Communications of the Association for Information Systems

Volume 31   Article 2

A Descriptive Literature Review and Classification of Cloud Computing Research

Haibo Yang
School of Information Management, Victoria University of Wellington, Haibo.Yang@vuw.ac.nz

Mary Tate
School of Information Management, Victoria University of Wellington

Follow this and additional works at: https://aisel.aisnet.org/cais

A Descriptive Literature Review and Classification of Cloud Computing Research

Haibo Yang

School of Information Management, Victoria University of Wellington

Haibo.Yang@vuw.ac.nz

Mary Tate

School of Information Management, Victoria University of Wellington

Abstract:

We present a descriptive literature review and classification scheme for cloud computing research. This includes 205 refereed journal articles published since the inception of cloud computing research. The articles are classified based on a scheme that consists of four main categories: technological issues, business issues, domains and applications, and conceptualising cloud computing. The results show that although current research is still skewed towards technological issues, new research themes regarding social and organisational implications are emerging. This review provides a reference source and classification scheme for IS researchers interested in cloud computing, and to indicate under-researched areas as well as future directions.

Keywords: cloud computing, descriptive literature review, classification

Editor's Note: The article was handled by the Department Editors for Information Technology and Systems.

A Descriptive Literature Review and Classification of Cloud Computing Research

I. INTRODUCTION

In an age of information and globalisation, massive computing power is desired to generate business insights and competitive advantage [Liu and Orban, 2008]. A traditional way for enterprises to process their data is to use the computing power provided by their own in-house data centres. However operating a private data centre to keep up with rapidly growing data processing requests can be complicated and costly.

Cloud computing offers an alternative. 'Cloud computing', as a term for Internet-based computing service, was launched by industry giants (e.g. Google, Amazon.com, etc.) in late 2006. It promises to provide on-demand computing power with quick implementation, low maintenance, fewer IT staff, and consequently lower cost. Such appealing promises have made cloud computing a dominant IT press topic over the past three years. As projected by market-research firm IDC, IT cloud-service spending will grow from about USD16 billion in 2008 to about USD42 billion by 2012 [Leavitt, 2009]. Cloud Computing regularly appears in the 'top 10' current issues for CIOs identified by industry commentators such as the VP and editor in chief of *Information Week* [Preston, 2011].

The relative novelty and rapidly increasing growth of cloud computing makes it an exciting area for research. The present paper aims to assess the state of cloud computing research. We portray a current landscape of this research stream, where it is today, and most importantly, given the current relevance of the topic, some suggestions as to where more effort should be focused in the future in order to produce more 'consumable research' [Robey and Markus, 1998]. The remainder of this article is organised as follows: First a brief overview of cloud computing is given. Next the research methodology and our classification schema are presented. This is followed by the results of our literature review and classification. Then we discuss the implications of this review, and finally offer some conclusions.

II. LITERATURE REVIEW

This section offers a short introduction to what cloud computing is, and how it can be distinguished from related concepts such as grid computing.

Cloud computing has been cited as 'the fifth utility' (along with water, electricity, gas, and telephone) whereby computing services are readily available on demand, like other utility services available in today's society [Buyya, Yeo, Venugopal, Broberg, and Brandic, 2009]. This vision is not essentially new. Dating back to 1961, John McCarthy, retired Stanford professor and Turing Award winner, in his speech at MIT's Centennial, predicted that in the future computing would become a 'public utility' [Wheeler and Waggener, 2009]. In 1969, Leonard Kleinrock, one of the chief scientists of the original Advanced Research Projects Agency Network (ARPANET) project which seeded the Internet, said: 'As of now, computer networks are still in their infancy, but as they grow up and become sophisticated, we will probably see the spread of "computer utilities" which, like present electric and telephone utilities, will serve individual homes and offices across the country' [Kleinrock, 2005, p. 4]. It could be argued that cloud computing has begun to fulfil this vision of computing on demand.

The first step of studying research into cloud computing is to clarify the concept. Attempts to define cloud computing have come from different perspectives within practice and academia (as listed in Table 1).

Among the various definitions, the one by the NIST (National Institute of Standards and Technology) has gained recent recognition and popularity. For the purpose of this study, the NIST definition of cloud computing is adopted to facilitate the following discussions.

The NIST further suggests that a cloud computing model should be composed of five essential characteristics, three service levels, and four deployment models [Mell and Grance, 2009] as shown in Figure 1. Ideally, a cloud should have all of the five following characteristics:

1. *On-demand self-service.* A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service's provider.

| Table 1: Definitions of Cloud Computing	
Definition	Reference
A style of computing where massively scalable IT-related capabilities are provided as a service across the Internet to multiple external customers.	Gartner [Plummer, Smith, Bittman, Cearley, Cappuccio, Scott, et al., 2009]
A pool of abstracted, highly scalable, and managed infrastructure capable of hosting end-customer applications and billed by consumption.	Forrester [Staten, 2008]
The illusion of infinite computing resources available on demand, the elimination of up-front commitments by cloud users, and the ability to pay for use of computing resources on a short-term basis as needed.	UC Berkeley [Armbrust, Fox, Griffith, Joseph, Katz, Konwinski, et al., 2009]
Cloud computing embraces cyber-infrastructure, and builds on virtualisation, distributed computing, grid computing, utility computing, networking, and Web and software services.	[Vouk, 2008]
A type of parallel and distributed system consisting of a collection of interconnected and virtualised 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.	[Buyya et al., 2009]
A large pool of easily usable and accessible virtualised resources (such as hardware, development platforms and/or services). These resources can be dynamically reconfigured to adjust to a variable load (scale), allowing also for an optimum resource utilisation. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the infrastructure provider by means of customised SLAs.	[Vaquero, Rodero–Merino, Caceres, and Lindner, 2009]
A model for enabling 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.	NIST [Mell and Grance, 2009]
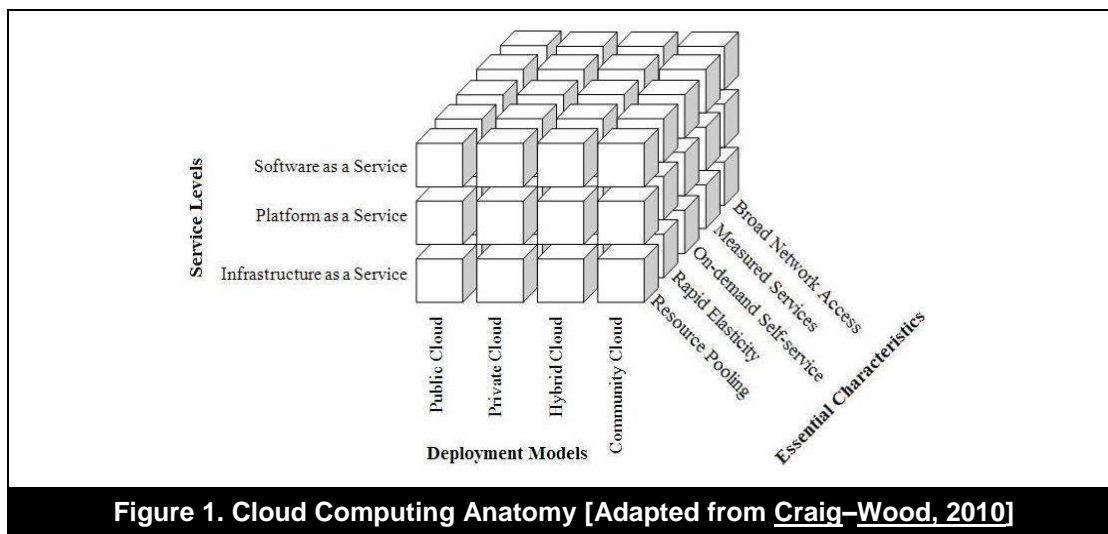
Figure 1. Cloud Computing Anatomy [Adapted from Craig–Wood, 2010]

2. *Broad network access.* Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g. mobile phones, laptops, and PDAs).

3. *Resource pooling.* The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. Examples of resources include storage, processing, memory, network bandwidth, and virtual machines.

4. *Rapid elasticity.* Capabilities can be 'elastically' provisioned and released, in some cases automatically, to quickly scale in and scale out.

5. *Measured Service*. Cloud systems automatically control and optimise resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g. storage, processing, bandwidth, and active user accounts) [Mell and Grance, 2009].

Depending on the relationship between the provider and the consumer, a cloud can be classified as:

1. *Public cloud,* the one most commonly referred to, is owned and operated by independent vendors and accessible to the general public.

2. *Private cloud* is an internal utilisation of cloud technologies which is maintained in-house and solely accessible to internal users within an organisation.

3. *Community cloud* is shared by several organisations and supports a specific community that has shared concerns (e.g. mission, security requirements, policy, and compliance considerations). It may be managed by the organisations or a third party and may exist on premise or off premise.

4. *Hybrid cloud* is a combination of two or more types of clouds (private, community, or public). For example, an organisation may bridge its internally operated private cloud with other public clouds together by standardised or proprietary technology in order to satisfy business needs [Mell and Grance, 2009].

Among the four deployment models, public cloud is what the term 'cloud computing' was initiated for and commonly refers to. Other deployment models are variations of public cloud but share a similar set of technologies and levels of services. The three service levels of cloud computing will be discussed in the following section.

Cloud computing services are generally classified into three layers:

1. *Infrastructure as a Service (IaaS):* IaaS provides the raw materials of cloud computing, such as processing, storage and other forms of lower level network and hardware resources in a virtual, on demand manner via the Internet [Leavitt, 2009]. Differing from traditional hosting services with which physical servers or parts thereof are rented on a monthly or yearly basis, the cloud infrastructure is rented as virtual machines on a per-use basis and can scale in and out dynamically, based on customer needs. Such on-demand scalability is enabled by the recent advancements in virtualisation and network management. IaaS users do not need to manage or control the underlying cloud infrastructure but have control over operating systems, storage, deployed applications, and in some cases limited control of select networking components (e.g. host firewalls) [Mell and Grance, 2009].

   Typical IaaS examples are Amazon EC2 (Elastic Cloud Computing) and S3 (Simple Storage Service) where computing and storage infrastructure are open to public access in a utility fashion. For a fee (e.g. USD0.085 per hour for an on-demand small Linux/UNIX server instance, or USD0.12 per hour for a Windows one), a user can easily access tens of thousands of virtual servers from EC2 to run a business analysis, and then release them as soon as the computational work is done. Another example, Eucalyptus [Nurmi, Wolski, Grzegorczyk, Obertelli, Soman, Youseff, et al., 2009], based on an open source framework, is a cloud implementation that provides a compatible interface to Amazon EC2, and allows users to set up a cloud infrastructure on premise and experiment prior to purchasing commercial services [Foster, Yong, Raicu, and Lu, 2008]. Some researchers suggest to further divide IaaS into HaaS (Hardware as a Service) and DaaS (Data as a Service) [Wang, Tao, Kunze, Castellanos, Kramer, Karl, 2008], but it is more common that IaaS is considered as a whole concept.

2. *Platform as a Service (PaaS):* PaaS moves one step further than IaaS by providing programming and execution environments to the user. A PaaS product acts as an integrated design, develop, test, and deploy platform. The PaaS user can create applications using programming languages and APIs supported by the provider, and then directly deploy the applications onto the provider's cloud infrastructure within a few clicks. The PaaS user does not manage or control the underlying cloud infrastructure (including network, servers, operating systems, or storage), but has control over the deployed applications and possibly application hosting environment configurations [Mell and Grance, 2009]. Such an approach can reduce most of the system administration burden (e.g. setting up and switching among development environment, test environment, and production environment) traditionally carried by the developers who can then concentrate on more productive problems. PaaS typically provides a complete set of development tools, from the interface design, to process logic, to integration [Lawton, 2008a]. Some other appealing features of PaaS include built-in instruments measuring the usage of the deployed applications for billing purposes and an established online community for collaboration and problem solving.

An example of PaaS is Google's App Engine, which enables users to build applications on the same scalable systems that power Google applications [Foster et al., 2008]. Google's App Engine aims to enable users to easily develop applications on the Internet in collaboration with other developers from around the world [Leavitt, 2009]. To facilitate collaboration, PaaS providers often intentionally cultivate online user communities and marketplaces (e.g. Google Apps Marketplace[1]) where developers can share, buy, and sell their codes, products, and services to each other.

PaaS offerings lower the entry level for online application development. WaveMaker, recently acquired by VMware, provides an easy and intuitive way of building Java-based websites, enabling non-programmer users to build their own online applications in the cloud. These types of platforms comprise a modern instantiation of the End User Computing (EUC) paradigm which has long been envisioned by generations of IS researchers [Huff, Munro, and Martin, 1988].

3. *Software as a Service (SaaS):* SaaS provides users with complete turnkey applications through the Internet, even complex systems such as those for CRM or ERP [Leavitt, 2009]. Software or applications are hosted as services in the cloud and delivered via browsers once subscribed to by the user. This approach can eliminate the need to install, run, and maintain the application on local computers. SaaS is known for its multi-tenant architecture in which all the users share the same single code base maintained by the provider. Authentication and authorisation security policies are used to ensure the separation of user data. Such a sharing mechanism enables the cost and price of SaaS to stay competitive compared to traditional off-the-shelf and bespoke software. SaaS is expected to alleviate the user's burden of software maintenance, and reduce the expense of software purchases by on-demand pricing [Wang et al., 2008].

A prominent example of SaaS is Salesforce.com's online CRM system. This system provides users with complete CRM applications as well as a user side customisation platform based on its PaaS by-product Force.com. Two types of customisations are available—one is 'point-and-click configuration' that requires no coding, the other is 'customise with code' that allows developers to create new functionalities beyond the constraints of configuration, with Apex—Salesforce.com's own native programming language. Thus on its own website, Salesforce.com declares that there are currently '77,300 Salesforce implementations. All of them unique'[2].

