

Cloud Computing Research Developments and Future Directions

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Abstract - Cloud computing has the potential to revolutionise the commercial world as we know it, but it also presents many unexplored avenues for study. To better understand the state of cloud computing research, we perform comprehensive literature evaluations. There were 188 scholarly journal and conference papers cited. After reading each article, we were able to deduce its essential ideas and use those to create a taxonomy. Our research has shown that there are four main categories related to cloud computing, including (1) advantages and disadvantages, (2) implementation, (3) results, and (4) the present technological and research status of the field. In its final section, the study poses a series of questions that need to be explored further, both theoretically and experimentally. In addition to identifying research gaps in the literature, this review offers a reference source and classification for IS researchers with an interest in cloud computing

Keywords: cloud computing, systematic literature review, themes, SAAS, IAAS, PAAS

1. INTRODUCTION

Armbrust et al. (2009) define cloud computing as the software and infrastructure that is made available as a service over the Internet. The development of massive datacenters, developments in scalability and portability in IT, the emergence of novel business models, and the potential for novel forms of application, such as interactive mobile software, are all driving forces. Cloud computing may be a new field of study in the field of information systems, but it has already attracted many businesses and individuals in quest of cost savings and increased productivity. Concerns concerning the services' dependability in terms of their usefulness, safety, and expected results continue to be voiced by these parties. A systematic literature evaluation was performed using a predetermined search strategy with the goal of locating unanswered questions in the field of cloud computing research. ABI/INFORM database and Google scholar were the only search engines used, and the term "cloud computing" was used as the keyword. Using these articles, we were able to see a pattern emerge and gain an understanding of the existing study fields in cloud computing, allowing us to spot untapped research opportunities. Following this, a variety of research questions are posed based on the data gleaned from the aforementioned literature review. Each article was dissected in order to extract its central argument. See Table 1 for a summary of the four categories we found in our analysis of cloud computing: (1) advantages and disadvantages; (2) adoption; (3) outcomes; and (4) the state of the field from a technological and research point of view.

| Cloud Computing research area | Studies |
|-------------------------------|---|
| Benefits and risks | Hosseini et al. (2010), Blumehnthal (2011), Aljabre (2012), Morar et al. (2011), Russell et al. (2010), Wang (2010), Katzan (2010), Rose (2011), Bisong and Rahman (2011), Durowoju et al. (2011), Marston et al. (2011), Berman et al. (2012). |
| Adoption | Heinle and Strebel (2010), Low et al. (2011), Yang and Hsu (2011), Barnes (2010), Truong and Dustdar (2010), Klems et al. (2009), Vaezi (2012). |
| Outcomes | Etro (2011), Truong (2010), Sharif (2011), Bajenaru (2010), Shen (2011), Han (2011). |
| Current state | Marston et al. (2011), Zhang et al. (2011), Hosseini et al. (2010), Wang et al. (2011), Limbasan (2011), Armbrust et al. (2009), Hoberg et al. (2012). |

Table 1 –Research Areas

2 ADVANTAGES AND HAZARDS OF CLOUD COMPUTING

2.1 Research on the broad consequences.

The advantages and disadvantages of cloud computing were investigated in three studies. Hosseini et al. (2010) conducted an empirical study to examine the pros and cons of moving an IT infrastructure to the cloud. Risks and benefits were examined

from different perspectives in Blumehnthal (2011) and Aljabre (2012). A summary of the benefits and drawbacks highlighted in these research papers are shown in Table 2.

Hosseini et al. (2010) claim that moving a legacy system to the cloud can result in significant savings, one of the most widely touted advantages of cloud computing. They took a wide range of stakeholder opinions into account and conducted empirical research into the potential benefits and hazards of moving an oil and gas industry IT system from an on-premises data centre to Amazon EC2. They looked at one company in detail, conducting interviews and analysing papers to determine prices and then contrasting those figures with those for the Amazon EC2 cloud. Their research showed that moving to the cloud might help a business save a lot of money, particularly on support and maintenance.

