

**Czech University of Life Sciences Prague**

**Faculty of Economics and Management**

**Department of Information Engineering**



**Master's Thesis**

**Transition to cloud services for SMEs**

**Nikhil Gill**

**© 2022 CZU Prague**

# CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

## DIPLOMA THESIS ASSIGNMENT

NIKHIL GILL

Systems Engineering and Informatics  
Informatics

Thesis title

Transition to cloud services for SMEs

---

### Objectives of thesis

The main objective of the thesis is to analyze approaches to cloud transition from the perspective of SMEs.

The partial objectives are:

- to make an overview of the current market of cloud services, digital transformation approaches and challenges;
- to analyze cloud services adoption approaches including security and privacy concerns;
- to summarize findings and elaborate recommendations for cloud services adoption for SMEs.

### Methodology

The thesis is based on the study and analysis of information available in the scholar and professional literature. Resulting from the literature study, research questions will be formulated and addressed in the practical part of the thesis. The analysis of the cloud services adoption approaches will be analyzed in a SME case study by using quantitative methods. The findings will be interpreted, summarized and used for formulating recommendations for SMEs.

**The proposed extent of the thesis**

60-80 pages

**Keywords**

Cloud services, SME, transition, security, privacy.

---

**Recommended information sources**

- Abdollahzadegan, A., Che Hussin, A. R., Moshfegh Gohary, M., & Amini, M. (2013). The organizational critical success factors for adopting cloud computing in SMEs. *Journal of Information Systems Research and Innovation (JISRI)*, 4(1), 67-74.
- Assante, D., Castro, M., Hamburg, I., & Martin, S. (2016, May 12). The Use of Cloud Computing in SMEs. Retrieved November 11, 2020, from <https://www.sciencedirect.com/science/article/pii/S1877050916302836>
- Indriastuti, M., & Fuad, K. (2020, July). Impact of Covid-19 on Digital Transformation and Sustainability in Small and Medium Enterprises (SMEs): A Conceptual Framework. In *Conference on Complex, Intelligent, and Software Intensive Systems* (pp. 471-476). Springer, Cham.
- Khayer, A., Talukder, M., Bao, Y., & Hossain, M. Cloud computing adoption and its impact on SMEs' performance for cloud supported operations: A dual-stage analytical approach. Retrieved November 11, 2020, from <https://www.sciencedirect.com/science/article/abs/pii/S0160791X19301599?via=ihub>
- Qian, H., & Medhi, D. (2011, March). Server Operational Cost Optimization for Cloud Computing Service Providers over a Time Horizon. In *Hot-ICE*.
- Rath, A., Kumar, S., Mohapatra, S., & Thakurta, R. (2012, December). Decision points for adoption cloud computing in small, medium enterprises (SMEs). In *2012 International Conference for Internet Technology and Secured Transactions* (pp. 688-691). IEEE.
- 

**Expected date of thesis defence**

2022/23 WS – FEM

**The Diploma Thesis Supervisor**

Ing. Miloš Ulman, Ph.D.

**Supervising department**

Department of Information Technologies

Electronic approval: 18. 11. 2020

doc. Ing. Jiří Vaněk, Ph.D.

Head of department

Electronic approval: 19. 11. 2020

Ing. Martin Pelikán, Ph.D.

Dean

Prague on 14. 11. 2022

## **Declaration**

I declare that I have worked on my master's thesis titled "**Transition to cloud services for SMEs**" by myself and I have used only the sources mentioned at the end of the thesis. As the master's thesis author, I declare that the thesis does not break any copyrights.

In Prague on 27.11.2022

---

## **Acknowledgment**

I would like to thank Ing. Miloš Ulman, Ph.D. (Thesis Supervisor), and all other persons, for their advice and support during my work on this thesis.

# Transition to cloud services for SMEs

## Abstract

We are listening to the word “cloud computing” in recent years, How and in what ways it is going to help the InformationTechnology (IT) infrastructure. This research aims to why it is becoming important for Small and Medium Enterprises (SMEs) adopt cloud services. What will be the impact of the adoption of cloud-based technologies by various organizations? Mainly, this research focuses on the behavior of Small and Medium Enterprises (SMEs). In what ways do Cloud services will help SMEs to grow their business without bothering about maintaining the data, database, security of data, and accessing of the data. In this thesis, there is a detailed explanation about Cloud Computing, Services Models, Deployments Models, Cloud Providers. In this thesis, the author will discuss a fiction company and selection of cloud services provider by multi criteria decision analysis (MCDA) and Analytical Hierarchy Process will be applied. Also, there will be an overview of the current market of cloud services, analyzing cloud services adoption approaches including security and privacy concerns. The result of this thesis is to summarize findings and recommendations for SMEs for the adoption of cloud services.

**Keywords:** Cloud Computing, Cloud Services, Small and Medium Enterprises SMEs, Infrastructure as a service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), Privacy, Security.

