, 2011).

4.2. The Future

Interoperability: The need for mobile business intelligence is growing rapidly as the usage of the mobile devices. According to analysts Bitterer and Sood (2011), "By 2013, 33 percent of business intelligence functionality will be consumed via handheld-devices". That suggests that mobile BI users will expect the same user experience from their BI system with Web, mobile devices; regardless the mobile platform (Jasmine, 2012). With HTML5, almost all of the internet content that we can interact will be able to coded

with HTML, Javascript and CSS (Cascade Style Sheets) which brings high interoperability within all of the different platforms and web browsers supporting HTML5 (Robb, 2011). In SAP's 2012 roadmap, they announced that one of the future directions will be covering all HTML5 capabilities (SAP Product Roadmap, 2012). In addition to HTML5, cloud computing supports developing interoperable application on mobile devices. Cloud functions as data storage and processing so that mobile applications are independent then type of mobile devices or operating systems (Qureshi, et al., 2011) as well as CPU power and storage capacity of mobile devices are not limiting the deploying mobile BI applications. Jaspersoft, the producer of the award winning Cloud BI Platform (Jaspersoft Cloud BI, 2010), develops cloud BI applications by providing their partners (SaaS vendors or system integrators) with mobile BI solution (Jaspersoft Cloud, 2012). IDC analyst Stephen Drake claims that BlackBerry will be still in mobile BI, but he also adds developers will develop more applications for more powerful devices like Apple's iPad or HTC Evo, which have better resolution and screen capabilities to make easier data analysis on mobile devices (Fitzgerld, 2010).

Availability/Reliability: It was not possible to use mobile BI over 2G network and it was a concern if the system will work exactly the same like in demo version. The improvement of the network technology made it possible (Fitzgerld, 2010). It is expected that contributions to increasing speed of communication, data transfer rate, and device options will be main reasons of steady growth on mobile devices in near future (Stipic and Bronzin, 2011). The technological improvements on memory capabilities of mobile devices have resulted with new creative solutions on mobile BI. Although the mobile devices still has limited memory capabilities, they support high compression rate than relational technologies. Thus, gives the availability of viewing data both online and offline (Laurent, 2009). The aim of cloud computing is provide real-time information to clients anytime anywhere (Song and Su, 2011). Qureshi, et al. (2011) have categorizes mobile cloud solutions to two; as General purpose mobile cloud computing (GPMCC) and Application specific purpose mobile cloud computing (ASMCC). While GPMCC solution focuses on improving mobile device performance, ASMCC solution is used as communication resource not only for data storage but also for better computational power.

The location based business intelligence lets you make effective decisions with more reliable data, based on who you are and where you are. The mobile business intelligence system creates only necessary reports based on location and simplifies data with the focus of the location (Dignan, 2007). Don Campbell, the vice president of product innovation and technology at IBM Cognos, points on some real-life examples of location based business intelligence. According to Campbell, with usage of location based business

intelligence; the police officer can have real-time reports according the area, or in another example airport worker can reach reports based on luggage locations (Dignan, 2007). The improvement on HTML5 technology will not only will bring high interoperability, but also availability. One of the key features of HTML5 is offline support, AppCache and Database APIs allow storing data locally (Cox, 2009).

Security: One of the challenges of adapting mobile BI is security. Wrong designed security might create crucial problems (Rosencrance, 2011). The most common and effective security approach is ensuring the user is connecting to organizational data from their own BI server (James, 2012).

Security in mobile BI should be designed with both device level and server level security in mind. In device level it is important to have access safeguarded. It should be authorization to access data with time-out ability after a significant time of inactivity (James, 2012). In the server level, it is necessary to have authorization centrally managed. Simple change in authorization system should be able to make stolen or lost devices disabled from the BI server (James, 2012). Using user ID policy and security solution like Okta (Access Management System) make the system even more secure (Morrissey, 2012). However, providing security in device and server level is not enough, transmission security also should be considered. According to Lopez, (2009) mobile BI security should be considered in three levels: (1) device security, (2) transmission security and (3) network security.

