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Cloud Computing for Standard ERP Systems: Reference Framework and Research Agenda

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ABSTRACT

Cloud Computing is a topic that has gained momentum in the last years. Current studies show that an increasing number of companies is evaluating the promised advantages and considering making use of cloud services. In this paper we investigate the phenomenon of cloud computing and its importance for the operation of ERP systems. We argue that the phenomenon of cloud computing could lead to a decisive change in the way business software is deployed in companies. Our reference framework contains three levels (IaaS, PaaS, SaaS) and clarifies the meaning of public, private and hybrid clouds. The three levels of cloud computing and their impact on ERP systems operation are discussed. From the literature we identify areas for future research and propose a research agenda.

Keywords: Cloud Computing, Enterprise Systems, IT Outsourcing, IT Services

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1 Background and Research Question

"In the wake of the 2008-09 financial and economic crises, firms have looked for ways to consolidate their ICT infrastructures and services and increase returns on their investments. Cloud computing appears an attractive option." (OECD 2010, p. 148)

Cloud computing is a concept that has gained increasing attention over the last years (OECD Report, p. 27). In many ways it is not a completely new phenomenon as it incorporates elements of IT outsourcing which has been available for more than 10 years (e.g. the provision of software over the Internet or the housing of IT infrastructure for client companies). There are clear signs that companies' interest in cloud computing services is rising: "Demand for cloud computing services is expected to continue to increase; according to IDC, the market for cloud computing services will grow by around 40% in 2010" (OECD 2010, p. 148). Some authors argue that cloud computing represents the future way of using information technology in businesses (Barnatt 2010; Velte et al. 2010). They point out that obtaining computer power over the Internet could have a profound impact on the whole computer industry and rid companies from having to install software on their own internally operated systems. As a consequence, they will not need to purchase or maintain hardware and software that can simply be rented online.

1.1 Emergence of Cloud Computing

The development of services for cloud computing (as a particular form of IT outsourcing) has been stimulated by three complementary and very influential technological achievements:

1. *AJAX technology*
   which enables a client to communicate with the server in the background and to dynamically change Web pages without reloading them. AJAX technology helps create a "rich client", a so called RIA, and has boosted the use of thin clients and mobile devices. (Linthicum 2009, p. 190)

2. The concept of *multitenancy*
   which describes the shared use of an installation of a single software program by multiple client companies using their own, private, individual data spaces. (Velte et al. 2010)

3. Last and most importantly *virtualization*
   which enables the sharing of physical computer resources. (Babcock 2010, p. 51ff.)

AJAX makes rich clients possible and thus improves the capability of running an externally hosted application locally, *Multitenancy* is the prerequisite to the shared use of software, and *virtualization* allows for dividing of physical resources – all three together drive the cloud computing market.

Cloud computing, like similar forms of IT outsourcing, is heralding certain promises to user companies (also see Loh and Venkatraman 1995; Clarke 2010):

- The decrease of *capital cost* because the customer does not acquire hardware or licenses up front any more (OECD 2010, p. 147)
- *Cost* transparency e.g. through pay-per-use or subscription models (Ovum 2010, p. 10)
- The decrease of *operational costs* (Velte et al. 2010, p. 3; OECD 2010, p. 147)
- Increased *flexibility* for business processes due to lower switching cost (Iyer and Henderson 2010)
- Guaranteed *service level* (Mell and Grance 2009)
- *Simplicity* through commodity services (Ovum 2010, p. 10)

These advantages of cloud computing are backed by the latest Ovum report (2010) and the OECD 2010 report on information technology: "Cloud computing is one of the most discussed and publicized technologies of recent years. Interest in cloud computing is mainly motivated by its potential to reduce capital expenditures and to deliver scalable IT services at lower variable costs." (OECD 2010, p. 147)

On the other hand, the literature discusses some open problems (Clarke 2010; Linthicum 2010):

- Permanent access (if Internet connection is down the service is down) (Velte et al. 2010, p. 5).
- Service provided can be down (Velte et al. 2010, p. 6)
- Sensitive or proprietary information which cannot be stored outside the company does not allow for cloud computing in certain application areas