Cloud computing, according to Aljabre (2012), can also reduce the need for expensive hardware and software. As a result of this discovery, new businesses may be able to lower their prohibitive launch costs and enter the market. Using these web services online can save time and money compared to creating those same software features in-house. The research also found that cloud computing can improve remote teams' ability to work together effectively. Hosseini et al. (2010) also noted that stakeholders can help an organisation succeed by providing feedback on current offerings and ideas for future enhancements to both existing and new products and services. There are a number of advantages, including low cost, scalability, and the chance for staff to learn new skills. On the other hand, cloud computing is not without its dangers. According to Blumehnthal (2011), the dangers and benefits of embracing cloud computing may vary by industry, hence each sector needs its own research. Blumehnthal also cautioned against hastily adopting cloud services without first carefully assessing the myriad of security risks associated with them. Each link in the cloud supply chain, from the end user to the company to the cloud service provider, may introduce new security vulnerabilities. There may also be dangers associated with the accessibility, dependability, policy, and regulation of services. According to Aljabre (2012), the advantages of cloud computing for small firms outweigh the potential downsides. Reasons for this include lowering infrastructure expenses and lowering operational personnel costs, and increasing the value that small enterprises provide to customers.

| Benefits | Risks | Studies |
|---|------------------------|--|
| Cost savings | Security threats | Hosseini et al. (2010) Aljabre (2012) Blumehnthal (2011) |
| Opportunity to concentrate on core competencies | Availability | |
| Elasticity of service | Reliability of service | |
| Facilitate online collaboration | Regulations | |
| Modules reusability | Privacy concerns | |
| | Lack of standards | |

2.2 Research on individual dangers and rewards

Multiple research examined one potential upside or downside of cloud computing. For instance, the improved efficacy was investigated by Morar et al. (2011) in an empirical investigation. The risks to service availability were examined by Russell et al. (2010), and the risks to privacy were examined by Wang (2010), in two more empirical studies that looked into the potential dangers of employing cloud computing technology in an organisation. The impact of security and scalability on cloud business processes was investigated by Durowoju et al. (2011). Table 3 provides a brief overview of these investigations. Depending on processing power or storage requirements, nearly unlimited resources can be used, which is why Morar et al. (2011) include efficiency as a benefit. They showed that a faster application may be achieved through the use of workflows and cloud resources without spending a lot of money on compute power. For an eBay data retrieval application, a case study based on a workflow was built. The system was then used to simulate the improvement in speed that may be realised by isolating parts of an application and running them in parallel, without the requirement for advanced knowledge of parallel programming. They discovered that their cloud parallelism-based system greatly outperformed alternatives in terms of scalability and speed. In a Decision Support System (DSS) setting, Russell et al. (2010) assessed how oscillations in cloud service availability affected the success of decision results. Researchers employed a hypothetical stock trading decision involving an S&P500 component for their experiment. They modelled the availability of resources using a probabilistic model and assessed how the outage affected the DSS's performance. Researchers found that cloud-based DSS performance can be affected by availability context information. In addition, there is a correlation between the availability of computational resources and the likelihood of making the right call.

In the second phase, we used queuing theory to examine why and how scalability should be taken into account when choosing cloud partners. According to the research, supply chain partners may only reap the benefits of using a cloud service if it is both highly safe and highly scalable.

As Katzan (2010) points out, privacy is more complicated in a cloud environment in terms of laws, policies, and repercussions, thus it's important to analyse and understand them before using cloud computing. However, Rose (2011) cautioned about the dangers posed by the "tragedy of the commons." That is to say, businesses that use the same cloud would be similarly affected. The performance of the entire cloud might be negatively impacted, and the availability of the cloud could be jeopardised, if one company's data or cloud service were to be attacked, crash, or require more resources than intended.