Modifiability: HTML5 brings high interoperability as explained in section 4.2 under “interoperability”. In application development, the ability of using the same standards for different mobile platforms brings not only interoperability but also modifiability. Any modification on HTML5 code will be applied regardless the mobile platform on HTML5 supporting browser (Jasmine, 2012). Cloud computing technology promises availability of accessing large data and high computing power with dealing all of the computing processes and related data in the cloud. Any kind of modification on cloud side code will be applicable for clients as long as input/output interfaces (client and cloud interfaces) are suitable enough (Song and Su, 2011). Jaspersoft provides their customers the first multi-tenant SaaS-enable BI suite which enables SaaS providers to implement mobile BI to their existing systems (Jaspersoft Mobile, 2012).

5. Analysis

In this section, we have analyzed the data collected. Analysis is structured same as data collection section; attributes of mobile BI is analyzed in the present and future. The purpose of such division is to evaluate the current and future state of mobile BI.

5.1. The Present

Mobile BI refers to providing BI content on mobile devices (Sajjad, et al., 2009). There are challenges limiting usage of BI content on mobile devices (Yamakami, 2008). Our findings suggest that challenges on mobile BI create the main requirements; interoperability, reliability, availability, security, modifiability. BI vendors examined in this study expend significant amount of time and energy to meet those requirements in their mobile BI software and satisfy the needs of users (Jaspersoft Mobile, 2012; SAP BusinessObjects, 2011; IBM Cognos Mobile, 2012). One subject that remains to be explored is to determine trade-offs among those requirements and evaluate the desired combination of quality attributes is being met in the present.

Users of mobile BI require accessing the information no matter what hardware and software technology is being used (Sajjad, et al., 2009). **Interoperability** is required in mobile BI in term of meeting the desired combination of hardware and software independence (Yamakami, 2008). BI vendors examined in this study aim to develop an interoperable system which does not limit the functionalities and usability of mobile BI based on type of mobile devices or operating systems; IBM Cognos provides its BI content on varied mobile devices and operating systems with varied solutions (IBM Cognos Mobile, 2012) as well as SAP Business Objects (SAP BusinessObject Mobile, 2011) and Jaspersoft (Jaspersoft Mobile, 2012). Web-based, native and hybrid solutions are developed that mobile BI works on different mobile devices such as smart phones, PDAs and pocket PCs, and operating systems such as Android, Symbian and Windows Mobile operating systems (IBM Cognos Mobile, 2012). By doing this, BI vendors aim to meet desired combination of hardware and software independence (Yamakami, 2008) and increase interoperability of mobile BI.

In order to facilitate decision-making, users of mobile BI require relevant and real-time business information when and wherever needed (Eckerson, 2011; Sajjad, et al., 2009; Stipic and Bronzin 2011); hence a reliable and available mobile BI. Different solutions are developed by BI vendors to meet **availability** and **reliability** as follows; an available mobile BI works independent of the Internet connectivity and a reliable mobile BI provides trusted and relevant information over reliable network.

IBM Cognos provides an available service that users can reach information and other BI content whether they are online or offline (IBM Cognos Mobile, 2012). SAP BusinessObjects offers availability to connection interruptions by saving documents locally (SAP BusinessObjects User Guide, 2012) as well as Jaspersoft offers strengthen the abilities in availability and reliability (Jaspersoft Mobile, 2012). By triggering actions from your mobile device based on real-time data, you can enable fast

decision making whether mobile device is online or offline (SAP BusinessObjects, 2011).

As Bass, et al. (2005) stresses that many services are available over unreliable network. Thus, BI content should be provided over reliable network. SAP BusinessObjects provides security services that users can access only trusted and relevant information (SAP Business Objects, 2011).