- Integration of applications run by different providers (Iyer and Henderson 2010)
- Lock-in with vendors (getting your data "out" when you want to move is connected to hefty moving fees) (Velte et al. 2010)
- Some vendors are not established players and might not be able to sustain their operations for long (Iyer and Henderson 2010)

1.2 Cloud Computing and ERP

This paper investigates the impact that cloud computing might have on the way standard ERP systems are operated (their "operations model"). ERP systems are integrated software packages with a common database that support business processes in companies (Staehr 2010). They comprise different functional modules that reflect the departmental structure of a company (accounting, procurement, sales, production, warehousing, etc.). They are developed and offered by ERP vendors and sold as "standard software" that fits the needs of many companies, often optimized for certain industries (industry or vertical solutions). Since ERP systems support the core processes and have to reflect the organizational structure of a company they come in many different sizes and specializations. Most importantly, they usually go through a substantial customization process to make them fit to the needs of a particular company; and they often need to be electronically linked with other software systems (e.g. legacy systems or partner systems). The feasibility of such adaptations need to be addressed before the decision for cloud computing is taken. Whilst there is little doubt that cloud computing can be beneficial in the areas of office computing and work group collaboration (Barnatt 2010), it is interesting to examine different forms of operating a complex business software system (such as an ERP system) in a cloud environment.

The parties that need to be discussed when looking at cloud computing as an operations model for ERP systems are the following:

1. User company (the company that uses the ERP system for their daily business processes)
2. ERP vendor (the company developing and selling licenses for the software)
3. ERP implementation partner (the company that supports the user company with the implementation), and the
4. Cloud service provider (the company running the cloud environment).

1.3 Definitions and Research Questions

There is no common definition of the term cloud computing in the literature yet (Velte et al. 2010. p. xiv). This paper synthesizes definitions and perceptions from a broad range of literature (academic and industry) and provides a framework of reference for IS research. We base our terms and definitions on the understanding reflected in the majority of literature sources and apply it to the area of ERP systems. At the basis, we are using the NIST 2009 definition of cloud computing which seems to have gained common acceptance in the literature (Mell and Grance 2009; Iyer and Henderson 2010; Babcock 2010; Vaquero et al. 2009; Buyya et al. 2009). The NIST definition describes different types of services in a layer model (infrastructure, platform, software) and distinguishes private, public, community and hybrid clouds depending on the exclusiveness of the service model. Table 2 contains terms and definitions and the following section explains these concepts in more detail.

The underlying research questions of this paper are the following:

What impact is cloud computing going to have on the operations model of ERP systems?

What are the future opportunities and challenges of cloud computing for ERP systems?

In order to discuss these questions, we first need to define and understand what exactly cloud computing is. For this we developed a reference framework of underlying terms and concepts. With the help of this framework we discuss cloud aspects which could be influential for ERP systems. Based on the literature and our own observations we then propose a research agenda for "cloud computing and ERP systems".

The remainder of the paper is structured as follows: First we present our literature analysis and the resulting reference framework for cloud computing. We then discuss the relevance of cloud computing for ERP systems. Next we propose and discuss an IS research agenda for cloud computing. The concluding section contains a reflection on our research findings and casts a look on future research.

2 Reference Framework for Cloud Computing

This section explains the research steps and introduces the reference framework for cloud computing.

2.1 Research Steps

We performed a review of the academic literature in order to identify the use (definitions) of terms and to analyze current topics and issues for cloud computing. Following Torrasco's guidelines for literature reviews we are providing an integrative literature review which is suited for topics that address new or emerging topics "that would benefit from a holistic conceptualization and synthesis of the literature to date." (Torrasco 2005, p. 357) Torrasco suggests that the outcome of such a work is normally a model or framework, the latter being ideally suited for our purpose. In essence, the literature review helped us (1) to define and clarify the problem, (2) to summarize previous investigations in order to inform the reader of the state of current research, (3) to identify relations, contradictions, gaps, and inconsistencies in the relevant literature and (4) to suggest the next step or steps in solving the problem.

