Research Strategy in Cloud Technologies

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Abstract - Cloud computing is nothing but the services such as network storage server services all such facilities provided by cloud computing through internet on demand or it may be on the basis of pay for per resource. The Information Technology industry is getting much facilitated by cloud computing but still, there is no any satisfactory research and development seen in cloud computing. What advanced research can be done in cloud computing and what can be the problems arise during the advanced research, this is the main motto of this paper. So with the help of this paper one can understand the cloud computing easily, the advanced research in cloud computing and the problems that arise during the advance research. In section ! there is an Introduction, in section 2 there is overview, in section 3 there are definitions and in section 4 there is a conclusion.

Keywords - Cloud computing, cloud technologies, review.

I. INTRODUCTION[1]

Recently popularity has been reached by cloud computing and major trend in IT has developed with cloud computing. Although Cloud research agenda is pushed at higher level by industries at high pace, but in academics there is only a sharp rise regarding cloud computing which can be seen through some rise in workshop and conferences regarding cloud computing . Lately, due to this there are lot of peer-reviewed papers on aspects of cloud computing, the result of this is made a systematic review necessary, which caused the analysis of research and explanation of research agenda. Thus the research agenda, basics of cloud and analysis is stated in this paper.

An overview of the field, [e.g. 1, 2, 3, 4, 5], is stated by no of several white papers and general information about cloud computing but yet there is no systematic review of the agenda challenges. A complete comprehensive review of the academic research done in cloud computing is presented in this paper and still research is going on the agenda of research in cloud computing. Even though a survey in such a fast moving field will soon be out of date, but a good base on Cloud Computing to set new work in context with can be provided by such a research, and the researchers who are new in this area can be use this as source of information. In two distinct viewpoints the research of this is divided. The technical issues that arise when building and providing clouds is investigated by one, and the implications of cloud computing on enterprises and users is looked after by the other. The advances and research questions in technical aspects of Cloud Computing is discussed in this paper, such as protocols, interoperability and techniques for building clouds, while the research challenges facing enterprise users, such as cost evaluations, legal issues, trust, privacy, security, and the effects of cloud computing on the work of IT departments, elsewhere [7] is discussed here. This paper is structured as follows: the methodology used to carry out this review is shown in the Section 2; Section 3 discusses various definitions of cloud computing; Section 4 concludes the review by summing up the research directions academia faces.

II. METHODOLOGY

This review surveyed the existing literature using a principled and systematic approach: we searched each of the major research databases for computer science, the ACM Digital Library, IEEE Xplore, SpringerLink, ScienceDirect and Google Scholar, for the following keywords: cloud computing, elastic computing, utility computing, Infrastructure as a Service, IaaS, Platform as a Service, PaaS, Software as a Service, SaaS, Everything as a Service, XaaS. The date range for this search was limited from 2005 until October 2009. This date range was chosen because this survey work was commenced in October 2009, and because all public clouds were launched after 2005. For example, Amazon first launched EC2 (Elastic Compute Cloud) in August 20061 and Google launched App Engine in April 20082. According to Google Trends, the term cloud. academia has taken. Pastaki Rad et al. [6] presented a preliminary survey that included a short overview of storage systems and Infrastructure as a Service (IaaS), which, however, was not systematic and fell short of providing a good overview of the state-of-the-art and lacked a discussion of the research computing started becoming popular in 2007 as shown in Figure 1.

The searches from the five target databases returned over 150 papers. The titles and abstracts of these papers were read and for quality reasons we decided to use only peer-reviewed papers for the review; only a small number of non peer-reviewed publications were included, such as well quoted definitions or a summary of a workshop discussing research challenges academia is facing, as these were relevant and not matched by comparable peer-reviewed work. Furthermore, papers that had misleading titles or abstracts and those that were purely focused on High Performance Computing and e-Science were also left out of the review as these areas are not within the core focus of our review. The citation-references of the selected papers were checked but no additional papers were found to be necessary to add to this review based on the criteria mentioned above. This resulted in a total of 56 publications being selected for review. The papers were split into three categories based on their main focus; the categories were: general introductions, technological aspects of cloud computing and organizational aspects. The latter category is discussed elsewhere [7]. The papers that provided general

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introductions to cloud computing are referenced throughout this paper. The technological category was further broken down into papers that dealt with protocols, interfaces, standards, lessons from related technologies, techniques for modelling and building clouds, and new use- cases arising through cloud computing.. Table 1 provides an overview of the papers reviewed in this review and their categories. As it can be seen in the table, the majority of the papers were published in 2009.

