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Cloud Computing

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Abstract*: Cloud computing is a technology that allows users to access and use computing resources, such as servers, storage, databases, networking, software, and more, over the internet. Instead of owning and maintaining their own physical hardware and software infrastructure, individuals and organizations can rent or lease these resources from cloud service providers. These resources are hosted in data centers around the world, and users can access them on a pay-as-you-go basis, scaling their usage up or down as needed.An increasing number of companies make use of Cloud Computing services in order to reduce costs and increase flexibility of their IT infrastructure. This has enlivened a debate on the benefits and risks of Cloud Computing, among both practitioners and researchers. This study applies quantitative content analysis to explore the Cloud Computing ecosystem. The analyzed data comprises high quality research articles and practitioner-oriented articles from magazines and web sites. We apply n-grams and the cluster algorithm k-means to analyze the literature. The contribution of this paper is twofold: First, it identifies the key terms and topics that are part of the Cloud Computing ecosystem which we aggregated to a comprehensive model. Second, this paper discloses the sentiments of key topics as reflected in articles from both practice and academia.*

Keywords: Virtualization, Scalability, Data Center, SaaS (Software as a Service), Security

I. INTRODUCTION

Cloud Computing is the delivery of computing services such as servers, storage, databases, networking, software, analytics, intelligence, and more, over the Cloud (Internet)

Cloud Computing provides an alternative to the on-premises datacentre. With an on-premises datacentre, we have to manage everything, such as purchasing and installing hardware, virtualization, installing the operating system, and any other required applications, setting up the network, configuring the firewall, and setting up storage for data. After doing all the set-up, we become responsible for maintaining it through its entire lifecycle.

But if we choose Cloud Computing, a cloud vendor is responsible for the hardware purchase and maintenance. They also provide a wide variety of software and platform as a service. We can take any required services on rent. The cloud computing services will be charged based on usage.

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Types of cloud computing

1. Infrastructure as a Service (IaaS):

- IaaS provides virtualized computing resources over the internet. It offers the fundamental building blocks for cloud-based IT infrastructure, such as virtual machines, storage, and networking.
- Users have control over their operating systems, applications, and storage, while the cloud provider manages the underlying infrastructure.
- Examples of IaaS providers include Amazon Web Services (AWS) EC2, Microsoft Azure VMs, and Google Cloud Compute Engine.

2. Platform as a Service (PaaS):

- PaaS provides a platform for developers to build, test, and deploy applications without worrying about the underlying infrastructure.
- It offers a complete development and deployment environment, including tools, frameworks, and runtime environments.
- Users can focus on application development, while the cloud provider handles the underlying infrastructure, including servers, storage, and networking.
- Examples of PaaS providers include Heroku, Google App Engine, and Microsoft Azure App Service.

3. Software as a Service (SaaS):

- SaaS delivers software applications over the internet on a subscription basis, eliminating the need for users to install and maintain the software locally.
- Users access the application through a web browser or a thin client, and the application and its data are hosted and managed by the cloud provider.
- Examples of SaaS applications include customer relationship management (CRM) systems like Salesforce, productivity suites like Microsoft Office 365, and collaboration tools like Slack.

These three types of cloud computing services offer different levels of abstraction and control for users, catering to various needs and requirements. Organizations can choose the type of cloud service that best aligns with their specifics goals and resources.

Cloud computing offers several benefits for individuals and organizations. Here are some key advantages:

1. Scalability: Cloud services allow for easy scalability, enabling users to quickly scale up or down their computing resources based on demand. This flexibility ensures that businesses only pay for the resources they need, reducing costs and optimizing efficiency.

2. Cost-effectiveness: Cloud computing eliminates the need for upfront infrastructure investments, as users can access resources on a pay-as-you-go basis. This pay-as-you-use model helps businesses avoid excessive spending on underutilized resources and reduces overall IT costs.

