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Design science research contribution to business intelligence in the cloud — A systematic literature review

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HIGHLIGHTS

- We conducted a systematic literature review on business intelligence in the cloud.
- We propose a 2-dimension framework to analyze research on BI in the cloud.
- We analyze the artifacts proposed by design science researchers on BI in the cloud.
- We sketch future research artifacts on BI in the cloud.

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ABSTRACT

Business intelligence (BI) helps managers make informed decisions. In the age of big data, BI technology provides essential support for decision making. Cloud computing also attracts many organizations because of its potential: ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services). This paper focuses on the deployment of BI in the cloud, from the vantage point of design science research (DSR). We produce a state of the art of research pertaining to BI in the cloud, following the methodology of systematic literature review. This literature review especially exhibits the different artifacts proposed by design science researchers regarding BI in the cloud. To structure the literature review, we propose a framework composed of two dimensions: artifact type and BI step. In particular, we propose a typology of artifact types, refining the coarse-grained typology commonly used in DSR. We use the two-dimensional framework both to map the current state of DSR regarding BI in the cloud, and to elicit future research avenues in terms of design science artifacts for BI in the cloud. The contribution is threefold: the literature review may help DSR researchers get an overview of this active research domain; the two-dimensional framework facilitates the understanding of different research streams; finally, the proposed future topics may guide researchers in identifying promising research avenues.

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1. Introduction

Business intelligence (BI) helps managers make informed decisions. In the age of big data, the support of BI technology is critical in guaranteeing effective and efficient decision making. BI tools facilitate the presentation of more accurate reporting, improve decision making, enhance customer relationships, and increase revenue [1]. BI must scale up to big volumes of data (big data analytics). The term of business analytics appeared in 2008 and tends to replace business intelligence. According to IDC [2], the business analytics software market will grow at a 9.7% compound annual rate through 2017. Even if the BI software market is mature and prolific, many research issues remain open in this domain. BI is a major topic since companies need to acquire more skills and to increase their maturity. They need robust methodologies to choose BI solutions, to implement them, to express business goals in terms of indicators and, more generally, to manage thanks to effective decision support systems.

Cloud computing also attracts many organizations because of its potential: ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) [3]. It

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provides innovative services to different types of users. The latter are freed from the underlying technical infrastructure. Beyond outsourcing, two concepts are highlighted in cloud computing: virtualization and agility. Through the cloud, organizations can acquire IT services without human intervention from the provider. According to IDC [2], spending on public IT cloud services alone was estimated a $47.4 billion industry in 2013 and is expected to more than double by 2017. Ultimately, cloud computing enables more efficient BI tasks. It allows faster deployment and greater flexibility compared to traditional BI solutions [4] and produces accurate results more rapidly than desktop computers [5]. Even if the cloud relies on well-known technologies, it raises new research questions: what guidelines are available for companies that want to adopt cloud architectures? What architecture must be preferred, given a context? Are there specific approaches to help a company migrate to the cloud? Hence, the many issues and opportunities associated with cloud computing also generate a dynamic research activity.

BI and analytics and cloud computing raise many issues for information systems researchers from various streams, more specifically quantitative research, qualitative research, and design science research. In this paper, we take the vantage point of design science research (DSR). DSR builds and evaluates artifacts [6], which may be constructs, models, methods, or instantiations [7]. DSR has much to contribute to BI and analytics [8] and cloud computing [9]. We consider the intersection of these two topics, focusing on the deployment of BI in the cloud, from the point of view of DSR. Our research question is: *What new artifacts can design science researchers bring to the domain of BI in the cloud*? To answer this question, we perform a systematic literature review (SLR) of BI in the cloud in DSR. The literature review exhibits the different artifacts proposed by design science researchers regarding BI in the cloud. Moreover, building on the literature and on a framework composed of two dimensions (artifact type and BI step), we elicit future research avenues in terms of design science artifacts for BI in the cloud. This article is an extension of a previous paper [3]: it proposes a systematic literature review (SLR) and enriches the two-dimensional framework.

