THE TECHNICAL CHALLENGES OF CLOUD COMPUTING AND THEIR EFFECTS ON USAGE

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Thesis Abstract

Ahmet Cihat Baktır, “The Technical Challenges of Cloud Computing and Their Effects on Usage”

Cloud computing is a computer technology that enable convenient, on demand and pay-as-you-go access to a pool of shared resources. Recently, cloud computing is taken into consideration by the companies that operate in many different sectors. It has an important role in the competition between the companies as it grows and increases the efficiency of companies by providing advantages more than in-house system. However, number of researches and studies about cloud computing is relatively less in Turkey than other countries. A considerable amount of companies are still not eager to adopt the cloud computing because besides advantages it provides, there are also several crucial challenges that are seen as a barrier to use cloud computing.

The aim of this study is analyzing the technical challenges of cloud computing and their effects on usage in companies that operate in Turkey. The technical challenges that are analyzed in this study are gathered and classified by studying the related researches. The analysis results examine that whether Information Technology (IT) personnel in Turkey are aware of these challenges and these challenges affect the usage of cloud computing within their organization.

According to the findings, the challenges about cloud applications and cloud migration negatively affect the usage of cloud computing while the challenges about privacy and security, account control, cloud structure, virtualization, monitoring, Internet connection and SLA do not affect the usage of cloud computing in negative way.

Tez Özeti

Ahmet Cihat Baktır, “Bulut Bilişimin Teknik Zorlukları ve Kullanıma Olan Etkileri”

Bulut bilişim, paylaşılan kaynak havuzuna elverişli, isteğe bağlı olarak ve kullandığın-kadar-öde sistemi ile erişime olanak veren bir bilgisayar teknolojisidir.Son dönemde, bulut bilişim farklı sektörlerde yer alan şirketler tarafından dikkat çekmektedir. Bulut bilişim geliştikçe, şirketler arasındaki rekabette önemli bir rol almaktadır ve kurum içi sistemlere göre sağladığı avantajlarla birlikte şirketlerin etkinliğini arttırmaktadır. Fakat, bulut bilişim Türkiye’de önemli bir araştırma konusu olarak dikkat çekmemektedir. Azımsanmayacak sayıda şirket bulut bilişimi henüz benimsememiştir çünkü bulut bilişimin sağladığı avantajların yanında, kullanıma engel olarak görülen bazı önemli zorlukları da bulunmaktadır.

Bu çalışmanın amacı, literatürde yer alan teknik zorlukları analiz etmek ve bunların Türkiye’de çalışmakta olan şirketlerdeki kullanıma olan etkilerini incelemektir. Bu çalışmada kullanılacak olan teknik zorluklar, konu ile ilgili çalışmalardan seçilmiştir. Bu analiz, Türkiye’deki Bilgi Teknolojileri (BT) personellerinin bu zorlukların farkında olup olmadıklarını ve bu zorlukların kullanıma etki edip etmediğini incelemektedir.

Yapılan çalışmanın sonuçlarına göre, bulut bilişim uygulamaları ve bulut bilişime geçiş süreci hakkındaki zorluklar, bulut bilişim kullanımını negatif olarak etkilemektedir. Bunun yanında, güvenlik ve gizlilik, kullanıcı hesabı kontrolü, bulut bilişiminin yapısı, sanallaştırma, gözlem-takip ve Servis Düzeyi Anlaşması hakkındaki zorluklar ise bulut bilişimin kullanımını negatif yönde etkilememektedir.

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CHAPTER 1

INTRODUCTION

Cloud computing is a popular technology in the area of Information and Communication Technology (ICT) and seen as an attractive research area. The cloud computing concept starts with the pay-as-you-go model. It is seen as a competitive advantage by the companies because by using cloud computing, they do not have their own infrastructure like in-house system and they can use what they need whenever they want. However, most of the companies that operate in Turkey still do not have enough knowledge about cloud computing, its advantages and disadvantages. Because of this situation, these companies still cannot decide on adoption of cloud computing.

Cloud computing provides countless advantages for the companies which result in an increase in the efficiency of the companies and decrease in costs. It brings pay-as-you-go model for the companies which may decrease the IT infrastructure costs of the companies. Pay-as-you-go model means that there is not a constant fee for cloud computing, users pay only for the amount of the used cloud service which is similar to the usage of electricity. It is considered as one of the most important advantages of cloud computing because IT costs are important for the companies and the company whose IT costs is lower has more advantage in the competition. Also, companies that use cloud computing can focus much more on business-side instead of technical issues and this situation results in an increase in the efficiency of the company.

A considerable amount of the companies uses cloud computing because cloud systems are seen as secure and reliable. On the other side, an important portion of the

companies do not use cloud computing because they do not think that cloud computing is secure or reliable as much as in-house computing systems. This contrast is the result of lack of knowledge and unawareness of cloud computing. Same situation applies for the costs of IT departments. In different scenarios, companies may think that using cloud computing system will increase or decrease their IT costs. Shortly, the concepts within the cloud computing can relatively change as an advantage or disadvantage according to the perception of the organization, and knowledge of users about cloud computing.

The aim of this study is analyzing the technical challenges of cloud computing and their effects on usage within companies that operate in Turkey. There are many challenges given by studies but none of these studies make an analysis that shows if these challenges really affect the organizations' usage. In order to accomplish the analysis of the relationship between the technical challenges and usage of cloud computing, challenges which may be seen as an advantage by some of the studies are gathered from the literature. These gathered challenges are processed and non-technical ones are eliminated in order to focus on technical side of the cloud computing technology. To choose the most important technical challenges, the cloud experts' opinions are received and the least important challenges are not taken into consideration.

After the literature review, the technical challenges are classified under nine different titles which include sixty-nine different technical challenges in total. These titles are *privacy and security, account control, cloud structure, virtualization, monitoring, cloud applications, Internet connection, cloud migration and Service Level Agreement (SLA)*.

In order to collect the required data, a survey is conducted which includes questions about usage of cloud computing and these nine technical challenges with sixty-nine items in total. This survey is conducted on the IT personnel of the companies that operate in Turkey in order to get a clear insight of the current status of cloud computing. Even cloud computing is a hot topic recently, the number of studies about it is not enough in Turkey. Because of this, cloud computing cannot reach to high popularity level when it is compared with other countries than Turkey. This study will be a milestone in the literature by analyzing an undiscovered part of the cloud computing and giving an up-to-date situation in Turkey. Collecting different challenges from different sources and combining them into one study is the indicator of the importance of this study. Even this study presents IT standards as a solution for technical challenges; the future studies may find additional solutions to the challenges that affect the usage most.

The introduction part is followed by literature review in Chapter 2 which includes different aspects of cloud computing such as its different definitions, comparison of cloud computing with other solutions, service and deployment models of cloud computing, virtualization, usage, advantages, and challenges of cloud computing. Second chapter is followed by theoretical framework in Chapter 3 that presents the model of this study, hypotheses and the variables. Then, methodology takes place in Chapter 4 and findings & analysis of the survey that is conducted are mentioned in Chapter 5. Solutions by IT Standards are presented at Chapter 6, and conclusion, last review and related future works of this study take place in Chapter 7.

CHAPTER 2

LITERATURE REVIEW

What is Cloud Computing?

Cloud computing has different definitions in different studies. Making a concise definition or explanation of cloud computing is still seen as an obstacle by the studies.

Study that is made by Datta *et al*. (2012) indicates that cloud computing is not a new concept; which was first indicated in back to 1960s, when John McCarthy presumed that "computation may someday be organized as a public utility".

One of the most popular definitions of cloud computing that is made by the NIST explains cloud computing as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal effort or service provider interaction" (Mell and Grace, 2009). According to the definition made by the NIST, on-demand self-service, broad network access, resource pooling, rapid elasticity or expansion, and measured service are the essential characteristics of cloud computing (Mell and Grace, 2009).

Cloud computing indicates the applications delivered as services, which are provided by the hardware and systems software in the data centers, via the Internet as stated by Armbrust *et al*. (2010). This study calls cloud as the data center hardware and software and states that cloud has the potential to transform IT industry including the design of IT hardware, making software more attractive as a service. Cloud computing is a phenomenon that represents a major change in the IT services

(Marston *et al*., 2011). This study also states that, there are different definitions of cloud computing but none of them are comprehensive enough to identify all the characteristics of it. They define cloud computing formally as "an information technology service model where computing services (both hardware and software) are delivered on-demand to customers over a network in a self-service fashion, independent of device and location" (Marston *et al*., 2011). Cloud computing is defined as a solution in which computing resources such as hardware, software, networking and storage are provided rapidly to users with regards to their demands (Masiyev *et al*., 2012). This definition provides the characteristics of cloud computing which are computation as a service, transparency, cost reduction, elasticity and scalability, and disaster-proof.

Asaduzzaman *et al*. (2012) defines cloud computing as "an emerging technology allowing a large number of interconnected computers, hardware and/or software to be rented as a commodity like electricity". They state that cloud computing has enough potential to meet computing demands. Cloud computing is a critical term in the IT world (Low *et al*., 2011). Erdogmus considered cloud computing as "a pool of highly scalable, abstracted infrastructure is capable of hosting end-customer applications that are billed by consumption" (as cited in Low *et al*., 2011). According to Wall Street Journal, CEO of Oracle, Larry Ellison states that "… we've defined Cloud Computing to include everything that we already do … I don't understand what we would do differently … other than change the wording of some of our ads" (as cited in Fox *et al*., 2009). According to a different perspective, development of the processing and storage technologies parallel to the development of the Internet, computing resources have become cheaper, more powerful and globally available, and these technologies have enabled the model called cloud

computing in which resources are provided as general utilities to be used by users over the Internet on-demand (Zhang *et al*., 2010).

Cloud computing has become a very promising model for both consumers and providers in distinct areas of enterprises (Lee and Zomaya, 2012). A cloud consists of multiple resources which are distributed and heterogeneous. An illustration of cloud computing model is shown at Fig. 1 which includes user devices, data centers and virtual machines.

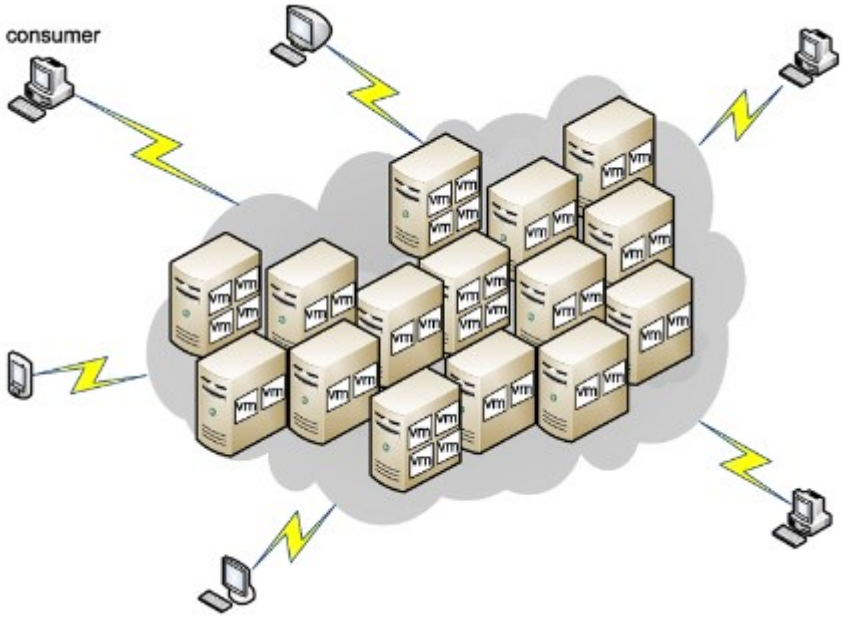

Fig. 1 Cloud model (Lee and Zomaya, 2012)

According to Leavitt (2009), cloud computing has an important trend and it is expected that cloud computing has an ability to modify IT processes and market while users with different types of devices such as PCs, laptops and smart phones can access applications, platforms, storage and processing over the Internet. Cloud computing has lots of benefits and is seen as an innovative computing model for both storage and applications (Egwutuoha *et al*., 2013). This study defines the players of cloud computing as cloud users and cloud providers.

Forrester interviewed more than thirty companies and Staten *et al*. (2008) defines cloud computing with the help of these interviews as "a pool of abstracted, highly scalable, and managed compute infrastructure capable of hosting end-customer applications and billed by consumption."

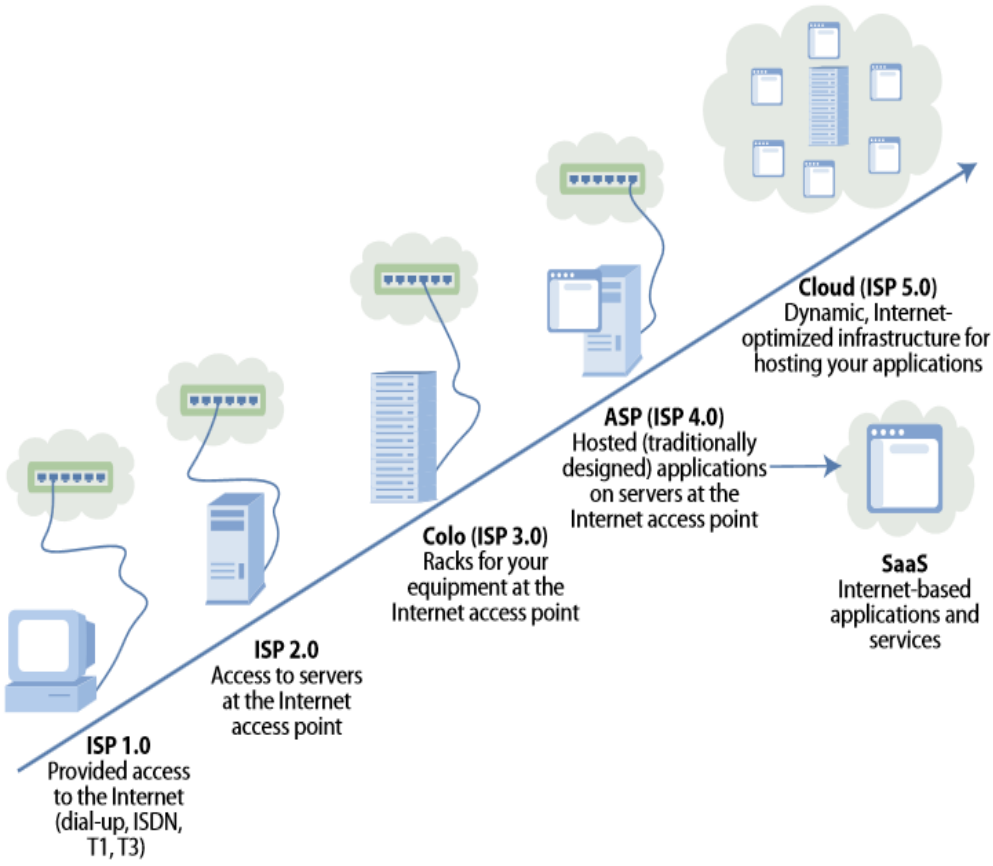

Fig. 2 Cloud Computing: The Latest Evaluation of Hosting (Staten *et al*., 2008) (Source: Forrester Research Inc.)

As stated by Kant, the term of Cloud Computing became popular in early 2007, and this term refers to virtual servers, distributed hosting in data center and shared resources which are available through the Internet (as cited in Kumar and Vidhyalakshmi, 2012). The Cloud has reconstructed the way of delivering IT services (Kumar and Vidhyalakshmi, 2012). There is a shift to use the cloud among the organizations with the faster, cheaper and more reliable Internet (Helvacioglu

Kuyucu, 2011). Cloud computing is based on delivering information, which is Internet-based and real time technology services which is seen as the most important aspect of cloud computing by this study.

According to Buyya *et al*. (2008):

- *A cloud is a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service level agreements (SLA) established through negotiation between the service provider and customers.*

Additionally, by using cloud-based system, consumers will be able to access applications and data on demand wherever the consumer is (Buyya *et al*., 2008). In other words, cloud seems to be a single point of access for customers to use computing.

Cloud computing is not a new concept for the web applications; it allows most cost-effective development of scalable web portals with highly available and fail-safe instructions (Rimal *et al*., 2009). Cloud computing has just emerged as a significant commercial success and it will play an important role in the business area (PR Newswire, 2013). In the same study, the need for cloud computing is explained as "companies are often held back by an inflexible and complex IT infrastructure that cannot keep up with the evolving needs of business and these restraints result in slow deployment of critical applications and services, limited resources, poor operation management, and unpredictable system integration" and to satisfy this need, cloud computing appears as an interesting and alternative solution for an important portion of the companies.

Comparison of Cloud, Grid and Cluster Computing

Cloud computing is not a new concept; it has a connection to the Grid Computing paradigm, and other relevant technologies such as utility computing, cluster computing, and distributed systems (Foster *et al*., 2008). According to the statement made by this study, the vision of cloud computing and grid computing is nearly same – to reduce cost of computing, increase reliability, and increase flexibility by transforming computers from something consumers buy to something that is operated by a service provider but there are differences between these concepts because grid computing is an older solution which cannot satisfy the need to analyze big data. This need is met by cloud computing.

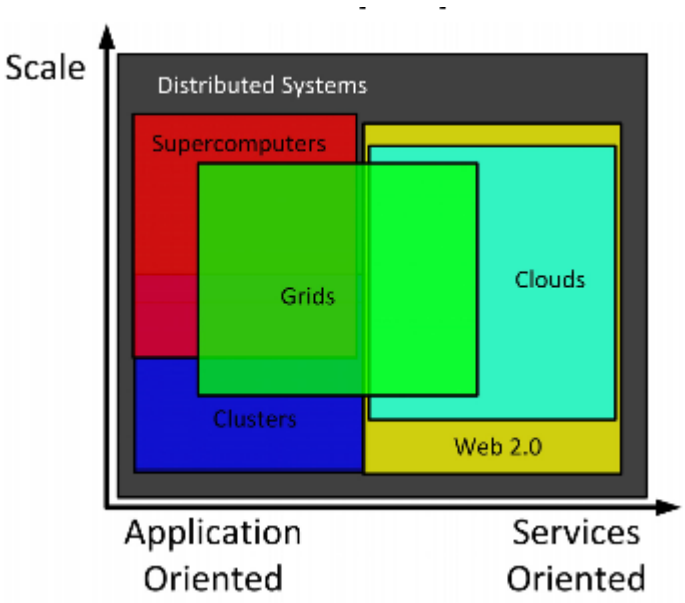

Fig. 3 Comparison of cloud-grid-cluster (Foster *et al*., 2008)

Ian Foster gave a three checkpoint list to help to define the concept of Grid (as cited in Foster *et al*., 2008):

- Coordinates resources that are not subject to centralized control
- Uses standard, open, general-purpose protocols and interfaces

- Delivers non-trivial qualities of services

The third point also holds for cloud computing, but other points are not clear if they hold for today's cloud (Foster *et al*., 2008).

Grid computing is defined as "a network that is not in the same place but distributed resources such as computers, peripherals, switches, instruments, and data" (Zhang *et al*., 2010). At the same study, utility computing is defined as paying for what is used on shared servers which is similar to the public utility concept. Cloud computing provides on-demand resource provisioning and this feature eliminates over-provisioning when it is used with utility pricing. In other words, cloud computing is a different model of grid computing. This study states that, both cloud and grid computing group all resources as a pool of resource. The structure of grid is to complete a stated assignment while cloud computing is not designed to complete a stated assignment but supplying a general application.

Cluster is defined as "a collection of parallel or distributed computers which are interconnected with using high-speed networks" by Sadashiv and Kumar (2011). They also state that, the distributed or parallel computers work together in the execution of assignments that would be not reasonable enough to execute on an individual computer. Also when multiple computers are linked together within same cluster, they share computational load of process as a single virtual computer. As stated by Krauter *et al.* to reach shared goal, computers from multiple administrative domains are combined by grid computing which may fade then (as cited in Sadashiv and Kumar, 2011). The comparison between grid, cloud and cluster computing that is made by the same study is represented by Table 1.

Table 1 Comparison between Grid, Cloud and Cluster Computing (Sadashiv and Kumar, 2011)

	Clusters	Grids	Cloud
SLA	Limited	Yes	Yes
Allocation	Centralized	Decentralized	Both
Resource Handling	Centralized	Distributed	Both
Loose Coupling	No	Both	Yes
Protocols/API	MPI, Parallel Virtual	MPI, MPICH-G, GIS, GRAM	TCP/IP, SOAP, REST, AJAX
Reliability	No	Half	Full
Security	Yes	Half	No
User Friendliness	No	Half	Yes
Virtualization	Half	Half	Yes
Interoperability	Yes	Yes	Half
Standardized	Yes	Yes	No
Business Model	No	No	Yes
Task Size	Single Large	Single Large	Small & Medium
SOA	No	Yes	Yes
Multi-tenancy	No	Yes	Yes
System Performance	Improves	Improves	Improves
Self Service	No	Yes	Yes
Computation Service	Computing	Max. Computing	On Demand
Heterogeneity	No	Yes	Yes
Scalable	No	Half	Yes
Inexpensive	No	No	Yes
Data Locality Exploited	No	No	Yes
Application	HPC, HTC	HPC, HTC, Batch	SME Interactive Apps.
Switching Cost	Low	Low	High
Value Added Services	No	Half	Yes

There are several computing models to deliver utility computing perception such as cluster computing, Grid computing and Cloud Computing (Buyya *et al*., 2009). According to the same study, the resources in clusters are located in a single administrative domain and managed by a single entity while in Grid systems resources are shared across multiple administrative domains. The characteristics of Cloud computing are same with both cluster's and grid's but it has own attributes and capabilities additionally. It is stated that clouds provide services to users who do

not have any knowledge about the location of the infrastructure and resources. The key characteristics of clusters, Grids and Clouds are stated in Table 2 by this study.