Security of mobile BI is crucial and concerns conserving the confidential enterprise data essentially. Mobile BI system should ensure that information goes to relevant user (Bass, et al., 2005). BI vendors examined in this study developed varied solutions to create a secure mobile BI system. Information for example, is accessible with authorization and require authentication. Different security levels are provided for the users who can access different type of confidential business data with authorization and authentication. Addition to authorized access, BI vendors offer secured system against lost and stolen device in both online and offline mode (IBM Cognos Mobile, 2012) by providing security both in server and device level (SAP Business Objects, 2011). Jaspersoft uses built-in based authentication and authorization with the ability of integrating external security systems (Jaspersoft BI Suite, 2007).

With growing numbers of contribution to capabilities and functionalities of mobile devices, mobile BI systems require being flexible to change in terms of adding, removing or updating the functionalities and services of the system at short notice (Yamakami, 2008); thus a **modifiable** mobile BI is essential. Jaspersoft mobile benefits from OSS development methodology—open source software that gets voluntary contributions to software development and maintenance (DiBona, et al. eds, 1999)—and reacts quickly to change (Jaspersoft Mobile, 2012). Due to the characteristics of proprietary software, it is difficult to examine IBM Cognos and SAP BusinessObjects mobile as developer’s aspect of modifiability. However, IBM Cognos developed different mobile BI solutions to increase flexibility. For instance, web-based, native or hybrid solutions are developed which fulfill the different requirements and reusable BI content simplifies the implementation on any device (IBM Cognos Mobile, 2012) as well as SAP BusinessObjects (SAP Business Objects, 2011).

Mobile BI challenges and characteristics of mobile devices create the main quality attributes of mobile BI and BI vendors examined in this study seek solutions to meet them in desired combination.

5.2. The Future

Our findings indicate that the directions of technological improvements on mobile devices in the near future have great impact on development of mobile BI (Stipic and

Bronzin 2011) therefore its requirements; interoperability, reliability, availability, security, and modifiability. BI vendors being examined in this study strive to adapt their mobile BI software to increasing capabilities and improvements on software, hardware and architecture of mobile devices (Jaspersoft Mobile, 2012; SAP BusinessObjects, 2011; IBM Cognos Mobile, 2012).

The mobile device market has a nature of rapid change nowadays. Wayne Eckerson (2011), consultant in business intelligence since 1995, says “The only certainty in the mobile device market right now is change”. Deploying mobile BI solutions in rapidly changing mobile device environment is challenging. Two strategies could be followed to overcome the challenge: (1) support multiple mobile platforms, (2) use mobile data management system (MDMS) to manage distribution, management and security (Eckerson, 2011). By following those strategies, BI vendors developed solutions to meet the quality requirements of mobile BI defined in this study.

Developing multiple solutions for different mobile platforms is expensive in cost and time. However, solid improvement on HTML5 technology gives ability to run applications on browser may overcome that issue (A-1 Technology, 2012). The increasing use of HTML5 will bring high **interoperability** to the mobile BI systems. The mobile BI vendors can deploy browser based applications regardless the mobile platform (Tunvall, 2012). The improvements on cloud computing will let us design more interoperable mobile BI systems. Cloud computing has ability to make mobile devices more hardware independent and provides to access too many applications through network with vary of mobile devices (Qureshi et. al, 2011).

The combination of mobile computing, mobile internet and cloud computing creates mobile cloud computing technology. The aim of cloud computing is provide real-time information to clients anytime anywhere (Song and Su, 2011). According to Song and Su (2011), cloud computing technologies make the mobile BI procedure possible, accessing data **available** anytime anywhere. Three service models are supported in cloud computing; Software as a Service (SaaS), Platform as a Service (PaaS) and Information as a Service (IaaS). Because of the limitations of the mobile devices (storage capacity, battery, poor display and so on), only SaaS model is being implemented to mobile cloud computing so far (Qureshi, et al. 2011).

