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Review

Cloud computing research: A review of research themes, frameworks, methods and future research directions.

1. Introduction

In recent times, the global use of computers and smartphones has increased significantly. This trend has heightened global competition and the need for businesses to expand into different geographical areas in order to be sustainable. To address this need, there is a necessity for efficient use of resources toward operational excellence. Cloud computing, an emerging innovation seeks to address these needs. Even though cloud computing is not totally new, its commercialization started around year 2000. Cloud computing simply involves the provision of information technology (IT) solutions as a service rather than as a product through the Internet (Senyo, Effah, & Addae, 2016). According to Gartner (2016), by year 2020, more than $1 trillion in IT expenditure will be directly or indirectly toward transition to cloud computing systems. As such, there is fierce competition among major cloud service providers such as Amazon, Microsoft, Salesforce, and Google for a share in this projected revenue.

In academia, cloud computing has attracted a growing number of studies in recent years. Among these studies are some literature reviews (e.g., Bayramusta & Nasir, 2016; El-Gazzar, 2014; Venters & Whitley, 2012; Yang & Tate, 2012). Although these reviews provide useful insights into cloud computing, some knowledge gaps still exist, thus the need for further reviews. These gaps are (1) limited knowledge on theories, frameworks and models that underpinned cloud computing research; (2) partial understanding of under-researched areas of cloud computing; (3) limited understanding of underpinning methodologies of cloud computing research; and (4) limited knowledge of level of analysis and geographical focus of cloud computing research. We argue that better understanding of these knowledge gaps will not only provide springboard for future studies but also enhance holistic understanding as well as contribute to the practical development of cloud computing. Thus, this paper provides a summative meta-analysis of cloud computing research from 2009 to 2015. With the aim of taking stock and providing insights into theoretical frameworks and models, research methodologies, geographical focus, and trends of cloud computing research over these years.

The rest of the paper is organized as follows. Section 2 presents a literature review of cloud computing with discussions on the general notions, delivery and deployment models of cloud computing. Section 3 presents the research framework that guided the literature classification. In Section 4, the methodology for this study is presented whilst Section 5 presents findings from the review. Discussions of the findings are presented in Section 6. Section 7 concludes the paper with contributions and direction for future research.

2. Literature review

The phenomenon of cloud computing has its genesis in other technologies, namely the grid, parallel and distributed systems, virtualization, multi-core chips, and Internet technologies (Buyya et al., 2009). Features that distinguish cloud computing from related technologies are on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service (Buyya, Broberg, & Goscinski, 2011). There is still not a standard definition of cloud computing but both academics and industry players are making significant strides for a standard definition. An attempt by Buyya et al. (2009) define cloud computing as “a parallel and distributed computing system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers.” According to the United States National Institute for Standards and Technology (NIST) “cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction” (Mell & Grance, 2011). In this study, cloud computing is defined as the delivery of IT infrastructure and applications as a service on-demand to individuals and organizations via Internet platforms (Senyo et al., 2016).

The types of service models that have emerged under cloud computing technology are Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS), and Infrastructure-as-a-Service (IaaS) (Zissis and Lekkas, 2012). SaaS is a cloud computing model where applications reside on the cloud infrastructure of service providers and are delivered to users through web interfaces and programs. The main notion behind SaaS is to eliminate the practice of applications residing locally on devices of individual user as the computing powers of these individual devices cannot be leveraged to provide high computing efficiency and performance to users. Cloud computing is believed to have built its genesis from Software as a Service (Mell & Grance, 2011).

PaaS is a service model which offers users a platform to build and run applications through a programming interface provided and supported by cloud service providers (Marston, Li, Bandyopadhyay, Zhang, & Ghalsasi, 2011). Therefore, the issues of scalability, high server speed and storage capacities are addressed under PaaS. Hence, PaaS users can build, run, and deploy their own applications using remote IT platforms. However, users do not have absolute control over the core cloud platforms such as servers, operating systems or storage (Sultan, 2010).

Under IaaS, cloud service providers supply a range of virtual infrastructures such as virtual servers, storage and other fundamental computing

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resources to users which enable them deploy and run their own operating system, applications, upload or download software or files into the cloud (Mateescu, Gentzsch, & Ribbens, 2011). Under the IaaS model, users have control over the arbitrary software and applications they have deployed into the cloud but have limited control over the virtual infrastructure provided by the cloud service provider.