Similar to PaaS, SaaS providers also leverage the 'power of crowd' by providing online user communities and marketplaces where SaaS users and third-party vendors can share, sell, and buy add-ons, modules, or customisation services to enhance the core application. An example of such a marketplace is Salesforce.com's AppExchange[3]. This marketplace acts as a specialized aggregator and enables features such as requesting quotes, sharing demos, etc. The new add-ons bought from the marketplace can be deployed by a few clicks in a few minutes.

IaaS, PaaS, and SaaS are inherently interrelated with each building on the former. These three layers reflect a full spectrum of cloud computing services.

Cloud computing has promised many technological and sociological benefits. The computing power is generated from highly centralised and standardised data centres which contain up to several million servers, with considerable economies of scale. From an enterprise standpoint, cloud computing can deliver on-demand computing power at a very low (or no) upfront cost for infrastructure and ongoing maintenance. Cloud computing also promises to provide better performance, reliability, and scalability [Erdogmus, 2009]. Some evidence shows that these are being delivered [Sultan, 2011]. From an environmental standpoint, owing to the advanced electrical and cooling systems used by its centralised data centres, cloud computing has promised to bring low environmental cost and high energy efficiency, compared to the traditional scattered enterprise data centres [Katz, 2009]. All in all, these seductive promises have attracted enormous interest from many organisations.

III. RESEARCH METHODOLOGY
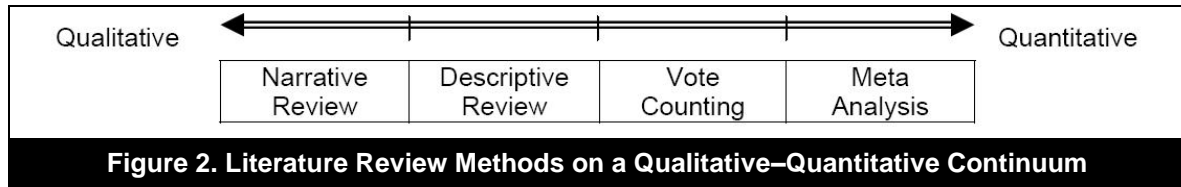
A Descriptive Literature Review

The literature review is an essential approach to conceptualise research areas and survey and synthesise prior research [Webster and Watson, 2002]. It directly contributes to a cumulative research culture. It is suggested that the lack of review articles has been hindering the progress of IS field [Webster and Watson, 2002].

---

[1] http://www.google.com/enterprise/marketplace
[2] http://www.salesforce.com/platform/customization (current 20 Apr. 2011). This figure was 82,400 in Dec. 2010.
[3] http://appexchange.salesforce.com/home

A literature review can be conducted in different ways. Figure 2 shows four methods of literature review: Narrative Review, Descriptive Review, Vote Counting, and Meta-Analysis. These four review methods are placed in a qualitative-quantitative continuum to illustrate their different focuses [King and He, 2005].

Qualitative	←			→	Quantitative
	Narrative Review	Descriptive Review	Vote Counting	Meta Analysis	

Figure 2. Literature Review Methods on a Qualitative–Quantitative Continuum

The narrative review is the traditional way of reviewing the literature and is skewed towards a qualitative interpretation of the literature. It is conducted by verbally describing the past studies, focusing on theories and frameworks, elementary factors and their research outcomes, with regard to a hypothesized relationship [King and He, 2005]. However, there is no standardised procedure for a narrative review. The conduct of a narrative review largely depends on the reviewer's personal preference, thus this approach is vulnerable to subjectivity. It is not uncommon for 'two reviews to arrive at rather different conclusions from the same general body of literature' [Guzzo, Jackson, and Katzell,1987, p. 408].

A descriptive review focuses on revealing an interpretable pattern from the existing literature [Guzzo et al., 1987]. It produces some quantification, often in the form of frequency analysis, such as publication time, research methodology, and research outcomes. Such a review method often has a systematic procedure including searching, filtering, and classifying processes. First a reviewer needs to conduct a comprehensive literature search to collect as many relevant papers as possible in an investigated area. Then the reviewer treats an individual study as one data record and identifies trends and patterns among the papers surveyed [King and He, 2005]. The outcome of such a review is often claimed to be representative of the current state of a research domain.

Vote counting is generally used to draw inferences about focal relationships by combining individual research findings [King and He, 2005]. Here a tally is made of the frequency with which existing research findings support a particular proposition. Often it is applied to generate insights from a series of experiments. The premise underlying this approach is that repeated results in the same direction across multiple studies, even if some of them are non-significant, may be more powerful evidence than a single significant result [King and He, 2005].

Meta-analysis aims at statistically providing support for a research topic by synthesising and analysing the quantitative results of many empirical studies [King and He, 2005]. In most cases, it may specifically examine the relationships between certain Independent Variables (IVs) and Dependent Variables (DVs) derived from existing research findings. Qualitative studies have to be excluded by a meta-analysis due to its extremely quantitative nature. Only similar quantitative studies are collected for a meta-analysis. The benefit of this approach is to generate a much less subjective literature review in a specific research context.

Our objective is to portray a landscape of cloud computing as an emerging research area and provide a snapshot to guide future development. Given the nascence of this research area, we do not and could not aim at examining any variables, correlations, or theories. We found a descriptive review approach was most appropriate for the current stage of this research. The procedure for conducting this descriptive review is described in the next section.

Scope of the Literature Search

The first step of a literature analysis study is to locate relevant literature through computer and manual searches. Traditionally this is done by targeting some prominent journals and conferences. This approach is relevant to other research topics like Electronic Commerce where some major publication outlets have been formed by the long development of the research area [Ngai and Wat, 2002]. However, focusing on limited outlets cannot be justified for a literature review on cloud computing, as this is a recent phenomenon which emerged only three years ago, and the publication channels are still scattered. In the meantime, using online database searches as a primary literature collecting approach has become an emerging culture among IS researchers who are interested in contemporary phenomena [Hwang and Thorn, 1999; Petter and McLean, 2009; Sabherwal, Jeyaraj, and Chowa, 2006]. Therefore, for a literature review on cloud computing, it is appropriate and practical to focus on online databases rather than library collections.

Four prominent online databases were targeted: General OneFile, IEEE Xplore, ProQuest (ABI/INFORM), and ScienceDirect (Elsevier). According to Levy and Ellis, these four databases cover forty-four of the ISWorld's top fifty

IS journals[4] [Levy and Ellis, 2006], and we therefore felt that these databases were comprehensive enough to produce a literature set that is representative of the current status of IS research.

We conducted keyword and abstract searches across all the four databases and for all years (until 25 May 2011) with the phrase 'cloud computing'. The search aimed at peer-reviewed, scholarly journal articles, therefore filters were used if available (e.g. the 'scholarly journals, including peer-reviewed' option was selected in ProQuest; the 'only journal' option was selected in ScienceDirect and IEEE Xplore; the 'limited to peer-reviewed' option was selected in General OneFile). The initial search resulted in 735 hits.

Filtering Process

The 735 articles were imported directly into an EndNote database. Fifty-nine duplicates were automatically removed by using the 'find duplication' function of EndNote, and fifty articles without author names or written by anonymous authors were also discarded. Following a staged selection process [Dyba and Dingsoyr, 2008], the remaining 626 articles in the database were then scanned and filtered in three rounds.

The first round involved manually scanning titles for apparently irrelevant articles. This round of filtering excluded those articles that did not address the cloud computing phenomenon in business and technology. These articles included irrelevant studies in 'Meteorology', 'Atmospheric Sciences', 'Geophysics', 'Fluid Dynamics', and 'Nuclear Risks'. They were mistakenly selected by the search engines. This first round of scanning also allowed the identification and exclusion of further duplicates not identified by EndNote due to the misplacement of authors' first names and surnames. In total 136 articles were discarded by the end of this round which resulted in 490 articles being retained in the EndNote database.

The second round involved manually scanning abstracts and reading full texts if necessary. This round was to exclude those articles that did not address cloud computing as a central theme of discussion, but instead merely mentioned cloud computing along with other technology phenomena for a general coverage. This round was the most comprehensive and time-consuming phase, as in-depth reading of the articles was required to perform the filtering tasks. Reading the abstracts and full texts also enabled us to exclude those book reviews, letters, briefs, and technical news without adequate academic references and insights. Moreover, some articles were identified in this round which, while they were not direct duplicates, covered nearly the same contributions by the same group of authors. In such cases, only the most recent paper was kept and the others were discarded. By the end of this round, 262 articles were discarded, which resulted in 221 articles left in the EndNote database.

The final round involved excluding articles from non-refereed journals. Though 'peer-reviewed' and 'scholarly' filters were applied during the literature search, we noticed the existence of non-refereed journals in the EndNote database during the first two rounds of filtering. Hence Ulrichsweb.com was used for reconfirming that all articles included in this study were from peer-reviewed journals. This step discarded sixteen non-refereed articles and resulted in the final 205 articles. These 205 peer-reviewed academic articles, with a clear focus on cloud computing, remained in the Endnote database for further analysis and classification.

Classification Scheme

To systematically reveal and examine academic insights on cloud computing, a literature classification scheme was developed. This classification was based on categorising the research focus of the 205 articles which remained after the filtering processes. A 'bottom-up' approach informed by grounded theory [Glaser and Strauss, 1967] was adopted to identify the categories used for this literature analysis. Such an approach has recently been recommended as a rigorous method for reviewing literature [Wolfswinkel, Furtmueller, and Wilderom, 2011]. Specific subcategories were assigned to each article and then synthesised into more generic top categories in three steps as described below.

The first step was an initial reading of the 205 papers. In the initial coding stages, we applied open coding techniques and generated a wide range of codes to capture the themes represented in each article [Strauss and Corbin, 1997]. Codes were generated from article keywords, analysis of the article abstract, and, where necessary to explicate the content of the paper further, careful reading of the entire article. In this process, thirty to forty codes were identified.

---

4   The remaining six journals—*Communications of the Association for Information Systems, Journal of the Association for Information Systems, International Journal of Electronic Commerce, Information Systems Journal, Human-Computer Interaction,* and *Informing Science*—were then manually searched.

In the next stage, we sought relationships between our initial categories (axial coding) and reduced the codes we initially identified into our final set of twenty-one subcategories [Strauss and Corbin, 1997]. This subcategory set was revised iteratively to make sure it was not only parsimonious but also represented the diversity of the initial coding.

Following the axial coding, the twenty-one subcategories were grouped further into four top level topics using affinity analysis. The K-J method (also called affinity diagramming) developed by Jiro Kawakita provides a systematic way to evaluate and agree on classifications [American_Society_for_Quality, 2006]. In order to derive the top level topics, we conducted an affinity workshop to negotiate and agree on the four broad research domains linking the twenty-one detailed codes. These high-level categories were further validated by comparison with the high-level categories in the influential classification scheme for IS keywords [Barki, Rivard, and Talbot, 1993].

Consequently, a classification framework, as shown in Table 2, was created. This classification is an upgraded version of that presented in a previous, related study [Yang and Tate, 2009].

Thus the 205 articles were full-text reviewed and eventually grouped into four broad categories: Technological Issues, Business Issues, Domains and Applications, and Conceptualising Cloud Computing. This grouping is based on assigning the single most applicable topic-category to a group of related subcategories (e.g. subtopics 'Cloud Performance', 'Data Management', 'Data Centre Management' were grouped into a higher level topic 'Technical Issues'). Each subtopic was assigned to individual articles according to the articles' specific research interest. It is inevitable that a piece of research may contribute to several of the subcategories. However, by assigning each article to only one primary subcategory, we are able to offer a simplified and structured classification of the major categories and subcategories within current cloud computing research and conceptualise the relationships between these categories.

A: Technological Issues: This category focuses on technology details of cloud computing. Articles in this category are produced by researchers who see cloud computing as a white-box and are interested in its components and mechanisms. Six categories are related to technological issues.

1. Cloud Performance: This subcategory covers articles focusing on the evaluation and optimisation of the performance of the clouds. This includes studies that attempt to quantify and compare performance across different clouds [Iosup et al., 2011], to enhance workflow scheduling and load balancing [Byun, Kee, Kim, and Maeng, 2011; Kong, Lin, Jiang, Yan, and Chu, 2011], to improve dynamic resource allocation [Streitberger and Eymann, 2009; Warneke and Kao, 2011], to enable automatic bottleneck detection [Iqbal, Dailey, Carrera, and Janecek, 2011], to estimate performance of cloud network with nodes failure [Lin and Chang, 2011], and to improve interoperability across different clouds.

2. Data Management: This subcategory includes specific issues associated with the large scale, distributed data processing in the clouds. This includes data consistency [Vogels, 2009], data redundancy [Pamies–Juarez, García–López, Sánchez–Artigas, and Herrera, 2011], data mining algorithms and methods [Grossman, Gu, Sabala, and Zhang, 2009; Johnson, 2009; Lin and Deng, 2010], integration of distributed data [Chen, Wu, Liu, Yang, and Zheng, 2011], and parallel RDBMS (Relational Database Management Systems) [Stonebraker, Abadi, DeWitt, Madden, Paulson, Pavio, et al., 2010].