Both Bisong and Rahman (2011) and Marston et al. (2011) addressed the topic of security in cloud computing, offering advice on how businesses may take precautions to keep their data safe. Before deploying cloud computing, authors advise organisations to check and understand cloud security risks, analyse them, and prepare strategies to fix them. Finally, Berman et al. (2012) polled 572 IT and business executives from throughout the world. The findings demonstrated that cloud computing is an acknowledged technology with significant promise that has not yet been fully realised. Three distinct "business archetypes" emerged from the analysis, each of which provides insight into the prevalence of cloud computing in modern businesses. Three distinct sorts of companies have emerged as a result of cloud computing: (1) optimizers, who increased productivity through cloud computing, (2) innovators, who developed new revenue streams based on cloud computing inside their ecosystem, and (3) disruptors, who introduced whole new value propositions to the market.

| Study | Benefit/Risk | Context | Main Findings |
|------------------------|----------------------|----------------------------------|---|
| Morar et al. (2011) | Efficiency | Workflows | Using cloud parallelism improved scalability and achieved higher speed |
| Russell et al. (2010) | Service availability | DSS | Even minor availability fluctuations caused serious changes in results of DSS |
| Wang (2010) | Privacy | Cloud Databases | Developed two privacy models for cloud DBs. |
| Durowoju et al. (2011) | Security/Scalability | Cloud enabled Business Functions | Guidelines to evaluate security and scalability |
| Berman et al (2012) | Innovation | Processes and Business model | Guidelines to help drive business innovation. |

3. The Use of the Cloud

Cloud computing usage is the second major topic of study. The organisational factors that influence the shift to cloud computing are investigated in four separate empirical investigations. What factors influence adoption in the high-tech sector? Low et al. (2011) investigated this question. Heinle and Strebel (2010) investigated what factors influence businesses' decisions to use infrastructure as a service (IaaS). However, Yang and Hsu (2011) proposed an alternative method (organisation lease) for investigating cloud computing's widespread use in businesses. To develop a comprehensive framework from which to gain a deeper comprehension of cloud computing, Vaezi (2012) employed the grounded theory method and compiled secondary data sources (such as interviews and case studies). Various articles' attempts to make sense of the adoption choice relied on a variety of theoretical models and underlying assumptions. For instance, Heinle and Strebel (2010) created a model of IaaS acceptability based on the factors that encourage and discourage the use of this service. Based on conversations with industry experts, we know that the presence of internal innovation champions and favourable attributes in IaaS providers (such as large scale and a good reputation) are major factors in the model's success. These were found to have a favourable effect on the likelihood of adopting IaaS. They also discovered that the lack of familiarity with IaaS and the difficulty in weighing the costs and benefits of existing IaaS products are two of the most significant obstacles. Technology-Organization-Environment (TOE) was utilised by Low et al. (2011) to create a theoretical model that looked into what prevents high-tech companies from adopting cloud computing. The information was gathered from 111 different Taiwanese businesses via a questionnaire survey. The appropriate hypotheses were developed and examined. Cloud computing adoption was found to be significantly influenced by factors like relative advantage, top management support, firm size, competitive pressure, and trade partner pressure. But Yang and Hsu (2011) took a different tack in their research on industry-level adoption, looking at it through the prism of "organising vision" to acknowledge the impact of the industry at large on individual businesses. They gave a secondary

examination of the institutional procedures that have led to the development of Taiwan's cloud computing sector. The authors point out that it is not appropriate to study an organisation in isolation, as each entity is part of a larger, more intricate network of organisations involved in the dialogue process of technological creation. The study indicated that many factors influencing an adoption decision are not based within the organisation, but rather are part of a larger community network, primarily linking internal cycles of interpretation to those at the institutional level.