The cloud service models are deployed to users through four main delivery channels based on needed control, number of users, security, and privacy needs. These cloud service delivery models are public, private, hybrid and community clouds (Hsu, Ray, & Li-Hsieh, 2014; Mouratidis, Islam, Kalloniatis, & Gritzalis, 2013). The public cloud is where a third party owns all the physical resources and then provides cloud services to multiple users over the Internet. The users that are served by the cloud service provider ranges from individuals to corporate organizations (Mell & Grance, 2011). Under the private cloud deployment, the cloud service is offered solely to a specific organization. The private deployment is mostly necessitated by the desire to take full control of corporate data, security guidelines and system performance. Though an organization can fully deploy its own cloud services, a third party organization can also be contracted to manage the deployment on its behalf. Additionally, the cloud services may reside off or on the premises of the organization (Zissis and Lekkas, 2012). A community cloud deployment is where cloud services are offered to a specific group of organizations having similar mission, security requirements, policy and compliance conditions (Marston et al., 2011). The community cloud deployment is seen as a generalization of the private cloud thus, has more than one organization in the deployment. The result of a merger between different cloud deployment models such as private, public and community is termed as the hybrid cloud deployment (Mateescu et al., 2011). Although these different deployments are merged together, they remain unique on their own but are held as one through proprietary technology and standards that enable application and data operability. The hybrid cloud combines the advantages and disadvantages of private, public and community cloud deployment hence, is regarded as an ideal model when organizations are torn between issues of control and cost.

3. Classification framework

Cloud computing is a relatively new, unique and multifaceted phenomenon hence, classification of its literature is challenging as all aspects must be taken into consideration. Therefore, the classification scheme of Yang and Tate (2012) was adapted with some modifications to reflect changes in cloud computing literature 3 years on. The scheme (see Table 1) classified cloud computing into 4 top and 26 sub-themes. The 4 top themes are *business issues, conceptualization, domains and applications, as well as technology issues.*

The business issues theme consolidates studies that border on business implications of cloud computing. The sub-themes under the business issues theme are cloud computing adoption, acceptance and implementation, privacy, legal and ethical issues, operational performance, trust, strategy, financial issues, and service value. The technology issues theme considers articles that pertain to the constituents, elements and mechanisms of the cloud computing technology. It mostly focuses on studies related to the technical infrastructure of cloud computing. The sub-themes under the technology issues are cloud systems performance, data center management, data management and analytics, security, architecture, service and resource management, and software development (Yang & Tate, 2012). The conceptualization theme includes articles that provide insight into the phenomenon of cloud computing with the aim of offering better understanding (Buyya et al., 2009). As such, the conceptualization theme is subdivided into foundational and prediction sub-themes to cater for articles that provide insight into current knowledge of cloud computing as well as future aspirations. The domains and applications theme consists of articles that are concerned with the impact of cloud computing on specific areas of society. The sub-themes include e-science, e-government, education, health, mobile computing, knowledge management, open source, as well as social media.

4. Methodology for the review

King and He (2006) indicate that the review of literature can be conducted in four different ways within the qualitative and quantitative domain viz. narrative, descriptive, vote counting and meta-analysis approaches. As such, this study adopted the meta-analysis technique for its review of literature. The choice of the meta-analysis approach is motivated by its ability to provide statistical support for the research being undertaken.

The primary source of literature for the review was electronic database searches as this practice has become apparent among information systems (IS) research (Hwang & Thorn, 1999; Petter & McLean, 2009). Therefore, the choice of electronic databases was deemed appropriate. The search for literature was conducted in two phases. First, the senior basket of IS journals (Association for Information Systems, 2011) were searched individually to ascertain the extent to which cloud computing research has been accorded credence in these journals. Since, this practice is evident in other studies (e.g., Duncombe & Boateng, 2009; Ngai & Wat, 2002; Yang & Tate, 2012). However, it became evident that the senior basket of information systems journals did not have many studies on cloud computing. A possible reason for less research on cloud computing in these senior basket of IS journals is the newness and technicality of cloud computing. Second, a wider search was conducted in electronic databases such as Ebscohost, ScienceDirect, Emerald, Sage, JStor, ACM Digital Library and Google Scholar. According to Levy and Ellis (2006), these sources cover an extensive size of the top fifty information systems journals. Therefore a fair representation is assumed to be achieved.

The search was conducted with the phrase “cloud computing” and keyword “cloud” on the abstracts, keywords and titles across the databases. However; the search was limited to peer-reviewed scholarly journal articles from 2009 and till 2015. The articles were subjected to manual filtering where editorials; review articles; and reports were eliminated because, the study set out to include only peer reviewed articles in the review. Conference papers; dissertations; books; working papers; and reviews of books were also excluded. Further checks were conducted to remove

Table 1
Cloud computing literature classification framework.
Adapted from Yang and Tate (2012).

Themes	Sub Themes
Business Issues	Cloud computing adoption, acceptance and implementation, Privacy, Legal and Ethical issues, Operational performance, Trust, Strategy, Financial issues, and Service value
Technology Issues	Performance, Data center management, Data management and analytics, Security, Cloud computing architecture, Service and resource management, and Software development
Conceptualization	Foundational and Prediction
Domains & Applications	E-Science, E-Government, Education, Health, Mobile computing, Knowledge management, Open source software, and Social media