3. Data Centre Management: This subcategory looks into the foundational enabler of cloud computing, the data centres. Articles in this category concentrate on energy efficiency, power conservation, and environmental considerations in the design of data centres [Beloglazov, Abawajy, and Buyya, 2011; Berl, Gelenbe, di Girolamo, Giuliani, de Meer, Dang, et al., 2010; Dougherty, White, and Schmidt, 2011; Katz, 2009]. In addition, algorithms for energy-aware scheduling are proposed [Mezmaz, Melab, Kessaci, Lee, Talbi, Zomay, et al., 2011].

4. Software Development: This subcategory represents a stream of software developer-oriented research. Articles in this subcategory range from generic discussions on developing distributed and parallel software in cloud computing environments [Lawton, 2008a; Louridas, 2010; Wang, Meng, Han, Zhan, Tu, Shi, et al., 2010], to specific analyses of particular cloud-based programming frameworks such as MapReduce [Liu, Li, Alham, and Hammoud, 2011]. Novel studies also look into component-based approaches for developing composite applications [Malawski, Meizner, Bubak, and Gepner, 2011] and automation in restructuring traditional applications into distributed/partitioned cloud-based ones [Böhm and Kanne, 2011].

5. Service Management: As an emerging research theme focusing on the administration of cloud computing services, this subcategory includes articles exclusively targeting aspects such as service lifecycle in the cloud [Breiter and Behrendt, 2009] and publishing, discovering, and selecting cloud-based services [Goscinski and Brock, 2010; Zhu, Wang, and Wang, 2011].

Table 2: Classification of Topics in Cloud Computing	
Topics	Subtopics
Technological Issues	Cloud Performance, Data Management, Data Centre Management, Software Development, Service Management, Security
Business Issues	Cost, Pricing, Legal Issues, Ethical Issues, Trust, Privacy, Adoption
Conceptualising Cloud Computing	Foundational/Introductions, Predictions
Domains and Applications	e-Science, e-Government, Education, Open Source, Mobile Computing, Other Domains

6. Security: Cloud security has been a common concern for the public [Bellovin, 2011]. Some articles in this subcategory look at general security mechanisms such as restrictions and audits [Spring, 2011a; Wang, Wang, Ren, Lou, and Li, 2011], multi-tenancy authorisation [Calero, Edwards, Kirschnick, Wilcock, and Wray, 2010], third-party assurance [Zissis and Lekkas, 2010], and cloud-based security services [Li, Li, Wo, Hu, Huai, Liu, et al., 2011]. Other articles addressing specific cloud related security issues fall into two categories: data security and network security. The data security category includes papers looking at data encryption [Anthes, 2010], data colouring, and software watermarking for multi-way authentications [Hwang and Li, 2010], and a data-partitioning scheme for implicit security [Parakh and Kak, 2009]. The network security category includes papers discussing intrusion detection in the cloud [Vieira, Schulter, and Westphall, 2010], and cloud-level defence against HTTP-DoS and XML-Dos attacks [Chonka, Xiang, Zhou, and Bonti, 2011].

B: Business Issues: This category concerns the business implications of cloud computing. Articles in this category treat cloud computing as a black-box technology which can generate business value to both providers and users. Seven categories have emerged in this category.

1. Cost: This subcategory examines the economic benefit from a cloud-user perspective. Topics in this category include a comparison between the cost of leasing cloud services and that of purchasing and using a local server cluster [Walker, 2009], techniques to estimate and monitor costs for cloud services [Truong and Dustdar, 2010], algorithms for finding minimum cost storage strategy [Yuan, Yang, Liu, and Chen, 2011], and more specific ones such as analysing operational costs for hosting online games in the cloud [Iosup, Nae, and Prodan, 2010].

2. Pricing: Articles in this subcategory mainly focus on the pricing strategies of cloud providers. A common approach for studying this topic is to compare different pricing strategies and analyse the pros and cons in terms of acceptance of customers. Comparisons can be made between fixed prices and variable prices [Yeo, Venugopal, Chu, and Buyya, 2009], or between piece-rate pricing and flat-rate pricing [Li, 2011].

3. Legal Issues: This subcategory examines legal issues associated with cloud computing. With rapid advancement in technology, regulators are often in a 'catch-up' mode with regard to policy, governance, and law [Kaufman, 2009]. Articles in this category introduce general legal risks of adopting cloud computing [Joint, Baker, and Eccles, 2009], as well as addressing specific topics such as digital forensic investigation in cloud computing systems [Taylor, Haggerty, Gresty, and Hegarty, 2010] and uncertain jurisdiction for Internet activities in geographically distributed cloud data centres [Ward and Sipior, 2010].

4. Ethical Issues: This subcategory analyses the cloud computing phenomenon from an ethical standpoint. It contains articles which propose that IT professionals, when making decisions about cloud computing deployment, should consider applied ethics methods such as Utilitarian, Deontologist, and Rawlsian [Miller, 2010].

5. Trust: This subcategory examines approaches for cloud providers to gain trust from prospective users. Articles in this category identified two factors affecting trust in the cloud—transparency [Bret, 2009] and public auditability [Wang, Ren, Lou, and Li, 2010]. In addition, an instrument for evaluating the transparency of a cloud provider is proposed [Pauley, 2010].

6. Privacy: This subcategory specifically addresses privacy issues from either an ethical or legal point of view. With cloud computing, privacy is an inevitable concern, as the cloud users have to upload and store (in some cases sensitive) business and personal information into remote data centres managed by external parties [Katzan, 2010c]. Articles in this subcategory propose a method for analysing privacy in cloud computing in the workplace [Barnhill, 2010] and argue that cloud providers need to display clear policies about how user data is used [Ryan, 2011].

7. Adoption: This subcategory explores topics related to cloud-computing adoption in businesses. Some articles in this category target general businesses by providing ROI (Return on Investment) models for firms to decide on the suitability of adopting cloud computing [Misra and Mondal, 2011], and a modelling tool for making buy-

or-lease storage decisions [Walker, Brisken, and Romney, 2010]. Other articles focus more on SMEs (Small and Medium Sized Enterprises) and look into inhibitors [Truong and Dustdar, 2011] and enablers of the adoption of cloud computing [Yogesh and Navonil, 2010], as well as the benefits of adoption, such as enhanced competitive advantages [Truong, 2010].

C: Conceptualising Cloud Computing: This category contains articles that provide a general view of cloud computing practice and research, with an aim to provide a general understanding of this area rather than to focus on any specific facet of it. These articles can be further classified into two subcategories.

1. Foundational/Introductions: This subcategory contains articles that introduce foundational concepts and components of cloud computing. Such introductory articles provide definitions and outline key features of cloud computing [Armbrust, Fox, Griffith, Joseph, Katz, Konwinski, et al., 2010; Katzan, 2010b; Mell and Grance, 2010; Vouk, 2008], reflect the timeline of cloud computing [Pallis, 2010], analyse the related benefits and obstacles, strengths and weaknesses of cloud computing and suggest future research directions [Armbrust, et al., 2010; Marston, Li, Bandyopadhyay, Zhang, and Ghalsasi, 2011]. To further articulate the essence of the cloud computing paradigm, some articles make comparisons between cloud computing and other concepts such as grid computing [Buyya et al., 2009; Shiers, 2009; Weinhardt, Anandasivam, Blau, and Stosser, 2009], cluster computing [Buyya, et al., 2009], virtual computing [Cervone, 2010], and even electricity [Brynjolfsson, Hofmann, and Jordan, 2010]. Comparisons are also made between public cloud and private cloud [Grossman, 2009], as well as across public cloud providers, such as Amazon, Microsoft, and Google [Buyya, et al., 2009].

2. Predictions: This subcategory contains articles focusing on forecasting the future of cloud computing and suggesting potential implications. Some project the technical and managerial effects of cloud computing on network and software vendors [Cusumano, 2010], as well as on HPC (High Performance Computing) systems [Sterling and Stark, 2009], while others speculate the economic prospects of cloud computing for developing nations [Greengard and Kshetri, 2010; Kshetri, 2010].

D: Domains and Applications: This category consists of articles which discuss the impact of cloud computing on particular domains or applications. They are further classified into six subcategories.

1. e-Science: This subcategory targets the implications of cloud computing for the e-Science community, which has long been yearning for infinite computing power. e-Science refers to the scientific disciplines (i.e. earth science, bio-informatics, particle physics, etc.) where rapidly increasing volumes of data gathered from sensors and instruments (i.e. the CREN Large Hadron Collider) need to be processed in a timely manner. Cloud computing, with its tremendous computing power and inexpensive cost, has drawn considerable attention from the e-Science community which has traditionally relied on scientific and academic computing grids. Articles in this subcategory aim at understanding the impact of cloud computing on the current computing infrastructure of e-Science [Armando, 2011]. Some look into specific processing of genomic and proteomic data [May, 2010], while others propose generic solutions for managing scientific workflow in the cloud [Yuan, Yang, Liu, and Chen, 2010; Yuan et al., 2011].

2. e-Government: This subcategory discusses the potential of cloud computing for governments. Governments are more hesitant than businesses to adopt cloud computing services. One of the reasons for this is the associated risks and security concerns [Paquette, Jaeger, and Wilson, 2010]. However, utilising cloud computing for electronic voting solutions has been argued to be beneficial and feasible [Zissis and Lekkas, 2011].

3. Education: This subcategory focuses on the impact of cloud computing on educational institutes, especially those in the higher education sector. Operating and maintaining IT infrastructure has cost universities enormous amounts of money; hence, some argue that by adopting cloud-based solutions, such money could be saved and used in places more meaningful to the students and teachers [Ercan, 2010]. Articles in this category discuss how a variety of educational areas can benefit from cloud computing, such as those for e-learning [Doelitzscher, Sulistio, Reich, Kuijs, and Wolf, 2011], online library resources [Jordan, 2011; Robert, 2009], and online collaborative writing [Calvo, O'Rourke, Jones, Yacef, and Reimann, 2011]. Some articles analyse more generic issues such as the influence of cloud computing on the job roles of IT staff in higher education [Currie, 2008] and the inevitable adoption of cloud computing driven by NetGens 2.0 students who are born digital natives and rely on cloud-based applications for their life and study [Brown, 2009].

4. Mobile Computing: This subcategory contemplates the potential of combining cloud computing and mobile technologies [Zhang, Kunjithapatham, Jeong, and Gibbs, 2011]. Articles in this category have fairly specific focuses, such as implementing a health-monitoring system based on a combination of cloud infrastructure, mobile phones, and sensors [Pandey, Voorsluys, Niu, Khandoker, and Buyya, 2011] or proposing a 'virtualised screen' which is rendered in the cloud and presented on the mobile phone for enabling graphically

rich services on thin clients [Lu, Li, and Shen, 2011], as well as arguing that migrating computing and storage capability to the cloud not only enhances the power of mobile systems but also extends the battery lifetimes of such systems [Kumar and Lu, 2010].

5. Open Source: This subcategory looks into merging the two paradigms—cloud computing and open source—to build open clouds. The key theme is the proposal that to ensure that the Internet becomes an interoperable 'network of networks', cloud platforms should be built on open standards, open interface, and open source software [Nelson, 2009]. In addition, some emerging open cloud platforms are introduced, such as Open Nebula [Milojicic, Llorente, and Montero, 2011] and Open Cirrus [Avetisyan, Campbell, Gupta, Heath, Ko, Granger, et al., 2010].

6. Other Domains: This subcategory contains articles which each represent a stand-alone topic relevant to the application of cloud computing. Topics include using cloud computing for improving analysing and reasoning capabilities of semantic search engines [Mika and Tummarello, 2008] for reducing the implementation cost of RFID solutions [Owunwanne and Goel, 2010], for building smaller, cheaper, and smarter robots [Guizzo, 2011], and for developing intelligent urban transportation systems [Li, Chen, and Wang, 2011].

This review takes a descriptive approach. We provide an overview of the current developments in cloud computing research by conducting a systematic literature classification using the classification scheme presented above. The results of the classification are presented next.

IV. RESULTS AND ANALYSIS

A total of 205 articles were classified according to our scheme. We also analysed the articles by year of publication, research methods, primary contribution, and the publication outlets.

Distribution of the Articles by Year

No articles related to 'cloud computing' were published before 2007 because no studies exist under this name. As previously mentioned, the term 'cloud computing' was coined by industry practitioners in 2006. Academic researchers started to engage with this trend in late 2007, but journal publications were sporadic until 2008.
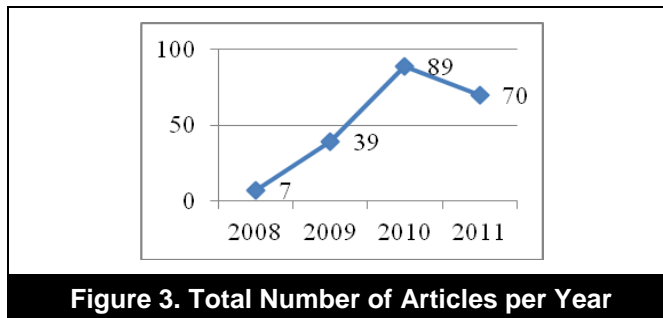

Figure 3. Total Number of Articles per Year

As shown in Figure 3, from 2008 to 2010 the number of peer-reviewed journal articles has increased substantially. Considering the 2011 figure represents only half a year, we can predict the total number for that year will easily exceed that of 2010. This explosive growth of journal publications reflects academia's increasing acceptance of cloud computing as a salient and legitimate research area.

Distributions of Articles by Topics

'Technological Issues' clearly stands out as the most heavily published research category (eighty-eight articles, 43 percent), followed by 'Conceptualising Cloud Computing' (forty-eight articles, 23 percent), and 'Domains and Applications' (forty-one articles, 20 percent), while the least published category was 'Business Issues' (twenty-eight articles, 14 percent). Technical issues are important, and there are still many technological obstacles for the growth of cloud computing, such as data security, data integrity, energy efficiency, and performance predictability [Armbrust et al., 2010; Berl et al., 2010]. However the small number of papers regarding business issues indicates a lack of business perspective in cloud computing research. This may be because the value and implications of cloud computing are still under-recognised in business disciplines.