Table 2 Key Characteristics of Clusters-Grids-Clouds (Buyya *et al*., 2009)

Characteristics	Clusters	Grids	Clouds
Population	Commodity computers	High-end computers (servers, clusters)	Commodity computers and high-end servers and network attached storage
Size/scalability	100s	1000s	100s to 1000s
Ownership	Single	Multiple	Single
Interconnection network speed	Dedicated, high-end with low latency and high bandwidth	Mostly Internet with high latency and low bandwidth	Dedicated, high-end with low latency and high bandwidth
Security/privacy	Traditional login/password based. Medium level of privacy – depends on user privileges	Public/private key pair based authentication and mapping a user to an account. Limited support for privacy	Each user/application is provided with a VM. High security/privacy is guaranteed. Support for setting per-file access control list
Discovery	Membership services	Centralized indexing and decentralized info services	Membership services
Service negotiation	Limited	Yes, SLA based	Yes, SLA based
User management	Centralized	Decentralized and also virtual organization-based	Centralized or can be delegated to third party
Resource management	Centralized	Distributed	Centralized/distributed
Allocation	Centralized	Decentralized	Both centralized/decentralized
Standards	Virtual Interface Architecture based	Some Open Grid Forum standards	Web Services (SOAP and REST)
Single system image	Yes	No	Yes but optional
Capacity	Stable and guaranteed	Varies but high	Provisioned on demand
Failure management	Limited	Limited	Strong support for failover and content replication. VM migration
Pricing of services	Limited, not open market	Dominated by public good or privately assigned	Utility pricing, discounted for larger customers
Internetworking	Multi-clustering within an organization	Limited adoption	High potential
Application drivers	Science, business, enterprise computing, data centers	Collaborative scientific and high throughput computing applications	Dynamically provisioned legacy and web applications. Content delivery
Potential for building 3rd party or value-added solutions	Limited due to rigid architecture	Limited due to strong orientation for scientific computing	High potential – can create new services by dynamically provisioning
Node Operating System (OS)	One of the standard OSs (Linux, Windows)	Any standard OSs (dominated by Linux)	A hypervisor (VM) on multiple OSs run

Cluster computing can be defined as a group of local computers which are connected straight with extremely high speed network connections to operate as a single computer (Asaduzzaman *et al*., 2012). Same study defines grid computing as a network based computing where resources such as network devices, computers, and information may not be in the same area but they may be separated. All the nodes in a cluster are set to perform the same task, controlled and scheduled by same operating system (OS) while all nodes in a grid perform different tasks from each other, may consist of several clusters and work as OS independently. It is stated in the same study that cloud computing is even a broader concept than grid where resources are physically spread and these resources are accessible via a computer network. Huge tasks can be split into smaller sub-tasks in Grid computing for each node to perform its own subtasks. Also it is stated that like grid computing, cloud computing provides a wide service pool by organizing all services but these services are provided in order to complete a particular task. This study summarizes some important attributes of cluster, grid and cloud computing in Table 3.

Table 3 Comparison of Cluster, Grid and Cloud (Asaduzzaman *et al*., 2012)

Characteristics	Cluster	Grid	Cloud
Origination	1960s	Early 1990s	Late 1990s
Scalability	Poor	Average	High
Node OS (original)	Linux	Unix	Various OSs
Ownership	Single	Multiple	Single
Single system image	Yes	No	Yes but optional
Failure management	Limited	Limited	Strong
Resource management	Centralized	Distributed	Centralized/distributed
Security management	Medium level	Limited	Security is guaranteed
User management	Centralized	Decentralized	Centralized/decentralized
Allocation/scheduling	Centralized	Decentralized	Centralized/decentralized
Speed	High bandwidth	Low bandwidth	High bandwidth
Capacity	Guaranteed	High	Provided on demand
Uniformity	Homogeneous	Heterogeneous	Heterogeneous
Coupling	Tightly coupled	Loosely coupled	Loosely coupled
Treat as a commodity like electricity	Not appropriate	Not appropriate	Very appropriate

Service Models

Cloud computing solutions are composed of cloud services offered by a service provider and there are currently three major services of cloud computing stated by Masiyev *et al*. (2012):

- *Infrastructure as a Service (IaaS)*
- *Platform as a Service (PaaS)*
- *Software as a Service (SaaS)*

At the IaaS level, the product is the hardware and hardware-related services, the PaaS level offers hardware-independent solutions to software developers such as OS, virtual machines and infrastructure software, and SaaS is the most visible layer of cloud computing for users where the software is provided and managed by one or more service providers along pay-as-you-go model as stated in the same study.

The delivered services of cloud computing have been referred to as Software as a Service (SaaS) but some of the vendors use titles such as IaaS (Infrastructure as a Service) and PaaS (Platform as a Service) in order to describe their products (Armbrust *et al*., 2010).

There are three types of cloud service models; Cloud Infrastructure as a Service (IaaS), Cloud Platform as a Service (PaaS) and Cloud Software as a Service (SaaS) (Helvacioglu Kuyucu, 2011). IaaS involves the provision of processing, storage, networks and other major computing resources. Amazon, IBM, and Microsoft's Azure can be given as examples for IaaS. PaaS provides computational resources via platform and Google App Engine, Windows Azure, and Force.com can be examples for PaaS. Lastly, SaaS qualifies provider's applications running on a cloud infrastructure to be ready for usage. The most popular examples for SaaS are Google Docs and Salesforce.

Along IaaS, cloud vendor provides the computing resources such as servers, storage, and connectivity domains with presenting the cost to the clients according to their usage (Garrison *et al*., 2012). In the same study, PaaS is described as a different model in which a cloud vendor provides the platform that enables users to deploy and create applications through the Internet. This study lastly defines SaaS as the software hosted by the cloud vendor which can be accessed by the organization through the Internet.

Mahesh *et al.*, Sultan, Truong and Dustdar, Ojala and Tyrvainen, Creeger, Li *et al.*, Durkee, Marston, Li, Bandyopadhyay, Zhang and Ghalsasi, Karadsheh, Rath, Neves, Marta, Correira, and de Castro and McAfee state in their studies that there are three cloud computing services (as cited in Gupta *et al.*, 2012):

- *Software as a Service (SaaS) is a service where applications like Word processing, Customer Relationship Management (CRM) are available over the Internet for the consumption of end-user. This is the biggest cloud model and its vendors are Yahoo Mail, Gmail, Hotmail, Facebook, Twitter, Google Apps, Salesforce.com etc.*
- *Platform as a Service (PaaS) is a service where platforms, software development kits and tools are available online. Microsoft Azure services, Google App Engine platform and Force.com can be given as examples of PaaS.*
- *Infrastructure as a Service (IaaS) refers to the physical devices like VMs, storage devices which are located in one central place but they can be accessed and used over the Internet. Amazon EC2 can be given as example of IaaS.*

Based on the requirements, the customers can choose one or more services provided by cloud as stated by Pocatilu *et al*. (2010) and these services are given by the study of Creeger (as cited in Pocatilu *et al*., 2010):

- *SaaS (Software as a Service)*
- *PaaS (Platform as a Service)*
- *IaaS (Infrastructure as a Service)*

The cloud computing architecture is divided into four different layers according to Zhang *et al*. (2010):

- The hardware layer
- The infrastructure layer
- The platform layer

- The application layer

The hardware layer carries out the physical resources of cloud, the infrastructure layer creates a pool of storage and computing resources, the platform layer is built on top of the infrastructure and consists of OS, and the application layer is at the highest level of hierarchy which consists of the essential cloud applications (Zhang *et al*., 2010). These layers are shown in Figure 4 with examples for each.

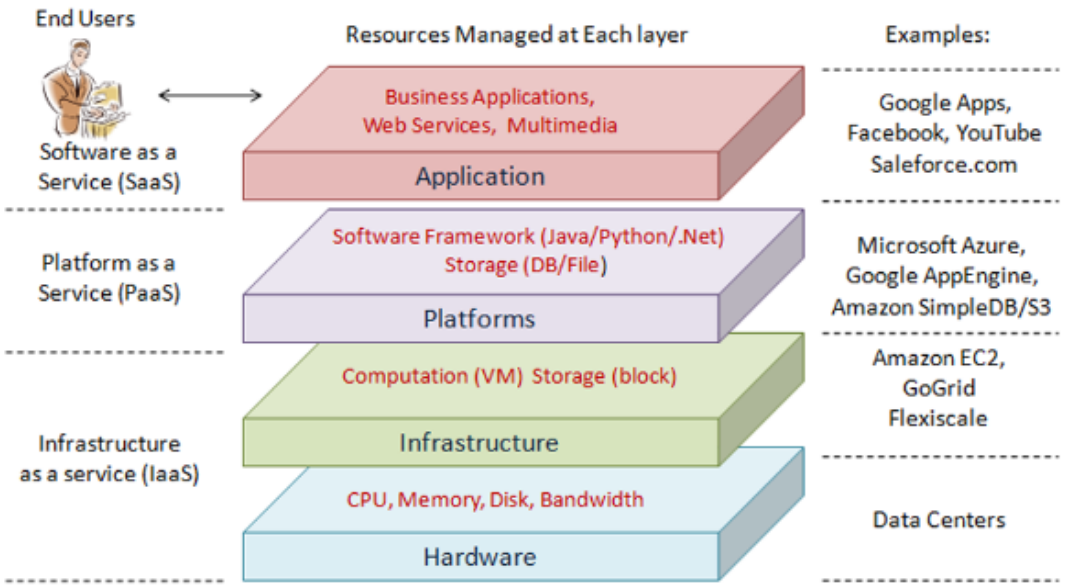

Fig. 4 Layers of cloud computing (Zhang *et al*., 2010)

There are three service models of cloud computing and these are explained as "the resources such as storage or network could be taken as a service from cloud (Infrastructure as a Service [IaaS]) or the platform to develop software for the organization could be taken as a service (Platform as a Service [PaaS]) or the whole software itself can be taken from the cloud as service (Software as a Service [SaaS])" (Kumar and Vidhyalakshmi, 2012). The same study states that SaaS is more valuable than other services to the organizations.

In the SaaS category, different software applications are provided by the service provider through the Internet as rental, the PaaS category represents cloud services that access to a broad variety of resources such as computer, database, and storage functions within a virtualized platform provided over the Internet, and the IaaS category is the delivery of computer infrastructure as a service (Low *et al*., 2011).

Clouds can use the on-demand computing items to deliver software as a service (SaaS), such as Salesforce.com, or provide a platform as a service (PaaS), such as Amazon EC2 (Grossman, 2009).

Deployment models

There are two types of cloud deployment models; when a cloud is made available with a pay-as-you-go model to a general public, it is called a public cloud, and the term private cloud mentions the data centers within business or other organizations which are not made available to the general public like public cloud (Armbrust *et al*., 2010).

There are different cloud deployment models within organizations (Marston *et al*., 2011). According to their definition, the public cloud is available from a service provider through the Internet which is a cost-effective solution, especially for small or medium sized businesses. Google Apps is a common example of public cloud which is used by considerable amount of organizations. Study made by Iosup *et al*. (2011) states that public cloud is not restricted within an enterprise or organization. A private cloud offers many of the benefits provided by public cloud computing environment, such as being elastic and service based while it is managed within an organization. Private clouds are often convenient for larger establishments

by providing better control over the cloud infrastructure. A community cloud is controlled and used by a group of organizations that have common objective or security requirements (Marston *et al*., 2011).

According to Masiyev *et al*. (2012), cloud computing classifications are Public, Private or Hybrid clouds. They define public clouds as cloud services provided by third parties but hosted and managed by service providers. By using public cloud, customers can access to and use the services and physical resources while they are charged only based on their use. They define private clouds as networks and data centers for the particular use of the organization and hybrid clouds as combination a of Private and Public cloud.

Cloud computing is classified under four groups according to type of use (Henkoğlu and Külcü). First of these four groups is public cloud which produces services for the general use on the Internet via web interface such as Google Apps, Amazon and Windows Azure. Second one is private cloud which composed of cloud services provided for a specific organization or institution. Hybrid cloud gathers public and private cloud together. Lastly, community cloud, which is the wider version of private cloud, is provided for a specific community or group.

Study made by Subashini and Kavitha (2011) proposes the Table 4 which compares the cloud service deployment models composed of public cloud, private/community cloud and hybrid cloud.

Table 4 Cloud service deployment models (Subashini and Kavitha, 2011)

	Infrastructure management	Infrastructure ownership	Infrastructure location
Public cloud	Third-party provider	Third-party provider	Off-premise
Private/community cloud	Organization or third-party provider	Organization or third-party provider	On-premise or off-premise
Hybrid cloud	Both organization and third-party provider	Both organization and third-party provider	Both on-premise and off-premise

There are different types of cloud, each with its own benefits and obstacles as stated by Zhang *et al*. (2010):

- *Public cloud: A cloud in which service providers offer their resources as services to the general public.*
- *Private cloud: Also known as internal clouds, private clouds are designed for exclusive use by a single organization. A private cloud may be built and managed by the organization or by external providers.*
- *Hybrid clouds: A hybrid cloud is a combination of public and private cloud models that tries to address the limitations of each approach. In a hybrid cloud, part of the service infrastructure runs in private clouds while the remaining part runs in public clouds.*
- *Virtual Private Cloud (VPC): An alternative solution to addressing the limitations of both public and private clouds is called Virtual Private Cloud (VPC). A VPC is essentially a platform running on top of public clouds.*

According to the NIST definition, there are four different deployment models and these deployment models are defined by Mell and Grance (2009):

- *For private cloud, the cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple customers. It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.*
- *For community cloud, the cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns. It may be owned, managed, and operated by one or more organizations in the community, a third party, or some combination of them, and it may exist on or off premises.*
- *For public cloud, the cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider.*
- *Lastly, for hybrid cloud, the cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability.*

Cloud models can be defined by three different types according to the study made by Rimal *et al*. (2009):

- *Private cloud: Data and processes are managed within organization without the restrictions of network bandwidth, security exposures and legal requirements that using public cloud services across open, public networks might entail.*

- *Public cloud: It describes the cloud computing in the traditional mainstream sense, whereby resources are dynamically provisioned on a fine-gained, self-service basis over the Internet, via web applications/web services, from an off-site third-party provider who share resources.*
- *Hybrid cloud: The environment is consisting of multiple internal and/or external providers.*

Virtualization

Server virtualization's aim is increasing the resource utilization by dividing the physical devices (servers) into multiple virtual devices each with its own environment (Baktir *et al*., 2013). Server virtualization technology enables multiple virtual machines to exist and operate on a single physical server while the problems that are occurred can be solved by migration of virtual machines (Khanna *et al*., 2006). According to a study, it is stated that only 20% of total workloads are running on the virtual machines by 2012 (Bittman, 2010). According to the study made by Baktir *et al*. (2013) in Turkey, more than half of the participants of the survey states that more than 70% of their servers are virtualized.

Virtualization has become a major piece of cloud system with the idea of abstraction and encapsulation (Foster *et al*., 2008). The importance of virtualization is expressed by this study, and they state that clouds need to run multiple user applications, and all the applications appear to the users as if the users could use all available resources in the cloud. According to this study, virtualization provides the required abstraction. The underlying infrastructure can be merged as a pool of resources and resource layer can be built on top of them. Also it is stated that

virtualization enables each application to be encapsulated to provide better security, manageability, and isolation. However it is stated that grids do not rely on virtualization technique as much as Cloud services do.

Cloud computer can provide better utilization of resources by using virtualization technique to remove the workload from the client-side (Seccombe *et al.*, 2009). Virtualization technique is one of the main components of a cloud (Subashini and Kavitha, 2011). The same study indicates that ensuring the isolation of each virtual machines running on a particular physical machine from each other is an important duty of virtualization. Virtualization is one of the main innovative technologies utilized by cloud computing with regards to virtual infrastructures, scalability and resource sharing (Gonzalez *et al*., 2012).

Cloud computing uses several ways to meet the customer necessities and virtualization is one of them but it brings its own vulnerability (Younis and Kifayat, 2013). Virtualization is a key element in cloud computing, because using virtualization provides notable benefits to cloud (Subashini and Kavitha, 2011).

With using virtualization, clouds can serve with a single set of physical resources to a large consumer platform with a wide range of needs (Iosup *et al*., 2011). The Amazon Elastic Computing Cloud is an example for IaaS cloud computing service that provides Amazon's large computing infrastructure to its users. The elasticity of service enables user to boost or compress its infrastructure by installation of new virtual machines as stated by the same study.

It is stated that virtualization can provide important benefits for cloud computing by enabling virtual machine migration in order to load balancing while

virtual machine migration enables effective procurement in data centers (Zhang *et al*., 2010).

Applications that run on virtual machines are separated from other virtual machines which reside on the same physical device (Viega, 2009). The study explains that to scale the high work-loads easily, providers can automatically increase or decrease the number of virtual machines on that physical device.

Virtual machine provisioning refers to the instantiation of one or more Virtual Machines (VMs) (Quiroz *et al.*, 2009). The virtual machine provisioning is one of the steps of cloud provisioning which is the process of application management and formation on cloud infrastructures (Calheiros *et al*., 2011).

Virtualization technology allows installing more than one operating system and virtual machine on one physical server, and executing them concurrently but detached from each other (Egwutuoha *et al*., 2013). This study defines the virtualization as an enabling technology for cloud computing, as it allows administrators of large data centers to strengthen existing resources which are unused and prevent these unused resources from being wasted. Besides, cloud computing is a pool of virtualized computer resources, and provides them with pay-as-you-go model to its users as stated by this study. Cloud services have been mostly enabled by the advancement in the area of virtualization and these cloud services are usually entirely virtualized while grid computing systems were generally installed on physical machines. In other words, cloud services provide more and advanced features to control the tasks than grid computing.

Virtualization is defined as a "technology that abstracts the coupling between the hardware and OS" (Rimal *et al*., 2009). Also, virtualization indicates the

abstraction of logical resources away from their elemental physical resources. According to a common interpretation made by this study, server virtualization is matching of single physical resources to multiple logical representations and sections.

For Infrastructure as a Service, infrastructure providers manage a set of computing resources such as storing and processing (Vaquero *et al*., 2008). As stated by this study, through virtualization, infrastructure providers are able to isolate, assign and dynamically resize the mentioned computing resources to build ad-hoc systems requested by customers and the service providers. The minimum definition of cloud computing made by this study includes the collection of features such as scalability, pay-per-use utility model and virtualization.

The underlying structure that enables cloud computing is virtualization technology on which cloud infrastructure mostly relies (Christodorescu *et al*., 2009). The relation between cloud computing and virtualization is expressed as "cloud computing already leverages virtualization for load balancing via dynamic provisioning and migration of virtual machines among physical nodes" (Lombardi and Di Pietro, 2011). The same study indicates that cloud computing is a service model for IT provisioning which is often based on virtualization.

Usage of Cloud Computing

Cloud computing is not a minor or an undeveloped part of IT (Patidar *et al*., 2012). According to this study, research firm IDC forecasted that cloud computing will reach $42 billion in 2012. Analyst firm Gartner forecasted an average annual growth

rate of worldwide SaaS with 22.1% through 2011, by reaching $14.5 billion (Gartner, 2008).

Worldwide cloud services revenue is forecasted to reach $68.3 billion in 2010, a 16.6% increase from 2009 revenue of $58.6 billion, according to Gartner Inc. while worldwide cloud services revenue is expected to reach $148.8 billion (Pettey and Tudor, 2010). Same study indicates that according to Gartner's estimation, along with the next five years, enterprises will spend $112 billion cumulatively on SaaS, PaaS and IaaS. The U.S. share of the worldwide cloud services market was 60% in 2009 and will be 58% in 2010, but by 2014, this percentage will be decreased to 50% because other countries than U.S. begin to adopt cloud services by significant amounts.

According to Columbus' study, Forrester Research firm predicted that the public cloud computing market will grow from $26 billion in 2012 to $160 billion in 2020 (as cited in Choudhary and Vithayathil, 2013). According to IDC cloud research's study, International Data Corporation (IDC) forecasted that public IT cloud services would increase to $72.9 billion in 2015 from $21.5 billion in 2010 while the cloud services growth rate surpasses the overall IT services with global rate of 6.7% (as cited in Choudhary and Vithayathil, 2013).

Worldwide cloud computing market is growing at a rapid rate and it is expected that this rate will reach to $25 billion by the end of 2013 (Wireless News, 2010). According to the same study, The SaaS market is growing at 17.04% and reached to $9 billion by the end of year 2009. It is expected that PaaS market size will reach $400 million by the year 2013. Moreover, the number of data center grows on average 9% each year during 2002 and this grow is expected to continue till 2020.

According to another study, it is determined that the value of global cloud computing services market will reach $35.6 billion in 2013 (PR Newswire, 2013).

According to a survey that we conducted in 2011, 61% of the participants indicate that they are using cloud computing services. 77.1% of the respondents think that, cloud computing will cause a shift in the area of IT and about 22%, 21% and 21% of the respondents respectively uses SaaS, PaaS, and IaaS at work.

