Business Intelligence in the Cloud: Fundamentals for a Service-based Evaluation Concept

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Abstract

Organizations can achieve many benefits by the integration of Cloud computing approaches in their Business Intelligence (BI) environments. However, the integrated and complex BI architectures make the integration of this new technology difficult. Since the Cloud is no universal remedy, it would be useful to have an evaluation model to decide when the use of Cloud BI is appropriate. This paper constitutes the first steps towards such a model by identifying and structuring consequences of Cloud computing on Service-based BI architectures. For this purpose, a comprehensive literature review and a case study in cooperation with Bayer, a large German company, were conducted. The results are illustrated on the basis of real life scenarios which indicate that an approach that considers the great number of complex interdependencies in BI architectures is required.

1 Introduction

Recently there has been a lot of talk about Cloud computing. Many people consider this new technology to have the potential to transform a large part of the IT industry. (Armbrust et al., 2010; Fenn & LeHong, 2011) While various sectors already use this new technology successfully (techconsult GmbH, 2012; Wallraff & Weber, 2012), the integration in more demanding areas such as Business Intelligence still holds many challenges (Baars & Kemper, 2010; Reyes, 2010; Willem & Jakobus, 2010).

Business Intelligence (BI) characterizes holistic approaches to build and run an integrated management support infrastructure. (Baars & Kemper, 2008; Moss & Atre, 2003) The wide range of this task raises the need for a great number of heterogeneous systems. (Kimball & Ross, 2002; McKnight, 2007a; Mohammed, Altmann, & Hwang, 2010) Over time, these systems often evolve into integrated and highly complex BI architectures.

(McKnight, 2007b) Moreover, new technologies like Cloud computing permanently pose new challenges to these infrastructures. In order to master the problems arising from this situation, organizational concepts like the idea of dedicated BI governance structures (Meredith, 2008) and BI service management (BISM) (Horakh, Baars, & Kemper, 2008; Kashanchi & Toland, 2006) emerged.

In an organizational context, the Cloud can be regarded as a new outsourcing alternative. (Baars & Kemper, 2010; Böhm, Leimeister, Riedl, & Krcmar, 2011) But apart from well-known issues with outsourcing, the Cloud comes with additional challenges that have to be taken into account when integrating this new technology into proprietary BI architectures. (Baars & Kemper, 2010; Willem & Jakobus, 2010) Problems often associated with Cloud-based BI such as vague data confidentiality, the fear of a vendor lock-in or simply technological limits indicate that not every service is appropriate to be obtained from the Cloud. (Armbrust et al., 2010; Chow et al., 2009; Reyes, 2010) It is therefore essential to be clear about the Cloud suitability of individual components and services in order to include Cloud Computing into a BI architecture successfully. Thus, the goal of this paper is to gather and structure impacts that have to be considered when planning the use of Cloud computing in the sophisticated domain of Business Intelligence. This represents the preliminary work in an on-going larger research process with the ambition to create an applicable framework for assessing the Cloud suitability of a BI service.

The paper will have the following course. Firstly, basic terms and concepts will be introduced and discussed on the basis of related literature. This part will mainly cover the basics of Cloud computing and IT service management as well as their adaption to the sector of Business Intelligence. Next, the methodical approach used in the research will be illustrated and the conducted case study will be introduced. Subsequently, the influences of Cloud BI derived from the reviewed literature and the conducted interviews, will be discussed in more detail to structure the problem further and carve out challenges. Afterwards, two real life scenarios that were developed in cooperation with an industrial partner will illustrate the major issues which mainly originate from the complexity and the interdependencies in a BI architecture. Finally, the results and next steps will be summarized in a concluding appraisal.

2 Overview of fundamental concepts and related topics

Since the combination of Cloud computing and BI service management is a rather new topic, the following section clarifies elementary terms and discusses the basic ideas behind related concepts and their adaption to the domain of Business Intelligence.