3. Flexibility and Mobility: Cloud services can be accessed from anywhere with an internet connection, providing users with the freedom to work from different locations and devices. This flexibility enhances productivity and collaboration, as teams can easily access and share data and applications.

4. Reliability and Availability: Cloud providers typically offer high availability and redundancy, ensuring that services remain accessible even in the event of hardware failures or natural disasters. Service level agreements (SLAs) guarantee uptime and provide assurance to businesses that their critical applications and data will remain available.

5. Security: Cloud providers invest heavily in security measures to protect data and ensure compliance with industry regulations. They employ advanced security technologies, such as encryption, access controls, and regular security audits, to safeguard data from unauthorized access, loss, or breaches. Cloud services also offer data backup and disaster recovery capabilities, enhancing data protection and business continuity.

6. Collaboration and Efficiency: Cloud computing enables seamless collaboration among teams, as multiple users can access and work on the same documents and files simultaneously. This promotes real-time collaboration, improves workflow efficiency, and streamlines project management.

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7. Automatic Software Updates: Cloud providers handle software updates and maintenance, ensuring that users always have access to the latest features and security patches. This eliminates the need for manual updates and reduces the burden on IT teams.

8. Environmental Benefits: Cloud computing allows for resource consolidation, which leads to reduced energy consumption and carbon footprint. By sharing computing resources and optimizing server utilization, cloud services contribute to a more sustainable and environmentally friendly IT infrastructure.

These benefits make cloud computing an attractive option for businesses and individuals looking to streamline operations, improve productivity, and reduce costs. However, it's important to carefully consider factors such as data privacy, vendor lock-in, and compliance requirements when adopting cloud services.

There are three main deployment models in cloud computing:

1. Public Cloud:

- Public cloud refers to cloud services that are provided by third-party cloud providers over the internet.
- These services are available to the general public or a large number of organizations, and resources are shared among multiple users.
- Public cloud offers scalability, cost-effectiveness, and ease of use, as users can access and utilize cloud resources on-demand without the need for upfront infrastructure investments.
- Examples of public cloud providers include Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform.

2. Private Cloud:

- Private cloud refers to cloud infrastructure that is dedicated to a single organization.
- It can be managed internally by the organization's own IT department or hosted and managed by a third-party provider.
- Private cloud offers enhanced control, security, and privacy, as resources are not shared with other organizations.
- It is often used by organizations with specific security or compliance requirements, or those that need more control over their infrastructure.
- Examples of private cloud solutions include VMware vCloud, OpenStack, and Microsoft Azure Stack.

3. Hybrid Cloud:

- Hybrid cloud is a combination of public and private cloud infrastructure.
- It allows organizations to leverage the benefits of both deployment models by integrating their on-premises infrastructure with public cloud services.
- Organizations can use their private cloud for sensitive or critical applications and data, while using the public cloud for scalability, cost optimization, and less sensitive workloads.
- Hybrid cloud enables seamless workload migration between private and public environments, providing flexibility and agility.
- Examples of hybrid cloud solutions include Microsoft Azure Hybrid Cloud, AWS Outposts, and Google Anthos.

Each deployment model has its own advantages and considerations. Organizations should assess their specific requirements, such as security, compliance, scalability, and budget, to determine the most suitable deployment model for their needs.

There are several cloud service providers in the market, each offering a range of cloud computing services. Here are some of the major cloud service providers:

1. Amazon Web Services (AWS):

- AWS is one of the leading cloud service providers, offering a wide range of services across infrastructure, platform, and software.
- It provides services such as Amazon EC2 for virtual servers, Amazon S3 for object storage, Amazon RDS for managed databases, and many more.
- AWS has a global presence and offers a comprehensive set of tools and services for various industries and use cases.

2. Microsoft Azure:

- Azure is a cloud computing platform provided by Microsoft, offering a wide range of services for building, deploying, and managing applications and services.