Advantages of Cloud Computing

Cloud computing is widely acknowledged today due to its major advantages as stated by Pocatilu *et al*. (2010):

- *The cost is low or even free in some cases. Also there are no costs (or very small ones) for hardware upgrades.*
- *For some applications, it can be used even in the offline mode, so when client goes back online a synchronization process is refreshing the data.*
- *The strong connection that exists today between the users and their personal computer can be completely broken because a customer can reach the same result by using any Internet connected device.*
- *Devices with minimal hardware requirements could be successfully used as cloud clients.*
- *In order to become part of the cloud, there is no need to download or install specific software, only Internet connection is required.*
- *The cost of licensing different software packages is moved to the data center level, so there is no need to upgrade the local system when new service packs or patches are released.*

- *Crash recovery is nearly unneeded. If the client computer crashed, there are almost no data lost because everything is stored into the cloud.*

The advantages of public cloud when it is compared to typical data centers are the existence of infinite computing resources on demand, elimination of an up-front commitment by Cloud users, ability to pay for use, economies of scale, higher utilization and simplifying operation, and increasing the utilization via resource virtualization (Armbrust *et al*., 2010).

There are several key advantages of cloud computing (Marston *et al*., 2011). Cloud computing decreases the cost for smaller organizations in order to compete, can provide an almost immediate access to hardware resources with no upfront capital investments for users, lowers the IT barriers to innovation, provides easier scale, and makes new classes of applications and delivers services available that were not possible before. According to Symantec.cloud (2011), the benefits of cloud computing are reduced costs that are related to IT and increased business skill.

One of the most important effects of cloud computing on today's organization is providing cost-efficiency (Masiyev *et al*., 2012). There are also several characteristics of cloud computing which brings advantage to users such as transparency, elasticity, scalability, and durability and business continuity.

Cloud computing provides resources such as computers at a lower cost (Asaduzzaman *et al*., 2012). The users of cloud services do not need to know the structure of cloud services as stated by the same study. This study proposes that the cloud services are getting more popular mainly among organizations that would like to store and handle their information. This situation would make cloud services cheaper, management easier and profit to reach maximum level. The cloud services

are accessible from anywhere in the world by appearing as a single point of access in order to satisfy customers' needs (Rimal *et al*., 2009).

One of the most valuable advantages of adopting cloud computing is making some of the IT administrative time available, which can be used for the business side of the organization then (Creeger, 2009). This study states some variables that affect the adoption of cloud computing by micro and small businesses:

- Cost reduction
- Ease of use and convenience
- Reliability
- Sharing and collaboration
- Security and privacy

If cloud systems are well-designed, the code which someone might want to exploit will be on the server side instead of client side, which is expressed as a significant advantage provided by a cloud system (Viega, 2009).

Cloud computing provides several important benefits (Grossman, 2009). Firstly, cloud computing's pay-per-use model offers some advantages such as reduced capital expense, a low barrier to entry, the ability to scale up depends on the demand, and the economies of scale. Also this study states that cloud computing architectures are extremely scalable.

Cloud computing provides several features that make it attractive to organizations (Zhang *et al*., 2010):

- *No up-front investment*
- *Lowering operational cost*

- *Highly scalable*
- *Easy access*
- *Reducing business risks and maintenance expenses*

According to PR Newswire (2013), cloud computing drivers are easy consolidation, the growth of open source cloud computing solutions, flexible and dynamic infrastructure, driving innovation, expanding collaboration, lowering costs.

There are some features of cloud computing that make it unique when a traditional system is considered (Staten *et al*., 2008). The cloud computing infrastructure is abstracted, fully virtualized and equipped with dynamic infrastructure software while the fee depends on the level of usage by users. Cloud, which is an OS independent solution, is also free of long-term contracts, application and software installation.

According to Leavitt (2009), Russ Daniels, Hewlett-Packard's vice president and chief technology officer, states that "the shift to cloud will dramatically reduce the cost of information technology, free customers from the expense and hassle of having to install and maintain applications locally". Simon Heron of Network Box stated that cloud computing also lowers the cost of application development and increases the stability of process as stated by the same study. Working through the large platforms shared by huge amount of users makes cloud computing cheaper according to this study. There are also several additional advantages proposed such as availability, application integration and support, and flexibility. This study present that according to the Forrester's Staten, for most enterprise data centers, the ratio of resource usage to the total capacity is 50%.

The main objective of cloud computing is using distributed sources more effectively and solving large-scale computation problems (Sadiku *et al*., 2014). Resources in the cloud are transparent to the user; there is no need for the users to know location of these resources. The major advantages of cloud computing presented by this study are on-demand self-service, universal network access, location-independent resource pooling and removal of risks. There are also additional advantages proposed such as lower costs, ease of utilization, quality of service and reliability.

There are several benefits of cloud computing (Thomas, 2009). Firstly, cloud computing reduces the total cost of ownership and this study gives an example for this benefit such as pay by use model of Amazon EC2 services. Another advantage of cloud computing is increased scalability and reliability which also brings benefits of backup, reduced latency, fault tolerance and the ability to support greatest demands. Last but not least, there are additional advantages of cloud computing such as enabling collaborative applications, increased application development agility and increased end user computing.

Study made by Rao and MeeraSaheb (2013) states that there are several benefits of Software as a Service (SaaS):

- *Easier administration*
- *Automatic updates*
- *Compatibility*
- *Easier collaboration*

Moreover, same study states the benefits of Platform as a Service (PaaS) which are:

- *OS features can be changed and upgraded frequently*
- *Rapid construction of business applications*
- *Reduced total cost of ownership*

There are also general advantages of cloud computing proposed by the same study that are composed of scalability, openness, carefree, security and just-in-time which enables for users to continue their work without wasting any time.

One of the important benefits of cloud computing is its pay-as-you-go model which removed the huge initial investments for IT infrastructure (Egwutuoha *et al*., 2013). Also, through cloud computing the need to plan ahead for provisioning is greatly reduced while demands can be managed easily thanks to its scalability. High availability and fault-tolerance are also some alternative benefits of cloud computing because cloud providers offer highly available services such as S3 provided by Amazon Web Services. Cloud systems refer to high-performance resource pool which can be easily accessed through the Internet via any device such as PCs, smart phone, tablets at anytime from anywhere.

Challenges of Cloud Computing

The unique characteristics of cloud computing may result in several threat (Zissis and Lekkas, 2012). Some of these threats are data compromise, privacy, confidentiality, authorization, data control, data interruption, integrity, management console security, malicious insiders, account control, and multi-tenancy issues. There are also several obstacles to growth of cloud computing (Armbrust *et al*., 2010). These obstacles are:

- Business continuity and service availability

- Data lock-in
- Data confidentiality/auditability
- Data transfer bottlenecks
- Performance unpredictability
- Scalable storage
- Bugs in large-scale distributed systems
- Scaling quickly
- Reputation fate sharing
- Software licensing

To accept cloud computing as a viable choice in business, the issues of cloud computing needs to be cleared up (Marston *et al*., 2011). One of them is the loss of physical control of data which is stored at the data centers provided by cloud computing. Besides of this, the high quality of service and maintaining availability are the issues. According to the same study, cloud computing will offer several security benefits in some ways because of its characteristics but cloud computing will increase some other security risks to the client.

Cloud computing might be seen as a solution to problems but besides of its advantages, it has several issues that should be taken into consideration stated by Masiyev *et al*. (2012):

- *Security issues related to the location of data, its accessibility to third parties and its sustainability to losses.*
- *Cost issues related to some hidden costs and future charges for the customers*
- *Integration that is related to the obstacles that company may face while integrating cloud computing to the business architecture.*

- *Knowledge*
- *Flexibility is the issue of cloud computing because it may not provide fair enough customization.*

Broadband Internet access is the most important challenge for cloud computing (Helvacioglu Kuyucu, 2011). Because providing everything on the Internet, it is important to improve the quality and access to broadband Internet.

Security and privacy issues are important obstacles for cloud computing adoption (Zhou *et al*., 2010). There are different phases of security such as availability, confidentiality, data integrity, control and audit. Data storage in multiple locations makes privacy issues even worse as stated by this study. Multiple locations may lead to several problems about data combination, data transfer and restrictions on techniques. Also, that according to a survey made by IDC in 2008, there are nine different challenges in which security is seen as the most important challenges according to the participants of the study. These challenges mentioned by IDC are given below and their significance rates are shown at Figure 5:

- Performance
- Availability
- Hard to integrate with in-house IT
- Not enough ability to customize
- Worried on-demand will cost more
- Bringing back in-house may be difficult
- Regulatory requirements prohibit cloud
- Not enough major suppliers yet

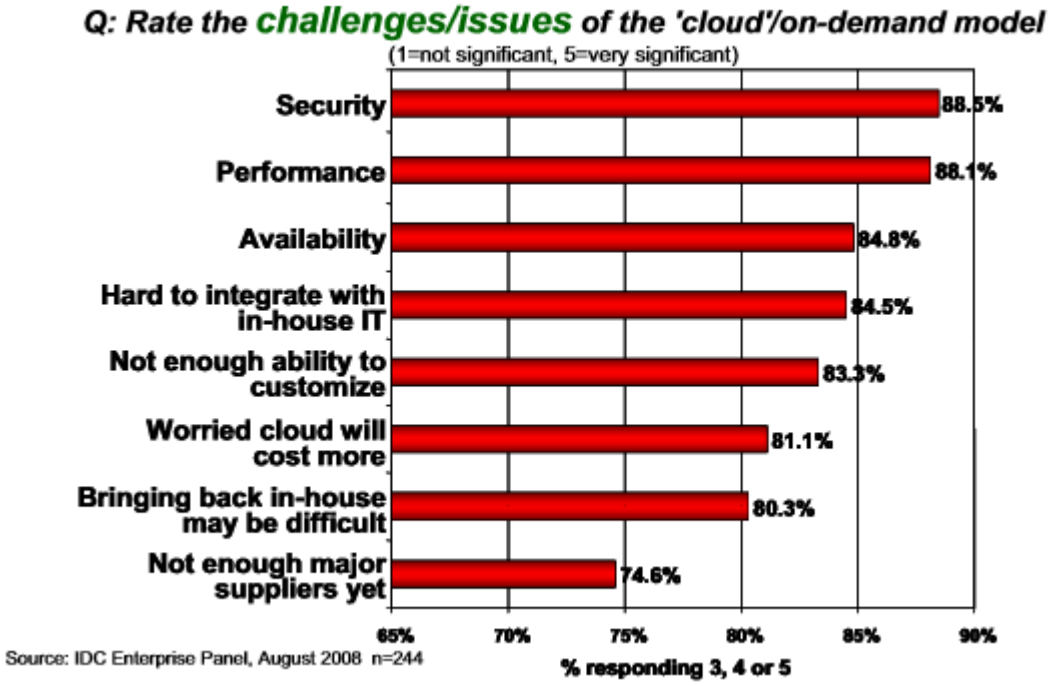

Fig. 5 Challenges of cloud (Source: IDC Survey, Aug 2008)

Hewlett-Packard Development Company and Symantec Corp. state that in addition to the benefits of cloud computing, organizations encounter obstacles such as technical vision and data security (as cited in Garrison *et al*., 2012).

Cloud adoption's current status is associated with several challenges (Dillon *et al*., 2010). These challenges are security, costing and charging model, service level agreement (SLA), and deciding on "what to migrate". According to a different study, the concerns of cloud computing are about network connectivity, privacy, data security, migration and cost issues (Asaduzzaman *et al*., 2012).

The cloud computing technology includes some challenges and risks for both the firms and end-users (Seyrek, 2011). These risks and challenges are security, privacy, performance and legal issues. Main problems that cloud computing brings are broadband Internet, privacy of personal information, location of data and interruptions in service (Henkoğlu and Külcü). McCreary states that there are

concerns about data privacy and security because of unauthorized access to information for malicious purposes (as cited in Kshetri, 2012). In many developing countries, factors such as corruption, lack of transparency and weak legal system can result in increase of risks about security (Kshetri, 2012). According to the same study, the cloud also increases the vulnerability of an organization to insiders.

One of the important issues for SMEs is "resource pooling provides computing resources that are pooled to serve multiple customers with different physical and virtual resources assigned and reassigned dynamically according to consumer demand" (Helvacioglu Kuyucu, 2011). Also, migration to cloud is an issue which affects the decisions of enterprises.

According to Georgia Tech's Schwan, one of the biggest challenges and risks is the lack of connectivity and enough bandwidth in many areas of the world (Greengard, 2010). Another problem is the stability of local power suppliers which may result in backup, privacy and security issues. On the other hand, there are legal issues within the context of cloud computing contract which seen as an important aspect of the cloud computing (Başgül and Chouseinoglou, 2013). This issue will become more serious because company, customer, personnel and work-related information are mostly stored on the cloud infrastructure. Beside of these, complexity is also considered as an obstacle because it may be negatively affects the adoption of cloud computing (Low *et al*., 2011). However the analysis made by this study shows that complexity is not important for the organizations when adoption is considered.

One of the important risks of cloud computing is the under-utilization of resources and under-provisioning (Fox *et al*., 2009). Also long-haul network is most

expensive cloud resource for big data and improving in the smallest rate. This situation is seen as an important challenge in the perspective of cost, for example copying 8 TB data to Amazon over 20mpbs network will take nearly thirty-five days and cost approximately $800. On the other hand, shipping the same data to Amazon will take only one day and cost $150 in total including shipping and transfer fees.

Because cloud services are remote, there will be latency and issues related to bandwidth (Grossman, 2009). The issues about various customers sharing the same hardware will arise because of multi-tenancy feature of cloud computing. Also, keeping data on cloud which is accessible to third parties can present security, compliance, and regulatory issues.

There are three different service models of cloud computing (SaaS, IaaS and PaaS) and these service models place a different level of security requirements in the cloud environment (Subashini and Kavitha, 2011). In SaaS, cloud providers are responsible for preventing users seeing each other's data. The following security elements should be considered as an essential part of SaaS as stated by the same study:

- *Data security*
- *Network security*
- *Data locality*
- *Data integrity*
- *Data segregation*
- *Data access*
- *Authentication and authorization*
- *Data confidentiality*

- *Web application security*
- *Data breaches*
- *Virtualization vulnerability*
- *Availability*
- *Backup*
- *Identity management and sign-on process*

While some cloud computing security issues are acquired from other alternative computing solutions, there are many new security questions that cloud computing arises, including those related to how the cloud services are organized and what kind of data can be placed in cloud (Gonzalez *et al*., 2012). The main problems about security are identified and grouped into a model composed of seven categories such as network security, interfaces, data security, virtualization, governance, compliance and legal issues. Each category includes several potential security problems and this architecture is shown at the Figure 6.

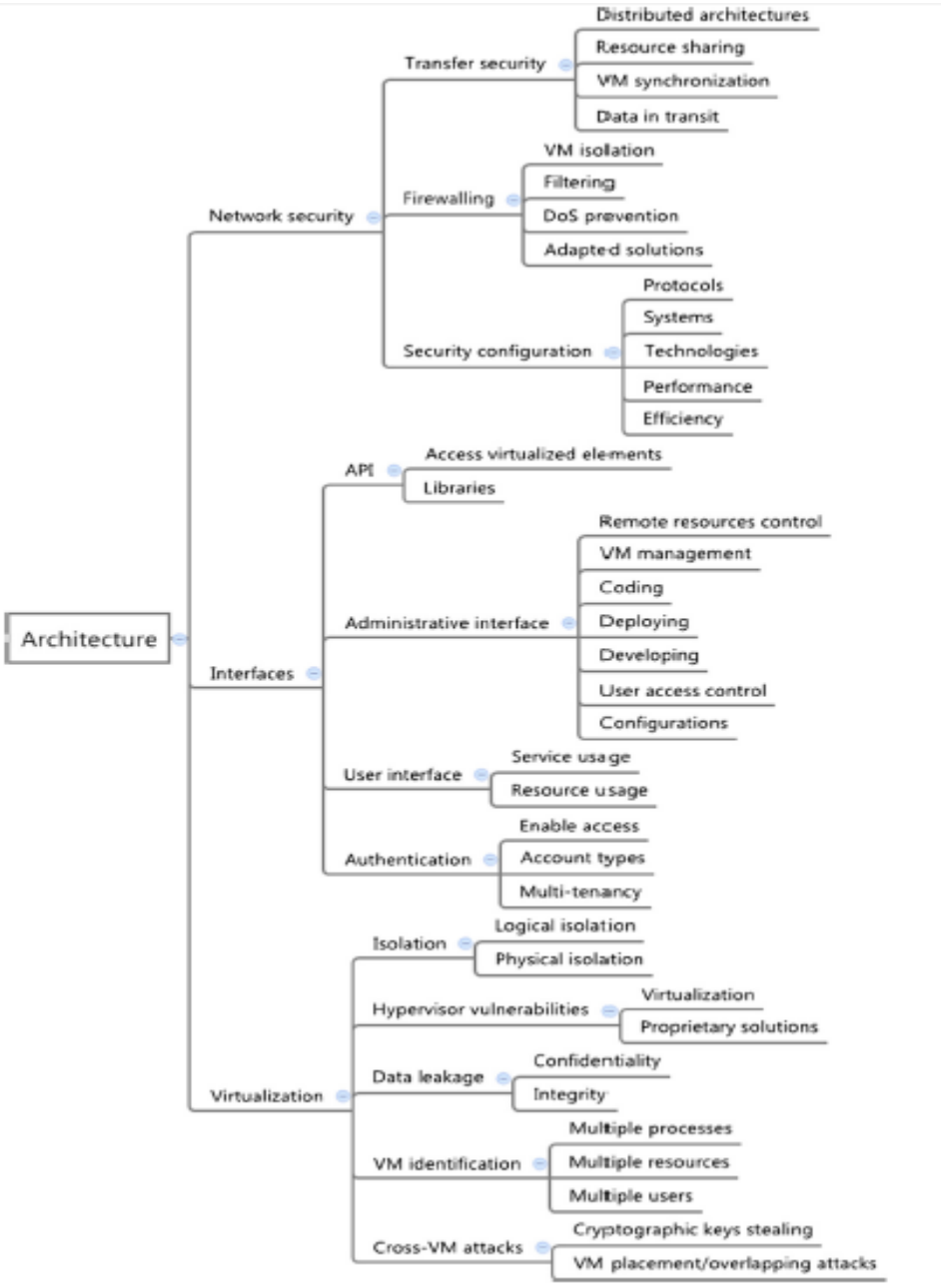

Fig. 6 Security taxonomy – architecture (Gonzalez *et al*., 2012)

Information and Communication Technology (ICT) consumes an increasing amount of energy but it can be reduced (Berl *et al*., 2010). In the studies of Gelenbe, Gelenbe and Lent, Dobson *et al.*, and Gelenbe, it is stated that a major challenge is the tradeoffs that can result in optimal balance between QoS (quality of service), performance and energy consumption (as cited in Berl *et al*., 2010). According to the same study, one needs to address not just the problems derived from individual

components such as storage and processing, resource utilization algorithm but all the concepts of cloud services.

The minimization of energy consumption plays an important role which can be reduced by improving the resource utilization (Lee and Zomaya, 2012). There are recent advances in this area which have reduced the energy consumption in a certain level but it is still an important concern. Resource under-utilization causes higher volume of energy consumption according to this study. Carbon emission and system reliability are the issues that computer system, which uses cloud computing, encounters.

Data centers where cloud applications reside consume huge amounts of energy and this issue causes operational costs to increase (Buyya *et al*., 2010). There is a need to manage multiple applications on a data center which creates the challenges of on-demand resource provisioning. Data centers are not only expensive to maintain, but also harmful for the environment. Also, lowering the energy usage of data centers is challenging and complex according to this study.

By using large shared servers and storage units, cloud computing can offer energy savings in the provision of computing and storage services (Baliga *et al*., 2011). On the other hand, cloud computing leads to increase in network traffic and related network energy consumption. It is stated that, power consumption in network represents an important proportion of total energy consumption for cloud services at medium and high usage rates. Under some circumstances, cloud computing can consume more energy than traditional computing systems which is the solution for users to perform all computing tasks on their own PCs. Even with energy-saving

techniques proposed such as server virtualization technology and advanced cooling systems, cloud computing is not always the most effective green technology.

When cloud computing is considered at large scale, hardware component failure is not an unexpected case (Vishwanath and Nagappan, 2010). A hardware failure can lead to decrease in performance and result in failures within business.

Cloud computing is a modern way to access and use computing resources over the Internet but it has some security risks and vulnerabilities because of the ordinary Internet characteristics (Younis and Kifayat, 2013). Moreover, it has brought new concerns to be considered. The challenges of cloud computing are data security and privacy, security attacks and threats, access controls, monitoring, risk analysis, Service Level Agreement (SLA), accounting, heterogeneity, virtualization, compliance, security in web browser and extensibility and shared responsibilities. The security requirements of distinct critical infrastructure services are analyzed to find the common security requirements which are presented by Fig.7.