Location based business intelligence lets you make more effective decisions based on who you are and where you are (Dignan, 2007), the access data is more **reliable** since the reports are being filtered according the location. Research report released in 2011 by Saugatuck Technology, defines the location based business intelligence as follows; “Integration of Location (GIS) and standard BI platforms brings location intelligence to greater usefulness by making it available as an option to anyone who is familiar with the

more readily-available BI solutions, and without the need to master new concepts or a new user interface. Spatial relationships also greatly enhance many of the details commonly reported by BI systems, providing an added level of analysis that is useful in viewing and assessing trends (and existing data types)” (James, 2012). New generation mobile devices have camera and speech recognition abilities. Mobile BI implementation combined with mobile device features will create new approach of business intelligence with more reliable information on our hands (Bitterer and Sood, 2011).

One of the main challenges in mobile BI is **security**. In the system design phase, solutions for lost and theft devices with confidential data should be considered (Bitterer and Sood, 2011). In device level, generally security is being handled with authorization and enabling timeout option after significant time of inactivity. Mobile device manufacturers have different security solutions in device level and it is crucial concern in mobile BI. In server level, security handling varies according to cloud computing model. SaaS model proves one more time why is being used and will be used widely in mobile BI with overcoming security concerns in server level. According to Shomron (2007) who is founder and CEO of Israel SaaS Center (ISC), “In companies where SaaS was already in use, having replaced a complete solution, concerns over security is noticeably lessened. This is also true in companies where the decision to replace a complete solution with SaaS had already been made and was about to be implemented” (Shomron, 2007). There is no generic security solution for mobile BI systems. Organization should decide confidentiality level of data on users and design security with consideration of three level of mobile BI security; (1) device security, (2) transmission security, (3) network security (Lopez, 2009).

Steady improvement in HTML5 brings the privilege of running applications on multi-platform flexibility. Using the same standards when developing the application increases **modifiability**, modify ones and use anywhere. The mobile BI vendors have already realized the potential of HTML5; Jaspersoft has an HTML5 solution, IBM Cognos works with Worklight (mobile development platform which supports HTML5), and SAP’s Sybase is working on HTML5 hybrid solutions (Tunvall, 2012). SaaS model approach provides modifiability as well as availability since all of the applications and related data is being stored in cloud (Anerousis and Mohindra, 2006). There will be no installation or update required to modify the system. SaaS model, with the advantages that brings to mobile BI, will keep its popularity in near future also. Together with HTML5 and cloud computing, mobile BI systems are expected to be high modifiable.

There is also evidence that future directions on mobile devices support the usability of mobile BI which is identified but not exposed in this study; Apple released iPad in April

2010 and hit the market with a huge impact. The reason is not only because it was a choice of consumers, but also a choice of BI vendors. Larger screen let user to interact with more data, and touch screen capability gave better interactivity to BI users (Bitterer and Sood, 2011). Mobile device producers keep manufacturing large screen devices with touchable screens to keep high and rich **usability and interactivity**. That makes tablets more useful devices than mobile phones in mobile BI purpose.

Based on the future directions in mobile devices, we identified potential new functionalities and capabilities which increase the degree of meeting quality attributes of mobile BI identified in this study.

Finally, the following table includes the quality attributes defined, the solutions developed by BI vendors for each attribute in the present, a brief review of interaction between future direction in mobile devices exposed and quality attributes of mobile BI defined, and results.

Attributes	The Present	The Future	Results
Interoperability	BI vendors develop solutions to meet desired combination of hardware and software independence by providing mobile BI on varied mobile devices and operating systems.	HTML5, mobile cloud computing and SaaS model bring high interoperability; desired combination of hardware and software independence.	Interoperability is one of high primary quality requirements of mobile BI.
Reliability and availability	Users of mobile BI require most relevant and up-to-date business information regardless of time, location and network connectivity.	Mobile cloud computing increases availability of the mobile BI and location based BI with GPS provides more relevant information.	Mobile BI aims to provide relevant and real-time information in order to facilitate the decision-making.
Security	Confidential enterprise information is conserved by BI vendors using authorization mechanism in both device and server level.	SaaS software delivery model will increase the security in server level.	Security of confidential business information is important and must be conserved.
Modifiability	Mobile BI requires rapid response to change and BI vendors develop different solutions to increase flexibility and reusability of services and components.	HTML5 bring flexibility and reusability of component on different platforms. Together with cloud computing and SaaS model, mobile BI are expected to be high modifiable.	Mobile devices have been evolving rapidly and mobile BI requires being flexible to change.