2.1 Cloud computing

There are numerous varying understandings of the term Cloud computing depending on the point of view. (Vaquero, Rodero-Merino, Caceres, & Lindner, 2008) While the Cloud is often just seen as ”infinite computing resources available on demand” (Armbrust et al., 2010, p. 51), there are also more sophisticated approaches which constitute Cloud computing as a new paradigm in IT sourcing that increases agility and enables new business models. (Baars & Kemper, 2010; Hayes, 2008; Willem & Jakobus, 2010) A widely used definition describes Cloud computing as ”a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (...) that can be rapidly provisioned and released” (Mell & Grance, 2009, p. 2). The services offered via the Cloud usually differ in between the supply of fundamental computing resources (IaaS) (Bundesverband Informationswirtschaft, 2009; Mell & Grance, 2009; Rodero-Merino et al., 2010) up to the provision of complex platform (PaaS) (Mell & Grance, 2009; L. Wang et al., 2008; Youseff, Butrico, & Da Silva, 2008) or application software (SaaS) (Bundesverband Informationswirtschaft, 2009; Kern, Lacity, & Willcocks, 2002; Mell & Grance, 2009).

Frequently associated advantages with Cloud computing are cost savings through Usage-Based Pricing models and the possibility to scale resources on demand. (Armbrust et al., 2010; Grossman, 2009; Hayes, 2008; Marston, Li, Bandyopadhyay, Zhang, & Ghalsasi, 2011) It is another common argument that the Cloud simplifies the IT and therefore improves the level of quality and increases agility. (Armbrust et al., 2010; Hayes, 2008; Reeves et al., 2009) Conversely, the use of Cloud computing also raises significant challenges such as a lack of Cloud trust and security, insufficient availability, legal issues or the fear of a vendor lock-in. (Armbrust et al., 2010; Dillon, Wu, & Chang, 2010; Hayes, 2008; Takabi, Joshi, & Ahn, 2010) Furthermore, in many cases the integration of a Cloud solution may not make sense for economic reasons or simply can’t be realized due to technological limits. (Armbrust et al., 2010; Dillon et al., 2010; Voorsluys, Broberg, & Buyya, 2011)

2.2 BI services

BI service management (BISM) is an adaption of IT service management (ITSM), which emerged from the increasing complexity of IT systems in order to implement a more coherent approach to improve flexibility and manageability of IT environments (Van Haren Publishing, 2007; Winniford, Conger, & Erickson-Harris, 2009). Therefore, it can be summarized as “defining, managing, and delivering IT services to support business goals and customer needs” (Winniford et al., 2009, p. 153), whereat the mentioned service term represents a combination of technology, people and processes. (Best Management

Practice, 2012; Van Haren Publishing, 2007) This definition clarifies the more holistic organizational character of service management and thus clearly distinguishes it from a purely technical service-oriented architecture (SOA) approach (Krafzig, Banke, & Slama, 2005; Papazoglou, 2003). Furthermore, service management frameworks used in practice, like ITIL® or COBIT, usually include additional concepts to design, monitor and maintain services. (Unger, 2011; Van Haren Publishing, 2007; Winniford et al., 2009)

BI service management structures and allocates technological and organizational elements of BI solutions to individual services. (Kemper, Baars, & Horakh, 2007; Van Haren Publishing, 2007) To depict such a BI service the framework shown in figure 1 can be used. It has been derived in the context of research on BI outsourcing to unbundle the complex structures of contemporary BI Solutions and slice them into well-defined services. (Kemper et al., 2007) For this purpose, the following three dimensions are defined.

Tool: BI services usually use various subsystems (tools) to fulfill their functions like data ware houses, analyzing software or front ends. In order to classify these components, it is useful to refer to existing BI frameworks. (Kemper et al., 2007)

Business specificity: This dimension depicts the closeness of a service to the business. The following layers can be distinguished to clarify the specification of this dimension. (Kemper et al., 2007; Kern et al., 2002)

- *Hardware:* The provision and running of the relevant computing resources such as storage and other equipment necessary to operate one or more BI components.
- *Tools:* Involves BI software like ETL tools or Data Warehouse software.
- *Templates:* Represent preconfigured applications and prearranged contents that can be adapted to individual needs (e.g. reference models from software vendors).
- *Content:* This layer is related to the actual business semantics and therefore contains concrete business content. An example is the filled instance of a data cube.