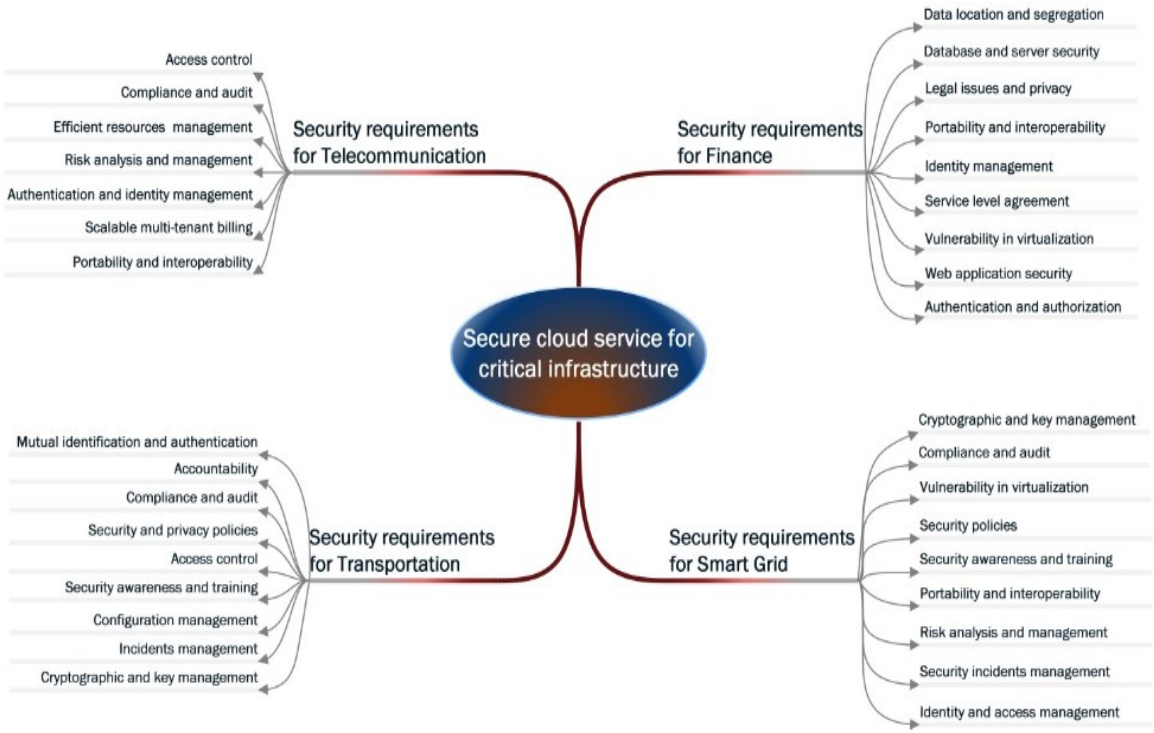

Fig. 7 Security requirements in different type of critical infrastructure services (Younis and Kifayat, 2013)

The time of transmission to receive data from cloud is one of the issues (Lin and Chang, 2011). This study states that, within the cloud computing network, the capacities of edges and nodes may be diversified due to failure, partial failure or maintenance.

There may be significant performance issues for scientific computing workload because of using virtualization and resource time sharing (Iosup *et al*., 2011).

Cloud computing raises crucial concerns especially with respect to the security level (Jensen *et al*., 2009). The security issues related to cloud computing are XML signature, browser security, cloud integrity and flooding attacks.

There are new challenges keep emerging while many existing ones are still not fully mentioned (Zhang *et al*., 2010). These challenges are automated service

provisioning, virtual machine migration, server consolidation, energy management, traffic management, data security, and software frameworks.

According to a survey made by the Department of Information Technologies at the Prague University of Economics in October - November 2010 for Czech companies, the main obstacles of cloud computing adoption are lack of knowledge, high price, security issues, IT governance issues, loss of control, lack of relevant services, availability issues, bandwidth issues which only holds for SaaS, dependence on external provider, and legal issues (Feuerlicht *et al*., 2011).

Along SaaS, users must trust densely to their cloud provider for security requirements (Viega, 2009). In addition, the provider must protect the underlying infrastructure from break-ins and be the responsible side for authentication and encryption. Along PaaS, the provider might give a part of the control to the user-side. Usually, provider will offer a little or no visibility into its operation and the platform provider must be able to offer strong guarantees that the data remains inaccessible between applications. Along IaaS, developer has much better control over the security environment. However, backing up data constitutes a problem within this situation. There are some providers do their own backups for customers' benefit but much can still go wrong. It is proposed that if an organization uses a cloud service, it should arrange its own backups of data. Authentication credential management is another concern for cloud computing as stated by this study.

Based on interviews with cloud vendors and IT users, Forrester has combined three main areas companies should consider as stated by Wang (2009):

- *Security and privacy such as data protection, operational integrity, vulnerability management, business continuity, disaster recovery and identity management*
- *Compliance*
- *Legal and contractual issues*

There will be significant problems about efficient provisioning and delivery of applications while using cloud based resources (Calheiros *et al*., 2011). These problems concern various levels such as workload modeling, virtualization, performance modeling, deployment and monitoring of applications. IT resources may behave in an uncertain way and this situation makes the achievement of QoS (quality of services) more difficult. The principal issues for designing a QoS-aware distributed architecture are dynamic configuration, monitoring, dispatching and load balancing (Ferretti *et al*., 2010).

While cloud computing provides many advanced features, it still has some drawbacks such as relatively high operating cost for both public and private cloud (Younge *et al*., 2010). According to this study, with limited energy resources and rising demand for computational power, Green Computing becomes much more critical.

There are some restrictions for cloud computing market (PR Newswire, 2013). These are trust and security, data transit vulnerabilities, vulnerability to massive outages, cloud commoditization, bandwidth issues, interoperability issues, data corruption, SLA & QoS, legal compliance, encryption limitation, customer identification, and physical security.

Cloud computing can be made secure but securing the cloud computing data is both a contractual and technical issue (Rimal *et al*., 2009). There are also other issues such as load balancing, interoperability, and scalable data storage.

Cloud computing is not even attractive for most of the enterprises because of the reasons mentioned (Staten *et al*., 2008):

- *Concerns about stability*
- *Few big-name players offering cloud*
- *Few enterprise reference accounts*
- *Concerns around security*
- *Little geographic locality*
- *Not very enterprise friendly*

IT departments are cautious about cloud computing because they do not control the cloud platform and because of this situation, cloud computing has still not been adopted widely (Leavitt, 2009). This study states that, according to Carl Howe, director of Anywhere Consumer Research Group for the Yankee Group, a market research firm, key risks of cloud computing consist of reliability, security, the additional cost of the necessary network bandwidth, and getting locked into specific cloud computing vendors.

Cloud computing provides access to data but there is a challenge about ensuring that only authorized individuals can access the data (Takabi *et al*., 2010). There are also challenges about security, privacy, trust, virtualization, heterogeneity, and SLA. The challenges about security and privacy this study proposes consist of authentication, access control/privacy, management such as agreements with external actors, and risk assessment.

There are many security threats at different levels of cloud computing which are defined as Cloud Service Provider (CSP) level, network level and user level (Turab *et al*., 2013). There are some CSP level attacks which involve guest-hopping attack, SQL injection, side channel attacks, and malicious insiders. The examples for attack at the network level are DNS attacks, IP spoofing, and Man in the Middle Attack. The last part is end user's attacks which are phishing, and exploitation of software vulnerabilities.

The most important challenges of cloud computing are security and privacy (Sadiku *et al*., 2014). Besides these challenges there is a latency issue for some applications. These concerns or challenges are affecting the adoption of cloud computing negatively.

There are risks, threats and vulnerabilities of cloud computing where some of them are cloud specific and some of them are non-cloud specific (Dahbur *et al*., 2011). These risks, threat and vulnerabilities are listed at Figure 8.

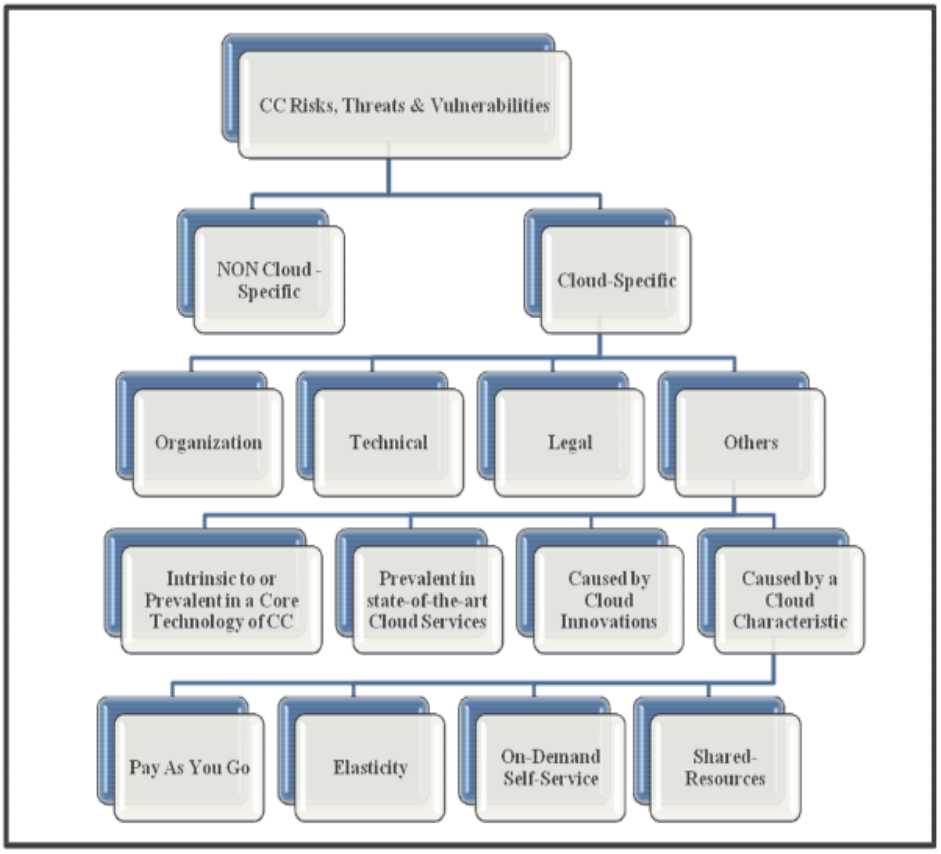

Fig. 8 Cloud computing Risks, Threats & Vulnerabilities (Dahbur *et al*., 2011)

Spanning Tree Protocol (STP) is a protocol for switches and routers used in cloud which works appropriately in Ethernet (Mishra *et al*., 2012). This protocol experienced with some limitations:

- *Reduction in aggregate bandwidth as a result of blocking of redundant paths*
- *Scalability*
- *Path isolation*
- *Multiple tenancy*
- *The need to discover a new path*

There are also some other issues mentioned by this study arise when cloud computing is considered. One of them is related with scheduling in hybrid clouds.

This study also proposes that there is a need for advance in the existing networks to provide high-bandwidth connectivity on demand.

The challenges of cloud computing are collected under the headings of Service Level Agreements, national data protectionism, application security, loosely coupled service design, and occasionally disconnected operation (Thomas, 2009).

Negotiating the balance of risk between customers and providers, ensuring the services to be aligned in order to secure operations, and ease of audit are stated as essential (Morrell and Chandrashekar, 2011). Understanding who "owns" the risks and what that risk means, governance, and control is important for decision makers according to this study. Also security must be assembled into the cloud solution itself as proposed by the same study.

Security threats, which are given below must be overcome in order to benefit fully from cloud computing and some of these security concerns are (Popovic and Hocenski, 2010):

- Loss of physical security
- Violation of law
- Compatibility of storage services (for different cloud vendors)
- Control of encryption/decryption keys
- Integrity of data
- Data logs must be provided, especially in case of Payment Card Industry Data Security Standard (PCI DSS)
- Keeping up to date with application improvements
- Government regulations

- The dynamic and fluid nature of virtualization which makes it difficult to maintain the consistency of security and ensure the availability of records
- Violation of privacy rights

The main security issues of cloud computing are categorized as traditional and new cloud security challenges (Rong *et al*., 2013). Traditional security challenges are authentication, availability, and vulnerability of virtual machines. On the other side, cloud security challenges are resource location, multi-tenancy issue, authentication, system monitoring and logs, and cloud standards to achieve interoperability. Also SLA is stated as an important factor for cloud security.

There are different types of adoption issues for cloud computing (Kim, 2009). These issues include availability, security and privacy, support, interoperability, and compliance.

The most important challenges that cloud providers of IaaS must address are organized (Moreno-Vozmediano *et al*., 2013). These challenges are dynamic service provisioning, service scalability, Qos-SLA negotiation, service monitoring, billing and payment, service deployment across different providers, interoperability, and portability.

Cloud computing is vulnerable to different security and privacy threats (Rao and MeeraSaheb, 2013). Besides the security and privacy threats, there are additional challenges of cloud computing such as service delivery and billing, reliability and availability, and performance and bandwidth cost.

The security and privacy of data in a cloud is an important challenge which may worry the organizations (Egwutuoha *et al*., 2013). This study also mentions

about some alternative challenges of cloud computing which include availability of services, reliability, ease of scalability, performance and elasticity, and SLA.

At this chapter, cloud computing terminology, key concepts of cloud computing, its advantages and especially its challenges are presented by reviewing the literature. Next chapter will present the model of this study that is constructed by the help of literature. The discussed challenges of cloud computing are gathered and these challenges are the core of the model of the thesis.

CHAPTER 3

THEORETICAL FRAMEWORK

The main goal of this study is finding and explaining the effects of the technical challenges of cloud computing on the usage. There are many studies which try to explain the cloud computing terminology and its challenges but none of them considers all the technical challenges as a whole and analyze if these challenges have an effect on usage of cloud computing.

Within the scope of this study, there are sixty-nine technical challenges which are gathered and collected by studying the literature and reviewing with cloud experts. After collecting the most important challenges, they are classified under nine different categories, which are the latest technical challenges and independent variables of this study since then. These challenges are *privacy and security, account control, cloud structure, virtualization, monitoring, cloud applications, internet connection, cloud migration and Service Level Agreement (SLA)* which are also considered as the determinant of the usage of cloud computing.

Firstly, nearly all the challenges that take part in the literature are gathered during the literature review session. The aim of this study is finding the effects of only technical challenges so the non-technical ones among the collected challenges are eliminated. Then, the meetings with cloud experts are arranged and it is decided to add some new challenges besides the gathered ones from the literature. After the last revisions on the technical challenges, there are sixty-nine technical challenges in total which are considered as obstacles for different parts of the cloud computing technology.

To construct a consistent and valid analysis, these sixty-nine technical challenges are reviewed and classified under nine different topics of challenges to be used as independent variables for this study. Classifying the challenges under the right topic is one of the challenging parts of this study. At this part, literature is studied again to decide on the right classification because classification of items under the variables directly affects the reliability of the study. This session results in nine different technical challenges as independent variables which have sixty-nine items in total. As discussed by chapter 5 in detail, the classifications point out reliable scales.

The first of the challenges, which is the most stated one in the literature, is *privacy and security*. The items of *privacy and security* are confidentiality, attacks, loss of data control, encryption, shared resources, important data info, integrity, physical security, network security, web browser security, programming framework security, backups, availability, and management control security.

Second challenge is *account control*. The items of the *account control* are unauthorized access, account control, identity management, authentication and malicious insiders.

Third challenge is the *cloud structure*. This is the widest challenge that has many items under its topic. There are challenges that occur due to the structure of cloud system when it is compared to other computing solutions. This is the reason for classifying some of the items under the variable of *cloud structure*. The items under the *cloud structure* are Quality of Service (QoS), scaling, multi-tenancy, not enough customization, lack of transparency, flexibility, bringing back to old system, data location, dynamically assigning resources, heterogeneity, complexity, task

scheduling, automated service provisioning, multi-location, dependability on local power suppliers, uncertain behavior, resource management, cloud interoperability, synchronization, cloud capacity, under-utilization, data combination, failure, capacity of edge and nodes, and data lock-in. All of these are gathered from literature and classified under *cloud structure* as a challenge.

Virtualization is the fourth challenge. The items under *virtualization* are VM vulnerability and VM migration.

Monitoring the cloud is the fifth challenge. There are four items under the *monitoring* which are audit, logs, maintenance, and tests. All of them are gathered from literature and classified under the topic of monitoring because monitoring is considered as a challenge of cloud computing by Younis and Kifayat (2013).

The sixth challenge is *cloud applications*. There are four items under the topic of application. The reason for classifying them under application is their direct relation to the applications that run on cloud infrastructure. The items under this topic are bugs, software licensing, update issues, and cloud application capacity.

The seventh challenge is about the *Internet connection*. The items of the *Internet connection* are bandwidth, performance, long term fee, high workload, interruption of Internet service, and traffic management.

The eighth challenge which takes part in literature but was eliminated before adding again according to the advices of the cloud experts is *cloud migration*. The issues under this topic are all encountered during the *cloud migration* progress and this is the reason of classifying them under the topic of *cloud migration*. These issues are integration, technical capability, changing technology, resistance to new system, and change of system analysis operations of the organization.

The last challenge is *Service Level Agreement (SLA)*. This topic has popularity as a challenge in the literature but it was eliminated due to being non-technologic issue. According to the cloud experts, this is an important technical issue of cloud computing. Thus, it was considered as a technical challenge by this study. The issues about *SLA* are determined with the cloud experts and these are content, preparation, carrying out, and chase of SLA.

These technical challenges are examined to analyze if they have effect on the usage of cloud computing. This means, *usage of cloud computing* is the dependent variable of this study. There are two items under *usage of cloud computing* which are related to cloud computing and virtualization usage.

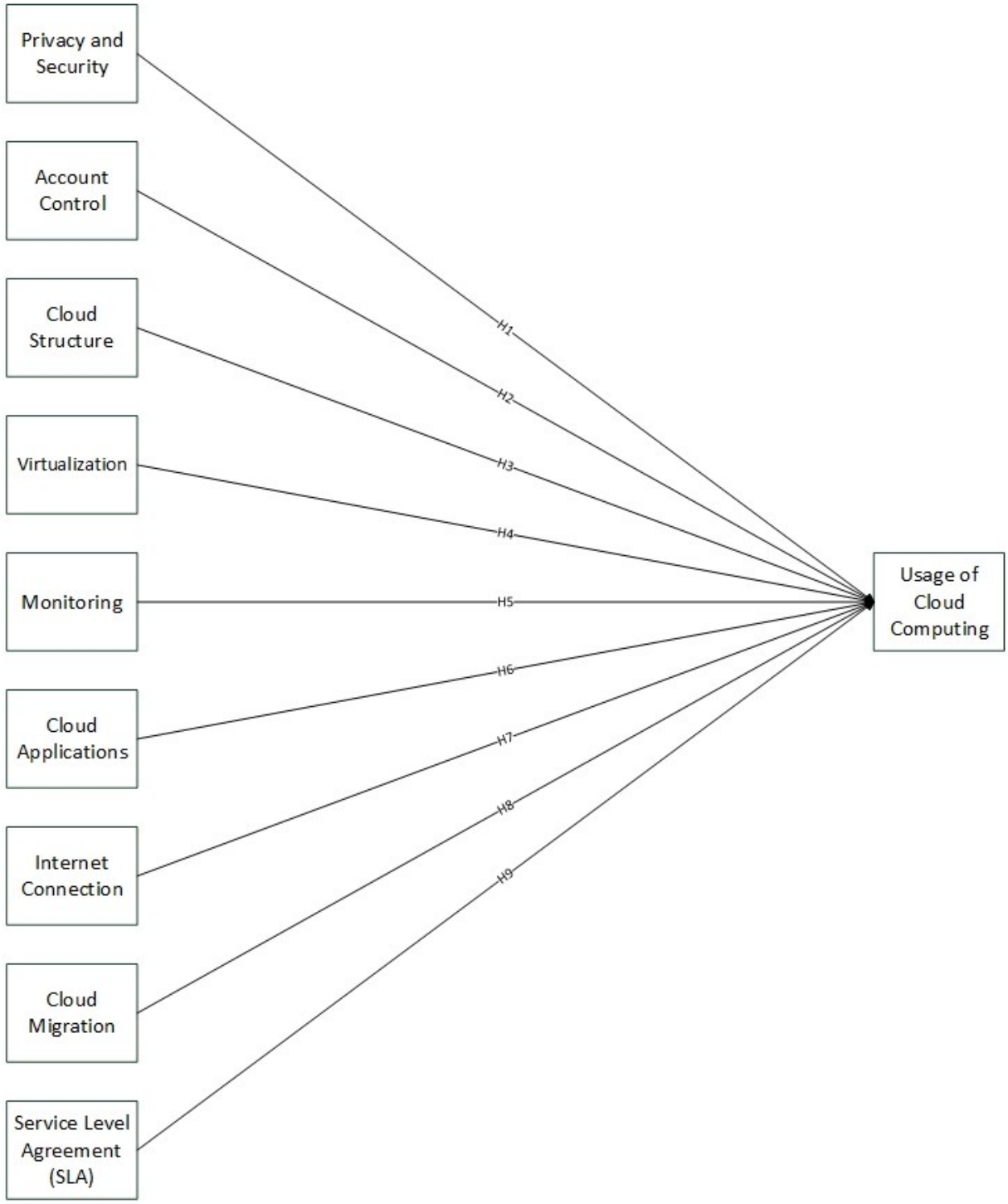

Fig. 10 Theoretical Framework of this study

As shown in the figure above, which is the theoretical framework of this study, the technical challenges of cloud computing are the independent variables where the dependent variable is *usage of cloud computing*. All the challenges in the context of this study which are *privacy and security, account control, cloud structure,*

virtualization, monitoring, cloud applications, internet connection, cloud migration and Service Level Agreement (SLA) are presented by the theoretical framework.

This study tries to find the effects of technical challenges on usage of cloud computing. Thus, there are nine hypotheses asserted by this study about the relations between technical challenges and usage of cloud computing.