Table 3. Overall evaluation of quality requirements of mobile BI in the present and future based on three BI vendors.

6. Conclusion

This study set up to expose the software quality requirements of mobile BI and evaluate as to whether they are being met in the industry and will be met or changed in the near future. Within this study, main conclusions are identified as follows;

- Users of mobile BI requires access to relevant and real-time business information when and wherever needed in order to facilitate decision making, data mining, documenting, and online processing regardless of time and location (Sajjad, et al., 2009).
- Through using first phase of ATAM, we have identified functionalities and quality attributes of mobile BI; interoperability, availability, reliability, security and modifiability.
- With the growing contributions to capabilities and functionalities of mobile devices, mobile BI promises higher satisfaction in terms of meeting quality requirements of mobile BI defined in this study.
- BI vendors strive for meeting the software requirements of mobile BI and following the future directions in mobile devices. Similar solutions are developed by IBM Cognos, SAP BusinessObjects and Jaspersoft to adapt their system to achieve desired combination of those requirements.

6.1. Future Research

A study could be conducted to identify the trade-offs among quality attributes of mobile BI defined in this study by using an evaluation method such as ATAM. It would thus be interesting to understand what trade-offs would be made in order to meet desired combination of those.

As mentioned in the related research, there is another quality requirement that satisfies different needs of mobile BI users; Usability. Paper did not focus on usability of mobile BI due to the method used for data collection. Another research involving users from industry would be conducted to investigate user experience and interaction on mobile BI.

Software quality requirements are common metrics used for evaluating the software systems and BI vendors should be aware of the risk factors in the present and future. Because mobile BI is still a new concept (Stipic and Bronzin, 2011); promising rapid grow in the close future (Dresner Advisory Services, 2011). A study could be conducted using risk management techniques to probe quality attribute scenarios of mobile BI for risks.