Table 3 lists the number of articles for each subcategory under technological issues. Clearly, 'Cloud Performance' (thirty articles, 34 percent) and 'Security' (twenty-nine articles, 33 percent) are two major issues in cloud computing research. This is unsurprising. Performance improvement has always been an important reason for users to adopt cloud computing, whereas the security concern has long been a most cited reason for users to object to cloud

computing [Armbrust et al., 2010]. Therefore, the measurement, assessment, and improvement of the cloud performance are of great interest to the researchers. Similarly, mechanisms, algorithms, and architectures for strengthening security are also popular. 'Data Management' (ten articles, 11 percent) seems to be more popular than 'Software Development' (eight articles, 9 percent), this might be due to the fact that all cloud computing consumers need to store data in the cloud in whatever form, but only some of them will develop and deploy applications over there. 'Service Management' (four articles, 5 percent) is currently the least researched topic in this area, but is expected to grow, along with the increasing popularity of research in 'service science' and 'service orientation'.

Table 3: Number of 'Technological Issues' Articles	
Technological Issues	Number of articles
Cloud Performance	30 (34%)
Security	29 (33%)
Data Management	10 (11%)
Software Development	8 (9%)
Data Centre Management	7 (8%)
Service Management	4 (5%)
Total	88 (100%)
Note: The percentage figures are rounded.	

Table 4 shows the number of articles in topics related to business issues. Topics in this category are treated more evenly than those in the 'Technological Issues' category. 'Adoption' (six articles, 21 percent) is the most discussed topic according to our classification. Cloud computing is not a panacea and not suitable for every organisation. Hence, evaluating and assessing the suitability of adopting cloud computing has attracted interest. 'Privacy' and 'Legal Issues' (each five articles, 18 percent) are both ranked in second place. These two have become major risks perceived by businesses when migrating to the cloud, hence, they are often analysed from the cloud consumer's perspective [Svantesson and Clarke, 2010]. 'Cost' and 'Trust' (each four articles, 14 percent) are jointly ranked third. Cost-saving may be the strongest incentive for many organisations to look into cloud computing. This echoes the trend that most organisations have refocused on cost efficiency with regard to IT investment under the current economic downturn. Evaluating and quantifying explicit and implicit costs of cloud computing services is very pertinent for those organisations which are planning to adopt cloud computing with a view to cost-saving. Trust-building in cloud computing has recently gained traction due to organisations' resistance and doubts regarding the rapidly increasing range of cloud providers. Hence studies in this direction often take a cloud provider's standpoint and look for effective approaches to establish consumers' trust towards cloud services. 'Pricing' and 'Ethical Issues' (each two articles, 7 percent) are the least researched, but both are emerging topics in cloud computing research and may gain more attention in the future.

Table 4: Number of 'Business Issues' Articles	
Business Issues	Number of articles
Adoption	6 (21%)
Privacy	5 (18%)
Legal Issues	5 (18%)
Cost	4 (14%)
Trust	4 (14%)
Pricing	2 (7%)
Ethical Issues	2 (7%)
Total	28 (100%)
Note: The percentage figures are rounded.	

Table 5 shows the number of articles in the 'Conceptualising Cloud Computing' category. It is unsurprising to see that thirty-six articles, the biggest group across all categories, are in the 'Foundational/Introductions' subcategory. These articles provide general introductions of foundational concepts and overviews of cloud computing. After all, cloud computing is still a fresh paradigm which needs more time to be well-conceptualised. Articles in the 'Predictions' subcategory account for only one third of all articles in this area.

Table 6 shows the number of articles classified as 'Domains and Applications'. Almost half the articles in this category are concerned with 'Education' (twenty articles, 49 percent), especially higher education. This indicates that the potential of cloud computing has been consciously envisaged and analysed by educators, and the future may see more universities collaborating with cloud providers. It is a bit surprising to see 'e-Science' (six articles, 15

Table 5: Number of 'Conceptualising Cloud Computing' Articles	
Conceptualising Cloud Computing	Number of articles
Foundational/Introductions	36 (75%)
Predictions	12 (25%)
Total	48 (100%)
Note: The percentage figures are rounded.	

percent) lagging behind higher education. Given the hunger for computing power in e-Science communities, one could expect them to show more enthusiasm towards cloud computing. Though 'Mobile Computing' (five articles, 12 percent) is in third place in this classification, this topic is becoming increasingly popular and the combined future of mobile devices and cloud infrastructures is not to be underestimated. 'Open Source' (four articles, 10 percent) is also an area worth watching. Open source communities are pushing cloud computing towards open standards. Currently, this is merely a proposal but later it may provoke a shift in the industry. That 'e-Government' (two articles, 5 percent) comes last represents the conservative attitude of most governments towards cloud computing.

Table 6: Number of 'Domains and Applications' Articles	
Applications	Number of articles
Education	20 (49%)
e-Science	6 (15%)
Mobile Computing	5 (12%)
Open Source	4 (10%)
e-Government	2 (5%)
Other	4 (10%)
Total	41 (100%)
Note: The percentage figures are rounded.	

Publication Outlets

The publication outlets of the articles were also analysed. The majority of the articles (144 articles, 70 percent) come from twenty journals (as shown in Table 7). Clearly cloud computing-related articles have not appeared yet in most of the top, theory-oriented IS journals such as MISQ, ISR, and EJIS. This is understandable as cloud computing research is still an immature area requiring better conceptualisation. It is not clear yet to what extent the new and changed affordances emerging from cloud computing technologies require theory-building and new theoretical explanations. Table 7 is a helpful resource for researchers wanting to publish cloud computing studies or for anyone looking for good quality cloud-computing references.

Table 7: Distribution of Articles by Journals (Top 20)	
Journal	No. publications
Future Generation Computer Systems	16
IEEE Security & Privacy	15
Communications of the ACM	14
IEEE Internet Computing	14
Computer	13
IT Professional	13
EDUCAUSE Review	9
Journal of Network and Computer Applications	7
Journal of Parallel and Distributed Computing	7
Procedia Computer Science	7
IEEE Spectrum	5
Computing. Archives for Informatics and Numerical Computation	4
Parallel and Distributed Systems, IEEE Transactions on	4
Journal of Systems and Software	3
Computer Law & Security Review	3
International Journal of Management and Information Systems	2
International Journal of Information Management	2
Computing in Science & Engineering	2
Expert Systems with Applications	2
Journal of Enterprise Information Management	2
Total	144

V. DISCUSSION

The intention of this article is to illustrate a landscape of current academic research from an IS standpoint. We have presented a descriptive review, classifying the literature of extant cloud computing research in a range of categories. The results presented in this article have suggested useful insights to both business and academic researchers.

First, even though our literature analysis has revealed that technology-focused articles outnumbered business-focused ones, in our view, these articles do not meet the challenge made by Robey and Markus [1998] more than ten years ago to produce more consumable research. Adoption of cloud computing is a major concern in our practitioner community, and in our view there is an urgent demand for articles explaining cloud computing technologies in business-friendly language. Existing articles in the 'Technological Issues' category focus mostly on specific technical details which are often addressed from cloud computing technical specialists' standpoint. These articles may be informative but do not offer much practical or applicable knowledge to business professionals who are on the user side of cloud computing. Business users may find it extremely difficult to read these articles, digest the knowledge, and envisage the implications to business strategies and practices, even when the topics of the articles (e.g. cloud performance, security, data management) are highly relevant to business interests. Second, there is an obvious need for more research in the 'Business Issues' category from both cloud providers' perspective and cloud consumers' perspective. Existing articles in this category tend to take a 'black-box' approach when studying cloud computing and fail to make nuanced distinctions between different service layers and deployment models of cloud computing. The three service layers (SaaS, PaaS, and IaaS) identified by the NIST all have distinct business implications. For instance, adopting PaaS can facilitate the processes of IS development (ISD) by enabling developers to collaborate globally, testing and releasing their products more quickly, and avoiding much non-productive system administration work [Lawton, 2008a]. However, it will not necessarily assist with the changes in application and database that require the intervention of IT professionals. The IT management implications of deploying PaaS may affect aspects of system testing and implementation phases, but have little impact on the design and development phases. Further research should acknowledge the differences across the three service layers and explore the implications for businesses in a more nuanced manner.

Third, 'adoption' has become a fundamental theme among the business oriented articles. All the other subtopics (e.g. trust, cost, privacy) under the 'Business Issues' category contribute in varying degrees to the decision making process for adopting cloud services. However, there are many other research opportunities beyond 'adoption' for IS scholars interested in cloud computing. Given that cloud computing potentially represents a 'paradigm shift' in IT delivery methods, many traditional IT management issues with high practical relevance deserve rigorous academic re-examination in the cloud-computing context. These questions could include: How does cloud computing impact current practices of IT management and governance? Does cloud computing improve IT business alignment and IT agility? What are the critical factors of a successful business model with cloud computing? Mainstream IS journals could encourage discussions and investigations in these areas.

Finally, our review indicates that theory-building is still not at the centre of cloud computing research. Instead, most studies focus on praxis. This is consistent with the trend in other nascent research areas, such as mobile business [Scornavacca, Barnes, and Huff, 2006]. The lack of solid theoretical foundations has long been a concern for IS academics. This is because of a traditional view that the academic legitimacy of a research field hinges on the presence or absence of core theories. However, Lyytinen and King have recently argued that to increase the legitimacy of an 'applied research' field like IS, relevance to praxis can and should be placed at the centre [Lyytinen and King, 2004]. Salience and strong results should be major determinants of the academic legitimacy of the IS research field. Cloud computing clearly has salience. Producing strong research results related to praxis may be a natural way to strengthen the legitimacy of this research area.

It would be interesting to explore whether there is a 'research cycle' associated with the emergence and widespread commercialisation of new technology affordances and innovations, and whether research in cloud computing is following a similar pattern to that of other major technology innovations. As we discussed, new technologies need to be robust before they can be widely adopted for mission-critical applications. Early business applications are frequently experimental, and disruptive changes in business models are not always apparent as they are occurring, but only with the benefit of hindsight, once they have stabilised. It is difficult to predict whether the widespread availability of computing 'on demand' will significantly alter the patterns of adoption and diffusion of new computing innovations and result in new business models. However, the research community should be ready to critically examine these issues, not merely to report and explain their occurrence after the event.

In general we expect an exponential growth in the amount of cloud computing research in the near future. According to our review, the number of research articles has been increasing dramatically every year since 2008. In the first five months of 2011, this number has already approached that of the whole of 2010. As the economic downturn is fuelling interest in cloud computing, there is no doubt that more researchers will engage with this topic. Though the

classification framework provided in this article helps to structure the process, conducting a similar literature analysis will be increasingly challenging due to the sheer volume of articles being published. However, we see it as a positive trend for IS researchers that a wide variety of publication outlets have started accepting research on cloud computing. We are expecting to see more cloud computing articles published in leading IS journals.

The global recession is forcing the IT functions of organisations to focus on cost saving and resource efficiency, which are promised as major benefits of cloud computing. We suggest that IS researchers could consider the following questions: Should an enterprise adopt cloud computing and when? This could be investigated from the point of view of IS strategy and organisational diffusion of innovation. If yes, what aspects should be considered when choosing a cloud provider? What criteria can be used to make a comparison across the different cloud services? This might be informed by insights from IT outsourcing literature. Will cloud computing help to mitigate the IS management problems typically experienced by small- and medium-sized enterprises (SMEs)? Do the affordances of cloud computing help achieve increased IT agility in large organisations? These questions are interesting and highly salient. Cloud computing has displayed huge potential for IS researchers to produce 'consumable research' [Robey and Markus, 1998]. By investigating these questions, IS researchers may be able to help the decision making of enterprises regarding cloud computing adoption and innovation.

VI. LIMITATIONS

This article has a number of limitations. First, our sample was mainly based on academic publications. As cloud computing is industry-driven in nature, many quality professional articles may also embrace this phenomenon. This may hinder the ability of the present article to present a complete picture of the current developments in this domain. Second, the articles included are all refereed journal articles. Therefore, the classification scheme might not reflect the topic distribution of conference papers related to cloud computing. Third, our search criteria might be incomplete, as some papers discussing cloud computing that do not have the term 'cloud computing' in the abstract or keyword list may not have been included.

VII. CONCLUSION

Practitioner and academic interest in the evolving phenomenon of cloud computing is intense. Although this review cannot claim to be exhaustive, it provides insights into the current state of cloud computing research. Our classification and descriptive review can provide a useful quality reference source for academics and practitioners with an interest in cloud computing, and suggestions for future lines of research that will have strong salience to our practitioner community. Also, this study contributes to our understanding of how research into the business applications of new technologies develops.

ACKNOWLEDGMENTS

REFERENCES

Editor's Note: The following reference list contains hyperlinks to World Wide Web pages. Readers who have the ability to access the Web directly from their word processor or are reading the article on the Web, can gain direct access to these linked references. Readers are warned, however, that:
1. These links existed as of the date of publication but are not guaranteed to be working thereafter.
2. The contents of Web pages may change over time. Where version information is provided in the References, different versions may not contain the information or the conclusions referenced.
3. The author(s) of the Web pages, not AIS, is (are) responsible for the accuracy of their content.
4. The author(s) of this article, not AIS, is (are) responsible for the accuracy of the URL and version information.