- *H1: Challenges about privacy and security negatively affect the usage of cloud computing*
- *H2: Challenges about account control negatively affect the usage of cloud computing*
- *H3: Challenges about cloud structure negatively affect the usage of cloud computing*
- *H4: Challenges about virtualization negatively affect the usage of cloud computing*
- *H5: Challenges about monitoring negatively affect the usage of cloud computing*
- *H6: Challenges about cloud applications negatively affect the usage of cloud computing*
- *H7: Challenges about internet connection negatively affect the usage of cloud computing*
- *H8: Challenges about cloud migration negatively affect the usage of cloud computing*
- *H9: Challenges about Service Level Agreement (SLA) negatively affect the usage of cloud computing*

Hypotheses of this study are prepared with negative relation. In other words, they state that the technical challenges of cloud computing reduces the cloud computing usage. A study made by Gupta *et al.* (2008) asserts some hypotheses related to the advantages of cloud computing such as:

- *The ease-of-use and convenience in using cloud solutions is positively related to SMEs use and adoption of cloud computing*

It is seen that hypotheses are constructed with a positive relation between the advantages of cloud computing and usage of cloud computing. On the other hand, this study analyzes the relation between technical challenges and usage of cloud computing. While advantages of cloud computing are positively related with the usage of cloud computing, the challenges should be negatively related with it. Thus, hypotheses of this study are prepared with negative relations to indicate that the challenges negatively affect the usage of cloud computing.

Chapter 4 is composed of the methodology in order to collect the data required to analyze the model. The survey results are analyzed in order to state if the hypotheses are accepted or rejected. The results are represented and explained at chapter 5 in detail. Besides, descriptive findings of the survey, which shows the current status of cloud computing in Turkey, are presented at same chapter.

CHAPTER 4

METHODOLOGY

Survey, which is a primary data source, is used as a methodology for data collection within the context of this study. The collected data via survey methodology is used for the verification of hypotheses that are proposed by the model. To accomplish these, an online questionnaire is prepared to be conducted on IT personnel and collect the required data.

The questionnaire was prepared by SurveyGizmo, which provides more and better features than any other similar survey tools such as criteria for showing the questions to the respondent, better UI, and more file extensions for exporting the responses. Moreover by the feature of SurveyGizmo, the trend-cycle of the survey can be seen with an increase until the middle of the progress and decrease then.

In order to collect more accurate data from IT personnel in Turkey, the questionnaire is prepared in Turkish (Appendix A) which is composed of three sections and four different topics of questions. First section of the questionnaire includes five questions which are all about demographics such as name of the organization, sector of the organization, number of employees, number of IT personnel, and the experience of the respondent for the position within the organization. The question which asks for the name of the organization is optional for respondents because one may not want to give the organization name. However, this question is asked due to track the responses and find the approximate number of organizations that participate in this study. All of the remaining questions except the last question in this questionnaire are required in order to get accurate and complete data.

First question of the second section asks for the knowledge of respondent about cloud computing. There are five items in this question which are prepared with 5-point Likert Scale where 1 represents “far too little” and 5 represents “far too much” knowledge about the given statements. The next question is about the usage of cloud computing and includes two items about the usage of cloud computing. The last question at the second section is about if the respondent has knowledge about the given nine independent variables. If one selects “none of the above” as an answer for this question, the questionnaire can be submitted before answering the questions about technical challenges.

Last section includes ten different questions which are all about the challenges of cloud computing. The first nine questions are related to the independent variables of this study, which are the technical challenges that shown at the theoretical framework. These questions ask respondent to rate the importance given to the challenges with regards to their usage. Last question is an open-ended question which asks for additional challenges if there is any missing in the questionnaire or comments about the study in general. This question is really helpful in order to understand the main thought of IT personnel about cloud computing. This question is optional as mentioned before.

All questions related to the technical challenges are prepared in negative way. These questions ask respondents to rate the importance of the given challenges (1 - not important, 5 - very important). This means that the questions are asked with contrast to the usage of cloud computing because if a challenge is important for usage, the answers for usage and importance of challenge should be contrast according to hypotheses. For instance, if a respondent answers “5” for the usage of cloud computing, this means that the respondent uses cloud computing in high

frequency but if that respondent answers “5” for a challenge, this means that this challenge is very important which may decrease the usage.

First question of the last section is related to *privacy and security* which has fourteen items. Second question is related to *account control* with five items. Third one is related to *cloud structure* which has twenty-five items. Fourth one is related to *virtualization* with two items. Fifth one is related to *monitoring* with four items. Sixth one is related to *cloud applications* with four items. Seventh one is related to *Internet connection* with six items. Eighth one is related to *cloud migration* with five items. Ninth one is related to *Service Level Agreement* (SLA) with four items and last question of this page and the questionnaire is asking if the respondent wants to add additional challenge about cloud computing which is an open-ended question. All of the items under the questions about technical challenges are gathered from the literature and the meetings with the cloud experts. The items at the last section about technical challenges are asked with 5-point Likert Scale. A list of technical challenges, which are independent variables, and the items under these challenges are given at the Table 5.

Table 5 Challenges and Items

Independent Variables	Items
Privacy and Security	Confidentiality
	Attacks
	Loss of Data Control
	Encryption
	Shared Resources
	Important Data Info
	Integrity
	Physical Security
	Network Security
	Web Browser Security
	Programming Framework Security
	Backups
	Availability
	Management Control Security

Account control	Unauthorized Access
	Account Control
	Identity Management
	Authentication
	Malicious Insider
Cloud Structure	QoS
	Scaling
	Multi-tenancy
	Not Enough Customization
	Lack of Transparency
	Flexibility
	Bringing Back to Old System
	Data Location
	Dynamically Assigning Resources
	Heterogeneity
	Complexity
	Task Scheduling
	Automated Service Provisioning
	Multi-location
	Dependability of Local Power Suppliers
	Uncertain Behavior
	Resource Management
	Cloud Interoperability
	Synchronization
	Cloud Capacity
	Under-utilization
	Data Combination
	Failure
	Capacity of Edge and Nodes
	Data Lock-in
Virtualization	VM Vulnerability
	VM Migration
Monitoring	Audit
	Logs
	Maintenance
	Testing
Cloud Applications	Application Bugs
	Software Licensing
	Update Issues
	Cloud Application Capacity
Internet Connection	Bandwidth
	Performance
	Long Term Fee
	High Workload
	Interruption of Internet Service
	Traffic Management
Cloud Migration	Integration
	Technical Capability

	Changing Technology
	Resistance to New System
	Change of System Analysis
Service Level Agreement (SLA)	Content
	Preparation
	Carrying Out
	Chase of SLA

The questionnaire is conducted online and the target population is IT personnel because it is assumed that IT personnel have the most extensive knowledge about cloud computing when they are compared with the rest of the population. For sampling technique, non-probability sampling is used because choosing the sample randomly is not appropriate for this study. There are three different techniques under non-probability sampling used for this study which are purposive sampling, snowball sampling and self-selection sampling. The questionnaire is mostly distributed to contacts via e-mail. This is the case for the purposive sampling because these contacts are selected due to accessibility. These contacts also distribute the questionnaire to their contacts that work at same or different organizations and are inaccessible at the first step. This type of sampling is the technique of snowball sampling. Last but not least, the questionnaire is distributed via online platforms such as Facebook and LinkedIn. Community groups are formed at these platforms where cloud computing related news and discussions are shared. By the help of these groups, the questionnaire is distributed easily and reached by the members of these groups immediately. This is the technique of self-selection sampling because the members of these platforms decide by themselves in order to participate in this study.

After using all the methods of distributions, there are total of 262 responses returned. 101 of them are partial responses which cause them to be eliminated. Labeling and displaying the partial responses is one of the important features of

SurveyGizmo. Partial responses indicate that the some of the respondents did not complete the whole questionnaire, and abandoned it before answering all questions. After the elimination of partial responses, 8 of the complete responses are eliminated too because these responses state that the respondent do not know anything about the challenges of the cloud computing to answer the questions about the technical challenges. After these last eliminations, the analysis part is done with 153 complete responses which are the sample of this study. Next chapter is composed of the analyses that are made by using these 153 responses. To use multiple regression analysis for this study, the ratio of observations to the independent variables, should not fall below five (Kotrlik and Higgins, 2001). For more accurate and conservative ratio, according to the study by Miller and Kunce, and Halinski and Feldt, the ratio of observations to the independent variables should be ten (as cited in Kotrlik and Higgins, 2001). The ratio of observations to the independent variable for this study is seventeen which means that, 153 responses are highly accurate for the sample size of this study.

Validity is concerned with if the findings of a study are valid or not (Saunders *et al.*, 2011). External validity, which is sometimes also referred to generalizability, looks for whether the findings of a study may be equally applicable to other organizations. This study is accepted as valid externally because the sample of this study includes many organizations from different sectors that operate in Turkey which is the indicator of applicability of this study to other organizations.

The same source defines internal validity as the ability of a questionnaire to measure what it is intended to measure. According to a study made by Cooper and Schindler, when the validity of a questionnaire is discussed, there are several

contents referred such as content validity, criterion-related validity and construct validity (as cited in Saunders *et al.*, 2011)

Saunders *et al.* (2011) defines content validity as an extent to which questionnaire provides acceptable coverage of questions. This coverage can be tested with literature review and discussion with experts of this subject. The content of this study's questionnaire is valid because all the challenges that mentioned in studies are gathered for this study in order to prepare the questionnaire and the least mentioned ones by studies are eliminated. To eliminate the challenges that decrease the validity of questionnaire, cloud experts' advices are taken which results in the acceptable coverage of questions. Last but not least, usage of cloud computing as dependent variable is studied from the literature and other surveys conducted in order to increase the content validity.

According to the definition made by Saunders *et al.* (2011), construct validity refers to the extent which the measurement questions measure what it is intended. Construct validity is also related to generalization like external validity. This term is mostly used for abstract constructs such as attitude and psychology scales which mean that the scope of this study is partly outside of the construct validity's scope. This study tries to measure the usage of cloud computing and the question here is if the questionnaire exactly measure the usage of cloud computing. The 5-point Likert scale question for usage of cloud computing includes two items which asks respondents to rate the cloud computing usage and virtualization usage. Virtualization usage question is asked by ESG Research Report (2013) which is highly valid and cloud computing usage is asked with same structure. By answering this question, a respondent rates the usage frequency from 1 to 5 where 1 represents "not using" and 5 represents for "far too much" usage frequency. Also, the

questionnaire measures the importance given to technical challenges by users with using 5-point Likert Scale where 1 represents for “not important” and 5 represents “very important”. In other words, users rate the challenges with regards to their usage. This question is constructed by the help of the question asked by IDC Survey (2008) which asks participants to rate the challenges of cloud computing. This survey is cited by countless studies and this is the indicator of validity for this study.

Criterion-related validity refers to the ability of one measure estimates the values of another measure (Salkind, 2006). There are two types of criterion-related validity which are predictive and concurrent validity. Concurrent validity is appropriate for this study where both measures are collected at the same period. The scale for cloud computing usage and technical challenges are prepared with using 5-point Likert scale in order to measure the importance given to technical challenges by users and their usage frequency. The questions about technical challenges are asking for respondent to rate the technical challenges and the scale for usage of cloud computing asks users to rate their cloud computing usage and virtualization usage frequency. This study tries to find the effects of technical challenges on usage. In other words, it is analyzed if technical challenges can estimate or predict the usage of cloud computing. According to the analyses which are deeply discussed in chapter 5, this model is valid with regards to concurrent validity because the measures, which are technical challenges, can estimate the main measure, which represents the usage of cloud computing, significantly.

Besides validity of the study, reliability should be considered too. Reliability is defined as the extent which data collection techniques, survey for this study, will output consistent findings (Saunders *et al.*, 2011). Moreover, reliability is concerned with the robustness of the questionnaire whether or not it will produce consistent

findings with different conditions and different targets. According to Mitchell's study, internal consistency is crucial for reliability (as cited in Saunders *et al.*, 2011). One of the mostly used methods for measuring internal consistency is Cronbach's alpha which can be calculated by SPSS' reliability analysis. As explained in detail at chapter 5, all of the scales are reliable when Cronbach's alpha is considered. Thus, it can be stated that this study produces consistent findings and it is reliable.

This chapter is composed of the methodology in order to collect the required data to analyze the technical challenges and corresponding hypotheses mentioned at chapter 3. Next chapter includes the analysis of the data collected such as descriptive findings, bivariate correlation and multiple regression analysis. Beside, findings are discussed according to the results of analyses.

CHAPTER 5

ANALYSIS & FINDINGS

This chapter includes analyses composed of descriptive findings, reliability analysis, bivariate correlation and linear regression analysis. In order to reveal the current status of cloud computing and validation of hypotheses, the analyses are constructed and carried out by using SPSS v19.0.

Descriptive Findings

The list of sectors which the companies operate in and their frequencies are shown at Table 6. Bank/Finance sector is the leader in this area with 27.5%. Second one in the list is the sector of IT Service Providers with 14.4%. The sectors that have the least proportion are public sector, health and energy. All other sectors are listed at the table with the given frequencies and percentages.

Table 6 Companies' sectors as a descriptive study

Sector	Frequency	Percentage
Bank/Finance	42	27.5%
IT Service Provider	22	14.4%
Electronics	17	11.1%
Other	17	11.1%
Internet	14	9.2%
Telecommunication and Media	14	9.2%
Education	9	5.9%
Industry	6	3.9%
Automotive	4	2.6%
Insurance	3	2.0%
Health	2	1.3%
Public Sector	2	1.3%
Energy	1	0.7%

Table 7 gives detailed information about the companies with regards to their total number of personnel. 43.1% of the companies have +1000 personnel and 20.3% have

250-1000 personnel. This means that more than half of the organizations that participate in this survey have more than 250 personnel. For EU standards, an organization that has more than 250 and less than 1000 personnel is considered as large business, and a company that has more than 1000 personnel is stated as enterprise. In other words, 43.1% of the companies that participate in this study are enterprises and 20.3% are large business.

Table 7 Descriptive Study for Number of Personnel

Number of Personnel	Frequency	Percentage
+1000	66	43.1%
250-1000	31	20.3%
50-250	19	12.4%
10-50	19	12.4%
1-10	18	11.8%

Table 8 shows related statistics with the previous table but this table gives only the number of IT personnel, not total number of personnel within an organization. 28.8% of the organizations have 1-10 IT personnel which are the highest proportion for this analysis result, 18.3% of the organizations have 10-150 IT personnel and 19.6% have 50-250 IT personnel. It is observed that, more than half of the companies have less than 250 IT personnel.

Table 8 Descriptive Study about Number of IT Personnel

Number of IT Personnel	Frequency	Percentage
1-10	44	28.8%
250-1000	37	24.2%
50-250	30	19.6%
10-50	28	18.3%
+1000	14	9.2%

Table 9 gives the respondents thought on the popularity of cloud computing in Turkey. More than half of the respondents think that cloud computing's popularity is below average in Turkey. The popularity of cloud computing is still not at enough

level and because of this reason; it should be promoted in order to be seen as a popular technology in the area of ICT by companies.

Table 9 Popularity of Cloud Computing According to Respondents

Popularity of Cloud Computing	Frequency	Percentage
Far too little	31	20.3%
Too little	78	51%
About right	36	23.5%
Too much	5	3.3%
Far too much	3	2%

Knowledge about cloud computing and usage of cloud computing in Turkey are still an unclear parts of the cloud computing. These two topics are related with each other and there are questions within this scope at the questionnaire. According to the results, 24.8% of the respondents do not use cloud computing and 11.1% of the respondents use cloud computing far too much. It can be seen that, 75.2% of the participants use cloud computing whatever their usage frequencies are. The result of the usage statistics is shown at Table 10.

Table 10 Usage of Cloud Computing

Usage Amount of Cloud Computing	Frequency	Percentage
Not using	38	24.8%
Too little	34	22.2%
About right	34	22.2%
Too much	30	19.6%
Far too much	17	11.1%

It can be interpreted that usage of cloud computing in Turkey is very high. Although respondents think that cloud computing is not very popular in Turkey, cloud computing is used at high rates. More than half of the respondents use cloud computing within their organization even approximately similar proportion of the respondents think that cloud computing's popularity is below average.

Besides, knowledge should be also considered when cloud computing is analyzed. There are four different topics of knowledge about cloud computing are covered by the questionnaire. These are:

- General knowledge about cloud computing
- Knowledge about benefits of cloud computing
- Knowledge about principles of cloud computing
- Knowledge about the difference between cloud computing and other systems such as in-house system

The percentage table for these four areas is given at Table 11. Via this table, it can be seen that only very small proportion of the respondents has far too little knowledge about cloud computing in all four topics. More than half of the people have average or above average knowledge about cloud computing. As seen at the related table, the percentages related to four different topics of knowledge are close to each other. When all areas of knowledge are considered, it is seen that the mostly known part is the benefits of cloud computing. On the other hand, the least known topic of cloud computing is its principles.

Table 11 Knowledge about Cloud Computing

	General	Benefits	Principles	Other systems
Far too little	6.5%	4.6%	7.2%	6.5%
Too little	18.3%	13.7%	21.6%	28.1%
About right	34%	32.7%	40.5%	27.5%
Too much	29.4%	34.6%	19.6%	24.8%
Far too much	11.8%	14.4%	11.1%	13.1%

Apart from the table represents knowledge about cloud computing, there are eight respondents who state that they do not know anything about cloud computing. Their responses are extracted from the analysis part of the study because it cannot

contribute to the analysis which tries to find the effects of technical challenge on cloud computing usage. This means that, 153 out of 161 respondents have knowledge about cloud computing which forms the 95% of the total responses.

The remaining analyses, which are related to the validation of hypotheses, are carried out with the respondents of the IT personnel. Within this context, the experience of the respondents about their position at the organization is important. The years of experiences of the respondents are shown at Table 12.

Table 12 Experience of the Respondents

Years of experience	Frequency	Percentage
0-1 year	27	17.6%
1-3 years	51	33.3%
3-5 years	23	15%
5-10 years	23	15%
+10 years	29	19%

It is seen that, only 17.6% of the respondents work for less than one years within that organization. This means that, responses will output valid results because respondents are aware of the situation within their organizations.

Cloud computing in Turkey is not an attractive research area but according to the result of this study, most of the IT personnel know what cloud computing is. Meanwhile, a huge proportion of the companies use cloud computing. However, cloud computing is still not acknowledged as popular technology in Turkey. This may be the result of higher rates in other countries than Turkey. Also, cloud computing should be promoted to not only organizations but also general public.

After investigating the statistics about respondents, some detailed descriptive analyses are constructed. For example, comparing the different sector with regards to cloud computing usage may give an important result that shows which sector uses

cloud computing most or least. Table 13 shows the sectors of the organizations and their average cloud computing usage over 5.

Table 13 Cloud Computing Usage With Regards to Sectors of Organizations

Sectors of organizations	Number of Respondent	Cloud computing usage rate (over 5)
Energy	1	5,00
Insurance	3	4,00
IT Service Provider	22	3,70
Internet	14	3,39
Telecommunication and Media	14	3,07
Other	17	2,76
Automotive	4	2,62
Education	9	2,61
Electronics	17	2,58
Health	2	2,50
Bank/Finance	42	2,41
Industry	6	1,91
Public Sector	2	1,50

It is seen that cloud computing is mostly used by the organizations that operates in the sector of energy. Organizations that operate in insurance, IT service provider, Internet, and telecommunication and media uses cloud computing in high rates as seen. On the other hand, cloud computing is not used with high rates by industry and public sector. This means that cloud computing should be promoted to the organizations that operate in these sectors. Most of the participants of this study work in bank/finance organizations but it is seen that usage of cloud computing in these organizations are below the average usage.

As seen, cloud computing usage differs with regards to the sectors. Also, sectors of the organizations may be the determinant of the importance given to the challenges. Table 14 shows the comparisons between sectors by considering their responses which indicate the importance given to the challenges analyzed by this study. Importance given to a challenge is rated over 5.

Table 14 Sectors and Technical Challenges (Sec. – Privacy and Security, Acc. – Account Control, Str. – Cloud Structure, Virt. – Virtualization, Mon. – Monitoring, App. – Cloud Applications, Int. – Internet Connection, Mig. – Cloud Migration)

Sectors of Organizations	Sec.	Acc.	Str.	Virt.	Mon.	App.	Int.	Mig.	SLA
Bank/Finance	4,09	3,94	3,68	3,52	3,72	3,47	3,93	3,60	4,01
IT Service Provider	4,08	4,00	3,69	3,78	3,69	3,00	3,93	3,60	4,01
Other	3,84	3,69	3,59	3,67	3,60	3,42	3,90	3,59	4,06
Education	4,04	4,18	3,70	3,47	3,61	3,12	4,13	3,81	4,06
Electronics	3,79	4,05	3,54	3,53	3,80	3,48	3,94	3,52	4,15
Industry	3,96	3,91	3,22	3,28	3,71	3,17	3,98	3,57	4,04
Energy	3,71	4,00	3,18	5,00	4,75	3,50	5,00	3,20	5,00
Internet	3,90	4,00	3,52	3,40	3,58	3,53	3,88	3,43	3,86
Public Sector	4,01	4,07	3,30	3,27	4,35	4,37	3,70	3,57	4,04
Automotive	3,47	4,07	3,39	3,51	3,71	2,84	3,87	3,57	4,03
Health	4,12	4,20	3,73	3,52	3,85	3,62	4,08	4,60	4,39
Insurance	4,32	4,27	3,96	3,68	3,97	3,46	3,60	3,57	4,18
Telecommunication and Media	4,21	3,87	3,52	3,42	3,72	3,17	3,80	3,56	3,94

Privacy and security challenges are mostly important for the organizations that operate in insurance sector. Same applies for the challenges about account control and cloud structure. However, challenges about virtualization are mostly important for the organizations that operate in energy sector and IT service providing. Moreover, the highest importance given to monitoring is by energy sector and insurance sector, cloud applications is by public sector, Internet connection is by energy and education, migration is by health sector and SLA is by energy and health sector. The sectors' separate thoughts on technical challenges can be seen at the table above.