Klems et al. (2009) provided a simple valuation step-by-step guiding framework to assess the worth of cloud computing and contrast it to traditional in-house IT infrastructure, which can be helpful in making an adoption choice. Finally, Vaezi (2012) used a grounded theory approach based on interviews, case studies, and scholarly articles to examine the landscape of adopting cloud computing from several vantage points. In the books he read, he discovered several types of ideas concerning adoption. Each of them was broken down into its own subcategory, such as: causes, cloud computing as the phenomena, context, mediators, responses, and outcomes. Based on these classifications, a theoretical model was developed that illustrated both the variables that hinder adoption and the methods that can be used to facilitate it. Articles discussing the spread of cloud computing are compiled in Table 4. Two conceptual studies explored the adoption in specific scenarios, indicating potential facilitators and constraints of cloud computing beyond the aforementioned studies. For instance, Barnes (2010) introduced cloud computing to the Records and Information Management (RIM) community by discussing the migration of records and RIM to the cloud. Barnes suggested thinking about things including price, security, performance, availability, business viability, and legal compliance while making a vendor selection. However, Truong and Dustdar (2010) investigated cloud computing acceptance amongst modest-sized CSE labs. The lack of cost estimation tools and the complexity of using IaaS for researchers are only two of the difficulties they've uncovered that limit widespread use of cloud computing by small CSE research organisations. They also listed advantages such as reduced expenditures, enhanced information exchange, and fruitful research findings

4. CLOUD COMPUTING'S RELEVANT RESULT(S)

The study of how cloud computing has affected various sectors and businesses is known as the "cloud computing outcomes" field. The majority of the research we looked at painted a positive picture of cloud computing's effects on end users. These predictions were based on speculation rather than hard data. Etro (2011) used a macroeconomic simulation model to investigate the long-term effects of cloud computing on the European economy. Etro discovered that the widespread adoption of cloud computing is associated with a higher rate of annual growth and the creation of new jobs each year thanks to the proliferation of small and medium-sized businesses (SMEs). The government may save money as well. When it comes to small firms, however, Truong (2010) has built a research model of cloud computing from a managerial perspective. Truong proposed a resource-based view of the firm to recommend adaptable cloud computing products and inter-connectivity as a means by which small enterprises might gain a competitive edge. That is to say, public cloud computing may provide a means to enhance connections with and collaborations between stakeholders. An organization's ability to innovate and work together with its partners is directly tied to how well the company's strategic usage of cloud computing resources is coordinated. Security, intellectual property, and trustworthiness of cloud services moderate this connection. The authors argue that doing so would give their company a distinct advantage in the market.

Sharif (2011) argued that the potential of cloud computing is real and not just a marketing gimmick for businesses. If used and adopted correctly, cloud computing has the potential to utterly transform businesses, much like the Internet did when it allowed for the exponential growth of businesses almost instantly thanks to its scalability and adaptability. This is possible if businesses are free to pick and choose which pieces of software, hardware, and services best suit their needs. Cloud computing, as noted by Bajenaru (2010), can play a significant role in bridging the "digital divide" between giant corporations and small and medium-sized businesses.

| Study | Theories used | Method | Enablers | Barriers |
|---------------------------|-------------------------------------|-------------------|---|---|
| Heinle and Strebel (2010) | Agency, DOI, IT governance theories | Experts interview | <ul style="list-style-type: none"> • Innovation champions • Cost transparency • Provider characteristics | <ul style="list-style-type: none"> • Unclear definition • Difficult cost-benefit evaluation • Unknown organizational impact • Difficulty in assessing provider risk • Service availability risks |

| | | | | |
|--------------------|---|----------------------------|--|--|
| | | | | <ul style="list-style-type: none"> • Lack of standards • Legal risks • Security • Lack of monitoring tools |
| Low et al.(2011) | Technology-Organization-Environment Framework | Questionnaire-based survey | <ul style="list-style-type: none"> • Relative advantage • Compatibility • Top management support • Firm size • Technology readiness • Competitive pressure • Trading partner pressure | <ul style="list-style-type: none"> • Complexity |
| Yang andHsu (2011) | OrganizationVision | Secondary analysis | <ul style="list-style-type: none"> • Community discourse, structure, and commerce. • IS practitioner subculture. • Adoption of core technology.Adoption and diffusion. | |
| Vaezi(2012) | Developed ownmodel | Grounded Theory | <ul style="list-style-type: none"> • Infrastructural Expenses • Unpredictable demand • Fluctuating demand • Ubiquitous demand | <ul style="list-style-type: none"> • Security/Privacy • Service Availability • Pricing Models • Legal Considerations |

Table 4: Factors Influencing Cloud Computing Adoption: An Empirical Analysis.