Life cycle: The last dimension to be considered is the phase of the application life cycle. In most cases this dimension can be divided into development and operation since those are the most significant stages of a service. However, if necessary, this dimension can be refined to any appropriate granularity. (Kemper et al., 2007)

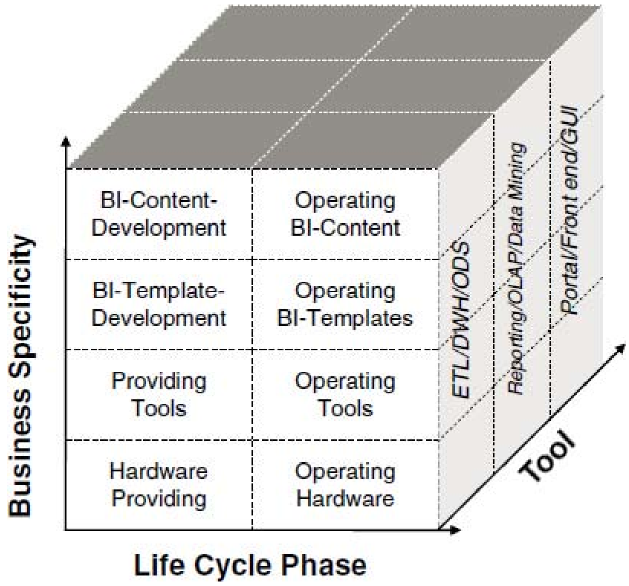

Figure 1: BI service framework – Kemper et al 2007

To enable a better coverage of customer needs and to achieve a higher scope of efficiency, compositions of BI services are delivered as holistic BI solutions which contribute to the user's business processes. (Akkermans et al., 2004; Horakh et al., 2008) The combination and the multiple usages of BI services lead to interdependencies between particular components, activities and processes as well as responsibilities of BI solutions.

2.3 Applications of Cloud computing in a Service-based BI environment

This section describes various ways how Cloud computing can be integrated into a Business Intelligence architecture which mainly differ in their scope and the related complexity. (Baars & Kemper, 2010) Table 1 outlines different scenarios that will be further described below.

Scenario	Characteristics
Add-on functionality	Isolated, short-term, few impacts
Tool integration	Integrated, long-term, high impacts
Solution provision	Complex structures, high impacts

Table 1: Scenarios for Cloud BI

The most straightforward idea is to obtain particular *add-on functionality* from the Cloud. These add-ons deliver particular functional blocks for a temporary use. (Baars & Kemper, 2010; Marston et al., 2011) Due to its additional and short-term character, this scenario usually has a low impact on a given BI service environment and is therefore relatively risk free. (Baars & Kemper, 2010)

A more long-term oriented approach is the integration or replacement of a tool with a Cloud-based alternative. This scenario can provide many advantages but depending on the type of the integrated tool it can also cause far reaching implications for the existing BI services. (Baars & Kemper, 2010; Cullen & Willcocks, 2003) One major issue here, especially for the domain of BI with its close collaboration between systems and the high number of dependencies, is the lack of standards for the combination of cloud and non-cloud parts (Rochwerger et al., 2009; Vaquero et al., 2008).

An expansion of this idea is a solution provision where a provider supplies a complete end to end system in the Cloud. Although this concept is much more complex to integrate in a proprietary architecture, it might be suited for special purposes e.g. for temporary systems which have to be set up rapidly. (Baars & Kemper, 2010)

3 Methodology

Due to the relatively new nature of the subject Cloud computing in the domain of Business Intelligence, a qualitative design with an exploratory character was used for this research. (Stebbins, 2001; Yin, 2010)

The ambition of this work is to examine the impacts of Cloud computing on Service-based BI architectures as figure 2 outlines. The study therefore tries to identify and analyze influencing factors and interdependencies in this context.