The remainder of the paper is structured as follows: in the ensuing section, we present the research gap and the research question. In Section 3, we describe our research method. Section 4 details our typology of DSR artifacts. In Section 5, we propose a framework synthesizing the current state of research for business intelligence in the cloud. Section 6 describes open research issues and opportunities for DSR and Section 7 concludes the paper.

2. Research gap and research question

Design science produces artifacts to attain human goals [10]. DSR in information systems (IS) seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts [6]. While behavioral research aims at understanding, the main objective of DSR is utility. DSR is now established as a major research paradigm in IS [11]. Many researchers support the view that the output of DSR is an artifact or a set of artifacts, even though others argue that its purpose should be the creation of theories [12]. In this paper, we adopt the view that the primary goal of DSR is the production of useful artifacts. March and Smith [7] distinguish four categories of artifacts: constructs, models, methods, and instantiations. According to these authors, constructs "*form the vocabulary of a domain. They constitute a conceptualization used to describe problems within the domain and to specify their solutions*". A model "*is a set of propositions or statements expressing relationships among constructs*". A method is "*a set of steps (an algorithm or guideline) used to perform a task. Methods are based on a set of underlying constructs (language) and a representation (model) of the solution space*". An instantiation is "*the realization of an artifact in its environment*". This typology of artifacts is the most widely used in DSR. Other typologies have been proposed, e.g. that of Offermann et al. [13]. These typologies help researchers and practitioners to represent, analyze, design, implement, and evaluate successful information systems. Our aim is to study which artifacts have been proposed regarding BI in the cloud. Building on the previous typologies of artifacts, we proposed an enriched typology that allows us to structure the literature review on BI in the cloud and detect open research questions [3].

Many artifacts have been designed and found valuable regarding BI. Cloud computing puts forward new architectures and new opportunities to share information and applications, but it also raises new risks. It may offer new economic models for information technology (IT) and information systems (IS) solutions. BI and analytics rely on huge data sets, requiring complex and robust algorithms to produce information and knowledge. Abundant literature can be found on BI and cloud computing and, more recently, on their combination.

The recent literature describes many research works investigating the specific opportunities and addressing the research issues of BI in the cloud. Since this is a recent topic, there is no comprehensive survey allowing researchers to quickly obtain a synthesized view of research results and opportunities. This paper aims at filling this gap by proposing a systematic literature review and a framework for analyzing significant results and identifying opportunities for further research. Considering the significant contribution of DSR to BI in the cloud, the paper focuses on this research paradigm.

BI in the cloud raises many new research issues for the IS community at large (quantitative and qualitative research, IS economics, design-science research). We acknowledge the potential contributions of the various research paradigms to BI in the cloud, especially when used in combination (e.g. combination of DSR with qualitative research), but we focus on DSR to reduce the search space. Thus, the research question addressed in the paper is: *What new artifacts can DSR bring to the domain of BI in the cloud?*

In a previous publication [3], we proposed a first answer to this question. We conducted a preliminary literature review to evaluate the state of the art of DSR for BI in the cloud. Using our artifact typology, we summarized this review by listing, for each artifact type, which functions were covered among data management, service management, and security management. More precisely, for each artifact type and for each function, we answered the following question: did authors propose such artifacts to manage this function (data, service, security) of BI in the cloud? Then, based on this preliminary literature review, we proposed future research avenues for BI in the cloud.

In this paper, we go beyond by first performing a systematic literature review to validate and strengthen our findings. Second, we organize the results into a two-dimensional framework. The first dimension is our typology of artifacts. The second one is dedicated to BI components. We use this framework both to analyze the literature and to suggest further research. The next section describes our research method.

3. Research method

In this paper, we present the result of a systematic literature review (SLR) that we performed to assess the current state of research on BI in the cloud.

Kitchenham and Brereton [14] mention three common motivations for undertaking a SLR in software engineering: (1) to summarize the existing evidence, the benefits and limitations of a specific

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