Figure 1: Searches for "cloud computing" on Google.com, taken from Google Trends.

III. DEFINITIONS

There has been much discussion in industry as to what cloud computing actually means. The term cloud computing seems to originate from computer network diagrams that represent the internet as a cloud. Most of the major IT companies and market research firms such as IBM [8], Sun Microsystems [1], Gartner [9] and Forrester Research [10] have produced whitepapers that attempt to define the meaning of this term. These discussions are mostly coming to an end and a common definition is starting to emerge. The US National Institute of Standards and Technology (NIST) has developed a working definition that covers the commonly agreed aspects of cloud computing. The NIST working definition summarises cloud computing as:

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 [11].

Table 1: Overview of the reviewed literature

Category	**Authors**
General introductions	Armbrust et al. 2009, Carr 2008, Erdogmus 2009, Foster et al. 2008, Pastaki Rad et al. 2009, Voas and Zhang 2009, Vouk 2008
Definitions	Mell and Grance 2009, Vaquero et al. 2009, Youseff et al. 2008
Protocols, interfaces, and standards	Bernstein et al. 2009, Dodda et al. 2009, Grossman 2009, Harmer et al. 2009, Keahey 2009, Lim et al. 2009, Matthews et al. 2009, Mikkilineni and Sarathy 2009, Nurmi et al. 2008, Ohlman et al. 2009, Sun et al. 2007
Lessons from related technologies	Buyya et al. 2008, Chang 2006, Foster et al. 2008, Napper and Bientinesi 2009, Sedayao 2008, Vouk 2008, Zhang and Zhou 2009
Building clouds	AbdelSalam et al. 2009, Buyya et al. 2009, Song et al. 2009, Sotomayor et al. 2009, Sriram 2009, Vishwanath et al. 2009
Use cases	Chun and Maniatis 2009, Ganon and Zilbershtein 2009, Matthew and Spraetz 2009, Wilson 2009

The NIST definition is one of the clearest and most comprehensive definitions of cloud computing and is widely referenced in US government documents and projects. This definition describes cloud computing as having five essential characteristics, three service models, and four deployment models. The essential characteristics are:

On-demand self-service: computing resources can be acquired and used at anytime without the need for human interaction with cloud service providers. Computing resources include processing power, storage, virtual machines etc.

Broad network access: the previously mentioned resources can be accessed over a network using heterogeneous devices such as laptops or mobiles phones.

Resource pooling: cloud service providers pool their resources that are then shared by multiple users. This is referred to as *multi-tenancy* where for example a physical server may host several virtual machines belonging to different users.

Rapid elasticity: a user can quickly acquire more resources from the cloud by scaling out. They can scale back in by releasing those resources once they are no longer required.

Measured service: resource usage is metered using appropriate metrics such monitoring storage usage, CPU hours, bandwidth usage etc.

The above characteristics apply to all clouds but each cloud provides users with services at a different level of abstraction, which is referred to as a service model in the NIST definition. The three most common service models are:

Software as a Service (SaaS): this is where users simply make use of a web-browser to access software that others have developed and offer as a service over the web. At the SaaS level, users do not have control or access to the underlying infrastructure being used to host the software. Salesforce's Customer Relationship Management software[3] and Google Docs[4] are popular examples that use the SaaS model of cloud computing.

Platform as a Service (PaaS): this is where applications are developed using a set of programming languages and tools that are supported by the PaaS provider. PaaS provides users with a high level of abstraction that allows them to focus on developing their applications and not worry about the underlying infrastructure. Just like the SaaS model, users do not have control or access to the underlying infrastructure being used to host their applications at the PaaS level. Google App Engine[5] and Microsoft Azure[6] are popular PaaS examples.