# Přechod na cloudové služby pro malé a střední podniky

## Abstrakt

V posledních letech nasloucháme slovu „cloud computing“, jak a jakým způsobem pomůže infrastruktuře informačních technologií (IT). Tento výzkum se zaměřuje na to, proč je pro malé a střední podniky (SME) důležité zavést cloudové služby. Jaký bude dopad přijetí cloudových technologií různými organizacemi? Tento výzkum se zaměřuje především na chování malých a středních podniků (SME). Jakými způsoby cloudové služby pomohou malým a středním podnikům rozvíjet jejich podnikání, aniž by se museli obtěžovat správou dat, databáze, zabezpečením dat a přístupem k datům. V této práci je podrobně vysvětleno cloud computing, modely služeb, modely nasazení, poskytovatelé cloudu. V této práci bude autor diskutovat o fiktivní společnosti a bude aplikován výběr poskytovatele cloudových služeb pomocí multikriteriální rozhodovací analýzy (MCDA) a Analytical Hierarchy Process. Rovněž bude uveden přehled současného trhu cloudových služeb, analyzující přístupy k přijetí cloudových služeb, včetně otázek bezpečnosti a soukromí. Výsledkem této práce je shrnutí poznatků a doporučení pro malé a střední podniky pro přijetí cloudových služeb.

**Klíčová slova:** Cloud Computing, cloudové služby, malé a střední podniky, malé a střední podniky, infrastruktura jako služba (IaaS), platforma jako služba (PaaS), software jako služba (SaaS), soukromí, bezpečnost.

# Contents

<b>1</b>	<b>Introduction .....</b>	<b>12</b>
<b>2</b>	<b>Objectives and Methodology .....</b>	<b>13</b>
2.1	Objectives .....	13
2.2	Methodology.....	13
<b>3</b>	<b>Literature Review .....</b>	<b>14</b>
3.1	What is Cloud Computing? .....	14
3.2	Types of Cloud Computing .....	15
3.2.1	Public Cloud .....	15
3.2.2	Private Cloud .....	16
3.2.3	Hybrid Cloud .....	17
3.2.4	Community Cloud.....	17
3.3	Cloud Service Models .....	18
3.3.1	Infrastructure as a Service (IaaS).....	19
3.3.2	Platform as a Service (PaaS).....	19
3.3.3	Software as a Service (SaaS) .....	19
3.4	Local Service Providers.....	20
3.5	Global Service Providers .....	22
3.6	Advantages of Cloud Computing .....	24
3.7	Disadvantages of Cloud Computing.....	25
3.8	Cloud Security .....	25
3.8.1	Cloud Security Challenges.....	25
3.8.2	Cloud Security Solution.....	26
3.8.3	Cloud Security Principles .....	27
3.9	Data Protection .....	28
3.10	Security and Privacy.....	31
3.11	Use of Cloud Computing Services .....	36
3.12	ICT security in Enterprise .....	39
3.13	Challenges of cloud service adoption by SMEs .....	40
3.14	Method used for Selection of Cloud Service Provider .....	41
3.14.1	Analytic Hierarchy Process (AHP).....	42
3.14.2	Row Geometric Mean.....	43
3.15	Today's application and usage.....	45
3.16	Issues of cloud transition .....	46
3.17	Why to adopt cloud services.....	48
3.18	Summary from the literature review.....	50
<b>4</b>	<b>Practical Part .....</b>	<b>53</b>

4.1	Background of the Organization (SME).....	53
4.1.1	SWOT Analysis for Cloud computing .....	55
4.2	Current State Analysis .....	58
4.3	Selection Criteria for cloud .....	59
4.3.1	Price: .....	59
4.3.2	Cloud Security: .....	60
4.3.3	Data Centers.....	60
4.3.4	Support.....	61
4.3.5	Cloud Storage: .....	61
4.3.6	Manageability .....	61
4.4	Comparison of Cloud Service Providers .....	62
4.5	Saaty’s Method.....	65
4.6	Criteria Prioritization.....	65
4.7	Evaluation of alternative cloud service providers .....	67
4.8	Estimation of costs .....	69
4.9	Summary of Evaluation.....	72
<b>5</b>	<b>Results and Discussion .....</b>	<b>72</b>
<b>6</b>	<b>Conclusion .....</b>	<b>75</b>
<b>7</b>	<b>References .....</b>	<b>77</b>

## List of Figures

Figure 1: Cloud Computing Scheme .....	14
Figure 2: Public Cloud.....	16
Figure 3: Cloud Service Models .....	18
Figure 4: Challenges in cloud computing.....	31
Figure 5: Percentage of Enterprises using Cloud computing .....	36
Figure 6: Use of Cloud Computing Service in terms of Type of Service.....	37
Figure 7: Use of cloud computing services, in terms of size of enterprises .....	38
Figure 8: ICT security in Enterprises.....	39
Figure 9: Hierarchical Problem Structure of Gilla Info.....	66

## List of Tables

Table 1: Comparison Scale AHP .....	43
Table 2: Index values of RI.....	44
Table 3: Key facts of Gilla Info .....	54
Table 4: SWOT analysis of Gilla Info regarding cloud computing.....	56
Table 5 : Comparison of Cloud Service Providers against the set Criteria .....	64
Table 6 : Comparison of Cloud Service Providers against the set Criteria .....	65
Table 7: Pairwise Comparison and Normalization between criteria .....	67
Table 8: Consistency index and consistency ratio .....	67
Table 9: Pairwise Comparison and Normalization between Alternatives .....	67
Table 10: Pairwise Comparison and Normalization between Alternatives .....	68
Table 11: Pairwise Comparison and Normalization between Alternatives .....	68
Table 12: Pairwise Comparison and Normalization between Alternatives .....	68
Table 13: Pairwise Comparison and Normalization between Alternatives .....	68
Table 14: Pairwise Comparison and Normalization between Alternatives .....	69
Table 15: Calculation of total utility of each alternative .....	69
Table 16: Estimation of price for local provider.....	70