7. References

- Airinei, D. and Homocianu, D., 2010. The Mobile Business Intelligence Challenge. *Economy Informatics*, vol. 10, no. 1. Faculty of Economics and Business Administration, Iași, Romania.
- Anerousis, N. and Mohindra, A., 2006. The Software-as-a-Service Model for Mobile and Ubiquitous Computing Environments. In: IBM Research. *3rd Annual International Conference on Mobile and Ubiquitous Systems: Networking & Services*. Hawthorne, New York. July 2006, pp. 1-6.
- A-1 Technology, 2012. *Developers Look For HTML5 For Mobile Business Intelligence Apps*. [online] 4 April. Available at: <<http://www.a1technology.com/blog/index.php/developers-look-for-html5-for-mobile-business-intelligence-apps/>> [Accessed 17 May 2012].
- Bass, L. et al., 2005. *Quality Attributes and Service-Oriented Architectures*. Carnegie Mellon University Software Engineering Institute.
- Business Intelligence News, 2011. *Jaspersoft 4.2 Delivers Industry's Most Flexible Mobile BI Offering* [online] 27 September. Available at: <<http://businessintelligence.com/jaspersoft-4-2-delivers-industrys-most-flexible-mobile-bi-offering/>> [Accessed 05 May 2012].
- Bitterer, A. and Sood, B., 2011. *Mobile Business Intelligence, Finally*. Gartner, Inc, [pdf], 4 November. Available at: <<http://www.dmgfederal.com/wp-content/uploads/2012/04/mobile-business-intelligence.pdf>> [Accessed on 21 May 2012]
- Candan, K. S. et al., 2009. Frontiers in Information and Software as Services. In: Arizona State Univ. *IEEE 25th International Conference: Data Engineering (ICDE)*. March 29-April 2 2009, pp. 1761-1768.
- Cox, J., 2009. *Why HTML5 is Important for Mobile Devices* [online] 22 July 2009. Available at: <<http://www.networkworld.com/community/node/43779>> [Accessed 17 May 2012].
- Cloud Taxonomy, 2010. Software as a Service (SaaS) [online] Available at: <<http://clountaxonomy.opencrowd.com/taxonomy/software-as-a-service/>> [Accessed 14 May 2012].
- DiBona, C. et al. eds., 1999. *Open Sources: Voices from the Open Source Revolution*. O'Reilly Media.
- Dignan L., 2007. *Business Intelligence: The Next Frontier* [online] 27 August. Available at: <<http://www.zdnet.com/blog/btl/business-intelligence-the-next-frontier/6037>> [accessed 16 May 2012].
- Dresner Advisory Services, 2011. Mobile Business Intelligence Market Study.
- Eckerson, W., 2011. *A Complete Primer to Mobile BI*, Sponsored by Oracle, [pdf]. Available at: <http://www.oracle.com/us/solutions/business-intelligence/oracle-mobile-bi-ebook-ds-501071.pdf> [Accessed on 5 March 2012].
- Fitzgerald, M., 2010. *Business Intelligence Goes Mobile*. Computerworld [online] 14 July. Available at: <http://www.computerworld.com/s/article/9179090/Business_intelligence_goes_mobile> Accessed on [13 May 2012].
- Heffan, Ira V., 1997. *Copyleft: Licensing Collaborative Works in the Digital Age*. Stanford Law Review 49:1490.
- IBM Cognos, 2012. *Business intelligence and performance management* [online] Available at <http://www-01.ibm.com/software/analytics/cognos/> [Accessed 02 May 2012].
- IBM Cognos Mobile, 2012. *Intelligence on go*. IBM Corporation, [pdf]. Available at: <<http://public.dhe.ibm.com/common/ssi/ecm/en/ytd03062caen/YTD03062CAEN.PDF>> [Accessed on 7 May 2012].