Infrastructure as a Service (IaaS): this is where users acquire computing resources such as processing power, memory and storage from an IaaS provider and use the resources to deploy and run their applications. In contrast to the PaaS model, the IaaS model is a low level of abstraction that allows users to access the underlying infrastructure through the use of virtual machines. IaaS gives users more flexibility than PaaS as it allows the user to deploy any software stack on top of the operating system. However, flexibility comes with a cost and users are responsible for updating and patching the operating system at the IaaS level. Amazon Web Services' EC2 and S3[7] are popular IaaS examples.

Erdogmus [12] described Software as a Service as the core concept behind cloud computing, suggesting that it does not matter whether the software being delivered is infrastructure, platform or application, "it's all software in the end" [12]. Although this is true to some extent, it nevertheless helps to distinguish between the types of service being delivered as they have different abstraction levels. The service models described in the NIST definition are deployed in clouds, but there are different types of clouds depending on who owns and uses them. This is referred to as a cloud deployment model in the NIST definition and the four common models are:

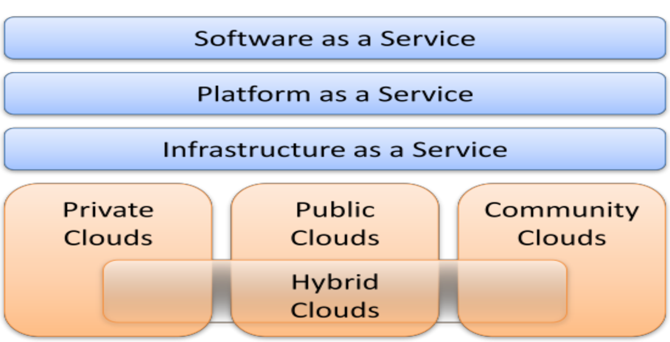
Private cloud: a cloud that is used exclusively by one organisation. The cloud may be operated by the organisation itself or a third party. The St Andrews Cloud Computing Co-laboratory[8] and Concur Technologies [13] are example organisations that have private clouds.

Public cloud: a cloud that can be used (for a fee) by the general public. Public clouds require significant investment and are usually owned by large corporations such as Microsoft, Google or Amazon.

Community cloud: a cloud that is shared by several organisations and is usually setup for their specific requirements. The Open Cirrus cloud testbed could be regarded as a community cloud that aims to support research in cloud computing [14].

Hybrid cloud: a cloud that is setup using a mixture of the above three deployment models. Each cloud in a hybrid cloud could be independently managed but applications and data would be allowed to move across the hybrid cloud. Hybrid clouds allow cloud bursting to take place, which is where a private cloud can burst-out to a public cloud when it requires more resources.

Figure 2 provides an overview of the common deployment and service models in cloud computing, where the three service models could be deployed on top of any of the four deployment models.



1) **Figure 2: Cloud computing deployment and service models**

Others such as Vaquero *et al.* [15] and Youseff *et al.* [16] concur with the NIST definition to a significant extent. For example, Vaquero *et al.* studied 22 definitions of cloud computing and proposed the following definition:

Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically re- configured to adjust to a variable load (scale), allowing also for optimum resource utilization. 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 customized SLAs.

This definition includes three of the five characteristics of cloud computing described by NIST, namely resource pooling, rapid elasticity and measured service but fails to mention on-demand self-service and broad network access. Youseff *et al.* [16] described a five-layer stack that can be used to classify cloud services; they use composability as their methodology where each service is composed of other services. The five layers are applications, software environment, software infrastructure, software kernel, and hardware. This is similar to the SaaS, PaaS and IaaS service models described in the NIST definition and only differs in the lower two layers, namely the software kernel and hardware layers. Grid and cluster computing systems such as Globus and Condor are examples of cloud services that fall into the software kernel layer, and ultra large-scale data centres as designed in IBM's Kittyhawk Project [17] are examples of hardware layer services [16]. However, these are not convincing examples of cloud services as they do not have the essential characteristics of cloud computing as described in the NIST definition, therefore we feel that the two extra layers used by Youseff *et al.* could reasonably be seen as unnecessary when describing cloud computing.