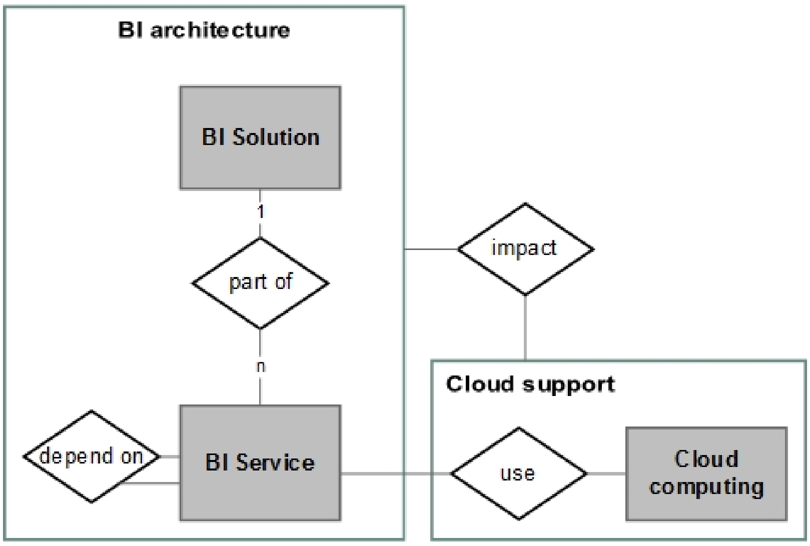

Figure 2: Conceptional framework

In the beginning, a comprehensive literature review (Auerbach & Silverstein, 2003; Yin, 2010) was conducted to get an overview of relevant topics and current research subjects. This review contained a semantic analysis of approximately 100 scientific papers, white-papers and market reports mainly from scientific databases like ACM, IEEE Xplore, SpringerLink and JSTOR as well as from other public accessible sources. Based on this theoretical foundation, a workshop and two group interviews with business intelligence experts at Bayer AG, a large German pharmaceutical company, were arranged to get a practical view on the subject.

The gathered information and an additional analysis of the existing BI infrastructure in the cooperating company were used to structure challenges and consequences of Cloud-based Business Intelligence. Since it turned out that the interdependencies of systems and services play an essential role in the Cloud BI context, a further in-depth interview was conducted and multiple real life scenarios were developed to examine the related issues more precisely.

4 Structuring of decision criteria for Cloud-based Business Intelligence

Since the usage of Cloud-based services in Business Intelligence can be treated as a special type of outsourcing (Baars & Kemper, 2010; Böhm et al., 2011), it seems appropriate to review established IT outsourcing approaches and afterwards carve out the special challenges with regard to Cloud computing in Business Intelligence services.

In order to justify an IT outsourcing decision, basically two main conditions have to be met: the technical feasibility has to be given and the gained business value, achieved through outsourcing, in this particular case over the Cloud, have to predominate the associated challenges and risks. (Akomode, Lees, & Irgens, 1998; Böhm et al., 2011; Cullen & Willcocks, 2003; Loh & Venkatraman, 1995)

Numerous heterogeneous factors and dependencies have to be considered in order to cope with these questions. Consequently, many established evaluation concepts in this context use Multi-Criteria Decision Making Methods with hierarchies to prioritize relevant criteria in order to decrease complexity of the problem. (Araz, Ozfirat, & Ozkarahan, 2007; Menzel, Schönherr, Nimis, & Tai, 2011; J.-J. Wang & Yang, 2007) According to these methods, the relevant Cloud decision criteria for BI services that were gathered from the literature review and conducted interviews, can be generalized by the following superior categories (Figure 3).