Alonso–Calvo, R., J. Crespo, M. Garc'ia–Remesal, A. Anguita, and V. Maojo (2010) "On Distributing Load in Cloud Computing: A Real Application for Very-large Image Datasets", *Procedia Computer Science* (1)1, pp. 2669–2677, doi: 10.1016/j.procs.2010.04.300.

American_Society_for_Quality (2006) "Idea Creation Tools—Affinity Diagrams," http://asq.org/learn-about-quality/idea-creation-tools/overview/affinity.html (current June 20, 2011).

Anthes, G. (2010) "Security in the Cloud," *Communications of the ACM* (53)11, p. 16.

Armando, F. (2011) "Cloud Computing—What's in It for Me as a Scientist?" *Science* (331)6016, p. 406.

Armbrust, M., A. Fox, R., Griffith, A.D., Joseph, R. Katz, A. Konwinski, et al. (2009) "Above the Clouds: A Berkeley View of Cloud Computing," www.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-28.pdf (current Jan. 20, 2010).

Armbrust, M., A. Fox, R., Griffith, A.D., Joseph, R.,Katz, A.,Konwinski, et al. (2010) "A View of Cloud Computing," *Communications of the ACM* (53)4, pp. 50–58.

Aslam, U., I. Ullah, and S. Ansari (2010) "Open Source Private Cloud Computing," *Interdisciplinary Journal of Contemporary Research In Business* (2)7, p. 399.

Avetisyan, A.I., R. Campbell, I. Gupta, M.T. Heath, S.Y. Ko, G.R. Ganger, et al. (2010) "Open Cirrus: A Global Cloud Computing Testbed," *Computer* (43)4, pp. 35–43.

Banerjee, P., R. Friedrich, C. Bash, P. Goldsack, B.A. Huberman, J. Manley, et al. (2011) "Everything as a Service: Powering the New Information Economy," *Computer* (44)3, pp. 36–43.

Barki, H., S. Rivard, and J. Talbot (1993) "A Keyword Classification Scheme for IS Research Literature: An Update," *MIS Quarterly,* June, pp. 209–225.

Barnhill, D.S. (2010) "Cloud Computing and Stored Communications: Another Look at Quon v. Arch Wireless," (Privacy Law) (Annual Review of Law and Technology), *Berkeley Technology Law Journal* (25), pp. 621–648.

Bellovin, S.M. (2011) "Clouds from Both Sides, *IEEE Security & Privacy* (9)3, pp. 88–88.

Beloglazov, A., J. Abawajy, and R. Buyya (2011) "Energy-aware Resource Allocation Heuristics for Efficient Management of Data Centers for Cloud Computing", *Future Generation Computer Systems* (28)5*,* pp. 755-768, doi: 10.1016/j.future.2011.04.017.

Berl, A., E. Gelenbe, M. di Girolamo, G. Giuliani, H. de Meer, M. Dang, et al. (2010) "Energy-Efficient Cloud Computing," *The Computer Journal* (53)7, p. 1045.

Blumenthal, M.S. (2010) "Hide and Seek in the Cloud," *IEEE Security & Privacy* (8)2, pp. 57–58.

Böhm, A., and C.–C. Kanne (2011) "Demaq/Transscale: Automated Distribution and Scalability for Declarative Applications", *Information Systems* (36)3, pp. 565–578, doi: 10.1016/j.is.2010.07.007.

Borenstein, N., and J. Blake (2011) "Cloud Computing Standards: Where's the Beef?" *IEEE Internet Computing* (15)3, p. 74.

Breiter, G., and M. Behrendt (2009) "Life Cycle and Characteristics of Services in the World of Cloud Computing," *IBM Journal of Research and Development* (53)4, pp. 3:1–3:8.

Bret, M. (2009) "In Clouds Shall We Trust?" *IEEE Security & Privacy* (7)5, pp. 3–3.

Bristow, R., T. Dodds, R. Northam, and L. Plugge (2010) "Cloud Computing and the Power to Choose," *EDUCAUSE Review* (45)3, p. 14.

Brown, M. (2009) "The NetGens 2.0: Clouds on the Horizon," *EDUCAUSE Review* (44)1, p. 66.

Brynjolfsson, E., P. Hofmann, and J. Jordan (2010) "Economic and Business Dimensions Cloud Computing and Electricity: Beyond the Utility Model," *Communications of the ACM* (53)5, p. 32.

Bungo, J. (2011) "Embedded Systems Programming in the Cloud: A Novel Approach for Academia," *IEEE Potentials* (30)1, pp. 17–23.

Buyya, R., C.S. Yeo, S. Venugopal, J. Broberg, and I. Brandic (2009) "Cloud Computing and Emerging IT Platforms: Vision, Hype, and Reality for Delivering Computing as the 5th Utility," *Future Generation Computer Systems* (25)6, pp. 599–616.

Byun, E.–K., Y.–S. Kee, J.–S. Kim, and S. Maeng, S. (2011) "Cost Optimized Provisioning of Elastic Resources for Application Workflows", *Future Generation Computer Systems (27)8,* pp. 1011-1026, doi: 10.1016/j.future.2011.05.001.

Calero, J.M.A., N. Edwards, J. Kirschnick, L. Wilcock, and M. Wray (2010) "Toward a Multi-Tenancy Authorization System for Cloud Services," *IEEE Security & Privacy* (8)6, pp. 48–55.

Calvo, R.A., S. T., O'Rourke, J. Jones, K. Yacef, and P. Reimann (2011) "Collaborative Writing Support Tools on the Cloud," *Learning Technologies, IEEE Transactions* (4)1, pp. 88–97.

Campbell–Kelly, M. (2009) "The Rise, Fall, and Resurrection of Software as a Service," *Communications of the ACM* (52)5, p. 28.

Cervone, H.F. (2010) "An Overview of Virtual and Cloud Computing," *OCLC Systems and Services* (26)3, p. 162.

Chakraborty, R., S. Ramireddy, T. Raghu, and H. Rao (2010) "The Information Assurance Practices of Cloud Computing Vendors," *IT Professional* (12)4, p. 29.

Chen, G., Y. Wu, J. Liu, G. Yang, and W. Zheng (2011) "Optimization of Sub-query Processing in Distributed Data Integration Systems," *Journal of Network and Computer Applications* (34)4, pp. 1035–1042, doi: 10.1016/j.jnca.2010.06.007.

Chiu, Y. (2010) "Taiwan Sees Clouds in Its Forecast," *IEEE Spectrum* (47)8, p. 13.

Chonka, A., Y. Xiang, W. Zhou, and A. Bonti (2011) "Cloud Security Defence to Protect Cloud Computing Against HTTP-DoS and XML-DoS Attacks," *Journal of Network and Computer Applications* (34)4, pp. 1097–1107 doi: 10.1016/j.jnca.2010.06.004.

Cooper, B. (2010) "The Prickly Side of Building Clouds," *IEEE Internet Computing* (14)6, pp. 64–67.

Crai–Wood, K. (2010) "Definition of Cloud Computing, Incorporating NIST and G-Cloud Views," http://www.katescomment.com/definition-of-cloud-computing-nist-g-cloud/ (current Apr. 23, 2010).

Currie, C. (2008) "Painting the Clouds," *EDUCAUSE Review* (43)6, p. 28.

Cusumano, M. (2010) "Technology Strategy and Management: Cloud Computing and SaaS as New Computing Platforms," *Communications of the ACM* (53)4, pp. 27–29.

Deelman, E. (2010) "Grids and Clouds: Making Workflow Applications Work in Heterogeneous Distributed Environments," *The International Journal of High Performance Computing Applications* (24)3, p. 284.

Deng, Y., and B. Pung (2011) "Conserving Disk Energy in Virtual Machine Based Environments by Amplifying Bursts," *Computing. Archives for Informatics and Numerical Computation* (91)1, p. 3.

Deniz Helvacioglu Kuyucu, A. (2011) "The Playground of Cloud Computing in Turkey," *Procedia Computer Science* (3), pp. 459–463, doi: 10.1016/j.procs.2010.12.077.

Diffin, J., F. Chirombo, and D. Nangle (2010) "Cloud collaboration: Using Microsoft Sharepoint as a Tool to Enhance Access Services," Author abstract (Report), *Journal of Library Administration* (50), pp. 570(511).

Doelitzscher, F., A. Sulistio, C. Reich, H. Kuijs, and D. Wolf (2011) "Private Cloud for Collaboration and e-Learning Services: From IaaS to SaaS," *Computing. Archives for Informatics and Numerical Computation* (91)1, p. 23.

Dougherty, B., J. White, and D.C. Schmidt (2011) "Model-driven Auto-scaling of Green Cloud Computing Infrastructure," *Future Generation Computer Systems* (28)2, pp. 371-378, doi: 10.1016/j.future.2011.05.009.

Douglis, F. (2009) "Staring at Clouds," *IEEE Internet Computing* (13)3, p. 4.

Durkee, D. (2010) "Why Cloud Computing Will Never Be Free," *Communications of the ACM* (53)5, p. 62.

Dyba, T., and T. Dingsoyr (2008) "Empirical Studies of Agile Software Development: A Systematic Review," *Information and Software Technology* (50), pp. 833–859.

Ercan, T. (2010) "Effective Use of Cloud Computing in Educational Institutions" [doi: 10.1016/j.sbspro.2010.03.130], *Procedia—Social and Behavioral Sciences* (2)2, pp. 938–942.

Erdogmus, H. (2009) "Cloud Computing: Does Nirvana Hide Behind the Nebula?" *IEEE Software* (26)2, pp. 4–6.

Foster, I., Z. Yong, I. Raicu, and S. Lu (2008) "Cloud Computing and Grid Computing 360-Degree Compared," Paper presented at the Grid Computing Environments Workshop, 2008, GCE '08. Austin, TX.

Garg, S.K., C.S. Yeo, A. Anandasivam, and R. Buyya (2011) "Environment-conscious Scheduling of HPC Applications on Distributed Cloud-oriented Data Centers," *Journal of Parallel and Distributed Computing* (71)6, pp. 732–749, doi: 10.1016/j.jpdc.2010.04.004.

Geer, D. (2009) "The OS Faces a Brave New World," *Computer* (42)10, pp. 15–17.

Gentry, C. (2010) "Computing Arbitrary Functions of Encrypted Data," *Communications of the ACM* (53)3, p. 97.

Glaser, B., and A. Strauss (1967) "The Discovery of Grounded Theory: Strategies for Qualitative Research," Chicago, IL: Aldine Publishing Company.

Gold, S. (2009) "Artificial Reality," *Infosecurity* (6)3, pp. 38–41, doi: 10.1016/S1754-4548(09)70062-2.

Golden, B. (2009) "Cloud Computing: 'Be Prepared,'" *EDUCAUSE Review* (44)4, p. 64.

Goscinski, A., and M. Brock (2010) "Toward Dynamic and Attribute Based Publication, Discovery and Selection for Cloud Computing," *Future Generation Computer Systems* (26)7, pp. 947–970, doi: 10.1016/j.future.2010.03.009.

Greengard, S., and N. Kshetri (2010) "Cloud Computing and Developing Nations," *Communications of the ACM* (53)5, p. 18.

Grobauer, B., T. Walloschek, and E. Stocker (2011) "Understanding Cloud Computing Vulnerabilities," *IEEE Security & Privacy* (9)2, pp. 50–57.

Grossman, R.L. (2009) "The Case for Cloud Computing," *IT Professional* (11)2, p. 23.

Grossman, R.L., Y. Gu, M. Sabala, and W. Zhang (2009) "Compute and Storage Clouds Using Wide Area High Performance Networks," *Future Generation Computer Systems* (25)2, pp. 179–183.

Guizzo, E. (2011) "Robots with Their Heads in the Clouds," *IEEE Spectrum* (48)3, pp. 16–18.

Guzzo, R.A., S.E. Jackson, and R.A. Katzell (1987) "Meta-analysis Analysis," *Research in Organizational Behavior* (9), pp. 407–442.

Han, Y. (2010) "On the Clouds: A New Way of Computing," *Information Technology and Libraries* (29)2, p. 87.

Hayes, B. (2008) "Cloud Computing," *Communications of the ACM* (9)3, p. 51.

Hewitt, C. (2008) "ORGs for Scalable, Robust, Privacy-friendly Client Cloud Computing," *IEEE Internet Computing* (12)5, p. 96.

Hofmann, P., and D. Woods (2010) "Cloud Computing: The Limits of Public Clouds for Business Applications," *IEEE Internet Computing* (14)6, p. 90.

Huff, S.L., M.C. Munro, and B.H.Martin,(1988) "Growth Stages of End User Computing," *Communications of the ACM* (31)5, pp. 542–550.

Hwang, K., and D. Li (2010) "Trusted Cloud Computing with Secure Resources and Data Coloring," *IEEE Internet Computing* (14)5, p. 14.

Hwang, M.I., and R.G. Thorn (1999) "The Effect of User Engagement on System Success: A Meta-analytical Integration of Research Findings," *Information & Management* (35), pp. 229–236.

Iosup, A., V. Nae, and R. Prodan (2010) "The Impact of Virtualisation on the Performance and Operational Costs of Massively Multiplayer Online Games," *International Journal of Advanced Media and Communication* (4), Author abstract, p. 364.

Iosup, A., S. Ostermann, M.N. Yigitbasi, R. Prodan, T. Fahringer, and D.H.J. Epema (2011) "Performance Analysis of Cloud Computing Services for Many-tasks Scientific Computing," *Parallel and Distributed Systems, IEEE Transactions* (22)6, pp. 931–945.