# 1 Introduction

Small and medium-sized enterprises (SMEs) are essential to a country's economic development, especially in the European market. Small and medium-sized businesses (SMEs) are tightly rooted throughout Europe's economy and the backbone of Europe's economy. 50 percent of Europe's GDP is from the SMEs only and it is not a surprise that 2 out of 3 jobs in the European market are offered by the SMEs. They are critical to Europe's competitiveness, prosperity, and economic and technological independence. There are more than 25.1 million SMEs in Europe. The financial crisis and economic recession because of the COVID -19 have a great effect on the SMEs.[1]

Cloud computing has numerous advantages and can assist businesses in improving their operations and utilizing technology more effectively. Everyday billions of emails are being sent and a huge amount of data is being generated. This number is unimaginable from a human perspective. It is expected that a huge amount of data and services is being shared amongst users in the world. And such services are requested from servers and the server is a computer that provides services to clients. Problem is that server as one unit has limited resources and it is not possible to anticipate how much performance the will company need now or in the future. [2]

And a server has limited resources and it is not possible to enumerate the performance an SME needs and what's its performance in the future. One of the solutions is that it will buy a server which will be very expensive with reverse performance, but most of the time the server will be ideal. Cloud computing enables users to store files and applications on remote servers and then access all the data via the Internet. In the first instance, cloud computing was expensive, but it becomes easily available and cost-effective with innovation in the technology.

## **2 Objectives and Methodology**

### **2.1 Objectives**

The main objective of the thesis is to analyze the approaches of cloud transitions from the outlook of Small and Medium Size Enterprises (SMEs). In the theoretical part of the work, there will be an overview of the current situation of the market of cloud services, digital transformation, and various challenges during the adoption of cloud services.

The partial objectives of the work are as follows:

- to make an overview of the current market of cloud services, digital transformation approaches and challenges.
- to analyze cloud services adoption approaches including security and privacy concerns.
- to summarize findings and elaborate recommendations for cloud services adoption for SMEs.

### **2.2 Methodology**

The methodology of the diploma thesis is based on the study and analysis of information gathered in the scholar and professional literature. After getting the appropriate result from the literature study, the research question will be formulated and will be carried out in the practical part of the thesis. The study of cloud services adoption will be examined in the SMEs case study by using Analytic Hierarchy Process (AHP) methods. It is also known as saaty comparison method. The findings will be evaluated, summarized, and used to develop suggestions for small and medium-sized businesses.

### 3 Literature Review

#### 3.1 What is Cloud Computing?

In the past few years, the term "cloud computing" has become very popular. It refers to the type of computing services that are hosted over the internet. Some of these include Amazon Web Services, Google Apps, and Microsoft Office 365.[3]

According to Microsoft, cloud computing is a type of distributed computing system that enables companies to access various computer services such as databases, networking, and storage. It allows them to improve their efficiency and reduce their cost. Most of the time, users pay for the services that they are already using, which helps them to reduce their prices and improve their infrastructure.[4]

According to IBM, cloud computing allows companies to access various computer services such as databases, networking, and storage. These services are hosted at a remote data center and can be accessed through the internet. The monthly subscription fee that the service provider charges for these services is based on the usage.[5]