Step 1 "*Source selection*": We began our search in the IS basket of eight top journals as according to Webster and Watson (p. xvi), major contributions in a field are likely to be in leading journals. Since cloud computing is a fairly new topic, our search yielded very few articles of relevance. We further extended the journal list to include 22 journals based on the Rainer and Miller (2005) MIS journal rankings.

This was supplemented by proceedings from eight IS conferences, including four that were considered major international conferences important for the IS field (Caya and Pinsonneault 2004, p. 2; Gonzalez et al. 2006, p. 822). Table 1 shows the number of papers that were found in the respective outlets.

Step 2 "*Time frame selection*": Although the term cloud computing was stated to have first been used in 2006 by Google's CEO, with the first Google Scholar article appearing in 2008 (Clarke 2010), we chose a time period of 2000 to 2010 to capture the development of the concept of cloud computing rather than picking up from when the term cloud computing started to gain prominence.

Step 3 "Paper selection": We started with the keywords" cloud computing", "software as a service" and "SaaS" and performed a snowball approach adding upcoming new keywords. A majority of the papers were discarded for irrelevance after reading them.

No. of papers	Outlet
0	MISQ, ISR, IJEC, I&M, ISJ, JACM, JCIS, IT&M, AJIS, JASIS, IJTM, SJIS, ECIS, CONF-IRM, MCIS, UKAIS
1	EJIS, JAIS, IS, AMCIS, MISQ exec, BLED, PACIS
2	JSIS, IJIM, ISM
3	JIT, ISF
4	CACM
5	JMIS
6	ICIS

Table 1. Number of papers found in the listed journals and conference proceedings

We used the literature review to (1) develop our definitions and the reference framework and (2) to identify themes for a research agenda. In the following section we introduce our reference framework for cloud computing. The research agenda will be introduced and discussed in the last section.

2.2 Definitions

Before engaging in the analysis of research issues in the literature, we needed to understand the phenomenon of cloud computing in detail. Table 2 contains the definitions which are pivotal to our discussion. In the first step we collected all available definitions (academic and industry) in a table. In the second step we identified the common concepts and distilled them into a single, coherent definition suitable for the area of ERP systems.

We then supplemented it with a graphical representation of the framework (cf. Figure 1). The suggested definitions reflect our common understanding and perceptions and are an important part of our research findings.

The definitions are grouped in three main areas:

1 = general terms and infrastructure
2 = service type (service model)
3 =cloud type (service boundaries)