Iqbal, W., M.N. Dailey, D. Carrera, and P. Janecek (2011) "Adaptive Resource Provisioning for Read Intensive Multi-tier Applications in the Cloud," *Future Generation Computer Systems* (27)6, pp. 871–879, doi: 10.1016/j.future.2010.10.016.

Ivanova, M., and G. Ivanov (2010) "Cloud Computing for Authoring Process Automation," *Procedia—Social and Behavioral Sciences* (2)2, pp. 3646–3651, doi: 10.1016/j.sbspro.2010.03.567.

Jaeger, T., and J. Schiffman (2010) "Outlook: Cloudy with a Chance of Security Challenges and Improvements," *IEEE Security & Privacy* (8)1, pp. 77–80.

Jann, J., N. Dubey, R.S. Burugula, and P. Pattnaik (2010) "AHAFS Subsystem for Enhancing Operating System Health in the Cloud Computing Era," *IBM Journal of Research and Development* (54)5, pp. 6:1–6:11.

Jiang, G. (2010) "Rain or Shine: Fair and Other Non-infringing Uses in the Context of Cloud Computing," *Journal of Legislation* (36), pp. 395–422.

Johnson, J.L. (2009) "SQL in the Clouds," *Computing in Science & Engineering* (11)4, pp. 12–28.

Joint, A., E. Baker, and E. Eccles (2009) "Hey, You, Get Off of That Cloud?", *Computer Law & Security Review* (25)3, pp. 270–274, doi: 10.1016/j.clsr.2009.03.001.

Jordan, J. (2011) "Climbing Out of the Box and into the Cloud: Building Web-scale for Libraries," Author abstract (Report), *Journal of Library Administration* (51), pp. 3(15).

Katz, R. (2009) "Tech Titans Building Boom," *IEEE Spectrum* (46)2, p. 40.

Katzan Jr., H. (2010a) "The Education Value of Cloud Computing," *Contemporary Issues in Education Research*, (3)7, p. 37.

Katzan Jr., H. (2010b) "On an Ontological View of Cloud Computing," *Journal of Service Science* (3), p. 1.

Katzan Jr., H. (2010c) "On the Privacy of Cloud Computing," *International Journal of Management and Information Systems* (14)2, p. 1.

Katzan Jr., H., and W. Dowling (2010) "Software-as-a-Service Economics," *The Review of Business Information Systems* (14), p. 27.

Kaufman, L.M. (2009) "Data Security in the World of Cloud Computing," *IEEE Security & Privacy* (7)4, pp. 61–64.

Kaufman, L.M. (2010a) "Can a Trusted Environment Provide Security?" *IEEE Security & Privacy* (8)1, pp. 50–52.

Kaufman, L.M. (2010b) "Can Public-Cloud Security Meet Its Unique Challenges?" *IEEE Security & Privacy* (8)4, pp. 55–57.

Keahey, K., M. Tsugawa, A. Matsunaga, and J. Fortes (2009) "Sky Computing," *IEEE Internet Computing* (13)5, p. 43.

Kecskemeti, G., G. Terstyanszky, P. Kacsuk, and Z. Neméth (2011) "An Approach for Virtual Appliance Distribution for Service Deployment," *Future Generation Computer Systems* (27)3, pp. 280–289, doi: 10.1016/j.future.2010.09.009.

Khan, K., and Q. Malluhi (2010) "Establishing Trust in Cloud Computing," *IT Professional* (12)5, p. 20.

Kim, H., H. Lim, J. Jeong, H. Jo, J. Lee, and S. Maeng (2011) "Transparently Bridging Semantic Gap in CPU Management for Virtualized Environments," *Journal of Parallel and Distributed Computing* (71)6, pp. 758–773, doi: 10.1016/j.jpdc.2010.11.005.

Kim, P., C. Ng, and G. Lim (2010) "When Cloud Computing Meets with Semantic Web: A New Design for e-Portfolio Systems in the Social Media Era," *British Journal of Educational Technology* (41)6, p. 1018.

King, J. (2010) "Clearing the Air on Cloud Computing," *EDUCAUSE Review* (45)3, p. 64.

King, W.R., and J. He (2005) "Understanding the Role and Methods of Meta-Analysis in IS Research," *Communications of the Association for Information Systems* (16) Article 32, pp. 665-686.

Kirschnick, J., J.M. Alcaraz Calero, L. Wilcock, and N. Edwards (2010) "Toward an Architecture for the Automated Provisioning of Cloud Services," *Communications Magazine, IEEE* (48)12, pp. 124–131.

Kleinrock, L. (2005) "A Vision of the Internet," *ST Journal of Research* (2)1, pp. 4–5.

Kong, X., C. Lin, Y. Jiang, W. Yan, and X. Chu (2011) "Efficient Dynamic Task Scheduling in Virtualized Data Centers with Fuzzy Prediction," *Journal of Network and Computer Applications* (34)4, pp. 1068–1077, doi: 10.1016/j.jnca.2010.06.001.

Kousiouris, G., T. Cucinotta, and T. Varvarigou (2011) "The Effects of Scheduling, Workload Type and Consolidation Scenarios on Virtual Machine Performance and Their Prediction Through Optimized Artificial Neural Networks," *Journal of Systems and Software* (84)8, pp. 1270-1291, doi: 10.1016/j.jss.2011.04.013.

Kritsonis, T. (2011) "Security Risks in the Cloud—Reality, or a Broken Record?", *Infosecurity* (8)1, pp. 20–23, doi: 10.1016/S1754-4548(11)70005-5.

Kshetri, N. (2010) "Cloud Computing in Developing Economies," *Computer* (43)10, pp. 47–55.

Kumar, K., and Y.–H. Lu (2010) "Cloud Computing for Mobile Users: Can Offloading Computation Save Energy?" *Computer* (43)4, pp. 51–56.

Lackermair, G. (2011) "Hybrid Cloud Architectures for the Online Commerce," *Procedia Computer Science* (3), pp. 550–555, doi: 10.1016/j.procs.2010.12.091.

Lagar-Cavilla, H., J. Whitney, R. Bryant, P. Patchin, M. Brudno, E. de Lara, et al. (2011) "SnowFlock: Virtual Machine Cloning as a First-class Cloud Primitive," *ACM Transactions on Computer Systems* (29)1, p. 1.

Lawton, G. (2008a) "Developing Software Online With Platform-as-a-Service Technology," *Computer* (41)6, pp. 13–15.

Lawton, G. (2008b) "Moving the OS to the Web," *Computer* (41)3, pp. 16–19.

Leavitt, N. (2009) "Is Cloud Computing Really Ready for Prime Time?" *Computer* (42)1, pp. 15–20.

Leiba, B. (2009) "Having One's Head in the Cloud," *IEEE Internet Computing* (13)5, p. 4.

Levy, Y., and T.J. Ellis (2006) "A Systems Approach to Conduct an Effective Literature Review in Support of Information Systems Research," *Informing Science Journal* (9), pp. 181–211.

Li, A., X. Yang, S. Kandula, and M. Zhang (2011) "Comparing Public–Cloud Providers," *IEEE Internet Computing* (15)2, p. 50.

Li, C. (2011) "Cloud Computing System Management Under Flat Rate Pricing," *Journal of Network and Systems Management* (19)3, p. 305.

Li, J., B. Li, T. Wo, C. Hu, J. Huai, L. Liu, et al. (2011) "CyberGuarder: A Virtualization Security Assurance Architecture for Green Cloud Computing," *Future Generation Computer Systems* (28)2, pp. 379-390, doi: 10.1016/j.future.2011.04.012.

Li, Z., C. Chen, and K. Wang (2011) "Cloud Computing for Agent-based Urban Transportation Systems," *IEEE Intelligent Systems* (26)1, p. 73.

Lin, G., D. Fu, J. Zhu, and G. Dasmalchi (2009) "Cloud Computing: IT as a Service," *IT Professional* (11)2, p. 10.

Lin, K.W., and D.–J. Deng (2010) "A Novel Parallel Algorithm for Frequent Pattern Mining with Privacy Preserved in Cloud Computing Environments," Author abstract, *International Journal of Ad Hoc and Ubiquitous Computing* (6), p. 205.

Lin, Y.–K., and P.–C. Chang (2011) "Maintenance Reliability Estimation for a Cloud Computing Network with Nodes Failure," *Expert Systems with Applications* (38)11, pp. 14185-14189, doi: 10.1016/j.eswa.2011.04.230.

Lindner, M.A., L.M. Vaquero, L. Rodero–Merino, and J. Caceres (2010) "Cloud Economics: Dynamic Business Models for Business on Demand," Author abstract, *International Journal of Business Information Systems* (5)*,* p. 373.

Liu, H., and Orban, D. (2008) "GridBatch: Cloud Computing for Large-Scale Data-Intensive Batch Applications," Paper presented at the Cluster Computing and the Grid, 2008, CCGRID '08, 8th IEEE International Symposium, Lyon, France.

Liu, K., H. Jin, J. Chen, X. Liu, D. Yuan, and Y. Yang (2010) "A Compromised-Time-Cost Scheduling Algorithm in SwinDeW-C for Instance-Intensive Cost-Constrained Workflows on a Cloud Computing Platform," *The International Journal of High Performance Computing Applications* (24)4, p. 445.

Liu, Q., C. Weng, M. Li, and Y. Luo (2010) "An In-VM Measuring Framework for Increasing Virtual Machine Security in Clouds," *IEEE Security & Privacy* (8)6, pp. 56–62.

Liu, X., Z. Ni, D. Yuan, Y. Jiang, Z. Wu, J. Chen, et al. (2011) "A Novel Statistical Time-series Pattern Based Interval Forecasting Strategy for Activity Durations in Workflow Systems," *Journal of Systems and Software* (84)3, pp. 354–376, doi: 10.1016/j.jss.2010.11.927.

Liu, X., J. Zhan, K. Zhan, W. Shi, L. Yuan, D. Meng, et al. (2011) "Automatic Performance Debugging of SPMD-style Parallel Programs," *Journal of Parallel and Distributed Computing* (71)7, pp. 925–937, doi: 10.1016/j.jpdc.2011.03.006.

Liu, Y., M. Li, N.K. Alham, and S. Hammoud (2011) "HSim: A MapReduce Simulator in Enabling Cloud Computing," *Future Generation Computer Systems,* in press, corrected proof, doi: 10.1016/j.future.2011.05.007.

Lombardi, F., and R. Di Pietro (2011) "Secure Virtualization for Cloud Computing," *Journal of Network and Computer Applications* (34)4, pp. 1113–1122, doi: 10.1016/j.jnca.2010.06.008.

Louridas, P. (2010) "Up in the Air: Moving Your Applications to the Cloud," *IEEE Software* (27), p. 6.

Lu, Y., S. Li, and H. Shen (2011) "Virtualized Screen: A Third Element for Cloud Mobile Convergence," *IEEE Multimedia* (18)2, pp. 4–11.

Luo, Y. (2010) "Network I/O Virtualization for Cloud Computing," *IT Professional* (12)5, p. 36.

Lyytinen, K., and J.L. King (2004) "Nothing at the Centre? Academic Legitimacy in the Information Systems Field," *Journal of the Association for Information Systems* (5)6, pp. 220–264.

Malawski, M., J. Meizner, M. Bubak, and P. Gepner (2011) "Component Approach to Computational Applications on Clouds," *Procedia Computer Science* (4), pp. 432–441, doi: 10.1016/j.procs.2011.04.045.

Marston, S., Z. Li, S., Bandyopadhyay J. Zhang, and A. Ghalsasi (2011) "Cloud Computing—The Business Perspective," *Decision Support Systems* (51)1, p. 176.

Mattmann, C., D. Crichton, A. Hart, S. Kelly, and S. Hughes (2010) "Experiments with Storage and Preservation of NASA's Planetary Data via the Cloud," *IT Professional* (12)5, p. 28.

May, M. (2010) "Forecast Calls for Clouds over Biological Computing," *Nature Medicine* (16)1, p. 6.

Mell, P., and T. Grance (2009) "The NIST Definition of Cloud Computing," http://csrc.nist.gov/groups/SNS/cloud-computing/index.html (current Aug. 23, 2011).

Mell, P., and T. Grance (2010) "The NIST Definition of Cloud Computing," *Communications of the ACM* (53)6, p. 50.

Mezmaz, M., N.,Melab, Y. Kessaci, Y.C. Lee, E.G. Talbi, A.Y. Zomaya, et al. (2011) "A Parallel Bi-objective Hybrid Metaheuristic for Energy-aware Scheduling for Cloud Computing Systems," *Journal of Parallel and Distributed Computing* (71)11, pp. 1497-1508, doi: 10.1016/j.jpdc.2011.04.007.

Mika, P., and G. Tummarello (2008) "Web Semantics in the Clouds," *IEEE Intelligent Systems* (23)5, pp. 82–87.

Miller, H., and J. Veiga (2009) "Cloud Computing: Will Commodity Services Benefit Users Long Term?" *IT Professional* (11)6, p. 57.

Miller, K. (2010) "Ethical Analysis in the Cloud," *IT Professional* (12)6, p. 7.

Miller, K., and J. Voas (2010) "Ethics and the Cloud," *IT Professional* (12)5, p. 4.

Milojicic, D., I.M. Llorente, and R.S. Montero (2011) "OpenNebula: A Cloud Management Tool," *IEEE Internet Computing* (15)2, pp. 11–14.

Misra, S.C., and A. Mondal (2011) "Identification of a Company's Suitability for the Adoption of Cloud Computing and Modelling Its Corresponding Return on Investment," *Mathematical and Computer Modelling* (53)3–4, pp. 504–521, doi: 10.1016/j.mcm.2010.03.037.

Mitrani, I. (2010) "Management of Server Farms for Performance and Profit," *The Computer Journal* (53)7, p. 1038.