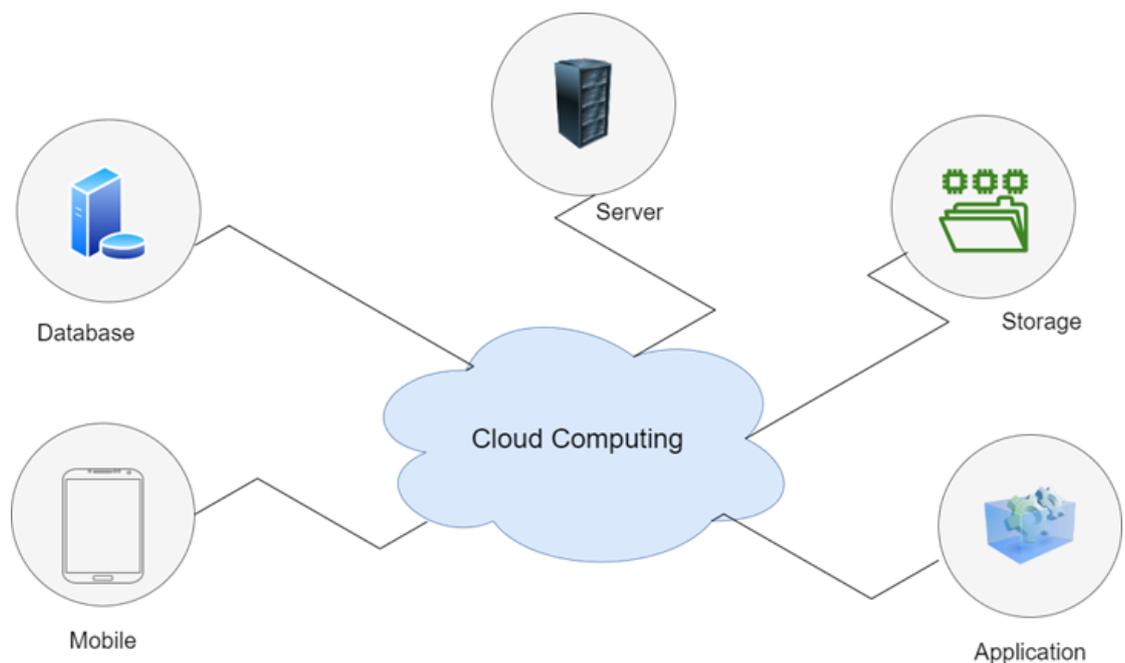


Figure 1: Cloud Computing Scheme [3]

## **3.2 Types of Cloud Computing**

Neither clouds are equal, nor its types is suitable for every situation. A wide range of models and services is required to figure it out the best solution as per the requirements. National Institute of Standards and Technology (NIST), defines the 4 different types of the clouds [6]. These are -

- Public Cloud
- Private Cloud
- Hybrid Cloud
- Community Cloud

### **3.2.1 Public Cloud**

In this development model, a provider is owning and operating the computing resources and is sharing it to publicly among various users with the help of internet. The public cloud provides computing resources to be easily buy to anyone and is shared to various users at the same time. Public Cloud has some cons like a user having to pay only for those services which are being used. Like, pay for the service user wants to use.[7]

A public cloud is designed for the public, including individuals and organizations. Some of the public cloud providers are – AWS, Microsoft Azure, Google App Engine, etc. Public cloud is managed at data center by service providers providing various clients.

The biggest advantage of the public cloud is cost savings. This means that one should only have to pay for the services which are being used or subscribed to. There will be no extra charges for the services which are not used or subscribed to. The organization that is using the public cloud have no burden for maintaining the infrastructure. Security, privacy, maintenance is carried out by the service provider. [2]

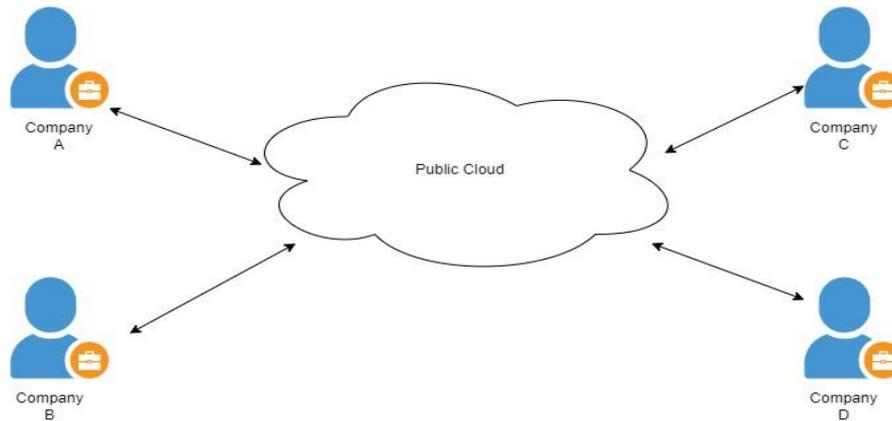


Figure 2: Public Cloud [7]

### 3.2.2 Private Cloud

In this type of development model computer services is to be shared to only approved users. Private cloud is also known as corporate cloud. The data security is provided with the help of firewalls and internal hosting so that only the authorized user only accesses the data. It also confirms that the data is not being used by the unauthorized users. Some of the examples of the private cloud are Microsoft, HP data centers, etc. [8]

The benefit of this development model that the hardware and the services is fully controlled compared to the public cloud because of its limited users. Another big advantage is security and privacy. In this type of cloud, there is a much more improved level of security as compared to a public cloud. Also, it improves the performance which helps in speed and space size.[2]

But with the advantages, there are also some disadvantages like there is a much more high cost of the private cloud comparison with the public cloud as maintenance of hardware resources and to set up the hardware requires high maintenance. Also, the high cost is because of the hiring of the skilled worker to maintain and operate cloud services.[9]

### **3.2.3 Hybrid Cloud**

The third type of the cloud computing is hybrid computing. It is the combination of two developments models i.e., public cloud and private cloud. The reason to combine public is to create a controlled link up and good computing environment. Public cloud only has the task which are not given that much importance where as private cloud handle the most important tasks in hybrid cloud. It is mostly used in the field of education e.g., in universities, healthcare, finance as well. Some of the hybrid cloud service providers are Microsoft, Amazon, Cisco, Google etc.