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- It provides services such as Azure Virtual Machines, Azure Blob Storage, Azure SQL Database, and many more.
- Azure integrates well with Microsoft's existing software products, making it a popular choice for businesses already using Microsoft technologies.

3. Google Cloud Platform (GCP):
- GCP is Google's cloud computing platform, offering a suite of services for computing, storage, networking, machine learning, and more.
- It provides services such as Google Compute Engine, Google Cloud Storage, Google BigQuery, and many more.
- GCP is known for its strong machine learning and data analytics capabilities and is popular among developers and data scientists.

4. IBM Cloud:
- IBM Cloud offers a range of cloud services, including infrastructure, platform, and software services.
- It provides services such as IBM Virtual Servers, IBM Cloud Object Storage, IBM Db2 on Cloud, and many more.
- IBM Cloud has a focus on enterprise-grade security and compliance and is often chosen by businesses which specific regulatory requirements.

5. Oracle Cloud:
- Oracle Cloud offers a comprehensive set of cloud services, including infrastructure, platform, and software services.
- It provides services such as Oracle Compute, Oracle Object Storage, Oracle Database Cloud, and many more.
- Oracle Cloud is known for its strong database offerings and is popular among businesses using Oracle technologies.

These are just a few examples of cloud service providers, and there are many others in the market. When choosing a cloud service provider, it's important to consider factors such as the range of services offered, pricing, performance, reliability, security, and customer support, as well as how well the provider aligns with your specific business needs and requirements.

Cloud computing has numerous use cases across various industries. Here are some common examples:

1. Data Storage and Backup:
- Cloud storage allows businesses to securely store and access large amounts of data without the need for on-premises hardware.
- It provides scalability, durability, and accessibility, making it an ideal solution for data storage and backup needs.
- Businesses can easily back up their critical data to the cloud, ensuring data redundancy and disaster recovery.

2. Application Development and Testing:
- Cloud platforms offer developers the ability to create and test applications without the need for on-premises infrastructure.
- Developers can provision virtual machines, databases, and other resources on-demand, accelerating the development process and reducing costs.
- Cloud-based development environments also facilitate collaboration among development teams.

3. Scalable Web Hosting:
- Cloud hosting allows businesses to host their websites and web applications on scalable and reliable infrastructure.
- It ensures high availability and performance, as resources can be dynamically allocated based on demand.
- Cloud hosting also provides flexibility in terms of scaling resources up or down, allowing businesses to handle traffic spikes efficiently.

4. Big Data Analytics:
- Cloud computing offers powerful tools and services for processing and analyzing large volumes of data.
- Businesses can leverage cloud-based analytics platforms to gain insights from their data, identify patterns, and make data-driven decisions.
- Cloud-based analytics also enables businesses to take advantage of machine learning and artificial intelligence capabilities.

5. Software as a Service (SaaS):
- SaaS providers deliver software applications over the internet, eliminating the need for users to install and maintain software locally.

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- Businesses can access a wide range of applications, such as customer relationship management (CRM), enterprise resource planning (ERP), and productivity tools, on a subscription basis.
- SaaS solutions offer scalability, regular updates, and reduced IT overhead for businesses.

6. Internet of Things (IoT):
- Cloud computing plays a crucial role in managing and processing data from IoT devices.
- IoT devices can send data to the cloud for storage, analysis, and real-time processing.
- Cloud platforms provide the necessary scalability, security, and analytics capabilities to handle the massive amounts of data generated by IoT devices.

7. Collaboration and Communication:
- Cloud-based collaboration tools, such as file sharing, project management, and communication platforms, enable teams to work together efficiently.
- These tools provide real-time collaboration, version control, and remote access to files, facilitating teamwork and streamlining communication.