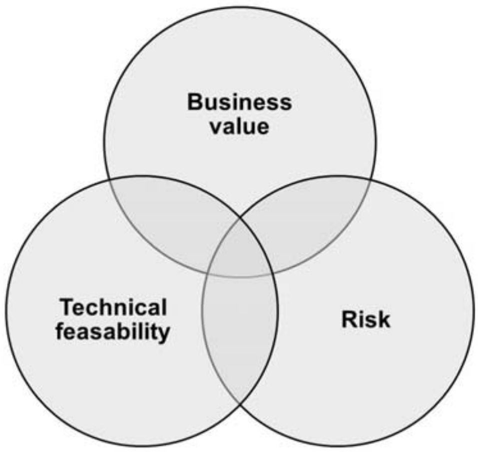

Figure 3: Superior categories of Cloud impact

Business value: The economic perspective is an essential pillar to assess the Cloud suitability of a BI service. (Armbrust et al., 2010; Marston et al., 2011; Mohammed et al., 2010; Skilton & Director, 2010) This category summarizes all criteria that affect the business value in a positive or negative way. Many decision criteria in this class are very obvious e.g. the reduction of costs or the increasing focus on key competencies. But there are also criteria which are more complicated to identify, for instance, the enabling of competitive advantages and new business models. A key problem here is that an assessment solely based on output measures is of limited value for understanding the whole range of IT impacts. (Mooney, Gurbaxani, & Kraemer, 1996) It is thus essential to consider the organizational dependencies and the long-range effects on the business value to constitute a realistic evaluation. (Mohammed et al., 2010; Mooney et al., 1996)

Technical feasibility: The technical feasibility is a basic condition, required to integrate the Cloud in an existing environment. Straightforward, the technical suitability of individual components can be verified by matching hardware and software requirements as well as technical indicators, such as data transfer volume or availability on Service Level Agreements of Cloud providers. (Buyya, Yeo, & Venugopal, 2008; Deb, 2010; Rimal, Jukan, Katsaros, & Goeleven, 2011)

However, despite this rather intuitive approach, the more profound issue is to assess the integration complexity of a Cloud-based component in an existing BI architecture. The sophisticated interdependencies in proprietary BI architectures (Horakh et al., 2008; McKnight, 2007b) and the lack of standards for the technical interoperability of Cloud services (Rochwerger et al., 2009; Vaquero et al., 2008) make integration to one of the major issues. The complexity manifests itself with factors such as the number of connected systems or the degree of individualization (e.g. through non-proprietary code). (Baars & Kemper, 2010; Deb, 2010)

Risk: Risk can be defined as “the possibility of loss or injury” (Boehm, 1991, p. 33) and plays an important role in any IT outsourcing decision. (Aubert, Patry, & Rivard, 1998; Earl, 1996; Hirschheim, Heinzl, & Dibbern, 2009) There are several approaches to assess the risk of IT outsourcing. They often consider hidden costs, contractual difficulties, Service Debasement and the loss of organizational competencies. (Aubert et al., 1998; Hirschheim et al., 2009)

In relation to Cloud BI, especially issues in security and trust are frequently referred to as the main risk factors. (Armbrust et al., 2010; Voorsluys et al., 2011) Regulatory and legal issues such as data privacy or legal liability are also often mentioned in this context. (Armbrust et al., 2010; Catteddu, 2010; Voorsluys et al., 2011) These risks mainly depend on factors like the confidentiality of the handled data or security requirements of the affected system. Other major concerns are the fear of a vendor lock in, which follows from the lack of standards and interoperability in Cloud computing (Marston et al., 2011; Meredith, 2008) and other technical risks like insufficient availability or unpredictable performance (Armbrust et al., 2010). In order to handle these risks the requirements and the available offers have to be aligned through service level agreements. (Buyya et al., 2008; Takabi et al., 2010)

A closer examination of the criteria in these three classes reveals many overlaps and interdependencies. For instance, a greater technical complexity directly affects the business value through increasing costs and higher technical and economic risks. Or similarly, gained business value through a more agile infrastructure strongly depends on the technical feasibilities of individual components as well as the BI architecture itself.

Complexity of BI services and its influence on the Cloud suitability

Preservative common denominators of the discussed issues are the high complexity of BI architecture and the strong interdependencies between the involved BI services. This observation indicates that the complexity of the surrounding BI environment significantly exerts influence on the Cloud suitability of particular BI services. This complexity mainly results from highly integrated multi-layer Business Intelligence architectures needed to provide a holistic management support. (Baars & Kemper, 2008; McKnight, 2007b) In order to implement this enterprise-wide approach, these architectures are interwoven with all sorts of transactional systems through all hierarchy levels and business functions. (Chamoni & Gluchowski, 2004; Horakh et al., 2008; Moss & Atre, 2003) This integrated structure entails numerous interdependencies between BI solutions and particular BI services which have to be considered when integrating Cloud-based systems. Furthermore, the organizational dependencies in such Service-based environments have to be considered. For instance, new components have to be integrated in existing operating structures like change or incidence management. This correlation between the complexity of a system and the ability to use a Cloud approach is also illustrated by the real life scenarios in the following section.