- IBM Mobile Apps, 2012. *Rich business intelligence in mobile apps* [online] Available at: <<http://www-01.ibm.com/software/analytics/rte/an/mobile-apps/index.html>> [Accessed 02 May 2012].
- IEEE Std. 1061, 1998. IEEE Standard for a Software QualityMetrics Methodology, *R2009*. Institute of Electrical and Electronics Engineers, New York.
- James, L., 2012. *Are Security Concerns Hampering Mobile BI Adaption* [online] 14 March. Available at: <<http://bx.businessweek.com/business-analytics/view?url=http%3A%2F%2Fwww.yellowfinbi.com%2FYFCommunityNews-Are-security-concerns-hampering-Mobile-BI-adoption-112402>> [Accessed 17 May 2012].
- Jasmine, T., 2012. *Jaspersoft Community Survey Points to 2012 for Strong Adaptation of Mobile BI Strategies* [online] 1 Feb. Available at: <<http://www.prnewswire.com/news-releases/mobile-business-intelligence-entering-the-mainstream-through-apps-138472314.html>> [Accessed 18 May 2012].
- Jaspersoft Cloud, 2012. *BI in the Cloud* [online] Available at: <<http://www.jaspersoft.com/cloud>> [Accessed 09 May 2012].
- Jaspersoft Cloud BI, 2010. *Jaspersoft Cloud BI Wins SIIA CODiE Award* [online] 12 May. Available at <<http://www.jaspersoft.com/press/jaspersoft-cloud-bi-wins-siia-codie-award>> [Accessed 09 May 2012].
- Jaspersoft Evaluation Center, 2012. *Why Jaspersoft?* [online] Available at: <<http://www.jaspersoft.com/getting-started#getStarted-middle-tab-3>> [Accessed 07 May 2012].
- Jaspersoft BI Platform, 2012. *Business Intelligence Platform* [online] Available at: <<http://www.jaspersoft.com/bi-platform>> [Accessed 07 May 2012].
- Jaspersoft BI Suite, 2007. *An Introduction to the Jaspersoft Business Intelligence Suite*. Jaspersoft Corporation, [pdf]. Available at: <<http://www.azinta.com/Services/Jaspersoft-Intro-JBIS-Suite-wp.pdf>> [Accessed on 07 May 2012].
- Jaspersoft Mobile, 2012. *Mobile Business Intelligence* [online] Available at <http://www.jaspersoft.com/mobile-bi>. [Accessed 07 May 2012].
- Kazman, R. et al., 2000. *ATAM: Method for Architecture Evaluation*. Carnegie Mellon University Software Engineering Institute.
- Laurent, W., 2009. *Business Intelligence Goes Mobile* [online] 13 July. Available at: <<http://www.dashboardinsight.com/articles/business-verticals/business-intelligence-goes-mobile.aspx>> [Accessed 18 May 2012].
- Lopez, M. L., 2009. *Deployments Require Robust Security: Firms Must Build Security Enabled Mobility*. Lopez Research LLC, [pdf]. Available at: <http://us.blackberry.com/business/leading/Successful_Mobile_Deployments.pdf> [Accessed on 22 May 2012].
- Lucas, S., 2012. *Putting Mobile First and the New Business Intelligence Priorities* [online] 09 January. Available at: <<http://blogs.sap.com/analytics/2012/01/09/putting-mobile-first-and-the-new-business-intelligence-priorities/>> [Accessed on 22 May 2012].
- Morrissey, P., 2012. *Mobile BI—Back to Future* [online] 03 May. Available at: <http://tidemark.net/blog/2012/05/mobile-bi-back-to-future/> [Accessed on 23 May 2012].
- Qian, K. et al., 2010. *Software Architecture and Design Illuminated*. Massachusetts: Jones and Barlett Publishers.
- Qureshi, et al., 2011. Mobile cloud computing as future for mobile applications - Implementation methods and challenging issues. In: Beijing Key Lab. of Network Syst. & Network Culture. IEEE International Conference Cloud Computing and Intelligence Systems