These are just a few examples of how cloud computing is used across industries. The flexibility, scalability, cost-effectiveness, and accessibility of cloud services make it a valuable technology for businesses of all sizes and sectors.
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II. CONCLUSION

The cloud computing technology has been around since industry started using mainframe computers for distributed computing. The distributed computing technology has been labelled as cluster computing, virtual computing, and other names. Yesterday, a company might have been an "application service provider" or a seller of "Software-as-a-Service." Today, they're in the business of "cloud computing." Many organisations, businesses, and individual users will realise that they are already computing in the cloud, after they understand what the technology is. Cloud computing refers to both the applications delivered as services over the Internet and the hardware and software in the data centres that provide those services. The services themselves have long been referred to as Software-as-a-Service (SaaS). The data centre hardware and software is what we will call a cloud. When a cloud is made available in a pay-as-you-go manner to the general public, we call it a Public cloud. We use the term Private cloud to refer to internal data centres of a business or other organisation, not made available to the general public. Cloud computing for individuals can be categorised as follows: cloud services and cloud storage. Individuals use cloud services, when they check their web mail, use a search engine for information or socialise on Facebook. Usage of cloud storage is when individuals upload their photos on Flickr, upload their video on YouTube or download music placed on their friend‘s ―torrent‖. However, it pays to be prudent in regards to the type of data that is placed on social networking sites, as that data can be mined and manipulated and there will be no control over it. For businesses, like any new technology, early adopters of cloud computing attempt to gain a competitive advantage. But economics will drive widespread adoption, and today with costs dropping, the migration to the cloud is accelerating. Cloud-based services also often come with added features and benefits. The dramatic increase in adoption of cloud computing services has largely been driven by the significant benefits of using cloud-based software applications versus buying, installing and maintaining on-premise solutions. Startup companies can be in business without investing in IT. An increase in the number of micro enterprises in a country will have a huge impact on its economic growth.