#	Term	Definition	Source
1	Cloud computing	The operation of infrastructure, platforms and software in a virtualized environment whose components can be accessed and used over the Internet. The word “cloud” signals that services are offered without the need of explicit knowledge about where these services are physically located.	NIST 2009; Smith 2010; Johnston Turner and Gens 2009, p. 3; Clarke 2010, p. 573
1	Cloud service	Any provision of access to computing devices or human resources including hardware, software, networks or staff which are based on a cloud computing delivery model.	Smith 2010
1	Virtualization	The configuration of a physical server that allows installing multiple instances of virtual servers on a single machine.	Velte 2010, p. 317
2	Software as a Service (SaaS)	The provision of an application which is hosted (off premise) by a provider as a service to customers who access it via the Internet. In contrast to application service providing (ASP), SaaS is based on a multi tenant model where many customers are using the same program code but have their own private data spaces. SaaS is only suited for software “out of the box” that does not require much customization or integration with other applications.	Iyer and Henderson 2010; Velte 2010, p. 11
2	Platform as a Service (PaaS)	The provision of resources required to build applications and services (software development environment) to a customer by an outsourcing provider. Typical use scenarios are application design, development, testing and deployment.	Velte 2010, p. 13
2	Infrastructure as a Service (also called hardware as a service) (IaaS)	The provision of computing resources (CPU cycles, memory, storage, network equipment) to a customer by an outsourcing provider. In this service model it is possible to share a server among multi tenants. The service is typically billed on a utility computing basis (resource consumption).	Velte et al. p. 15
3	Private cloud	The provision of a cloud computing environment that is based on a collection of physical servers that are exclusively run for one customer. When referred to in an outsourcing scenario, the customer rents physical servers as a dedicated resource.	Iyer and Henderson 2010, p. 119; Velte 2010, p. 317; Iyer and Henderson 2010, p. 119; Mell and Grance 2009, p. 2
3	Public cloud	The provision of a cloud computing environment that is based on a collection of virtual servers where multiple customers share a physical hardware. In this outsourcing model the customer rents virtual servers on demand.	Iyer and Henderson 2010, p. 118; Velte 2010, p. 318; Iyer and Henderson 2010, p. 119, Mell and Grance 2009, p. 2
3	Hybrid cloud	The provision of a cloud computing environment that comprises two or more clouds (public and/or private). In this outsourcing model the customer operates (on premise) or rents (off premise) a base set of physical servers and adds virtual servers on demand.	Iyer and Henderson 2010, p. 120; Smith 2010, p. 25; Iyer and Henderson 2010, p. 120, Mell and Grance 2009, p. 2
3	Community cloud	The provision of a cloud computing environment that is shared by several organizations and which is managed by either a participating organization or a third party.	Iyer and Henderson 2010, p. 119; Smith 2010, p. 18; Iyer and Henderson 2010, p. 119; Mell and Grance 2009, p. 2
3	Internal cloud	Cloud network that exists entirely within a company’s own IT infrastructure (on premise)	Barnatt 2010, p. 95
3	External cloud	Cloud network that is provided to a customer by a cloud service provider on the provider’s IT infrastructure (off premise)	Barnatt 2010, p. 95