Some of the benefits of the hybrid cloud is that it gives the flexibility and security of the resources because of combination of both the cloud i.e., public, and private. Another main cons that it is not that much expensive compared to other development models.[9]

As it gives features of both public and private cloud it can easily handle the storage, power, requirements that any organization have as the critical jobs is operated by private cloud, the hybrid cloud is fully secure. To control and prevent the risks in any business the hybrid cloud is very useful. [10]

But with cons there are some pros as well like in this type of cloud there is great networking complexity, network compatibility is one of the problem. As both public and private cloud run on different infrastructure reliability is dependent on service providers.[3]

### **3.2.4 Community Cloud**

It enables various organizations to share data or resources by accessing systems and services. More than one firms in the group, or a third-party organization or all together can operate, access, and managed in the community cloud. Let take an example that a government firm within the Europe sharing computing architecture in the cloud to manage and access the data. [3]

The whole cloud is shared by different organizations or a community, so it become less expensive. Since it is accessible among users, so it is easy to adapt also it enable users to make changes in the documents as per the requirement. Another point to note that a community cloud is much more secure as compared to public cloud but less secure as compared to private cloud.

Also, some points to keep in mind that community cloud is not favorable for every company as each, and every organization have different requirements. In this, the data is slow to adopt, and bandwidth and capacity of data is with limited capacity. If compare with the public cloud it is much more costly and it is major problem to share the responsibility between the companies.

### 3.3 Cloud Service Models

Three main types of service models are: -

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

To achieve the requirement of an organization it is very important to understand these models, and these are differ from one another. These service models are placed at the top of one another. [11]

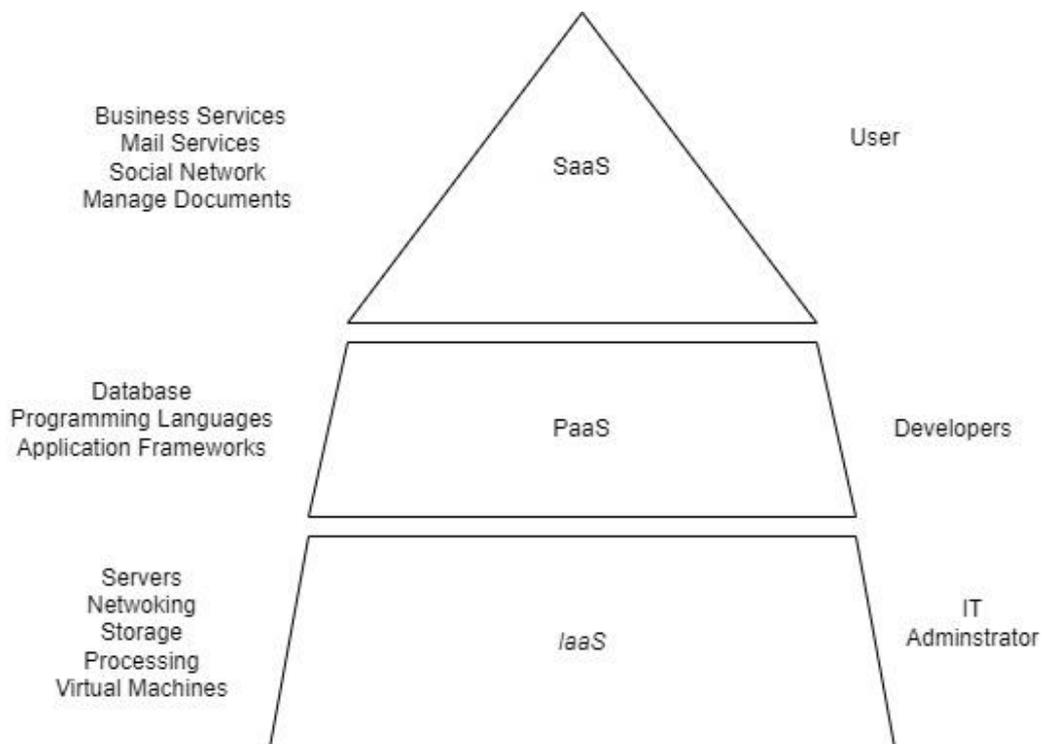


Figure 3: Cloud Service Models [12]

### **3.3.1 Infrastructure as a Service (IaaS)**

With the help of IaaS an organization can rent the IT infrastructure i.e., server, storage, operating systems (OS), from a cloud service provider and pay for the resources which is used. Another name of IaaS is Hardware as a Service (HaaS). Every resource in this computing model is managed over internet. It helps the organization to avoid the complexity and the running cost of buying and managing the servers. Some of its features is many users at a same time can use its services, Resources are accessed with the help of internet, Users are free to access and didn't have any problem related to software upgrades. Amazon Web Service (AWS), Google Compute Engine (GCE), Microsoft Azure etc. provides the facilities of IaaS.[13]

### **3.3.2 Platform as a Service (PaaS)**

The Platform as a Service (PaaS) lies in between the Infrastructure as a Service (IaaS) and Software as a Service (SaaS). It helps programmers to code, develop, run the applications. User can access to an environment where they can develop and access applications without downloading and work with IDEs, which is expensive. Some features of Platform as a Service (PaaS) is Multiple users can access the application in the same time, Programmers didn't have to care about the management, No need to buy any type of hardware or software, also it includes the feature of auto scale. Some of the examples of the PaaS providers is Windows Azure, Apache Stratos, Google App Engine, Force.com etc.[14]

### **3.3.3 Software as a Service (SaaS)**

"On-demand software" is another term for Software as a Service (SaaS). In Software as a Service (SaaS) cloud service providers have the access to the applications and is maintained and controlled by them. To access or use these applications the user is just require an internet connection and web browser that's why it is also named as on-demand software. Cloud provider manages the SaaS and it facilitates the new business with billing systems. Also, it monitors the user activities which is easily tracked by the organization. Some of the features of the Software as a Service (SaaS) is no need to have so much of hardware, it is operated and managed from a single place, very easy to maintain, The remote server helps

in hosting websites, software updates is automatically, user have to pay only for the services which is used.[15]

### **3.4 Local Service Providers**

There are many local cloud service providers in Czech Republic and in India.