Table 15 Number of personnel and cloud computing usage

Number of personnel	Cloud computing usage rate (over 5)
1-10	2.66
10-50	3.52
50-250	3.23
250-1000	2,40
+1000	2.78

Table 15 shows the relation between number of personnel within an organization and cloud computing usage by that organization. As seen, the highest rate of cloud computing is related with the organizations which have 10-50 personnel in total. The least usage rate of cloud computing is related with the organizations which have 250-1000 personnel in total.

Table 16 Number of personnel and technical challenges (Sec. – Privacy and Security, Acc. – Account Control, Str. – Cloud Structure, Virt. – Virtualization, Mon. – Monitoring, App. – Cloud Applications, Int. – Internet Connection, Mig. – Cloud Migration)

Number of personnel	Sec.	Acc.	Str.	Virt.	Mon.	App.	Int.	Mig.	SLA
1-10	3,81	4,04	3,51	3,71	3,80	3,32	3,86	3,46	4,05
10-50	3,83	3,66	3,70	3,65	3,68	2,85	3,82	3,54	4,08
50-250	4,00	3,96	3,60	3,55	3,83	3,63	3,94	3,65	4,17
250-1000	3,98	3,99	3,55	3,45	3,67	3,38	4,00	3,65	4,17
+1000	4,08	3,95	3,55	3,47	3,69	3,39	3,88	3,58	4,03

Table 16 is the indicator of the relation between the number of personnel within and organization and the importance given by them to technical challenges which are over 5. The organizations with 1-10 personnel give highest importance to the challenges about SLA and account control which is also same for the organizations with 250-1000 personnel. Beside, organizations with 10-50 personnel give highest importance to challenges about privacy and security, and SLA which also applies for the organizations with 50-250 and +1000 personnel. It can be seen that when organizations are grouped by their number of personnel, most important challenges for groups are privacy and security, account control, and SLA.

Table 17 Number of years as an experience of respondent and technical challenges (Sec. – Privacy and Security, Acc. – Account Control, Str. – Cloud Structure, Virt. – Virtualization, Mon. – Monitoring, App. – Cloud Applications, Int. – Internet Connection, Mig. – Cloud Migration)

Number of years as exp.	Sec.	Acc.	Str.	Virt.	Mon.	App.	Int.	Mig.	SLA
0-1	3,93	3,95	3,44	3,42	3,72	3,29	4,00	3,55	4,00
1-3	3,98	3,90	3,57	3,52	3,65	3,34	3,85	3,58	3,96
3-5	4,17	4,07	3,76	3,75	3,80	3,54	4,03	3,75	4,21
5-10	3,97	4,13	3,68	3,62	3,74	3,55	3,98	3,62	4,21
+10	4,00	3,84	3,61	3,53	3,72	3,07	3,76	3,40	3,94

As seen with the help of Table 17, challenges about SLA and, privacy and security are the most important ones for the most experienced IT personnel. On the other hand, challenges about Internet connection is one of the most important technical challenges for the least experienced IT personnel. However, challenges about SLA have the highest rate (over 5) of importance by nearly all of the respondents.

Table 18 Number of years as an experience and cloud computing knowledge

Number of years as experience	Cloud computing knowledge (over 5)
0-1	2,8704
1-3	3,3235
3-5	3,1196
5-10	2,9130
+10	3,5517

When the knowledge of cloud computing is considered, the experience of the IT personnel should be also considered. Table 18 shows that the most experienced IT personnel have the highest knowledge among all respondents. However, the least experienced IT personnel do not have the least knowledge. This means that, cloud computing is becoming popular where people have knowledge about it before working within an organization.

Last but not least, knowledge of a respondent about cloud computing is a determinant for the importance given to technical challenges which gives the result which challenges are the most important ones for the most informed respondents.

Table 19 Knowledge about cloud computing and technical challenges (Sec. – Privacy and Security, Acc. – Account Control, Str. – Cloud Structure, Virt. – Virtualization, Mon. – Monitoring, App. – Cloud Applications, Int. – Internet Connection, Mig. – Cloud Migration)

Knowledge	Sec.	Acc.	Str.	Virt.	Mon.	App.	Int.	Mig.	SLA
Far too little	4,03	3,95	3,51	3,87	3,71	3,48	3,82	3,61	4,20
Too little	3,90	3,58	3,66	3,60	3,62	3,35	3,88	3,58	4,01
About right	4,01	4,11	3,53	3,43	3,74	3,36	3,94	3,60	4,01
Too much	4,03	3,90	3,62	3,42	3,71	3,20	3,88	3,51	4,09
Far too much	4,02	4,29	3,69	4,22	3,81	3,69	3,95	3,65	3,97

The IT personnel who have the highest knowledge about cloud computing give high importance to the challenges about account control and virtualization. Challenges about SLA is important for all respondents no matter their knowledge about cloud computing. The other details can be extracted by the table given above.

After giving the current status of cloud computing in Turkey with the help of statistics gathered by analyzing the collected data, analyses for validating hypotheses are constructed.

Reliability Analysis

A variable is accepted as reliable if it reflects the true score. Reliability analysis is constructed to evaluate if the scales of this study are reliable. There are ten different variables used for the analyses, one for usage of cloud computing and nine for technical challenges. Shortly, there are ten different reliability analyses constructed

for scales with related items of each. The items for each variable are given at chapter 4.

Reliability tests are done because these scales will be used later for bivariate correlation analysis and multiple regression analysis if they are extracted as reliable. A reliability analysis is done by using the items for a related variable. Cronbach's alpha is a measure of integral consistency. In other words, it shows how closely a related set of items are grouped together. It normally ranges between 0 and 1 (Gliem & Gliem, 2003). George and Mallery stated rules of thumb about Cronbach's Alpha value that shows the rate of consistency (as stated by Gliem & Gliem, 2003):

- If value is greater than 0.9, it refers to excellent consistency
- If value is greater than 0.8, it refers to good consistency
- If value is greater than 0.7, it refers to acceptable consistency

According to the result of the regression analyses, it is shown that all entered scales are reliable to be used in multiple regression analyses because all of the scales' Cronbach's Alpha values are above 0.7 which are also shown at Table 20. This table includes three different values for each scale. One of them is for scale name, second one is for Cronbach's Alpha value for that scale and last one is for the number of item within that scale. The least reliable value is about the scale of usage of cloud computing which is also reliable according to the analyses with the value of 0.742.

Table 20 Reliability Analyses Results

Scale Name	Cronbach's Alpha	Number of Item
Usage of Cloud Computing	0,742	2
Privacy and Security	0,927	14
Account Control	0,912	5
Cloud Structure	0,910	25
Virtualization	0,916	2
Monitoring	0,854	4
Cloud Applications	0,818	4
Internet Connection	0,843	6
Cloud Migration	0,777	5
SLA	0,904	4

The values show that the classifications of challenges are made consistently because all of them are extracted as reliable. As stated at chapter 4, reliability of a study is important which shows the robustness of the questionnaire. It can be stated that this study results in consistent findings.

Bivariate Correlation Analysis

Bivariate correlation analysis results in if the relationship between two variables is linear, which means increase in one of the variables result in an increase in the other variable or contrast. This type of analysis requires variables as scales and it is done to show the relationships between independent variables and dependent variable. Also, the relationships between each of the independent variables can be extracted additionally. Correlation analysis does not show the cause and effect relationship between variables which is needed to validate hypotheses.

First of all, to construct bivariate correlation analysis the means of each scale are computed which are cloud computing usage and the technical challenges. The means are also used for regression analysis. Bivariate correlation analysis is done via

SPSS. There are ten variables entered into this analysis which are all computed means of scales.

The dependent variable in this analysis is entitled as “MeanUsage” which represents the calculated means of usage scale. The relationship between this variable and other variables are the main subject of this analysis. As shown in Table 21, which stands for the correlation matrix, sample size *N* is equals to 153. There are three significant relationships that dependent variable have according to the result of bivariate correlation analysis. The challenges about privacy and security and the usage of cloud computing are strongly correlated, $r(151) = 0{,}185$, $p = 0{,}022$. Also, challenges about account control and usage of cloud computing are strongly correlated, $r(151) = 0{,}230$, $p = 0{,}004$. Challenges about virtualization and usage of cloud computing are also strongly correlated where $r(151) = 0{,}272$, $p = 0{,}001$. Within the formulated correlation analysis results, number 151 represents the degree of freedom that stands for N-2, *p* stands for the significance value of the correlation and *r*(N-2) stands for the Pearson correlation coefficient which shows the strength of the relationship between the variables.

Table 21 Bivariate Correlation Analysis

		MeanUsage
MeanUsage	Pearson Correlation	1
	Sig. (2-tailed)	
	N	153
MeanAccount	Pearson Correlation	,230**
	Sig. (2-tailed)	,004
	N	153
MeanSecurity	Pearson Correlation	,185*
	Sig. (2-tailed)	,022
	N	153

MeanStructure	Pearson Correlation	,115
	Sig. (2-tailed)	,157
	N	153
MeanVirtualization	Pearson Correlation	,272**
	Sig. (2-tailed)	,001
	N	153
MeanMonitoring	Pearson Correlation	,102
	Sig. (2-tailed)	,207
	N	153
MeanApplication	Pearson Correlation	-,074
	Sig. (2-tailed)	,365
	N	153
MeanInternet	Pearson Correlation	,106
	Sig. (2-tailed)	,191
	N	153
MeanMigration	Pearson Correlation	-,044
	Sig. (2-tailed)	,587
	N	153
MeanSLA	Pearson Correlation	,100
	Sig. (2-tailed)	,219
	N	153

According to the table given by SPSS, there were also significant correlations between independent variables with each other but this is out of scope thus only correlations between dependent variable and independent variables are shown.

As mentioned, privacy and security, account control and virtualization are significantly correlated with usage of cloud computing but it is still not known how all independent variables predict the usage of cloud computing together. Bivariate correlation analysis only looks for the correlation. In order to predict the usage by analyzing the technical challenges, multiple correlation analysis needs to be

constructed. While bivariate correlation analysis shows the strength of a correlation, to consider all technical challenges' effects on usage of cloud computing, multiple regression model analysis is accomplished.

Multiple Regression Analysis

As mentioned at the previous chapters, there are nine independent variables in the theoretical model of this study and one dependent variable. The number of item is two for usage of cloud computing which is the dependent variable and the number of item for related technical challenges varies because there are different numbers of items for each independent variable. These numbers, item names and their related variables are given at Chapter 4.

Regression analysis allows to model and explore the relationships, and to explain the factors. It is a technique for studying the linear relationships. The regression analysis begins by a general form for relationship, which is also known as regression model:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \varepsilon$$

Y is the dependent variable and X variables are the predictors or independent variables where X_1 is the first independent variable, X_2 is the second independent variable and X_k is the last independent variable. The result of the regression analysis estimates the coefficients of the regression model which β values for each independent variable, and α value. The value ε is the residual term or error value which shows the composite effect of all other types of individual differences that not identified in the model. This value is created as a result of incomplete relationship

between the predictors and dependent variable in order to represent the amount of difference between the observed value and estimated function value. This analysis will result in the validation of hypotheses which includes the cause and effect relationships between challenges and usage.

Ten variables are entered to the regression analysis. The variables' name and their corresponding variables in the formula are given at the Table 22.

Table 22 Regression Model Variables

Variable Name	Corresponding Variable in Formula
Usage of cloud computing	CU
Privacy and Security	PS
Account Control	AC
Cloud Structure	CS
Virtualization	VT
Monitoring	MT
Cloud Applications	CA
Internet Connection	IC
Cloud Migration	CM
Service Level Agreement	SLA

With the given corresponding variables of scales, the regression model of this study is revised as:

$$CU = \alpha + \beta_1 \times PS + \beta_2 \times AC + \beta_3 \times CS + \beta_4 \times VT + \beta_5 \times MT + \beta_6 \times CA + \beta_7 \times IC + \beta_8 \times CM + \beta_9 \times SLA + \varepsilon$$

The regression analysis is done for predicting the value of dependent variable (CU) by using independent variables. For constructing regression analysis, "linear regression" function of SPSS is used. As mentioned, means for all scales are computed in order to construct the correlation and regression analysis. Mean of usage is used as dependent variable, which is CU at the regression model, and for predictors, means of each technical variable are used.

Before constructing the regression analysis, there are some assumptions need to be issued. If all of these assumptions match the specific criteria, regression analysis can be constructed more accurately.

First of these assumptions is about autocorrelation. This step is ignored by this study because autocorrelation needs to be considered when there is a time-series data. Data collected by survey methodology of this study do not include time-series data.

Normality needs to be considered after ruling out autocorrelation. Regression analysis assumes that variables have normal distribution. Thus, normality of the variables needs to be considered before constructing the regression analysis because non-normally distributed variables may alter the relationships as well as significance values. To check the normality of variables, Kurtosis and Skewness values need to be considered. As stated by Ghasemi and Zahediasl (2012), in small samples (less than 200), values greater or lesser than 1.96 are sufficient and in large samples (200 or more), values greater or lesser than 2.58 are sufficient. The sample for this study is 153 so Kurtosis and Skewness values should be lesser or greater than 1.96.

Table 23 Normality of the Variables

Variable Name	Kurtosis	Skewness
Usage	0.021	-0.920
Privacy and Security	-0.315	-0.453
Account Control	-0.905	0.901
Cloud Structure	-0.580	0.876
Virtualization	-0.514	-0.193
Monitoring	-0.150	-0.854
Cloud Application	-0.385	-0.230
Internet Connection	-0.239	-0.930
Cloud Migration	-0.111	-0.77
SLA	-0.641	-0.415

As presented by Table 23, all of the Kurtosis and Skewness values of the variables are between -1.96 and +1.96. This means that the variables are considered as normal to construct the regression analysis.

The last assumption of regression analysis is multicollinearity which is the indicator of high correlation between two or more independent variables. To construct an accurate multiple regression analysis, there should not be any linearly related variables. Detecting the collinearity can be done by VIF value. If calculated VIF value is equal to 1, this means that the related variable is not linearly related to the other variables (McClave *et al.*, 2013).

Table 24 Multicollinearity for Independent Variables

Variable Name	VIF Value
Privacy and Security	1.127
Account Control	1.257
Cloud Structure	1.346
Virtualization	1.172
Monitoring	1.201
Cloud Application	1.111
Internet Connection	1.304
Cloud Migration	1.170
SLA	1.318

Table 24 shows the VIF values for each independent variable. It is seen that, all VIF values are close to 1, so it is assumed that none of the variables is linearly related with the other variables. However, to guarantee for eliminating the multicollinearity, the method for regression analysis is selected as “stepwise”. For entry value 0.09 and for removal value 0.10 is selected. It is observed that stepwise regression analysis runs with 5 steps and then it gives the latest result.

The first result of the regression analysis is given at Table 25 with the R Square value. This table shows the values after the fifth step of the regression

analysis. R Square value refers to the coefficient of correlation between the predictors and dependent variable. In other words, it shows how good the model fits and at what rate the predictors can explain the dependent variable.

Table 25 Model Summary as a Result of Regression Analysis

R	R Square	Adjusted R Square	Std. Error of the Estimate
0,413	0.171	0.142	1.13855

First value that is presented by Table 25 is R value. This value tells how strongly the multiple independent variables (technical challenges) are related to the dependent variable (usage of cloud computing). More importantly, the value that should be considered as mentioned is R Square. This value is useful because it gives the coefficient of measurement. The regression analysis results in 0.413 as R value and 0.171 as R Square value. As stated before, the R Square value shows at what proportion predictors can explain the dependent variable, which is the usage of cloud computing for this study. The value of R Square shows the explanation rate of dependent variable by technical challenges.

The value of 0.171 can be stated as a weak prediction by some researchers. This value means that the technical challenges can explain the 17.1% of the usage of cloud computing. In other words, 82.9% of the usage is explained by other factors that are related to cloud computing or something else which has an effect on cloud computing. However, this result is expected when the model of this study is considered because there are many other factors can explain the usage of cloud computing apart from the technical challenges such as non-technical challenges, benefits of cloud computing and so on. With considering the all factors that affect the usage of cloud computing, it can be stated that explanation made by technical

challenges' can be relatively lower than the others. For instance, the benefits of cloud computing are reviewed at chapter 2 which may affect the usage of cloud computing more than the technical challenges. A user should consider both benefits and challenges of cloud computing for using the cloud system. If users decides that benefits are higher in number than challenges or more important than challenges, that user may decide using cloud computing even the challenges of cloud computing are taken into consideration. According to the result of the regression analysis, technical challenges cover the 17.1% of the usage and benefits or other factors cover the remained proportion. Shortly, this value can be stated as weak but it is expected as explained above.

The last value at Table 25 is the standard error of the estimate. This value is the square root of mean square for the residuals in the ANOVA table which is shown at Table 26. The standard value is the estimation of the standard deviation of the coefficient. This value is 1.13855 which is the standard deviation of the coefficient which is also one of the results of the regression analysis.

Table 26 ANOVA Table

	Sum of Squares	df	Mean Square	F	Sig.
Regression	39.179	5	7.836	6.045	.000
Residual	190.556	147	1.296		
Total	229.735	152			

The first important part of ANOVA table is sum of squares. The sum of squares part is associated with the three different sources of variance which are regression, residual and total. The division of regression's sum of squares by the total sum of squares results in the R Square value which is 0.171. Total variance is divided into

two which can be explained by independent variables (regression) and cannot be explained by independent variables (residual).

More importantly, ANOVA table indicates if the model predicts the dependent variable significantly. To clarify the significance of the prediction, the significance value of the ANOVA table should be examined by looking at "Sig." column of the table. This significance value is notated with p-value or *p*. For this model $p = 0.000$ which indicates that this model is significant for 1% significance level in order to make the regression analysis and to find the coefficients of the model.

The summary and ANOVA table of the regression analysis result represent an important part of the analysis by showing the regression model's significance. Table 27 presents the excluded variables among the nine independent variables due to their significance values because removal value is selected as 0.10 for stepwise regression analysis. The variables are removed from the regression model and because of this; the related coefficients are not given.

Table 27 Excluded Variables

Excluded Variables	Beta In	t	Sig.
Cloud Structure	0.023	0.280	0.780
Monitoring	0.037	0.467	0.641
Internet Connection	0.058	0.709	0.479
SLA	0.013	0.163	0.871

The coefficients table for included variables is presented by Table 28. The information needed by the model is prediction of dependent variable made by the independent variables which is given by this table in order to examine the coefficients of the regression model.

Table 28 Included Variables with Their Coefficients

Included Variables	B (Unstandardized Coefficients)	Std. Error (Unstandardized Coefficients)	Beta (Standardized Coefficients	t	Sig.
(Constant)	0.733	1.006		0.688	0.493
Virtualization	0.459	0.123	0.290	3.741	0.000
Account Control	0.353	0.139	0.203	2.533	0.012
Cloud Applications	-0.223	0.116	-0.148	-1.917	0.057
Privacy and Security	0.324	0.165	0.154	1.962	0.052
Cloud Migration	-0.412	0.240	-0.134	-1.720	0.088

As seen at the Table 28, there are six different coefficients resulted by the regression analysis. These coefficients are constant, which stands for α in the regression model, coefficients for privacy and security (β_1), account control (β_2), virtualization (β_4), cloud applications (β_6) and cloud migration (β_8). First of all, the contributions of independent variables' significance should be examines by looking at the "Sig." column. The constant value of regression model, α, is equal to 0.493 and it is included in the regression model no matter its significance value is. The significant independent variables according to the result of regression analysis are *privacy and security, account control, virtualization, cloud applications and cloud migration*. Privacy and security, cloud applications and cloud migration are significant for 10% significance level, account control is are significant for 5% significance level, and virtualization is significant for 1% significance level.

As extracted in the light of the significance values, challenges about cloud structure, monitoring, Internet connection and SLA does not contribute to the usage of cloud computing significantly because they are also excluded from the regression analysis by stepwise model after five steps. This means, the variables for these

challenges do not take place in the regression model because of their significance values.

After eliminating the insignificant variables, the new version of regression model is given below:

$$CU = \alpha + \beta_1 \text{ x } PS + \beta_2 \text{ x } AC + \beta_4 \text{ x } VT + \beta_6 \text{ x } CA + \beta_8 \text{ x } CM + \varepsilon$$

The coefficients of the remaining predictors can be determined by the B (Unstandardized Coefficients) column at Table 28. These values are the coefficients for the related predictors. Some of these values are positive and some of them are negative. A positive coefficient indicates that every unit increase in the related variable results in an increase in the dependent variable with that coefficient unit as predicted. A negative coefficient indicates that every unit increase in the related variable results in a decrease in the dependent variable with that coefficient unit as predicted. This calculation applies while holding other variables as constant.