SaaS (Software as a Service) enables SMEs to use large-scale systems, such as Enterprise Resource Planning (ERP) or Customer Relationship Management (CRM) systems, which were previously only affordable to and used by multinational corporations. According to Shen (2011), BI can be enhanced in the following ways: information agility; data accessibility; process transformation; cost reduction; scalability; efficiency and performance; and performance. Businesses can also benefit from this because it allows them to focus on what they do best. In 2011, Han gave a talk about his work transferring a library's catalogue to the cloud. The author remarked that switching to cloud computing resulted in huge savings—up to 90%—and system flexibility. The author also thought that the system's overall security and availability were superior to those of the in-house system. Articles discussing the results of using the cloud are compiled in Table 5.

5. PROGRESS REPORTS ON CLOUD COMPUTING STUDIES

Numerous subsequent works (Marston et al. 2011, Zhang et al. 2011, Hosseini et al. 2010, Wang et al. 2011) continue to introduce cloud computing's fundamental ideas and aim to catalogue the field's existing status and future research directions. Table 6 is a compilation of the studies' suggested research goals. Cloud computing was first introduced by Marston et al. (2011), who also analysed its benefits, drawbacks, prospects, and risks. They suggested which businesses should utilise cloud computing and which apps (like customer relationship management systems at salesforce.com) to migrate there. It could be too soon to move older, in-house apps and systems to the cloud, though. Cost-effectiveness analysis shows that small and medium-sized businesses (SMEs) have more to gain from moving to the cloud than large ones. This is because larger organisations may already have cost-efficient ICT systems, but virtualization technologies may still help them. Economic benefits, strategic research (e.g, the effect of cloud computing on company culture), information systems policy, research into the adoption and implementation of new technologies, and studies of government policy and regulation were all highlighted. The current state of cloud computing was reviewed by Zhang et al. (2011). They explained the fundamental ideas and frameworks of cloud

computing. They also discussed some potential future routes in computer science research and provided an overview of the commercial cloud products now on the market. Hosseini et al. (2010) also covered some additional fields of study. Organisational changes (the new function of IT department, the shift in political power, and the economic and organisational implications of cloud) were cited as areas that need more research in the context of cloud computing. Further study is required because of concerns about cloud computing's legality, privacy, and security. In a quick overview, Wang et al. (2011) analysed existing gaps and new developments in cloud computing research. They argue that cloud computing is one of the most significant technological developments of the past decade, and that the quick pace of technological development makes it difficult for businesses to keep up. The study divides cloud computing studies into two distinct types: technical and organisational. Several research concerns, including the socio-technical impact of cloud computing and reliability, have not been extensively addressed in the literature, the authors suggest. Furthermore, research into the administrative procedures of cloud computing development has lagged behind. They also urge research into cloud computing services' benefits over the conventional model. They are also concerned about the effects of this change on productivity and the entire organisation.

| Study | Level/Context | Outcomes/Impact |
|-----------------|-----------------|---|
| Etro (2011) | Macroeconomic | <ul style="list-style-type: none"> • Positive annual growth rate, • Help create new jobs every year through the development of new SMEs. • There would also be savings in public sector. |
| Truong (2010) | Organization | <ul style="list-style-type: none"> • Offers a prescription for getting an un-substitutable competitive advantage |
| Sharif (2011) | Business Sector | <ul style="list-style-type: none"> • Revolutionize businesses • Create whole new business sectors and industries similar to the Internet revolution |
| Bajenaru (2010) | Business Sector | <ul style="list-style-type: none"> • Cloud computing can narrow the “digital divide” between large organizations and SMEs |
| Shen (2011) | BI Applications | <ul style="list-style-type: none"> • Transform (BI) apps to a self-service process • Improve BI in the areas of information agility, data accessibility, process transformation, cost reduction, scalability, efficiency and performance. |
| Han (2011) | Library System | <ul style="list-style-type: none"> • Cost savings up to 90% • More flexibility • Better availability and Security |

Table 5: Outcomes/Impact of Cloud Computing Studies.