The following are the cloud service providers in the Czech Republic are: -

#### **1. Algotech Cloud**

Algotech was founded in 1997 under the name Tservis97. It provides the services in contact centers, telecommunication, cloud solutions, software, and hardware, etc. They have three datacenters in Czech Republic and is mostly used for central European customer. AlgoCloud have technologies and services, that is one of the best tools of the information and communications without any large investments. It can be used by any type of the company means small or medium sized without any obstacles, whether public company or private company. AlgoCloud promise to customer satisfaction with safety of services. AlgoCloud provides unique wrap of services, configuration of the services, low price, high security comparable to PCI DSS, technical level comparable to the Tier III classification, full portfolio of the cloud services – SAAS, IAAS, PAAS, BPAAS, Supervisory center in operation available all the time, hardware availability at different areas for security purposes, hosting server. The AlgoCloud makes a word that there is no big investment needed for their services and in total there will be cost saving, independence of the platform, sharing of the capacity and performance according to the needs, all the services are up-to-date, centralized and infrastructure, only pay for the services which is used, safety etc. Algocloud is suitable for all type of company's whether it will be small or medium sized, public, or private organization. It satisfies high demands, safety of the services etc. of the customers. The Algocloud provides systems security against web attack with the help of latest security devices and standards, high standards for users by providing unique accesses name, password, PIN and security against internal attacks by dividing the user data, trying to allot only one system for individual customer, providing the rights to avoid unauthorized access.[16]

## 2. Forpsi Cloud

Forpsi group was founded in 1997. It has the datacenter in Czech Republic. Forpsi has its offices in Poland, Slovakia, and Hungary. It is the part of Aruba group since 2005 and provide cloud services in Czech Republic under FORPISCLOUD. Forpsi Cloud provides a variety of services named as Cloud VPS, Cloud Pro, Private cloud, Database as a Service, Cloud Backup, Cloud object storage, Domain center, Cloud monitoring etc. Forpsi Cloud VPS is very easy and quick to be activated. The virtual server meets the high standard of performance and reliability. Forpsi virtual server includes pre-configured server in four variants with all the required resources which are based on VMware technology and local SSD. Some features of Cloud VPS service is that it is user friendly, pre-configured, flexible, easy to afford. Forpsi Cloud Pro is a IaaS solution that provides an individual to create its own cloud infrastructure which can be based on high performance hardware, guarantee unusual reliability and flexibility.[8] It is a public cloud platform that allows to create own virtual mini data centers, network, storage which can be changed and scaled in real time and all this with the help of VMware vSphere and Microsoft Hyper-V technologies. Forpsi private cloud is an IaaS solution with support for the VMware NSX virtualization platform for software defined data centers. The Forpsi private cloud guarantee high compatibility and easy integration. It allows easy management of all computing and network resources, creating virtual data centers, individual virtual servers and configuring networks and firewalls. It also scales cloud infrastructure according to the needs in real time. Forpsi private cloud is ideal solution for hosting of information system, data migration to the cloud, bare metal backup, disaster recovery as a service[8]. Forpsi cloud backup ensure the safety of the data while adhering to disaster recovery principles. Forpsi has online backup infrastructure which is also very easy to maintain and use. With cloud backup service one can easily choose starting and destination of data, also where the data should be stored by choosing from data centers in the European network of the parent company i.e., Aruba.[17]

## 3. T- Mobile

T-Mobile is founded in 1999. The parent company of T mobile is Deutsche Telekom. The previous name of T-Mobile was 'Paegas' in Czech Republic The organization is currently working in most of the countries in Europe. It provides the services related to

Mobile Communication, DSL, etc. The T-cloud working together with the Microsoft in the field of cloud computing. T-cloud provides the services of the Microsoft and in 2020, Deutsche Telekom AG extends the longtime partnership with the Microsoft. The strategic partnership has the best solutions that fits the customer's needs, frictionless interplay between the cloud and the service providers. This helps the customers to access the Microsoft resources and skills in Europe as well as globally through digital and cloud services, delivering the capabilities across all the regions and on any scale, customized solutions and integration into existing IT environment based on Microsoft Azure, offices and other services, real end-to-end cloud solutions including connectivity and network, hybrid scenarios including public and private cloud services.[18] T cloud provides various digital and cloud services such as Microsoft Azure services to achieve business agility, elasticity, performance, and scale through migration on the Azure platform, also provides modern workplace solutions, IoT services to build digital-industrial disruptive IoT solutions at the convergence of physical and digital and many other services such as Data and analytics, SAP on cloud, Blockchain as a service, digital app development etc. T cloud also provides the services like adoption of cloud with variety of tools and services, also cloud services with monitoring and business commitment (SLA's), accountability for the network, applications and infrastructure, cloud adoption in a cloud governance framework aligned with business goals and strategy. [19]