Cloud Computing Potential

Individuals and organizations are sceptical about whether cloud computing services will have adequate availability. Availability depends on a range of stakeholders that are involved. Some of them are: power [electricity] supplier, telecommunications provider, internet service provider, computer hardware, computer software, and the list go on. Pointing the finger to the cloud service provider can only happen after troubleshooting this exhausting list. However, existing cloud service providers have already set high standard benchmarks in this regard. The costs associated with cloud computing facing early adopters include the potential costs of service disruptions, data security concerns, potential regulatory compliance issues arising out of sensitive data being transferred and processed or stored beyond defined borders, limitations in the variety and capabilities of the development and deployment platforms currently available, difficulties in moving proprietary data and software from one cloud service provider to another, integration of cloud services with legacy systems, cost and availability of programming skills needed to modify legacy application to function in the cloud environment, legacy software CPU-based licensing costs increasing when moved to a cloud platform, etc., Developing countries have their highly skilled IT people working in developed countries. These people are skilled to write new kinds of software that will fuel the cloud computing growth back home. This has the potential and is already causing a reverse immigration trend amongst highly skilled IT workers who have chosen to return back to their home countries to pursue such existing opportunities. These skilled people are likely to bring in their experience of the western world to build new generations of tools and applications and innovative ways to serve their people. Cloud computing will play a big role in enabling the IT revolution in the developing nations to help companies market products and services to four billion consumers at the bottom of the pyramid. At the end of 2009, there were four billion mobile phones. By 2013, that number is projected to grow to six billion. That is many times the number of personal computers. When we start including other Internet capable devices into the mobile world, like eBook readers, photo frames, printers, photo and video cameras, personal navigators, 200 the numbers go way up. Small portable devices that can access information are already part of everyday life for hundreds of millions of people in the developed world. Computers and internet connectivity are not realistic given the economic and infrastructure of developing countries. Therefore, it is evident that developing countries will be using the mobile cloud computing before they get to the _regular‘ one and will probably never need the broadband internet experience. (Capobiancoa, 2009). The popular uptake of mobile phones for personal use in developing countries only started around 2003-2004 with the development of the pay-as-you-go business model for mobile services and the lowering of the cost of mobile phone devices. Currently, there is an intense competition among device manufacturers for the establishment of an ultimate and pervasive platform for mobile devices. The competition among Nokia‘s Symbian, Google‘s FOSS Android, Apple‘s iPhone, RIM‘s Blackberry, Microsoft‘s Windows Mobile, and others is similar to the early days of the personal computer and the struggle between Windows and Apple. Mobile phone technology in developing countries is in Phase 1 (emerging phase) with 2G phones, while the developed countries are using 3G and 4G phones for entertainment. With the innovative use of 2G phone technology by developing countries‘ users, one can wonder if they will ever embrace computers and the Internet like developed countries. The mobile phone revolution in developing countries has changed the way people communicate in their daily lives and conduct business. Many people never had a landline and in some case no electricity. Some of them charged their mobile phones using a charger that generates electricity from a bike. As the cellular data networks become more and more mature and reliable, the same consumers will have access to the Internet on their mobile phones without having a computer or broadband at home. This will enable a range of applications for computing in the cloud. The evolution of mobile applications enabled via cloud computing technology for use in developing countries clearly unfolds at a much greater speed than the evolution and adoption of personal computing and the Internet. ICT4Ds [information communications technology for development] are also not developing in isolation from technological and business model solutions for developing countries. ICT4D clouds will greatly enhance and bring dramatic improvements to existing development efforts. Cloud computing has interesting implications and potential for developing countries. There is an initiative to use cloud computing to help universities and public libraries in developing countries adopt open source integrated library systems, a transition they are struggling with as they lack local technical support. Using cloud computing might reduce incentives for developing ICT capacity at the local level. Cloud computing makes new classes of applications possible and delivers services that were not possible before. Examples include (i) mobile interactive applications that are location, environment, and context-aware and that respond in real time to information provided by human users, nonhuman sensors (e.g. humidity and stress sensors within a shipping container) or even from independent information services (e.g. worldwide weather data); (ii) parallel batch processing, which allows users to take advantage of huge amounts of processing power, to analyse terabytes of data for relatively small periods of time, while programming abstractions like Google‘s MapReduce or its open-source counterpart Hadoop, which performs the complex process of parallel execution of an application over hundreds of servers, transparent to programmers; (iii) business analytics that can use the vast amount of computer resources to understand customers, buying habits, supply chains, and so on from voluminous amounts of data; and (iv) extensions of compute-intensive desktop applications that can offload the data crunching to the cloud, leaving only the rendering of the processed data at the front-end with the availability of network bandwidth, reducing the latency involved (Bandyopadhyay et al., 2009). According to several presentations at Digital Africa, there is strong