Table 2. Definitions of terms

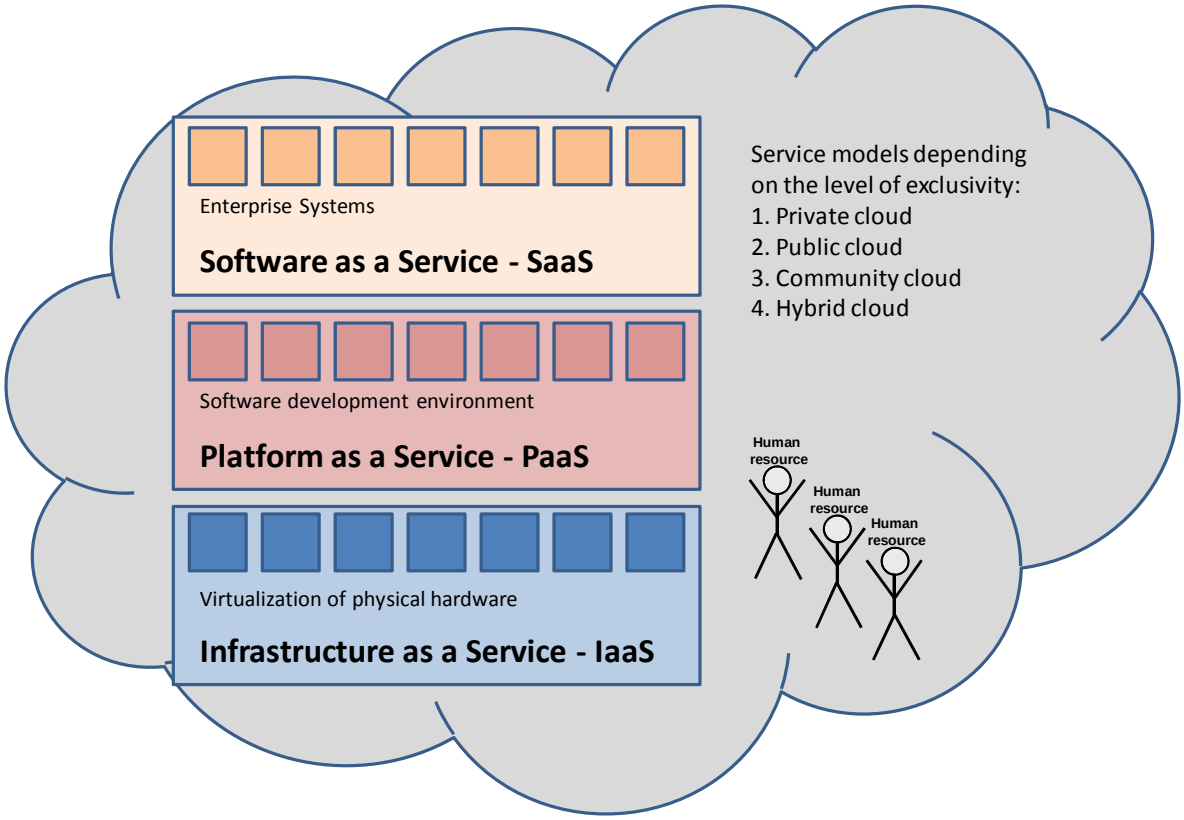

Figure 1. Level model for cloud computing

A key concept for cloud computing is server virtualization. Figure 2 shows a physical server which has been subdivided into three separate virtual servers. The virtualization software (e.g. VMWare) provides the necessary resources to the virtual servers. Each virtualized server perceives the system resources (such as CPU, memory, NIC, and disk) as unique to them (Velte 2010, p. 265). This topology helps switching virtual machine disks from one data storage system to another with no downtime and dynamically balancing the storage workload and addressing performance bottlenecks.

The "*public* cloud" is often just described as "available to everyone" and run by a third party (cf. Iyer and Henderson 2010, p. 118 or Velte et al. 2010, p. 318). While this describes the word "public" it does not really give an explanation on how this "public access" is technically realized. One option is the use of virtualization technology (cf. Figure 3) to share servers among many users.

As a logical consequence the user of a "private cloud" would then have the physical server at their exclusive use (as suggested by Barnatt 2010, p. 95). Even a private cloud could then, of course, still make use of server virtualization (but exclusively for this company). Such a virtualized environment could be called *private* cloud and be operated by a third party (*external* cloud) or the user company itself (*internal* cloud).

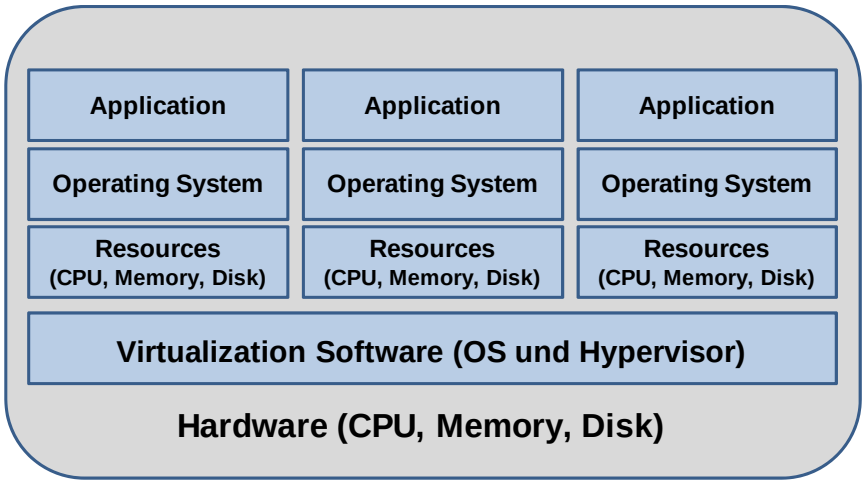

Figure 2. Server virtualization

We find the most controversial explanations for the term "hybrid cloud". Some see it as the combination of physical (private) servers as a permanent resource plus the on demand adding of virtual (public) servers (Barnatt 2010, p. 95). Others claim that hybrids combine two clouds that remain unique entities but that are bound together for enabling data and application integration (Mell and Grance 2009; Iyers and Henderson 2010, p. 120). We follow the first definition because it is the most useful concept from an IT management perspective due to its aspects of scalability and clear cost structure.

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