### **3.5 Global Service Providers**

Global service providers are: -

1. Amazon Web Services (AWS)

Web services form Amazon was launched in 2002. AWS provide the services including networking, storage, database, IoT, etc. AWS is the one of the largest cloud computing platforms which is offering more than 200 features and services from infrastructure, cloud computing to machine learning. Amazon first cloud computing service was Amazon EC2 which was launched in 2008. No other cloud providers have as much features and services as AWS have and it also provide free tiers with access to AWS console in which the user has access to manage their services.[20] AWS service like Amazon EC2

(Elastic Compute Cloud) offers secure and resizable compute capacity helps with access and usability for rapid growth of cloud computing which gives full access over all computer resources. Another AWS service is Amazon RDS (Relational Database Service) which helps in database management, scaling, and configuration. RDS supports database engines including Amazon Aurora, PostgreSQL, MySQL, MariaDB, Oracle database, and SQL server, on a variety of database instances used for performance and storage. Another AWS service is Amazon S3 (Simple Storage Service) which enables object storage and provide scalability, data accessibility, security, and performance. Amazon Lambda helps to run code without managing servers, only the compute time used is charged to the user.[11]

## 2. Microsoft Azure

Microsoft Azure offers more than 500 service. Microsoft Azure data center are located all over the world. It is commonly used as a platform which is hosting the database. Azure can provide both Infrastructure as a platform (IaaS) and Platform as a service (PaaS) service to enterprises to create and launch web applications without putting extra efforts. MS Azure also provides hybrid cloud computing which is its one of the unique features. It improves the performance by utilizing VPNs, caches, CDNs, etc. Azure's commonly used services is Azure Active Directory (AD). It guarantees the management and security of identities. Azure Content Delivery Network (CDN) is also commonly used Azure service which speed up businesses by Its server which creates free space in the database, web applications, and Azure cloud services. The platform as a service (PaaS) category includes Azure SQL database, which handles most database maintenance tasks like backups, monitoring, patching, and updating without the need for user interaction. The software as a service (SaaS) in Azure helps to code and launch software's which offers easy integration facilities. [4]

## 3. Google Cloud Platform

Google cloud is launched in 2008 by google. It provides IaaS, PaaS, and serverless computing environments. Google cloud provides computing services like Compute engine. An IaaS element of GCP is Compute Engine. In Google's data centers, it enables users to create and manage virtual machines. It supports many CPU cycles and storage. In networking, GCP provide cloud CDN and Media CDN. The Cloud CDN offered by GCP is

a vast, private, and secure worldwide network. Similar work is done by Media CDN, but with streaming media. Networking services such as Google Cloud DNS, Cloud VPN In data storage and analytics the GCP provides cloud storage with low cost, high security. Google Cloud SQL, Google Cloud Spanner, Google Cloud Storage, and Persistent Disk on Compute Engine are services listed under Cloud Storage and Databases. Data scientists, developers, and infrastructure administrators can now access AI services through Google Cloud Platform features like Video AI which provide video analysis or can be used for content discovery. It also provides high performance hardware. GCP provides all the components needed for a strong security posture to ensure privacy and security. The pay-as-you-go model is used by Google Cloud Platform, and each service's price is determined by a specific set of factors. Both an upfront fee and a termination fee are not required of users.[14]

### **3.6 Advantages of Cloud Computing**

Cloud Computing has a number of significant advantages. The Cloud applications upgraded coordination by giving access to data quickly and easily in cloud via cloud server. It is considerably easier to back up and restore data after it has been stored within the cloud. Also, it become easy for the organization to control and manage data remotely, at any moment, using internet service quickly and easily. A cloud-based infrastructure increases company's quality and performance by guaranteeing that the data is always available. With the help of cloud services, access of data can be done from mobile devices, laptops, tablets etc. [21]It also helps in low-cost maintenance as companies can save costs on both software and hardware by using cloud computing. The enterprise can pay only when there is need of computer resources and only for how much they can use rather than having to make a big investment in data centers and servers before knowing how to utilize them. Another crucial point is data security as several strong security techniques is present into cloud computing to assure information is stored and protected from unauthorized access. The cloud provides storage capacity to a company which helps to keep important data like papers, photos, audio, video, and other sorts of multimedia in one place. [21]

### **3.7 Disadvantages of Cloud Computing**

With the benefits of the technology there will always be some of its drawbacks. Unlike other types of computing, cloud computing allows service providers to control and monitor the operations of their infrastructure. This eliminates the need for customers to exert any influence over the services that they use. All of the data stored in the cloud is stored and accessed through an internet connection. No one can access these files without good internet access. There is no other way to access the data stored in the cloud. One of the biggest disadvantages of cloud computing is vendor lock in. This occurs when an organization switches from one provider to another, and this can lead to issues. Since there are many platforms that are offered by different companies, it can be very challenging to switch between them. Although cloud computing companies follow high security standards when it comes to storing sensitive data, it is still important for companies to be aware of the risks associated with sending their data to the cloud. This is because hackers can easily access the information that they send. [22] Another disadvantage is that it is very time consuming and very difficult to move the huge amount of data between the clouds so for that high-speed internet is required. [23]

### **3.8 Cloud Security**

The various controls, rules, and technologies that are used to protect the data and applications stored in the cloud are referred to as cloud security. This includes the best practices and protocols that are designed to ensure that the environment is secure. Understanding the various aspects of cloud security is the first step in ensuring that the services are secure. The security of the cloud is a joint responsibility of the two parties that use it: the provider and the customer. The three types of responsibilities that are part of the Shared Responsibility Model are those that are always the provider's, those that are usually the customers, and those that are shared depending on the service model i.e. SaaS, PaaS, IaaS. [24] .