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evidence that with each 10% of any population in Africa having access to mobile or Internet technologies, there is a corresponding 1.8% increase in that nation‘s GDP. There is strong evidence that simply bringing mobile education to the rural and unwired population will increase the national wealth and quality of life by an annual increase of 1.8%. Computing has long been recognized as a means of ensuring that people from developing countries have a pathway to bettering their lives and joining the rest of the international community. Computing has been at the heart of many developmental programs in both the urban centres and rural centres. In today's academic environment, the value of a computer lab not connected to the Internet is negligible. Faculty and students must be connected with the research community in order to contribute to and benefit from it. Much of the due diligence in Sub-Saharan universities has uncovered no shortage of computers but rather a severe lack of connectivity. The 202 Google University Access Program aims to address the underlying cause of the high cost of Internet bandwidth and access to experienced engineers. The program offers Internet bandwidth, Google Apps for Education, training and integration grants, and the support of Google engineering. This is in return for the university committing to invest in their campus infrastructure – ultimately the Internet bandwidth will reach faculty and students. Cloud computing has some attractive qualities for scientific researchers. It delivers data storage and processing as a service, rather than software that is loaded onto a hard drive or something that sits on a desk somewhere. Information is held in massive data centres spread all over the world and available upon request. In the cloud, the _supercomputer‘ exists virtually, meaning no clunky hardware; the software interface is easy to use, and scientists have access to their data and simulations from just about anywhere by simply logging in. Amazon has been leading the way in on-demand computing for the past decade, invaluable for organizations with large databases that do not necessarily want to hire an IT department. The service is flexible and pay-as-you-go. An hour will set you back 80 cents, or as little as 10 cents per gigabyte. Subscribers buy only what they use, which is ideal for research departments that face periodic peaks in computational power they require (Werth, 2009). Another opportunity provided by cloud services is to support researchers in reducing the costs involved with computation. Only a small number of researchers need capability computing – high-performance computing (HPC) systems with large numbers of cores. The majority of researchers are well served with capacity computing – systems that share their computing power with several and up to many users. This capacity computing is exactly where cloud computing excels. Recently, Microsoft and the National Science Foundation announced an agreement that will offer selected individual researchers and research group‘s free access to the Windows Azure cloud computing resources. This initiative opens up a whole new spectrum of opportunities for both researchers and institutions (Bristow et al., 2010). Cloud services offer higher education and research institutions the power to choose: the opportunity to rethink which services are needed to support education and research and the best way to deliver those services. Many services are readily available in the public cloud. Only a few services will require custom development, either alone or in partnership with other institutions. The final result will most likely be a loosely coupled, customised arrangement, consisting of off-the-shelf systems and services based on proven technology.

Simplicity

This is a very important attribute in today‘s enterprise applications because the user behaviour regarding how applications are consumed has changed drastically. Mainly due to the consumerisation of IT, the application consumption pattern has changed from bloated desktop apps to consumption of application features from multiple devices and even from multiple applications. In short, modern day applications serve a dual purpose of both an application for direct consumption (mostly through browsers or mobile apps) and a platform for consumption through APIs. In order to do that the application should be simple and fast. Any complexity will be a big turn off to users in the new consumption era. A good example highlighting this attribute is Google Apps which offers seamless user experience across many different devices both as a native app and on browser. If any application vendor want to attract mindshare among today‘s users, it is important that they ensure simplicity in their applications.

Cloud Scale Architecture

Modern cloud applications have a completely different architecture from the traditional applications which are more suitable for scaling up. Cloud application is architected to take advantage of the underlying low cost distributed infrastructure. Such an infrastructure allows applications to programmatically take advantage of dynamic scaling using a scale out approach, to meet the rapid scaling needs of a multi-tenant environment. On the other hand, it also involves designing the application for hardware failures. 205 Unless the enterprise cloud applications are architected for cloud scale, they cannot meet the needs of a globally dispersed workforce with access from wide variety of devices. Even though legacy applications can be hosted on the cloud, it cannot offer some of the scalability and cost advantages offered by the actual cloud applications. If an application vendor is not architecting for the cloud scale, they are bound to hit roadblock sooner than later and may not be able to meet the needs of modern day mobile workforce.

Open APIs

In today‘s world, APIs are key for any modern application. As the consumption model changes from accessing a desktop application to accessing functionality through many different devices and applications, all the modern day applications also behave as platforms. The only way for these applications to gain traction and be relevant in the market is by exposing its functionality through Open APIs. Open APIs not only extend the functionality of enterprise cloud applications but also make integration with other applications seamless.

Mobile Platform

Support As mobile phones and tablets proliferate the enterprise either by the organizationsupplied devices or BYOD (Bring Your Own Device) approach, mobile platform support has become a critical attribute to any enterprise cloud application. There are two ways to support mobile platforms, native apps popularized by Apple‘s iPhone and mobile web apps made possible by HTML 5. Most of the features are made available to the mobile devices using either of these two approaches. There are pros and cons to each of these two approaches and, lately, there is emergence of a hybrid model incorporating mobile web into native applications

Social Awareness

All modern enterprise cloud applications are expected to have social integration both internally and externally. Even though the social networking tools like Twitter, Facebook, etc. are expected to be integrated with customer facing applications, even the internal applications are expected to have collaborative features built in that makes modern day global scale collaboration easy and seamless. Human beings are inherently social. However, social technologies like Twitter and Facebook taught us how social features can be implemented for more effective collaboration and, hence, increased productivity. As enterprise applications became cloud native, it was easy to implement these new age social features into these applications and, thereby, increasing the productivity of entire organizations.