Moreno–Vozmediano, R., R.S. Montero, and I.M. Llorente (2011) "Multicloud Deployment of Computing Clusters for Loosely Coupled MTC Applications," *Parallel and Distributed Systems, IEEE Transactions* (22)6, pp. 924–930.

Murphy, M.A., and S. Goasguen (2010) "Virtual Organization Clusters: Self-provisioned Clouds on the Grid," *Future Generation Computer Systems* (26)8, pp. 1271–1281, doi: 10.1016/j.future.2010.02.011.

Naghshineh, M., R. Ratnaparkhi, D. Dillenberger, J.R. Doran, C. Dorai, L. Anderson, et al. (2009) "IBM Research Division Cloud Computing Initiative," *IBM Journal of Research and Development* (53)4, pp. 1:1–1:10.

Navonil, M. (2010) "Exploiting Grid Computing, Desktop Grids and Cloud Computing for e-Science," *Transforming Government: People, Process and Policy* (4)4, p. 288.

Nelson, M.R. (2009) "Building an Open Cloud," *Science* (324)5935, p. 1656.

Nevin, R. (2009) "Supporting 21st Century Learning Through Google Apps," *Teacher Librarian* (37)2, p. 35.

Ngai, E.W.T., and F.K.T. Wat (2002) "A Literature Review and Classification of Electronic Commerce Research," *Information & Management* (39)5, pp. 415–429, doi: 10.1016/S0378-7206(01)00107-0.

Nicolae, B., G. Antoniu, L. Bougé, D. Moise, and A. Carpen–Amarie (2011) "BlobSeer: Next-generation Data Management for Large Scale Infrastructures," *Journal of Parallel and Distributed Computing* (71)2, pp. 169–184, doi: 10.1016/j.jpdc.2010.08.004.

Nurmi, D., R. Wolski, C. Grzegorczyk, G. Obertelli, S. Soman, L. Youseff, et al. (2009) "The Eucalyptus Open-source Cloud-computing System," Paper presented at the Cluster Computing and the Grid, 2009, CCGRID '09, 9th IEEE/ACM International Symposium, Shanghai, China.

Owens, D. (2010) "Securing Elasticity in the Cloud," *Communications of the ACM* (53)6, p. 46.

Owunwanne, D., and R. Goel (2010) "Radio Frequency Identification (RFID) Technology: Gaining A Competitive Value Through Cloud Computing," *International Journal of Management and Information Systems* (14)5, p. 157.

Pallis, G. (2010) "Cloud Computing: The New Frontier of Internet Computing," *IEEE Internet Computing* (14)5, p. 70.

Palmer, B., K. Bubendorfer, and I. Welch (2010) "A Protocol for Verification of an Auction Without Revealing Bid Values," *Procedia Computer Science* (1)1, pp. 2649–2658, doi: 10.1016/j.procs.2010.04.298.

Pamies–Juarez, L., P. García–López, M. Sánchez–Artigas, and B. Herrera (2011) "Towards the Design of Optimal Data Redundancy Schemes for Heterogeneous Cloud Storage Infrastructures," *Computer Networks* (55)5, p. 1100.

Pandey, S., W. Voorsluys, S. Niu, A. Khandoker, and R. Buyya (2011) "An Autonomic Cloud Environment for Hosting ECG Data Analysis Services," *Future Generation Computer Systems*(28)1, pp. 147-154, doi: 10.1016/j.future.2011.04.022.

Paquette, S., P.T. Jaeger, and S.C. Wilson (2010) "Identifying the Security Risks Associated with Governmental Use of Cloud Computing," *Government Information Quarterly* (27)3, pp. 245–253, doi: 10.1016/j.giq.2010.01.002.

Parakh, A., and S. Kak (2009) "Online Data Storage Using Implicit Security," *Information Sciences,* (179)19, pp. 3323-3331.

Pauley, W.A. (2010) "Cloud Provider Transparency: An Empirical Evaluation," *IEEE Security & Privacy* (8)6, pp. 32–39.

Pendyala, V.S., and S.S.Y. Shim (2009) "The Web as the Ubiquitous Computer," *Computer* (42)9, pp. 90–92.

Peterson, G. (2010) "Don't Trust. And Verify: A Security Architecture Stack for the Cloud," *IEEE Security & Privacy* (8)5, 83–86.

Petter, S., and E.R. McLean (2009) "A Meta-analytic Assessment of the Delone and Mclean IS Success Model: An Examination of IS Success at the Individual Level," *Information & Management* (46)3, pp. 159–166.

Plummer, D.C., D.M. Smith, T.J. Bittman, D.W. Cearley, D.J. Cappuccio, D. Scott, et al. (2009) "Five Refining Attributes of Public and Private Cloud Computing," http://www.gartner.com/DisplayDocument?doc_cd= 67182&ref=g_fromdoc (current Apr. 24, 2010).

Preston, R. (2011) "Top 10 CIO Priorities," *Information Week,* Oct. 20*,* http://www.informationweek.com/news/global-cio/interviews/231901248 (current Oct. 25, 2011).

Ramakrishnan, L., J.S. Chase, D. Gannon, D. Nurmi, and R. Wolski (2011) "Deadline-sensitive Workflow Orchestration Without Explicit Resource Control," *Journal of Parallel and Distributed Computing* (71)3, pp. 343–353, doi: 10.1016/j.jpdc.2010.11.010.

Robert, F. (2009) "Library in the Clouds," *OCLC Systems and Services* (25)3, p. 156.

Robey, F., and M.L. Markus (1998) "Beyond Rigor and Relevance: Producing Consumable Research About Information Systems," *Information Resources Management Journal* (11)1, pp. 7–15.

Rochwerger, B., D. Breitgand, A. Epstein, D. Hadas, I. Loy, K. Nagin, et al. (2011) "Reservoir—When One Cloud Is Not Enough," *Computer* (44)3, pp. 44–51.

Rodero–Merino, L., L.M. Vaquero, V. Gil, F. Galán, J. Fontán, R.S. Montero, et al. (2010) "From Infrastructure Delivery to Service Management in Clouds," *Future Generation Computer Systems* (26)8, pp. 1226–1240, doi: 10.1016/j.future.2010.02.013.

Ryan, M. (2011) "Viewpoint Cloud Computing Privacy Concerns on Our Doorstep," *Communications of the ACM* (54)1, p. 36.

Sabherwal, R., A. Jeyaraj, and C. Chowa (2006) "Information System Success: Individual and Organizational Determinants," *Management Science* (52)12, p. 1849.

Schaffer, H. (2009) "X as a Service, Cloud Computing, and the Need for Good Judgment," *IT Professional* (11)5, p. 4.

Scornavacca, E., S.J. Barnes, and S.L. Huff (2006) "Mobile Business Research Published in 2000–2004: Emergence, Current Status, and Future Opportunities," *Communications of the Association for Information Systems* (17) Article 28, pp. 635–646.

Sharif, A.M. (2010) "It's Written in the Cloud: The Hype and Promise of Cloud Computing," *Journal of Enterprise Information Management* (23)2, p. 131.

Sheth, A., and A. Ranabahu (2010a) "Semantic Modeling for Cloud Computing, Part 1," *IEEE Internet Computing* (14)3, p. 81.

Sheth, A., and A. Ranabahu (2010b) "Semantic Modeling for Cloud Computing, Part 2," *IEEE Internet Computing* (14)4, p. 81.

Shi, W., Y. Lu, Z. Li, and J. Engelsma (2011) "SHARC: A Scalable 3D Graphics Virtual Appliance Delivery Framework in Cloud," *Journal of Network and Computer Applications* (34)4, pp. 1078–1087, doi: 10.1016/j.jnca.2010.06.005.

Shiers, J. (2009) "Grid Today, Clouds on the Horizon," *Computer Physics Communications* (180)4, pp. 559–563, doi: 10.1016/j.cpc.2008.11.027.

Spring, J. (2011a) "Monitoring Cloud Computing by Layer, Part 1," *IEEE Security & Privacy* (9)2, pp. 66–68.

Spring, J. (2011b) "Monitoring Cloud Computing by Layer, Part 2," *IEEE Security & Privacy* (9)3, pp. 52–55.

Staten, J. (2008) "Is Cloud Computing Ready for the Enterprise?" http://vu2aut.persiangig.com/ECommerce/Forrester-Cloud-computing-report080307%5B1%5D.pdf (current Mar. 11, 2010).

Stein, S., and H. Schaffer (2010) "Cloud with a Long Tail: The VCL in Support of Pedagogy," *EDUCAUSE Review* (45)3, p. 10.

Sterling, T., and D. Stark (2009) "A High-Performance Computing Forecast: Partly Cloudy," *Computing in Science & Engineering* (11)4, pp. 42–49.

Stonebraker, M., D. Abadi, D. DeWitt, S. Madden, E. Paulson, A. Pavlo, et al. (2010) "MapReduce and Parallel DBMSs: Friends or Foes?" *Communications of the ACM* (53)1, p. 64.

Strauss, A., and J. Corbin (1997) *Grounded Theory in Practice,* London, England: Sage Publications.

Streitberger, W., and T. Eymann (2009) "A Simulation of an Economic, Self-organising Resource Allocation Approach for Application Layer Networks," *Computer Networks* (53)10, pp. 1760–1770, doi: 10.1016/j.comnet.2008.10.020.

Subashini, S., and V. Kavitha (2011) "A Survey on Security Issues in Service Delivery Models of Cloud Computing," *Journal of Network and Computer Applications* (34)1, pp. 1–11. doi: 10.1016/j.jnca.2010.07.006.

Suess, J., and K. Morooney (2009) "Identity Management & Trust Services: Foundations for Cloud Computing," *EDUCAUSE Review* (44)5, p. 24.

Sultan, N.A. (2010) "Cloud Computing for Education: A New Dawn?", *International Journal of Information Management* (30)2, pp. 109–116, doi: 10.1016/j.ijinfomgt.2009.09.004.

Sultan, N.A. (2011) "Reaching for the 'Cloud': How SMEs Can Manage," *International Journal of Information Management* (31)3, pp. 272–278.

Svantesson, D., and R. Clarke (2010) "Privacy and Consumer Risks in Cloud Computing," *Computer Law & Security Review* (26), pp. 391(397).

Takabi, H., J.B.D. Joshi, and G. Ahn (2010) "Security and Privacy Challenges in Cloud Computing Environments," *IEEE Security & Privacy* (8)6, pp. 24–31.

Tao, J., H. Marten, D. Kramer, and W. Karl (2011) "An Intuitive Framework for Accessing Computing Clouds," *Procedia Computer Science* (4), pp. 2049–2057, doi: 10.1016/j.procs.2011.04.224.

Taylor, M., J. Haggerty, D. Gresty, and R. Hegarty (2010) "Digital Evidence in Cloud Computing Systems," *Computer Law & Security Review* (26)3, pp. 304–308, doi: 10.1016/j.clsr.2010.03.002.

Thomas, P.Y. (2011) "Cloud Computing," *The Electronic Library* (29)2, p. 214.

Truong, D. (2010) "How Cloud Computing Enhances Competitive Advantages: A Research Model for Small Businesses," *The Business Review, Cambridge* (15), p. 59.

Truong, H., and S. Dustdar (2010) "Composable Cost Estimation and Monitoring for Computational Applications in Cloud Computing Environments," *Procedia Computer Science* (1)1, pp. 2175–2184, doi: 10.1016/j.procs.2010.04.243.

Truong, H., and S. Dustdar (2011) "Cloud Computing for Small Research Groups in Computational Science and Engineering: Current Status and Outlook," *Computing. Archives for Informatics and Numerical Computation* (91)1, p. 75.

Upson, S. (2011) "Cloud Computing," *IEEE Spectrum* (48)1, p. 43.

Vaquero, L., L. Rodero–Merino, J. Caceres, and M. Lindner (2009) "A Break in the Clouds: Towards a Cloud Definition," *SIGCOMM Computer Communication Review* (39)1, pp. 50–55.

Vaquero, L., L. Rodero–Merino, and D. Morán (2011) "Locking the Sky: A Survey on IaaS Cloud Security," *Computing. Archives for Informatics and Numerical Computation* (91)1, p. 93.

Vasan, R. (2011) "A Venture Perspective on Cloud Computing," *Computer* (44)3, pp. 60–62.

Vieira, K., A. Schulter, and C. Westphall (2010) "Intrusion Detection for Grid and Cloud Computing," *IT Professional* (12)4, p. 38.

Vogels, W. (2009) "Eventually Consistent," *Communications of the ACM* (52)1, p. 40.

Vouk, M.A. (2008) "Cloud Computing—Issues,Research and Implementations," *Journal of Computing and Information Technology* (4), pp. 235–246.

Walker, E. (2009) "The Real Cost of a CPU Hour," *Computer* (*42*)(4), pp. 35–41.

Walker, E., W. Brisken, and J. Romney (2010) "To Lease or Not to Lease from Storage Clouds," *Computer* (43)4, pp. 44–50.

Walz, J., and D. Grier (2010) "Time to Push the Cloud," *IT Professional* (12)5, p. 14.

Wang, C., K. Ren, W. Lou, and J. Li (2010) "Toward Publicly Auditable Secure Cloud Data Storage Services," *IEEE Network* (24)4, p. 5.

Wang, L., J. Tao, M. Kunze, A.C. Castellanos, D. Kramer, and W. Karl (2008) "Scientific Cloud Computing: Early Definition and Experience," Paper presented at the High Performance Computing and Communications, 2008, HPCC '08, 10th IEEE International Conference, Dalian, China.