However, Limbasan (2011) did construct a CRM prototype using a design science approach (Hevner et al., 2004) even though no other studies were discovered to do so. SaaS Level 2 architecture and a distributed database were employed in their model for a customer relationship management system that combined multiple e-marketing and SaaS features and techniques. They came up with a modular approach to achieving CRM and e-marketing goals in the real estate industry. Last but not least, Hoberg et al. (2012) surveyed the literature on cloud computing from an economic viewpoint. Characteristics, adoption factors, governance methods, and business effect are the four facets of cloud computing that have been highlighted by the researchers. While there has been a shift away from focusing on the technical aspects of cloud computing, there is still a lack of empirical study from a commercial standpoint.

6. DISCUSSION OF RESULTS AND DEFICIENT AREAS

According to this paper's literature evaluation, many previous studies have focused on the potential drawbacks and advantages of cloud computing. Service availability, privacy, security threats, service reliability, a lack of legislation, and a lack of standards were all named as potential dangers. On the flip side, it was determined that there is a need for theoretical and empirical support for research efforts with statistical evidences in order to open up new venues for researchers and practitioners. These include: cost savings, scalability, focus on core competencies, elasticity of service, facilitation of online collaboration, and reusability. The second topic of study is how companies are implementing cloud computing. Our search did not turn up any studies that focus on adoption on a micro- or macro-level. Since cloud computing may also affect people, this may be considered

a gap in the research. SaaS service, for instance, is commonly used as office software and document storage. How much will people's habits alter as a result of this shift? Furthermore, there is still a lack of clarity regarding the factors (or structures) that may lead to widespread adoption of cloud computing. What, moreover, would account for unsuccessful cloud adoption? This paper also highlights the importance of studying the results of cloud computing implementation. Despite the numerous promising results introduced, current research in this field is still regarded as subjective since it lacks empirical data based on theoretical models. This presents a chance to learn more about how embracing the cloud might modify an organisation, its personnel, and its degree of knowledge. Finally, there are a number of interesting study questions that could be asked using design science. Practical experiences naturally give rise to the most intriguing research problems. Organisations may eventually confront a challenge if SaaS becomes the dominant platform trend; however, this challenge can be lessened by the availability of a trusted model to lead the process of moving legacy software into a SaaS model. In conclusion, our review analysis highlighted several open research questions in cloud computing. We provide a number of theoretical and empirical concerns that need to be explored further.

- How do you ensure that your company will benefit from cloud computing?
- What personal considerations lead one to use cloud computing services?
- When businesses implement cloud computing, what happens, how does that go over, and how is it received?
- How can a business use the cloud to gain an edge over rivals in the marketplace?
- How does a company determine which cloud service or services to use? Which functions should be moved to the cloud first? Design-based model construction.

| Study | Research Gaps |
|------------------------|--|
| Marston et al. (2011) | <ul style="list-style-type: none"> • Economic benefits of cloud computing • Impact of cloud computing on corporate culture • Information systems policy • Technology adoption and implementation research • Government policy/regulation research. |
| Hosseini et al. (2010) | <ul style="list-style-type: none"> • Organizational changes caused by the migrating to the cloud • Political changes in power • Economic and organizational implication of cloud • Security, legal and privacy issues that cloud computing raises |
| Wang et al. (2011) | <ul style="list-style-type: none"> • Socio-technical impact of cloud computing • Reliability of cloud computing. • Exploring the managerial processes of cloud computing • Value of adopting cloud computing services in contrast to using traditional model • Impact of adoption on productivity and on the organization as a whole. |
| Hoberg et al. (2012) | <ul style="list-style-type: none"> • Customer-perspective of cloud computing • Empirically studying Factors driving or inhibiting the adoption of cloud services • Business impact • Research on structures, processes and employee qualification to govern cloud services from a customer's perspective |

Table 6: Areas of Research suggested by studies

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