Cloud Computing Challenges

While it is evident that cloud providers endeavour to improve their offerings to meet clients' enterprise-grade security needs, it may not be enough in some key sectors. In sectors such as defense, aerospace and brokerage, security and compliance requirements which include the physical location of the data have made SaaS and Hardware public clouds unacceptable for a while (Swaminathan, 2008). In a recent survey, 64% of respondents in the US Federal Government say security is their topmost concern in the context of Cloud Computing (Chabrow, 2009). Every one of the web's elite destinations has suffered from major outages at some point. In light of that history, what does a fault-tolerant cloud environment look like, require and cost? How does optimization work in a cloud? A company selling cloud services may be optimizing power consumption, say, while customer A wants stable (not necessarily fast, but predictable) transaction times for a shopping cart scenario. Customer B needs fast compute capability despite big and frequent reads and writes to disk. How can all three parties go home happy at the end of the day? Although, in most cases, performance in a cloud is quite stable, there are times when the cloud infrastructure is under heavy loads. This may be observed at certain times in a business day typically during the business hours. The performance for an application in a cloud environment will depend on network traffic and the resources other virtual machines running on the same physical machine as the application's virtual machine are taking. It can be difficult to repeat the performance demonstrated from one run to another (Armsbrust, 2009). Due to the fact that different cloud providers may offer different levels of services (e.g. Google App Engine provides PaaS, Amazon EC2 provides IaaS, Salesforce provides SaaS) and APIs, it may be difficult for a user to switch from one cloud provider to another (Spinellis, 2004). This is also known as the "lock-in" problem in other literatures. In general, IaaS provides easier possibilities of switching than PaaS while SaaS is the most difficult one to switch to or from. Data theft is a special concern in the economic recession as the number of security breaches has increased in the downturn. Many executives say a top concern is the security threat posed by laid-off workers, according to Robert McMillan in his computerworld.com article "With economic slump, concerns rise over data theft." 209 The network speed is seen as another constraint of cloud computing. There are two network speeds that need to be mentioned here: one is intra-cloud network speed and the other is inter-cloud speed. Intra-cloud network speed is the network transfer speed inside the cloud infrastructure. It is usually limited by switches in the cloud infrastructure network. Depending on the cloud infrastructure network setup, this intra-cloud network speed may vary. For some data or message passing intensive applications, the latency might not be acceptable. Inter-cloud speed refers to the network speed between the cloud provider and the user or among different cloud providers (Ahuja, Curba, 2001)

Security challenges

related to system complexity, shared multi-tenancy, Internet-enabled services and loss of control are pertinent to cloud computing. Cloud computing might be a new way of delivering computing resources, but it is definitely not a new technology. This reflects that there is nothing more to fear as most security threats are already known and already have effective security measures already in place. This could mean that cloud computing security issues are more of a hype and over-reaction from sceptics aimed at stifling the adoption of cloud computing. 212 Cloud service providers are trying and investigating every possible avenue to overcome these failures and privacy, security, and trust violations. Some of them are redesigning their processes, while others are adding more security features and stringent firewalls. To ensure CIA (Confidentiality, Integrity and Availability) of client's data and information, cloud service provider should offer tested encryption schema, stringent access controls and schedule backups for data and information security and integrity. (Kaufman, 2009).