- (CCSI). Beijing, China. 15-17 September 2011, pp. 467-471.
- Robb, D., 2011. *HTML5 Will Transform Mobile Business Intelligence and CRM* [online] 18 October. Available at: <<http://www.enterpriseappstoday.com/business-intelligence/html5-mobile-business-intelligence-crm.html>> [accessed 14 May 2012].
 - Rosencrance, L., 2011. *3 Tips of Delivering Mobile BI to Your Company* [online] 21 July. Available at: <<http://smartdatacollective.com/brett-stupakevich/38409/3-tips-delivering-mobile-bi-your-company>> [Accessed 17 May 2012].
 - Ryhänen, T., 2009. Future of Mobile Devices – Energy efficient sensing, computing, and communication. *Symposium: VLSI Circuits*. Nokia Research Center, Eurolabs, United Kingdom. 16-18 June 2009, pp. 98-101.
 - Sajjad, B. et al., 2009. An Open Source Service Oriented Mobile Business Intelligence Tool (MBIT). In: Found. for Advancement of Sci. & Technol., Nat. Univ. of Comput. & Emerging Sci. *Information and Communication Technologies (ICICT)*. Islamabad, Pakistan 15-16 August 2009, pp. 235-240.
 - Safeer, M. and Zafar, S., 2011. Impact of Business Intelligence Competency Center in Success/ Failure of B.I. Applications. In: Department of Computer Science Shaheed Zulfiqar Ali Bhutto Institute of Science & Tech. *14th International Multitopic Conference (INMIC)*. Islamabad, Pakistan. 22-24 Dec. 2011, pp. 267-272.
 - Sallam, R. L. et al., 2011 *Magic Quadrant for Business Intelligence Platforms*. Gartner RAS Core Research, [pdf], 27 January. Available at: http://www.board.com/download/press/EN/Gartner_BI_MagicQuadrant_2011.pdf [Accessed on 13 May 2012].
 - SAP Business Intelligence, 2012. *Business Intelligence Solutions* [online] Available at: <<http://www.sap.com/solutions/analytics/business-intelligence/solutions-overview.epx>> [Accessed 07 May 2012].
 - SAP BusinessObjects, 2011. Putting Business Intelligence in the Palm of Your Hand. SAP AG, [pdf]. Available at: <http://www.google.se/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CGwQFjAA&url=http%3A%2F%2Fdownload.sap.com%2Fdownload.epd%3Fcontext%3D85AFDD5E2BD78797E5FAAE085E5FF868BDDD3DD9FF6FDC722357035306F6BF1FB8943C07BDA9AAE99A13E1CA81E88A279961979710CB5870&ei=7oHHT5_cFISB4ASo8MyADw&usg=AFQjCNHOqD66GJBAqMhc_6CcHHT7bKWV8w>. [Accessed on 14 May 2012].
 - SAP BusinessObjects User Guide, 2012. *SAP BusinessObjects Mobile 4.0.3 User Guide*. SAP AG, [pdf]. Available at: <http://help.sap.com/businessobject/product_guides/boexir4/en/xi4_mobile_user_en.pdf> [Accessed on 15 May 2012].
 - SAP Product Roadmap, 2012. SAP User Interfaces. SAP AG, [pdf]. Available at: <<http://www.sdn.sap.com/irj/scn/go/portal/prtroot/docs/library/uuid/1036f12f-0aab-2e10-29ac-f0a733a16214?QuickLink=index&overridelayout=true&53987738927730>> [Accessed on 16 May 2012].
 - Shomron, D., 2007. *Implementing SaaS Solutions Reduces Security Concerns* [online] 12 December. Available at: <<http://saasperspective.blogspot.se/2011/12/implementing-saas-solutions-reduces.html>> [Accessed 18 May 2012].
 - Sommerville, I., 2011. *Software Engineering*. 9th International ed. Pearson.

- Song, W. and Su, X., 2011. Review of mobile cloud computing. In: Department of computer science and technology CUMT. *IEEE 3rd International Conference: Communication Software and Networks (ICCSN)*. XuZhou, China. 27-29 May 2011, pp. 1-4.
- Stipic, A. and Bronzin, T., 2011. Mobile BI: The Past, the Present and the Future. In: Bus. Dev. Dept., IN2 d.o.o. *MIPRO, Proceedings of the 34th International Convention*, Zagreb, Croatia. 23-27 May 2011, pp. 1560-1564.
- Tunvall, F., 2012. *Vendors look to HTML5 to deliver mobile BI* [online] 2 April. Available at: <<http://ovum.com/2012/04/02/vendors-look-to-html5-to-deliver-mobile-bi/>> [Accessed 15 May 2012].
- Wang, J. and Jiang, N., 2009. Secure Authentication and Authorization Scheme for Mobile Devices. In: Sch. of Comput. & Inf. Technol., Beijing Jiaotong Univ. *IEEE International Conference: Communications Technology and Applications (ICCTA)*. Beijing, China. 16-18 October 2009, pp. 207-211.
- Wu, L. et al., 2007. A Service-oriented Architecture for Business Intelligence. In: HP Laboratories. *IEEE International Conference: Service-Oriented Computing and Application (SOCA)*. 19-20 June 2007, pp. 279-285.
- Yamakami, T., 2008. Business Model Engineering Analysis on Mobile Client-side Software Platform Strategies. *7th International Conference Mobile Business (ICMB)*. Tokyo, Japan. 7-8 July 2008, pp. 59-64.