5 Inspected scenarios

In the course of the conducted case study, several scenarios based upon real life cases from the Business Intelligence environment of the involved industrial partner were analyzed. Below, two of these scenarios are used to illustrate the previously discussed issues.

Scenario 1: A temporary Social Media Analytics platform

This case originated from an innovation project with the aim to gather relevant marketing information from social networks and online communities. The unique character of social media raised the need for special tools. For instance, data- and text-mining algorithms e.g. sentiment analysis, were required to gain knowledge from unstructured content. Furthermore, the large size of data sets raised additional performance challenges. (Barbier & Liu, 2011; Kaplan & Haenlein, 2010) The use of a Cloud-based solution in this scenario seems likely since many providers offer a short-term provision of the needed functionality with a scalable environment.

Based on the previous classification, this case represents a typical *add-on* scenario where special functions are obtained from the Cloud. Due to the inexistence of proprietary tools and the isolated short-term use in a project, the usage of a Cloud-based solution in this case would have little impact on the existing BI architecture; hence, there is no need for an extensive integration process. In addition, the fact that there are barely interdependencies with existing BI systems entails that the focus of a Cloud evaluation in this case is mainly on local decision criteria like economic and technical factors of the system.

Scenario 2: Cloud support in a complex best-of-breed BI solution

The second scenario is based upon a large proprietary BI solution. Due to the wide range of activities, the system over time has evolved into a complex best-of-breed solution; hence, it contains multiple subsystems across all conceptional levels and is highly integrated into the Service-based BI architecture as well as into operational systems.

In consideration of the large scale, this system provides a wide range of *tool replacement* and *add-on* possibilities across all conceptional layers. For instance, services on the data layer can benefit from on demand scaling of computing resources to handle big data volumes or load peaks. But also more sophisticated applications like a short-term SaaS provision of particular user interfaces on the access layer are imaginable.

Since the services all interplay in a holistic BI solution, the manifold interdependencies in this architecture have to be considered when it should be enriched with Cloud-based components. As previously outlined, trust issues are a major concern when Cloud providers are involved. Consequently, data confidentiality has to be ensured across all internal and especially external systems in this end-to-end solution. The strong collaborations between the various systems in the case complicate this issue further.

A change in the given BI architecture can moreover provoke far-reaching organizational impacts. It must be guaranteed that services obtained from the Cloud provide the quality and performance that users and other depending services require. Furthermore, a seamless integration into the solution life cycle must be possible to ensure a long-term integration. Therefore, an integration in given service management structures such as change and incident management is absolutely essential.

Comparison of the scenarios

These two scenarios illustrate the various circumstances and connected problems that could occur when integrating Cloud approaches into BI architectures.

The obvious difference between the cases is the level of complexity. While scenario one has an isolated, short-term character and comes with nearly no integration effort. The second case, in contrast, deals with a large and highly integrated BI solution. The integration effort in this sophisticated environment is rather large since the manifold interdependencies between the affected services have to be considered. Moreover, the long-term replacement of a component in this holistic approach comes with the need of an organizational integration in existing BI governance structures.

6 Conclusion and next steps

The closer examination of the impacts of Cloud Computing on Service-based Business Intelligence environments has shown that many factors have to be considered to reasonably assess the use of a Cloud-based solution. Apart from common issues with Cloud BI, like security and trust, especially the complex structure of BI architectures raises the need of a more coherent perspective to evaluate the Cloud suitability of particular BI services. The previously discussed scenarios illustrate, that such an approach have to particularly consider the dependencies between BI services and the resulting technical and organizational integration complexity.

The next step in the research process towards a Service-based evaluation concept for Business Intelligence in the Cloud is to substantiate the discussed issues and to operationalize the decision criteria from this initial work in a prototype framework that considers the sophisticated interdependencies in a BI architecture. Additionally, further application scenarios have to be developed to verify the use of the framework in practice.

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