RESULTS

Exploring the Cloud Computing ecosystem from different perspectives offers interesting insights into the discrepancy between science and practice. For instance, the n-gram and cluster analyses revealed a strong focus on Cloud Computing providers in practice (cf. Table 3). Obviously, user companies are interested in new Cloud Computing services and products. Especially popular and long-established providers (like AWS and Salesforce) have a positive reputation (cf. Table 4), as they were first movers in Cloud Computing. In contrast, Microsoft's development platform Azure is discussed less benevolently (61.9 % negative words). The topic "technology" receives quite a positive interpretation in both practice and science (cf. Table 7). In comparison to Table 4 in which technical issues are evaluated rather negatively, a more detailed analysis is necessary. For instance, researchers [12] wrote:"A key concept in cloud computing is that cloud providers can use *resources more *pos*efficiently through statistical multiplexing, and may operate at lower cost than medium-sized data centers" (words that match the topic are highlighted with a "*"; positive/negative words by "*pos*" or "*neg*"). In practitioner-oriented articles, sentences can be found like:"Scaling a web application – adjusting *resources *pos*smoothly in response to growing traffic – is a do-or-die proposition for most web startups."[27] However, the analysis of cluster 2 "Technical Topics" (cf. Table 4) reveals that in the respective articles expressions like "problem", "costly" and "difficult" are used frequently, leading to a slightly negative sentiment (58.9% negative words). Nevertheless, we assume that the sentence-based sentiment analysis (Table 7) provides a more reliable picture on technical topics. Security issues in Cloud Computing offer interesting results as well. Table 4 and 5 suggest that security is positively discussed in practice. The outcomes presented in Table 7 provide a contradicting impression. In both practice and science, security issues are discussed fairly negatively. Here, the question arises, why there is no cluster which deals with security topics in science. Of course, several authors touch security issues, but their works on this topic are by far not as comprehensive so that the cluster algorithm could shape an additional cluster. For instance, some articles represent research in progress [32] and others are largely restricted to mere descriptions of the Cloud Computing paradigm. Moreover, an analysis of the term "security" shows that the strongest influence in science is shown in the general topic cluster (centroid: 0.046). Summarized, security issues are recognized as a success factor for Cloud Computing in both science and practice, but a strong research field is not built yet. Another negatively associated topic is compliance, which is exemplified by the following sentences from the scientific corpus:"From an individual's perspective, cloud computing presents *neg*risks of personal data exposure, and *neg*lack of awareness regarding the location and *jurisdiction of their data."[16] On the other hand, the following sentence is typical for a practitioner-based article:"For example, if there's a security *failure in a service that comprises financial data, a company might be required to notify customers under state or federal *law, and potentially face legal action."[2] The discussion on data centers (which are occasionally called clouds [40]) points at another difference and is worth discussing. It becomes evident from Table 3 that practitioners frequently discuss the topic of "clouds". In general, cloud concepts are differentiated between private (internal), public (external) and hybrid (hybrid types of the aforementioned) clouds [4]. In science, this topic is not extensively discussed (cf. Table 2 and 3). For example, Wlodarczyk et al. [40] support this finding as well and provide a first insight by developing an inter-company solution to deal with security issues. Summing up, in both practice and science there seems to be a detailed discussion what Cloud Computing actually is and is not [40]. In science the tone is slightly more negative on general topics, but in the end Cloud Computing has a quite positive sentiment. The three negative associated topics security, compliance and personnel indicate open issues. Apparently, companies have problems in adopting Cloud Computing services and integrate them into their IT architecture. Researchers try to uncover the core of Cloud Computing by analyzing business models and business processes (cf. Table 3), while practitioners are more interested in revealing information about market actors and new Cloud Computing services. Figure 3 gives an overview about the Cloud Computing ecosystem as resulting from our qualitative content analyses. It synthesizes the major topics and most relevant key words related to the still evolving Cloud Computing paradigm. Words discussed only in practice are highlighted with a "*". Purely scientific notions are marked by a "†". All other words are relevant to both practice and academia

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