Wang, P., D. Meng, J. Han, J. Zhan, B. Tu, X. Shi, et al. (2010) "Transformer: A New Paradigm for Building Data-Parallel Programming Models," *IEEE Micro* (30)4, p. 55.

Wang, Q., C. Wang, K. Ren, W. Lou, and J. Li (2011) "Enabling Public Auditability and Data Dynamics for Storage Security in Cloud Computing," *Parallel and Distributed Systems, IEEE Transactions* (22)5, pp. 847–859.

Wang, S.–S., K.–Q. Yan, and S.–C. Wang (2011) "Achieving Efficient Agreement Within a Dual-failure Cloud-computing Environment," *Expert Systems with Applications* (38)1, pp. 906–915, doi: 10.1016/j.eswa.2010.07.072.

Ward, B.T., and J.C. Sipior (2010) "The Internet Jurisdiction Risk of Cloud Computing," *Information Systems Management* (27), pp. 334(336).

Warneke, D., and O. Kao (2011) "Exploiting Dynamic Resource Allocation for Efficient Parallel Data Processing in the Cloud," *Parallel and Distributed Systems, IEEE Transactions* (22)6, pp. 985–997.

Webster, J., and R.T. Watson (2002) "Analyzing the Past to Prepare for the Future: Writing a Literature Review," *MIS Quarterly* (26)2, pp. iii–xiii.

Wei, Y., and M. Blake (2010) "Service-oriented Computing and Cloud Computing: Challenges and Opportunities," *IEEE Internet Computing* (14)6, p. 72.

Weinhardt, C., A. Anandasivam, B. Blau, and J. Stosser (2009) "Business Models in the Service World," *IT Professional* (11)2, p. 28.

Wheeler, B., and S. Waggener (2009) "Above Campus Services: Shaping the Promise of Cloud Computing for Higher Education," *EDUCAUSE Review* (44)6, p. 52.

Winans, T., and J. Brown (2009) "Moving Information Technology Platforms to the Clouds: Insights into IT Platform Architecture Transformation," *Journal of Service Science* (2)2, p. 23.

Wolfswinkel, J.F., E. Furtmueller, and C.P.M. Wilderom (2011) "Using Grounded Theory as a Method for Rigorously Reviewing Literature," *European Journal of Information Systems* advance online publication 29 Nov., doi: 10.1057/ejis.2011.51

Woo, M., and M. Dieckmann (2010) "The Multiple Personalities of Cloud Computing," *EDUCAUSE Review* (45)3, p. 12.

Xu, B., C. Zhao, E. Hu, and B. Hu (2011) "Job Scheduling Algorithm Based on Berger Model in Cloud Environment," *Advances in Engineering Software* (42)7, pp.419-425 doi: 10.1016/j.advengsoft.2011.03.007.

Yang, H., and M. Tate (2009) "Where Are We at with Cloud Computing? A Descriptive Literature Review," Paper presented at the ACIS 2009 Proceedings, Melbourne, Australia.

Yeo, C.S., S. Venugopal, X. Chu, and R. Buyya (2009) "Autonomic Metered Pricing for a Utility Computing Service," *Future Generation Computer Systems* (26)8, pp. 1368-1380.

Yogesh, K.D., and M. Navonil (2010) "It's Unwritten in the Cloud: The Technology Enablers for Realising the Promise of Cloud Computing," *Journal of Enterprise Information Management* (23)6, p. 673.

Yuan, D., Y. Yang, X. Liu, and J. Chen (2010) "A Data Placement Strategy in Scientific Cloud Workflows," *Future Generation Computer Systems* (26)8, pp. 1200–1214, doi: 10.1016/j.future.2010.02.004.

Yuan, D., Y. Yang, X. Liu, and J. Chen (2011) "On-demand Minimum Cost Benchmarking for Intermediate Dataset Storage in Scientific Cloud Workflow Systems," *Journal of Parallel and Distributed Computing* (71)2, pp. 316–332, doi: 10.1016/j.jpdc.2010.09.003.

Communications of the Association for Information Systems

Yunis, M.M. (2010) "A 'Cloud-free' Security Model for Cloud Computing," *International Journal of Services and Standards* (5), Author abstract, p. 354.

Zhang, Q., L. Cheng, and R. Boutaba (2010) "Cloud Computing: State-of-the-art and Research Challenges," *Journal of Internet Services and Applications* (1)1, pp. 7–18.

Zhang, T., Z. Du, Y. Chen, X. Ji, and X. Wang (2011) Typical Virtual Appliances: An Optimized Mechanism for Virtual Appliances Provisioning and Management," *Journal of Systems and Software* (84)3, p. 377.

Zhang, X., A. Kunjithapatham, S. Jeong, and S. Gibbs (2011) "Towards an Elastic Application Model for Augmenting the Computing Capabilities of Mobile Devices with Cloud Computing," *Mobile Networks and Applications* (16)3, p. 270.

Zhu, Y., J. Wang, and C. Wang (2011) "Ripple: A Publish/subscribe Service for Multidata Item Updates Propagation in the Cloud," *Journal of Network and Computer Applications* (34)4, pp. 1054–1067, doi: 10.1016/j.jnca.2010.06.002.

Zissis, D., and D. Lekkas (2010) "Addressing Cloud Computing Security Issues," *Future Generation Computer Systems* (28)3, pp.583-592 , , doi: 10.1016/j.future.2010.12.006.

Zissis, D., and D. Lekkas (2011) "Securing e-Government and e-Voting with an Open Cloud Computing Architecture," *Government Information Quarterly* (28)2, pp. 239–251, doi: 10.1016/j.giq.2010.05.010.

APPENDIX A: CLASSIFICATION OF REVIEWED ARTICLES

Table A-1: Classification of Reviewed Articles	
Topics	References
Technological Issues	
Cloud Performance	Alonso–Calvo, Crespo, Garc'ia–Remesal, Anguita, and Maojo, 2010; Byun et al., 2011; Iosup et al., 2011; Iqbal et al., 2011; Jann, Dubey, Burugula, and Pattnaik, 2010; Kecskemeti, Terstyanszky, Kacsuk, and Neméth, 2011; Kim et al., 2011; Kirschnick, Alcaraz Calero, Wilcock, and Edwards, 2010; Kong et al., 2011; Kousiouris, Cucinotta, and Varvarigou, 2011; Lagar–Cavilla et al., 2011; Li, Yang, Kandula, and Zhang, 2011; Y.–K. Lin and Chang, 2011; Liu et al., 2010; Xiao Liu et al., 2011; Xu Liu et al., 2011; Luo, 2010; Mitrani, 2010; Moreno–Vozmediano, Montero, and Llorente, 2011; Murphy and Goasguen, 2010; Palmer, Bubendorfer, and Welch, 2010; Ramakrishnan, Chase, Gannon, Nurmi, and Wolski, 2011; Rochwerger et al., 2011; Shi, Lu, Li, and Engelsma, 2011; Streitberger and Eymann, 2009; Tao, Marten, Kramer, and Karl, 2011; S.–S. Wang, Yan, and Wang, 2011; Warneke and Kao, 2011; Xu, Zhao, Hu, and Hu, 2011; T. Zhang, Du, Chen, Ji, and Wang, 2011
Security	Anthes, 2010; Bellovin, 2011; Blumenthal, 2010; Borenstein and Blake, 2011; Calero et al., 2010; Chakraborty, Ramireddy, Raghu, and Rao, 2010; Chonka et al., 2011; Gentry, 2010; Gold, 2009; Grobauer, Walloschek, and Stocker, 2011; K. Hwang and Li, 2010; Jaeger and Schiffman, 2010; Kaufman, 2010a, 2010b; Kritsonis, 2011; Li et al., 2011; Liu, Weng, Li, and Luo, 2010; Lombardi and Di Pietro, 2011; Owens, 2010; Parakh and Kak, 2009; Peterson, 2010; Spring, 2011a, 2011b; Subashini and Kavitha, 2011; Vaquero, Rodero–Merino, and Morán, 2011; Vieira et al., 2010; Q. Wang et al., 2011; Yunis, 2010; Zissis and Lekkas, 2010
Data Management	Chen et al., 2011; Grossman et al., 2009; Johnson, 2009; K.W. Lin and Deng, 2010; Mattmann, Crichton, Hart, Kelly, and Hughes, 2010; Nicolae, Antoniu, Bougé, Moise, and Carpen–Amarie, 2011; Pamies–Juare et al., 2011; Stonebraker et al., 2010; Vogels, 2009; Walz and Grier, 2010
Software Development	Böhm and Kanne, 2011; Cooper, 2010; Geer, 2009; Lawton, 2008a; Liu et al., 2011; Louridas, 2010; Malawski et al., 2011; P. Wang et al., 2010
Data centre Management	Beloglazov et al., 2011; Berl et al., 2010; Deng and Pung, 2011; Dougherty et al., 2011; Garg, Yeo, Anandasivam, and Buyya, 2011; Katz, 2009; Mezmaz et al., 2011
Service Management	Breiter and Behrendt, 2009; Goscinski and Brock, 2010; Rodero–Merino et al., 2010; Zhu et al., 2011
Business Issues	
Adoption	Misra and Mondal, 2011; Sultan, 2011; D. Truong, 2010; H. Truong and Dustdar, 2011; Walker et al., 2010; Yogesh and Navonil, 2010
Privacy	Barnhill, 2010; Katzan, 2010c; Ryan, 2011; Svantesson and Clarke, 2010; Takabi, Joshi, and Ahn, 2010
Legal Issues	Jiang, 2010; Joint et al., 2009; Kaufman, 2009; Taylor et al., 2010; Ward and Sipior, 2010
Cost	Iosup et al., 2010; H. Truong and Dustdar, 2010; Walker, 2009; Yuan et al., 2011

Table A-1: Classification of Reviewed Articles – Continued	
Trust	Bret, 2009; Khan and Malluhi, 2010; Pauley, 2010; Wang et al., 2010
Pricing	Li, 2011; Yeo et al., 2009
Ethical	K. Miller, 2010; K. Miller and Voas, 2010
Conceptualising Cloud Computing	
Foundational/ Introductions	Armbrust et al., 2010; Banerjee et al., 2011; Brynjolfsson et al., 2010; Buyya et al., 2009; Campbell–Kelly, 2009; Cervone, 2010; Erdogmus, 2009; Grossman, 2009; Han, 2010; Hayes, 2008; Hewitt, 2008; Hofmann and Woods, 2010; Katzan, 2010b; Katzan and Dowling, 2010; Keahey, Tsugawa, Matsunaga, and Fortes, 2009; Lackermair, 2011; Lawton, 2008b; Leiba, 2009; G. Lin, Fu, Zhu, and Dasmalchi, 2009; Marston et al., 2011; Mell and Grance, 2010; Miller and Veiga, 2009; Naghshineh et al., 2009; Pallis, 2010; Schaffer, 2009; Sharif, 2010; Sheth and Ranabahu, 2010a, 2010b; Shiers, 2009; Upson, 2011; Vasan, 2011; Vouk, 2008; Wei and Blake, 2010; Weinhardt et al., 2009; Winans and Brown, 2009; Q. Zhang, Cheng, and Boutaba, 2010
Predictions	Chiu, 2010; Cusumano, 2010; Deniz Helvacioglu Kuyucu, 2011; Douglis, 2009; Durkee, 2010; Golden, 2009; Greengard and Kshetri, 2010; King, 2010; Kshetri, 2010; Leavitt, 2009; Lindner, Vaquero, Rodero–Merino, and Caceres, 2010; Sterling and Stark, 2009
Domains and Applications	
Education	Bristow, Dodds, Northam, and Plugge, 2010; Brown, 2009; Bungo, 2011; Calvo et al., 2011; Currie, 2008; Diffin, Chirombo, and Nangle, 2010; Doelitzscher et al., 2011; Ercan, 2010; Ivanova and Ivanov, 2010; Jordan, 2011; Katzan, 2010a; Kim, Ng, and Lim, 2010; Nevin, 2009; Robert, 2009; Stein and Schaffer, 2010; Suess and Morooney, 2009; Sultan, 2010; Thomas, 2011; Wheeler and Waggener, 2009; Woo and Dieckmann, 2010
e-Science	Armando, 2011; Deelman, 2010; May, 2010; Navonil, 2010; Yuan et al., 2010, 2011
Mobile Computing	Kumar and Lu, 2010; Lu et al., 2011; Pandey et al., 2011; Pendyala and Shim, 2009; Zhang et al., 2011
Open Source	Aslam, Ullah, and Ansari, 2010; Avetisyan et al., 2010; Milojicic et al., 2011; Nelson, 2009
e-Government	Paquette et al., 2010; Zissis and Lekkas, 2011
Unclassified	Guizzo, 2011; Li et al., 2011; Mika and Tummarello, 2008; Owunwanne and Goel, 2010

ABOUT THE AUTHORS

Haibo Yang is a Ph.D. candidate in information systems at Victoria University of Wellington. Haibo's professional background includes online application development, database management, and business intelligence. From an academic perspective his research interests include understanding the dynamics between technologies and online service delivery. Haibo's recent work focuses on IT agility and cloud computing and has been presented at conferences such as AMCIS and ACIS.

Dr. Mary Tate is a Senior Lecturer in Information Systems at Victoria University of Wellington, New Zealand. She has twenty years of experience in the IT industry including channel management, service delivery, project management, and business analysis. Since joining Victoria University in 2001 Mary has embarked on a research career with more than fifty peer-reviewed publications in journals such as the *Journal of the Association of Information Systems* and *Behaviour and Information Technology.* Mary has served as track chair and AE for e-commerce and research methods tracks in a range of IS conferences including ICIS, PACIS, and ACIS.