According to Table 28, $\alpha = 0.733$, $\beta_1 = 0.324$, $\beta_2 = 0.353$, $\beta_4 = 0.459$, $\beta_6 = -0.223$ and $\beta_8 = -0.412$. Therefore, the latest version of the regression model according to the regression analysis is:

$$CU = 0.733 + 0.324 \text{ x } PS + 0.353 \text{ x } AC + 0.459 \text{ x } VT - 0.223 \text{ x } CA - 0.412 \text{ x } CM$$

This equation states that, a unit increase in privacy and security results in 0.324 unit increase in usage, a unit increase in account control results in 0.353 unit increase in usage, a unit increase in virtualization results in 0.459 unit increase in usage, a unit increase in cloud applications results in 0.223 decrease in usage and a unit increase in cloud migration results in 0.412 unit decrease in usage. As a reminder, the variables represent the importance of that variable given by users.

As stated at Chapter 3, hypotheses of this study are given below in order to analyze one by one:

- *H1: Challenges about privacy and security negatively affect the usage of cloud computing*
- *H2: Challenges about account control negatively affect the usage of cloud computing*
- *H3: Challenges about cloud structure negatively affect the usage of cloud computing*
- *H4: Challenges about virtualization negatively affect the usage of cloud computing*
- *H5: Challenges about monitoring negatively affect the usage of cloud computing*
- *H6: Challenges about cloud applications negatively affect the usage of cloud computing*
- *H7: Challenges about internet connection negatively affect the usage of cloud computing*
- *H8: Challenges about cloud migration negatively affect the usage of cloud computing*
- *H9: Challenges about Service Level Agreement (SLA) negatively affect the usage of cloud computing*

According to the result of the regression analysis, judgments can be made for all hypotheses. H3, H5, H7 and H9 are rejected because their related variables are not significant even for %10 significance level and corresponding independent variables are excluded by regression analysis as shown by Table 27.

For H3, it is found that there is not a significant relationship between the challenges about cloud structure and usage of cloud computing. The importance given for challenges about cloud structure by users does not significantly predict the usage of cloud computing.

For H5, it is found that there is not a significant relationship between the challenges about monitoring and usage of cloud computing. The importance given for challenges about monitoring by users does not significantly predict the usage of cloud computing.

For H7, it is found that there is not a significant relationship between the challenges about internet connection and usage of cloud computing. The importance given for challenges about internet connection by users does not significantly predict the usage of cloud computing.

For H9, it is found that there is not a significant relationship between the challenges about SLA and usage of cloud computing. The importance given for challenges about SLA by users does not significantly predict with the usage of cloud computing.

As a result, the corresponding challenges that are mentioned by the rejected hypotheses actually do not have a significant relationship with the usage of cloud computing. Users or researchers may emphasize the challenges about cloud structure, monitoring, internet connection and SLA but the usage of cloud computing is not affected by these challenges significantly. There may be several explanations for this situation. For instance, while considering the importance given to these challenges, users may ignore other factors such as benefits of cloud computing or organization's reasoning which can be the main reason for using or not using the cloud computing.

Organizations' viewpoint on cloud computing and IT personnel's viewpoint can be contrast. Because of this situation, the challenges even do not significantly related with the usage of cloud computing. Also it can be said that other challenges that enter to regression analysis dominates these challenges which results in to the insignificance. Within these rejected variables, SLA needs to be considered separately because SLA is prepared by the manager-level personnel and is highly probable that IT personnel do not have detail knowledge about SLA which may be the cause of the situation of SLA in this study's result.

As presented by Table 28, the remaining variables that take place in the latest regression model are challenges about privacy and security, account control, virtualization, cloud applications and cloud migration. However, significance of these variables does not mean that the related hypotheses are accepted.

According to H1, challenges about privacy and security negatively affect the usage of cloud computing. As a result of the regression analysis, it is observed that the importance given to the challenges about privacy and security contribute to the model significantly. On the other hand, the extracted coefficient for privacy and security is 0.324. This means that, every unit increase in the importance given to the challenges about privacy and security leads to 0.324 unit increase in usage of cloud computing. This result rejects H1 because H1 states that privacy and security negatively affects the cloud computing but the result shows that it positively affects the cloud computing. This contrast can be clarified by several explanations. One can give high importance to the challenges about privacy and security but usage may increase in parallel because the benefits can dominate the challenges about privacy and security or some may see privacy and security as an advantage of cloud computing as mentioned at the previous chapters. Also, company's general

perception of cloud computing can be opposite of its IT personnel's which may results in that the IT personnel uses cloud computing unwillingly within the organization. Shortly, even the importance given to the challenges about privacy and security contributes to the usage of cloud computing significantly, H1 is rejected due to its positive effect. However, this variable still takes place in the regression model because of its significance.

Same situation applies for the challenges about account control. H2 states that challenges about account control negatively affect the usage of cloud computing. At regression model, it seen that the coefficient for account control is 0.353 which means that every unit increase in the importance given to the challenges about account control results in 0.353 unit increase in the usage of cloud computing. Thus, H2 is rejected. Same explanations made for H1 may apply for H2 too. The benefits of cloud computing can dominate the challenges about account control. Also, while the IT personnel of the organization give high importance to the challenges about account control; the management part of the organization may think that these challenges are not important when usage is considered. Thus, they may decide on using cloud computing within organization even IT personnel do not want to use because of challenges about account control. Again it can be stated that there may be other factors that decrease the usage of cloud computing because challenges about account control do not decrease the usage.

When the coefficient for challenges about virtualization is considered, it is seen that every unit increase in the importance given to the challenges about virtualization results in 0.459 unit increase in the usage of cloud computing. This statement indicates the opposite result of H4. Even it is a significant contributor to the model; H4 states that challenges about virtualization negatively affect the usage

of cloud computing which is rejected by the result of this study. Moreover, virtualization is the most significant contributor to this model when all variables of this study are taken into consideration. Virtualization is nested with the cloud systems and it provides lots of benefits to the cloud computing such as resource provisioning, resource utilization, abstraction and isolation. It can be stated that the importance given to the benefits of virtualization highly dominate the importance given to the challenges of virtualization. It does not mean that challenges about virtualization are not important for usage. The increase in the importance given to the challenges of virtualization increases the usage of cloud computing because these challenges are not the only factor for usage. The challenges of virtualization are important but benefits of virtualization are more important for users or organization. Virtualization cannot be considered only by its challenges because it is an enabling technology for cloud computing.

The rejected hypotheses are examined and explained in the light of features of cloud computing and viewpoint of organizations. There are two predictors remained which negatively affect the usage of cloud computing. H6 states that, challenges about cloud applications negatively affect the usage of cloud computing. This hypothesis is accepted because the result of the regression analysis shows that every unit increase in the importance given to challenges about cloud application results in 0.223 unit decrease in usage of cloud computing. This is the proof of H6 which asserts the same statement. Contrast to the challenges about privacy and security, account control, cloud structure, virtualization, monitoring, internet connection and SLA, challenges about cloud applications decrease the usage of cloud computing. In other words, they affect the usage of cloud computing in negative way. The challenges about cloud applications that take part in this study are:

- Bugs
- License issues
- Update issues
- Cloud application's capacity

These are the challenges related to the cloud applications that are supplied by the cloud service provider to the users via Internet connection. According to the result of the survey made by this study, these challenges are considered as important obstacles for using cloud computing.

Last but not least important hypothesis that remained is H8 which states that the challenges about cloud migration negatively affect the usage of cloud computing. This is the second and last accepted hypothesis of this study because the result of the regression analysis and the latest version of regression model indicate that every unit increase in the importance given to the challenges about cloud migration leads to 0.412 unit decrease in the usage of cloud computing. This result is parallel with the statement made by H8. The challenges about cloud migration negatively affect the usage of cloud computing. Also it can be seen that the most effective variable among all is the challenges about cloud migration with its coefficient, 0.412. This is the highest value of the regression model which also affects the cloud usage negatively. Contrast to the challenges about privacy and security, account control, cloud structure, virtualization, monitoring, internet connection and SLA, challenges about cloud migration and cloud applications decrease the usage of cloud computing. As mentioned at the previous chapters, most of the challenges are gathered from the literature, except cloud migration. Challenges about cloud migration process are not mentioned a lot by the researchers thus it was not selected as challenges for this study. However, after an interview with a cloud expert, cloud migration challenges,

which are given below, are added as one of the most important part of cloud computing systems:

- Integration with the old system
- Technical capability of the organization
- Changing technology
- Resistance to the new system (cloud system)
- Change of system analysis process of the organization

Also, some of the respondents state the importance of cloud migration process as an answer for the last question of the questionnaire which asks if there is any additional challenge or comment that respondent want to mention. Although challenges about cloud migration take part in the questionnaire, it is mentioned by respondents specific as an answer to the last question.

Shortly H3, H5, H7 and H9 are rejected due to the insignificance of their prediction. Besides, H1, H2 and H4 are rejected too but the rejection reason of these hypotheses is different. They predict the dependent variable significantly but their coefficients are not negative which means that the corresponding variables do not negatively affect the usage of cloud computing. Thus, these hypotheses are rejected.

H6 and H8 are the accepted hypotheses of this study because of their significance and negative effect on the usage of cloud computing. The results of these hypotheses are shown at the Table 29.

Table 29 Results of Hypotheses

Hypothesis	Result
H1	Rejected
H2	Rejected
H3	Rejected
H4	Rejected
H5	Rejected
H6	Accepted
H7	Rejected
H8	Accepted
H9	Rejected

According to the result of the bivariate correlation analysis, there are significant correlations between usage of cloud computing and privacy and security, account control, and virtualization. However it seen that hypotheses related to these challenges are rejected. According to the result of the regression analysis it is seen that they predict the dependent variable in positive way significantly. Also bivariate correlation analysis shows that they are significantly correlated with the dependent variable but in positive way.

The challenges about cloud applications and cloud migration do not have a significant correlation with the usage of cloud computing, but have negative Pearson coefficient according to the bivariate correlation analysis. On the other hand, regression analysis states that these variables significantly predict the dependent variable with negative coefficient value. None of these two variables significantly correlated with usage of cloud computing individually but when all challenges composed together, challenges about cloud applications and cloud migration can predict the usage significantly. These situations show that bivariate correlation analysis and regression analysis are almost parallel except significance values because bivariate correlation analysis considers each correlation independently. While bivariate correlation analysis only looks for the association, regression

analysis looks for the prediction which is the main of this study in order to study the hypotheses.

As mentioned shortly at chapter 4, criterion-related validity refers to the capability of one measurement to estimate the values of another measure (Salkind, 2006). The aim of regression analysis is predicting the value of dependent variable with independent variables. It can be asserted that the regression analysis is the indicator of criterion-related validity of this study. According to Table 26, the significance value of ANOVA table p=0.000 which shows that the estimation made by independents variable for dependent variable is significant. In other words, this study's criterion-related validity is high because the measures have ability to estimate another measure, which is the dependent variable.

This chapter firstly discusses about some descriptive findings by considering the demographics and responses of the participants. Then, reliability and bivariate correlation analysis are made before constructing the multiple regression analysis in order to analyze the technical challenges given by this study. After discussion about the validation of hypotheses asserted by the thesis, next chapter includes topics about IT standards in order to find solutions to the technical challenges of cloud computing.

CHAPTER 6

IT STANDARDS FOR CHALLENGES

The previous chapter deeply analyzes the technical challenges of cloud computing and their effects on usage. However, most of these challenges can be prevented or solved by globally accepted methods. Some of the challenges stated and analyzed by this study such as cloud structure is the nature of using cloud computing. Because of this situation, solving all challenges of cloud computing is a difficult objective. On the other hand, the methods to prevent and solve cloud computing challenges should match the criteria such as cost and ease of implement. One of the most common methods among them is adopting the standards for IT governance which include several objectives and practices for the organizations. Cloud computing is the new trend for ICT and because of this, IT standards can be applied for cloud computing terminology.

International IT Standards

The risks that cloud computing poses are not new, they can be seen in many enterprises today (Ahmed, 2011). Outsourcing the cloud computing proposes some risks:

- Loss of governance
- Compliance
- Data protection
- Cloud service provider selection

COBIT (Control Objectives for Information and Related Technology) is a set of standards which minimizes the IT-related risks and maximizes the advantages of cloud computing at the same time.

ITIL (Information Technology Infrastructure Library) is a set of practices for Information Systems Service Management (ITSM). ITIL has an important role because it manages the gains that cloud computing promises (Sreekumar and Prabhakara, 2011). Cloud computing provides a huge virtual environment which needs to be managed. ITIL can be applied to this environment as well as almost all types of IT environment (Popovic and Hocenski , 2010).

ITIL is related with the security management practices in cloud while it looks for ensuring the information security at different levels such as strategic, operational and tactical because information security is an iterative process. Adopting ITIL by an organization helps them to answer the question "how do I ensure that my services are secure". To ensure the information security, ITIL breaks down the information security into different aspects:

- *Policies: The overall objectives an organization is attempting to achieve*
- *Processes: What has to happen to achieve the objectives*
- *Procedures: Who does what and when to achieve the objectives*
- *Work instructions: Instructions for taking specific actions*

On the other hand, adopting ITIL offers a wide range of benefits:

- *Reduced costs*
- *Improved IT services through the use of proven best practices*
- *Improved customer satisfaction by more professional service delivery*

- *Standards and guidance*
- *Improved productivity*
- *Improved use of skills and experience*
- *Improved delivery of third party services through the specification of ITIL or ISO 20000 as the standard for service delivery in services procurements*
- *ITIL helps to separate administrative tasks and technical tasks so that the most appropriate resources are assigned*
- *Better measure technical support performance*

In addition, ITIL is also related with virtualization security. Virtual machine migration is one of the challenges of cloud computing as stated before. It is stated that, virtual machine migration should go through ITIL process (Luo *et al.,* 2011).

Besides ITIL, in ISO/IEC 20000 IT Service Management (SM) includes procedures in order to control and protect access to organization's data, information, resources and IT Services (Kretzschmar *et al.,* 2011). These SM procedures include methods for authentication, encryption, authorization, and so on.

ISO/IEC 20000 is the highest level for IT service management (ITSM) but it is difficult to obtain without best practices (Fry, 2010). It is generally accepted that ITIL is best practice when service management is considered and COBIT is best practice for quality control and ITSM assurance.

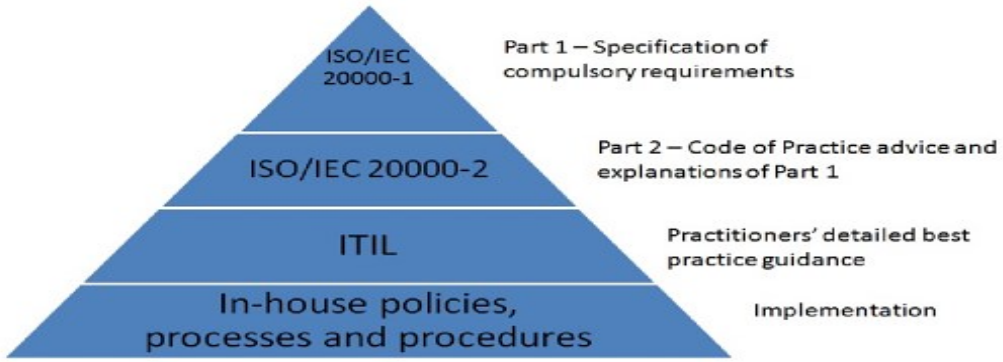

Fig. 11 Relationship between ISO/IEC 20000 and ITIL (Kunas, 2012)

ISO/IEC 20000-1 defines the Service Management System Requirements (SMSR) while ISO/IEC 20000-2 is constructed with same structure which consists of (Buchsein and Dettmer, 2008):

- *Introduction, objectives*
- *Terminology and definitions*
- *Requirements for a management system*
- *Planning and implementation of service management*
- *Planning and implementation of new or changed services*
- *Service level management*
- *Service reporting*
- *Availability and service continuity management*
- *Financial planning and cost estimates for IT-services*
- *Capacity management*
- *Information security management*
- *Business relationship management*
- *Supplier management*

- *Incident management*
- *Problem management*
- *Configuration management*
- *Change management*
- *Release management*

In addition, ISO/IEC 20000-7 is guidance on the application of ISO/IEC 20000-1 to the cloud structure (Kunas, 2012). Its aim is explaining the importance of ISMS for cloud service providers (CSP) and showing the benefits of ISO/IEC 20000-1 for both CSP and consumers. All deployment and service models of cloud computing are included. As mentioned, ISO/IEC 20000-1 and 20000-2 provides objectives for change management. This means that, adopting ISO/IEC 20000 family provides a solution for the challenges during Cloud Migration which includes a process for change management.

The ISO 27001 contains control objectives for ISMS, the ISO 27002 summarizes control mechanisms for reducing the risks, and ISO 27004 includes ISMS measurement and metrics (Beckers *et al.,* 2011). All of these are for Information Systems governance but these objectives, measurements and metrics can be applied to cloud computing in order to the risks posed by cloud computing.

Solutions for Technical Challenges

The security benefits that COBIT with cloud provides are customer compliance, selected authentication methods, customizable access control, enforcement of 4-eyes authorization, and forensics and contracts (SLA). This means that, using COBIT

standards may be a complete solution for solving the challenges related to privacy and security. Moreover, “the COBIT is a measurement-driven framework which provides several metrics to measure IT processes including metrics for measuring SLA and security performance” (Putri and Mganga, 2011).

Table 30 COBIT and Technical Challenges of Cloud Computing

Solutions provided by COBIT	Corresponding Technical Challenges Presented by Thesis
Security benefits, metrics for security performance	Privacy and Security
Authentication methods, authorization	Account Control
Contracts, metrics for measuring SLA	SLA

As stated by Putri and Mganga (2010), COBIT 4.1 includes descriptions of ten objects:

1) Configuration Management

According to COBIT, configuration management provides the integrity and system availability. As stated by this study, integrity and availability are issues for privacy and security which can be solved by the configuration management process of COBIT.

2) Change Management

Change management is related to IT structure and applications. It can be stated that challenges about cloud migration and cloud applications are related with this process. If process during cloud migration can be managed effectively, the challenges may be easily minimized. Also, changes during an application development on cloud may result in several challenges such as license issues or bugs. Thus an effective management during change of applications will decrease the risks’ impact.

3) Problems and Incident Management

This is one of the processes of ITIL and COBIT have in common which increases the system availability and service levels in order to maximize the customer's satisfaction. It is seen that, this process is related with privacy and security. More importantly, it is related with SLA. Thus, managing the service level and preparing SLA accordingly may minimize some important problems.

4) Operations Management

It includes monitoring IT infrastructures. As mentioned, monitoring is one of the challenges given by this study. Thus, this process aims to minimize the risks about monitoring of cloud computing.

5) Performance and Capacity Management

This process reviews the performance and capacity of cloud computing periodically. Capacity and performance are important challenges that are mentioned by the studies in literature as well as this study. These challenges are stated as "cloud structure" by this study. By reviewing the performance and capacity requirements of cloud computing infrastructure, provider can handle the demands of customers and increase QoS.

6) Continuity of IT Services

Continuous IT services requires maintaining and testing IT continuity plans which is related with the challenges about monitoring as given by this study. Thus this process provided by COBIT may be a solution for the challenges about monitoring.

Beside the processes defined by COBIT, there are 340 metrics defined by COBIT and 41 of them are about SLA. As mentioned by previous chapters, SLA is one of the most important processes that CSP and customer need to emphasize. Preparing a SLA without any knowledge may result in crucial problems. The metrics defined by COBIT about SLA is important in order to prepare an appropriate SLA which may minimizes the impacts of risks resulted by SLA.

The aim of SM methods provided by ISO/IEC 20000 is ensuring the confidentiality, integrity and availability (Kretzschmar *et al.,* 2011). These are the challenges of cloud computing as expressed by some studies. This means that ISO/IEC 20000 procedures may provide a secure cloud platform. The challenges mentioned by this study are directly related with these standards which are *privacy and security and account control*.

Besides, structure that ISO/IEC 20000-1 and 20000-2 consist of includes the management of processes that needs to be considered for cloud computing (Buchsein and Dettmer, 2008). Table 31 gives the processes and corresponding technical challenges which can be minimized by managing the processes.

Table 31 ISO/IEC 20000-1, 20000-2 and Technical Challenges of Cloud Computing

Benefits provided by ISO/IEC 20000-1 and 20000-2	Corresponding Technical Challenges Presented by Thesis
Information security management, problem management, availability	Privacy and Security
Planning and implementation, change management, release management	Cloud Migration
Capacity management, problem management, incident management	Cloud Structure
Service Level Management	Service Level Agreement (SLA)
Service reporting	Monitoring

A paper presented by Cloud Standards Customer Council (2013), discussed ten steps for cloud service customers in order to manage security risks. Table 32 shows important steps that are related to the technical challenges mentioned by this study with standard and certification recommendations.

Table 32 Standard and Certification Recommendations for Evaluation Steps (Cloud Standards Customer Council, 2013)

Step	Corresponding Technical Challenge Presented by Thesis	Standard Recommendation	Certification Recommendation
Audit operational and business process	Monitoring	SSAE 16, ISO 27000	ISO 27002, ISO 27017, SSSAE 16
Ensure proper protection of data and information	Privacy and Security	HTTPS, SFTP, VPN, OASIS KMIP	ISO 27002, ISO 27017,
Enforce privacy policies	Privacy and Security		ISO 27018
Assess the security provisions for cloud apps	Cloud Applications	Ensure CSP supports technologies such as firewalls, VPN	ISO 27002, ISO 27017
Ensure cloud networks and connections are secure	Internet Connection	ISO/IEC 27033	ISO 27002, ISO 27017
Security controls on physical infrastructure	Cloud Structure	ISO 27002, ISO 27017, ISO 27018	ISO 27002, ISO 27017
Manage security terms in the cloud SLA	SLA	ISO 27004:2009, CIS Consensus Security Metrics	SSAE 16, ISO 27002, ISO 27017

As discussed by this chapter, adopting IT standards within an organization provides important benefits for cloud computing users. Different IT standards may solve for each of the cloud computing challenges presented by the model of this study. Previous chapter analyzes the effects of technical challenges on cloud computing

usage where some of them are decreasing the cloud computing usage in dramatic way. Adopting IT standards is one of the most secure and easy way to eliminate the challenges of cloud computing.