It is useful to think of a *cloud* as a collection of hardware and software that runs in a data centre and enables the cloud computing model [18]. "Scalability, reliability, security, ease of deployment, and ease of management for customers, traded off against worries of trust, privacy, availability, performance, ownership, and supplier persistence" are the benefits of cloud computing for Erdogmus [12].

Although there are still many internet forum and blog discussions on what cloud computing is and is not, the NIST definition seems to have captured the commonly agreed aspects of cloud computing that are mentioned in most of the academic papers published in this area. However, cloud computing is still in its infancy and as acknowledged by the authors Mell and Grance [11], this and any definition is likely to evolve in the future as new developments in cloud computing are explored. The current two-page NIST definition of cloud computing could be nicely summarised using Joe Weinman's retro-fitted *CLOUD* acronym that describes a cloud as a **C**ommon, **L**ocation-independent, **O**nline **U**tility provisioned on-**D**emand [19].

IV. CONCLUSION

This paper has presented the work published by the academic community advancing the technology of cloud computing. Much of the work has focussed on creating standards and allowing interoperability, and describes ways of designing and building clouds. We were surprised so far not to see significant contributions to the usage and scaling properties of Hadoop/MapReduce, which is a new programming paradigm in the cloud. Similarly, there was no work published yet on effective usage of PaaS offerings such as Google Apps.

Various definitions of cloud computing were discussed and the NIST working definition by Mell and Grance [11] was found to be the most useful as it described cloud computing using a number of characteristics, service models and deployment models. The socio-technical aspects of cloud computing that were reviewed included the costs of using and building clouds, the security, legal and privacy implications that cloud computing raises as well as the effects of cloud computing on the work of IT departments. The technological aspects that were reviewed included standards, cloud interoperability, lessons from related technologies, building clouds, and use-cases that presented new technological possibilities enabled by the cloud.

A number of authors have discussed the new research challenges that are raised by cloud computing. Bernstein *et al.* [34] listed a research agenda and open questions to achieve interoperability, and Birman *et al.* [29] described a research agenda that seeks to facilitate industry in building successful clouds. Vouk [21] described the problems of managing virtual machine (VM) images. It would be difficult to manually update a large number of VM images and verify their integrity by checking their contents. Mei *et al.* [51] compared the input-output, storage and processing features of cloud computing with pervasive computing and service computing to highlight new research challenges. Cloud computing could benefit from the functionality modelling issues studied in service computing, and the context-sensitivity issues studied in pervasive computing [51]. However, it is difficult to talk about cloud computing without having a particular abstraction layer in mind. The comparisons done by Mei *et al.* are reasonable at an IaaS layer, but they are not very meaningful at the SaaS layer where storage and processing features might not be visible at all. Youseff *et al.*

[16] briefly discussed the research challenges in IaaS clouds mentioning that system monitoring information could be used for application optimization in clouds. However, making such information available to users in a useful manner is a challenge [16]. Armbrust *et al.* [18] looked at other research challenges in cloud computing. They highlighted ten obstacles in cloud computing that included technical challenges relating to the adoption of cloud computing, such as availability of service and data lock-in. The lack of scalable storage, performance unpredictability and data transfer bottlenecks are also obstacles that could limit the growth of cloud computing. These obstacles present a number of new research opportunities in cloud computing and Armbrust *et al.* provided some ideas of how these obstacles could be tackled.

To conclude, this paper discussed the research academia has pursued to advance the technological aspects of cloud computing, and highlighted the resulting directions of research facing the academic community. In this way the various projects were set in context, and the research agenda followed by and facing academia was presented. The review showed that there are several ways in which the cloud research community can learn from related communities, and has shown there is interest in academia for describing these similarities. Further, there have been attempts at building unified APIs to access clouds which seem to be more politically than technically challenging. Then, the perhaps clearest research agenda was presented towards interoperability in the cloud and the challenges that need to be overcome. Finally, both for building clouds and presenting use cases in the cloud, the research efforts were shown to be very diverse, making it hard to suggest in which way academia will be moving. This paper reviewed the technical aspects of research in cloud computing. Together with [7], which discussed the work on implications of cloud computing on enterprises and users, this forms a complete survey of all research published on Cloud Computing, providing a solid basis for the 1st ACM Symposium on Cloud Computing.

V. REFERENCES

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