CHAPTER 7

CONCLUSION

Cloud computing is a developing technology for ICT and at the same time, it is an attractive topic for research area. It has both advantages and disadvantages for companies who use cloud computing. However, it is observed that cloud computing is not a main research area in Turkey. Because of this, there is not much up-to-date study that gives the status of cloud computing in Turkey.

As stated, cloud computing has several important challenges beside of its countless benefits. These challenges are mentioned by the studies in the literature but these studies do not examine the importance of these challenges with regards to usage of cloud computing. The aim of this study is exploring if technical challenges of cloud computing affect the usage of cloud computing. To accomplish this aim, challenges are gathered from the literature and non-technical ones are eliminated. Also, some technical challenges are added to study later which are advised by cloud experts.

At last, there were sixty-nine technical challenges gathered. These technical challenges are classified under nine different challenge topics with the help of literature and cloud experts. These challenges are *privacy and security, account control, cloud structure, virtualization, monitoring, cloud application, Internet connection, cloud migration and SLA*.

The theoretical framework of this study is prepared considering the variables. There are nine independent variables of this study which are challenges about *privacy and security, account control, cloud structure, virtualization, monitoring,*

cloud application, Internet connection, cloud migration and SLA. The dependent variable of this study is *usage of cloud computing*. According to the model, there are nine hypotheses proposed by this study:

- *H1: Challenges about privacy and security negatively affect the usage of cloud computing*
- *H2: Challenges about account control negatively affect the usage of cloud computing*
- *H3: Challenges about cloud structure negatively affect the usage of cloud computing*
- *H4: Challenges about virtualization negatively affect the usage of cloud computing*
- *H5: Challenges about monitoring negatively affect the usage of cloud computing*
- *H6: Challenges about cloud applications negatively affect the usage of cloud computing*
- *H7: Challenges about internet connection negatively affect the usage of cloud computing*
- *H8: Challenges about cloud migration negatively affect the usage of cloud computing*
- *H9: Challenges about Service Level Agreement (SLA) negatively affect the usage of cloud computing*

A questionnaire is prepared in order to find the effects of technical challenges on the usage of cloud computing by collecting the required data. This questionnaire is conducted on IT personnel that works in companies operate in Turkey. Beside of

the effects of technical challenges, an up-to-date status of cloud computing is given as a result of the questionnaire. At questionnaire, there are demographic questions, the questions about cloud computing usage, the knowledge of user about cloud computing and the importance given to the challenges by the respondent.

Analyses are made by SPSS 19.0 and composed of descriptive analysis, reliability analysis, bivariate correlation analysis and regression analysis. According to the result of the analysis, 43.1% of the organizations have more than 1000 personnel and 20.3% of the organizations have more than 250 personnel but less than 1000 personnel. When the number of IT personnel is considered, the situation becomes different. 28.8% of the organizations have more than one but less than ten IT personnel and 24.2% of the organizations have more than 250 but less than 1000 IT personnel.

The popularity of cloud computing is an important aspect for researchers. As a result of this study, 71.3% of the respondents think that cloud computing's popularity in Turkey is below average out of five. This shows the current popularity of cloud computing which is very low.

24.8% of the respondents expressed that they do not use cloud computing within organization. This means that, 75.2% of the respondents use cloud computing within organization without considering the usage statistics. Also it is extracted that, 153 out of 161 respondents have knowledge about cloud computing where the remaining respondents are eliminated before the analysis part.

Besides these statistical findings, it is extracted that 17.6% of the respondents have been working for less than one year for their organization. In other words, 82.4% of the respondents have been working more than one year which states that

they have enough knowledge about the organization to accurately answer the questions about organizations.

After descriptive studies, reliability analyses are made in order to check if the scales of this study are reliable. There are ten variables within this study, nine of them are independent variables also known as technical challenges and the last one is the dependent variable which represents the usage of cloud computing. As a result of the reliability analyses, all scales are reliable in order to construct bivariate correlation and regression analysis.

Bivariate correlation analysis is made to show if there is any linear relationship between the independent variables and dependent variable. As a result of this analysis, there are three significant linear relationships that dependent variable has are extracted:

- Privacy and security
- Account control
- Virtualization

There are also several significant relationships between the independent variables but these are not inside the scope of this study.

The results of both reliability analysis and bivariate correlation analysis show that the model of this study is appropriate for regression analysis. Before constructing the regression analysis, assumptions such as multicollinearity and normality are tested. After validating that data is normal and there is not collinearity between independent variables, regression analysis is constructed by using "stepwise" method. The regression analysis shows that this model is significant and

fit. The regression model of this study is formed with nine predictors (technical challenges) and one dependent variable (usage of cloud computing).

H3, H5, H7 and H9 are rejected because according to the regression analysis, the prediction of these hypotheses' related variables are not significant. Besides of this, H1, H2 and H4 are rejected even related variables' prediction are significant. As a result of regression analysis H1 is rejected because the challenges about privacy and security do not affect the usage negatively, H2 is rejected because the challenges about account control do not affect the usage negatively and H4 is rejected because the challenges about virtualization do not affect the usage negatively.

The accepted hypotheses as regression analysis results in are H6 and H8. H6 states that the challenges about cloud applications negatively affect the usage of cloud computing and H8 states that the challenges about cloud migration negatively affect the usage of cloud computing. These two hypotheses are the accepted ones among nine hypotheses.

H3, H5, H7 and H9 are rejected due to their insignificant prediction. There may be several reasons for this situation. There are countless benefits of cloud computing systems besides of its challenges. User can decide to use cloud computing mostly because of its benefits. This means that, benefits of cloud computing can dominate the challenges of it even these challenges cannot be related with usage of cloud computing. While giving answers to the questions of the questionnaire, one may consider only the importance given to the challenges while they ignore other factors such as benefits of cloud computing or organization's reasoning but these factors can be the main reason for using or not using the cloud computing. For example, IT personnel have knowledge about SLA challenges but they are not

included in the process of preparing SLA. This means, the importance given to SLA by IT personnel does not related with usage because they are not related with SLA.

Privacy and security, account control and virtualization are significantly related to the usage of cloud computing but they do not affect the usage of cloud computing in negative way. These contrasts can be clarified by several additional explanations. One can give high importance to the challenges about cloud computing but the usage may increase in parallel because the benefits of cloud computing can dominate the challenges about privacy and security, account control and virtualization. Also, company's general approach to cloud computing usage and its challenges can be contrast to the respondents' viewpoint which may result in that the respondents, who are IT personnel, use cloud computing unwillingly within the organization. On the other hand, the decrease in the importance given to these challenges also leads to decrease in the usage of cloud computing. This means that there are other factors except the challenges about account control, privacy and security, and virtualization which decreases the usage of cloud computing. Also, while some studies states privacy and security as a challenge for cloud computing, there are many studies which state that privacy and security is an advantage for cloud computing. It can be seen that privacy and security, and virtualization does not affect cloud computing usage negatively. This means that privacy and security can be seen as relatively more advantageous. Moreover, virtualization is one of the major technologies which enable the cloud computing terminology. It can be extracted that the benefits of virtualization such as isolation and abstraction dominates the challenges about it.

IT standards can be adopted as a solution for most of the technical challenges. Because of its global usage, companies may adopt the most-used IT standards in order to minimizes the risks occurred as a result of using cloud computing.

The analysis part is made with 153 responses, which could be higher, and this is one of the important limitations of this study. The reason of this limitation is the lack of contacts for some of the organizations. Besides, the questionnaire was shortened in order to get more responses by the sample. A longer and more detailed questionnaire could be constructed but that would decrease the responses. Last but not least, some of the items could be eliminated too or they could be classified more accurately under another or new topic.

As further research areas, the challenges about cloud applications and cloud migration need to be studied in depth because they decrease the usage of cloud computing significantly. If the challenges under the topic of cloud applications and cloud migration are solved, it may contribute to an increase in the usage of cloud computing in Turkey.

The challenges about privacy and security, account control, cloud structure, virtualization, monitoring, Internet connection and SLA do not decrease the usage of cloud computing significantly but they need to be studied together with cloud computing's benefits and other factors in order to find more accurate result.

Also, a study can be made with more responses which will give a relatively more accurate result. Besides, the sample needs to be wider which should also include manager-level personnel of the organization because they may participate in the process of adopting cloud computing such as preparation of SLA. Also, the

decisions about the organizations such as cloud computing migration are made by the managers which mean they can give more accurate responses to the questionnaire.

According to results, popularity of cloud computing is very low. To improve the popularity of cloud computing, it should be marketed and promoted not only to organizations but also general public. Also, seminars about cloud computing can be organized in order to increase the awareness. As a result of these, its popularity may increase and it may be an attractive topic for researchers.

This study is very important for the literature because there are countless studies that mention the challenges of cloud computing but this study is the first that explore their effect on usage with the widest range of challenges gathered. This study also reveals the latest status of cloud computing in Turkey because finding the latest status of cloud computing is challenging. By this, Turkey and other countries can be compared with regards to the cloud computing.

This study will also help organizations that operate in Turkey because there are still many organizations that cannot decide on using cloud computing. By exploring and solving the mentioned challenges, the usage rate of cloud computing by organizations can be increased.

APPENDICES

A. Questionnaire

Bulut Bilişimin Kullanımı ve Karşılaşılan Teknik Zorluklar

Çalıştığınız Kurum

1) Çalıştığınız kurumun ismi? (Bu alanı doldurmak zorunda değilsiniz.)

_____

2) Çalıştığınız kurum hangi sektör alanında yer almaktadır?*

( ) Otomotiv
( ) Banka/Finans
( ) Enerji
( ) Sağlık
( ) Elektronik
( ) İnternet
( ) Eğitim
( ) Ticaret
( ) Endüstri
( ) BT Servis Sağlayıcısı
( ) Lojistik
( ) Kamu Sektörü
( ) Telekomünikasyon ve Medya
( ) Sigorta
( ) Diğer

3) Şirketinizde bulunan çalışan sayısı?*

( ) 1-10 çalışan
( ) 10-50 çalışan

( ) 50-250 çalışan

( ) 250-1000 çalışan

( ) +1000 çalışan

4) Şirketinizin BT departmanında bulunan çalışan sayısı?*

( ) 1-10 çalışan

( ) 10-50 çalışan

( ) 50-250 çalışan

( ) 250-1000 çalışan

( ) +1000 çalışan

5) Çalıştığınız pozisyonda kaç yıllık deneyiminiz bulunmaktadır?*

( ) 0-1 yıl

( ) 1-3 yıl

( ) 3-5 yıl

( ) 5-10 yıl

( ) +10 yıl

Bulut Bilişim Hakkındaki Bilgi Birikimi ve Bulut Bilişim Kullanımı

6) Lütfen bulut bilişim bilgisi hakkında aşağıda yer alan soruları cevaplayınız.*

	1 (çok az)	2 (az)	3 (orta)	4 (fazla)	5 (çok fazla)
Bulut bilişim hakkındaki bilgi dereceniz?	( )	( )	( )	( )	( )
Bulut bilişimin sağladığı	( )	( )	( )	( )	( )

faydalar hakkındaki bilgi dereceniz?					
Bulut bilişimin çalışma prensipleri hakkındaki bilgi dereceniz?	( )	( )	( )	( )	( )
Bulut bilişim ve diğer kullanılan sistemler (Örn. kurum içi) arasındaki farklar hakkında bilgi dereceniz?	( )	( )	( )	( )	( )
Bulut bilişimin Türkiye'de ne derecede yaygın olduğunu düşünüyorsunuz?	( )	( )	( )	( )	( )

7) Lütfen aşağıda yer alan bulut bilişim kullanım dereceleri hakkındaki soruları cevaplayınız.*

	1 (kullanılmıyor)	2 (nadiren kullanılıyor)	3 (bazen kullanılıyor)	4 (sık sık kullanılıyor)	5 (her zaman kullanılıyor)
Şirketinizdeki bulut bilişim kullanımı	( )	( )	( )	( )	( )
Şirketinizde sanallaştırma teknolojisi kullanımı	( )	( )	( )	( )	( )

8) Aşağıda yer alan bulut bilişim hakkındaki seçeneklerden hangileri konusunda bilginiz olduğunu düşünüyorsunuz? (Facebook, Gmail gibi örnekler üzerinden düşünebilirsiniz.) (Birden fazla seçenek işaretleyebilirsiniz.)*

[ ] Güvenlik - Gizlilik

[ ] Kullanıcı hesapları

[ ] Bulut bilişimin yapısı

[ ] Sanallaştırma

[ ] Gözlem - Takip

[ ] Uygulamalar

[ ] İnternet bağlantısı

[ ] Bulut bilişime geçiş süreci

[ ] Servis Düzeyi Anlaşması (Service Level Agreement - SLA)

[ ] Yukarıdaki seçeneklerden hiçbiri hakkında bilgim yok.

Bulut Bilişimin Teknik Zorlukları

9) Aşağıda yer alan bulut bilişimin güvenliği-gizliliği hakkındaki zorlukların kullanımınız açısından önem derecelerini belirtiniz.

	1 (önemli değil)	2 (az)	3 (makul derecede)	4 (fazla)	5 (çok fazla)
Gizlilik	( )	( )	( )	( )	( )
Ataklar	( )	( )	( )	( )	( )
Veri kontrolünün kaybı	( )	( )	( )	( )	( )
Şifreleme	( )	( )	( )	( )	( )
Ortak kullanılan kaynaklar	( )	( )	( )	( )	( )

Önemli bilgilerin paylaşılması	( )	( )	( )	( )	( )
Veri bütünlüğü	( )	( )	( )	( )	( )
Fiziksel güvenlik (altyapı güvenliği)	( )	( )	( )	( )	( )
Ağ güvenliği	( )	( )	( )	( )	( )
Web tarayıcısı güvenliği	( )	( )	( )	( )	( )
Programlama alanının güvenliği	( )	( )	( )	( )	( )
Yedekleme	( )	( )	( )	( )	( )
Her zaman kullanılabilir durumda olması	( )	( )	( )	( )	( )
Yönetim kontrolünün güvenliği	( )	( )	( )	( )	( )

10) Aşağıda yer alan bulut bilişime erişim kontrolü hakkındaki zorlukların kullanımınız açısından önem derecelerini belirtiniz.

	1 (önemli değil)	2 (az)	3 (makul derecede)	4 (fazla)	5 (çok fazla)
İzinsiz erişim	( )	( )	( )	( )	( )
Kullanıcı	( )	( )	( )	( )	( )

hesaplarının kontrolü					
Kullanıcı kimliği yönetimi	( )	( )	( )	( )	( )
Kimlik doğrulama	( )	( )	( )	( )	( )
İçeride yer alan zarar verici kullanıcılar	( )	( )	( )	( )	( )

11) Aşağıda yer alan bulut bilişimin yapısı hakkındaki zorlukların kullanımınız açısından önem derecelerini belirtiniz.

	1 (önemli değil)	2 (az)	3 (makul derecede)	4 (fazla)	5 (çok fazla)
Sağladığı servis kalitesi	( )	( )	( )	( )	( )
Ölçeklendirme	( )	( )	( )	( )	( )
Birden fazla kullanıcıya hizmet vermesi	( )	( )	( )	( )	( )
Özelleştirmeye fazla imkan vermemesi	( )	( )	( )	( )	( )
Şeffaflığın ortadan kalkması	( )	( )	( )	( )	( )
Esneklik	( )	( )	( )	( )	( )
Eski sisteme geri dönüş (şirket içi sistem)	( )	( )	( )	( )	( )

Verilerin saklandığı yer	( )	( )	( )	( )	( )
İşlem ve dosya saklama kaynaklarının dinamik olarak tahsis edilmemesi	( )	( )	( )	( )	( )
Heterojen bir ortam olması	( )	( )	( )	( )	( )
Kompleks bir sistem olması	( )	( )	( )	( )	( )
Görevlerin zamanlanması	( )	( )	( )	( )	( )
Otomatikleştirilmiş servis konfigürasyonu	( )	( )	( )	( )	( )
Verilerin birden fazla lokasyonda saklanması	( )	( )	( )	( )	( )
Yerel güç sağlayıcılara olan güvenilirlilik	( )	( )	( )	( )	( )
Bulut bilişim sistemlerinin değişken davranışlarda bulunabilmesi	( )	( )	( )	( )	( )
Kaynak yönetimi	( )	( )	( )	( )	( )
Bulut bilişim sistemlerinin bir arada çalışabilirliği	( )	( )	( )	( )	( )
Senkronizasyon	( )	( )	( )	( )	( )
Bulut bilişim sisteminin kapasitesi	( )	( )	( )	( )	( )

(talepleri karşılayabilme kapasiteleri)					
Kaynaklardan tam kapasitede yararlanamamak	( )	( )	( )	( )	( )
Verilerin düzeni	( )	( )	( )	( )	( )
Arızalanma, sistemin aksaması	( )	( )	( )	( )	( )
Ağ üzerinde bulunan düğümlerin kapasitesi	( )	( )	( )	( )	( )
Verilerin kilitli kalması - Verileri almanın zorluğu	( )	( )	( )	( )	( )

12) Aşağıda yer alan sanallaştırma hakkındaki zorlukların kullanımınız açısından önem derecelerini belirtiniz.

	1 (önemli değil)	2 (az)	3 (makul derecede)	4 (fazla)	5 (çok fazla)
Sanal makinelerin hassas yapıda olması	( )	( )	( )	( )	( )
Sanal makinalare veya sanal makinelerden göç etme	( )	( )	( )	( )	( )

13) Aşağıda yer alan bulut bilişim sistemlerinin gözetimi hakkındaki zorlukların kullanımınız açısından önem derecelerini belirtiniz.

	1 (önemli değil)	2 (az)	3 (makul derecede)	4 (fazla)	5 (çok fazla)
Denetim	( )	( )	( )	( )	( )
Sistem günlükleri	( )	( )	( )	( )	( )
Sistem bakımı	( )	( )	( )	( )	( )
Sistem üzerinde yapılan testler	( )	( )	( )	( )	( )

14) Aşağıda yer alan bulut bilişim uygulamaları hakkındaki zorlukların kullanımınız açısından önem derecelerini belirtiniz

	1 (önemli değil)	2 (az)	3 (makul derecede)	4 (fazla)	5 (çok fazla)
Yazılım hataları	( )	( )	( )	( )	( )
Uygulamaların lisans sorunları	( )	( )	( )	( )	( )
Yazılım güncellemeleri	( )	( )	( )	( )	( )
Uygulamaların kullanıcı taleplerini karşılayabilme kapasitesi	( )	( )	( )	( )	( )

15) Aşağıda yer alan bulut bilişimden yararlanmak için kullanılan internet bağlantısı hakkındaki zorlukların kullanımınız açısından önem derecelerini belirtiniz.

	1 (önemli değil)	2 (az)	3 (makul derecede)	4 (fazla)	5 (çok fazla)
Yüksek bant genişliği gereksinimi	( )	( )	( )	( )	( )
Internet bağlantısından alından performans	( )	( )	( )	( )	( )
Uzun vadede yüksek bağlantı ücretleri	( )	( )	( )	( )	( )
Yoğun iş yükü olduğu zamanlarda yüklerin dengelenmesi	( )	( )	( )	( )	( )
Internet servisinin kesintiye uğraması	( )	( )	( )	( )	( )
Internet trafiğinin yönetimi	( )	( )	( )	( )	( )

16) Aşağıda yer alan bulut bilişime geçiş sırasında karşılaşılan zorlukların kullanımınız açısından önem derecelerini belirtiniz.

	1 (önemli değil)	2 (az)	3 (makul derecede)	4 (fazla)	5 (çok fazla)
Eski sistemle	( )	( )	( )	( )	( )

entegrasyonu					
Şirketin teknik kapasitesi	( )	( )	( )	( )	( )
Sürekli değişen teknoloji	( )	( )	( )	( )	( )
Bulut bilişime geçiş aşamasında karşılaşılan direnç	( )	( )	( )	( )	( )
BT analiz aşamalarının değişmesi	( )	( )	( )	( )	( )

17) Aşağıda yer alan bulut bilişimin Servis Düzeyi Anlaşması (Service Level Agreement - SLA) hakkındaki zorlukların kullanımınız açısından önem derecelerini belirtiniz.

	1 (önemli değil)	2 (az)	3 (makul derecede)	4 (fazla)	5 (çok fazla)
Servis Düzeyi Anlaşması'nın içeriğinin hazırlanması	( )	( )	( )	( )	( )
Servis Düzeyi Anlaşması'nın uygulanması	( )	( )	( )	( )	( )
Servis Düzeyi Anlaşması'nın takibi	( )	( )	( )	( )	( )
Servis Düzeyi Anlaşması'nın	( )	( )	( )	( )	( )

içeriği					

18) Yukarıda yer alan bulut bilişimin zorlukları dışında, sizin önemli gördüğünüz başka zorluklar varsa belirtebilir misiniz?

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Anketi doldurduğunuz için teşekkür ederiz.

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