#### **3.8.1 Cloud Security Challenges**

One of the biggest issues that cloud-based companies face when it comes to security is the lack of visibility and control over the infrastructure layer. In the IaaS model, the providers

are not revealing to their customers the details of the infrastructure. This is especially true in the SaaS and PaaS cloud architectures. Cloud services users have difficulties to find out the cloud assets, and cloud environment. Unauthorized access keeps attacking the secure cloud to get access of data in the cloud, and public cloud become a challenge and hackers keep attacking on this environment. Malware, zero-day exploits, account takeovers, and a slew of other harmful threats have become common.[25] Because public cloud environments contain several client infrastructures under the same roof, it's likely that the hosted services will be hacked as collateral damage when hostile attackers target other firms. Regulatory compliance management can be perplexing for businesses that uses any one of public or hybrid cloud. The company retains all responsibility for data privacy and security, and a large dependence on other solutions to take care which can be a little bit expensive. In 2019, misconfigured assets accounted for 86 percent data breaches, which was a great challenge for cloud computing settings. Misconfigurations didn't include creating suitable privacy settings or leaving default administrative passwords in place.[26]

### **3.8.2 Cloud Security Solution**

Username and password combinations are normally used and is not that that much capable to provide full security from unauthorized access. To stole information is most prevalent way for scammers to access data and products stored on the internet. Cybercriminals can easily access all cloud-based applications and services if they obtain the login credentials. Encryption is a good solution to protect information over the cloud. Before transmitting or storing the data in cloud server it best to encrypt the data so that it can be secure from unauthorized access. [27] Only the owner can grant the permission who can access the data by providing encryption key. Not only does allocating access control defend against the attackers who have access of employee's login, but also it helps the employee from accidentally changing credentials which is not authorized to see. End-user activity can be controlled, managed in real time, for e.g. logins from last used unknown IP addresses or any other devices. These actions signal to breach in system and helps to find the attackers s and tracks and address security issues before any attack. A data security model has authentication, encryption, integrity, recovery, user protection must design to improve the security over cloud. Encrypted data become fully useless and normal encryption can make complicate availability. [25] To make sure employees didn't have any access to cloud

storage, systems, data, client information, when resign from the organization. Is it also possible for the hackers to access to private information by stealing any employees' login credentials with the help of social engineering techniques for e.g. phishing, and social media monitoring. So before transmitting data over the cloud server the user can store the data in backup drivers. Hash calculation of the file before transmitting can ensure the data is not altered but the hash calculation is one of the hardest and toughest to maintain. It is possible to inform the user of which portions of the data can access using permission as a service. The owner can assign most computationally heavy tasks to cloud servers by using fine-grained access control mechanisms. For the processing and sharing of data across cloud users in a secure manner, a data-driven framework can be created. Real-time threat detection is accomplished via network-based intrusion prevention systems. to calculate files with a very large size and dealing via remote data protection by using an RSA-based storage security mechanism.[28]

### **3.8.3 Cloud Security Principles**

The National Cyber Security Center announced 14 cybersecurity principles in 2016, all targeted at assisting cloud computing companies in protecting their customers from unwanted actions. Firstly, as data transfers between networks, there should be adequate security against barrier. Another is that there should be safeguards in place to secure user information and the components that handle it from any type of disruption. [29]Clients should be self-contained so that a breach of one user's data has no bearing on the other. For easy and consistent management, each provider should have a governance framework. Providers must provide their services in a secure manner and use simple techniques to detect malicious activity before it manifests. To limit the chances of hostile actions growing within, the provider's workers should be carefully trained and evaluated. Providers should plan their models around secure security protocols. If a provider takes particular security precautions, their supply chain will fall into line. To limit the risk of unwanted access to one's data, providers should make available any tools that a user requires to securely use their services. Access to service interfaces should only be allowed to people who can be validated beyond a reasonable doubt. Outside service interfaces should be defined and insulated appropriately. Unauthorized access to management systems could lead to dangerous access to a large amount of user data, so they must be well-protected. Users should be allowed to access audit

data so that harmful behaviors can be identified as soon as they occur. Users must adhere to specific criteria in order to utilize a service securely.[30]

### **3.9 Data Protection**

Data protection is a vital component of any organization's strategy to ensure that important information is not lost, stolen, or tampered with. Due to the immense amount of data being collected and stored, it is important that the protection of this information is carried out properly. This can be done through the use of various techniques such as continuous monitoring and recovery. One of the most important factors that a data protection strategy should consider is ensuring that the data is restored quickly after a loss or corruption.[31] One of the most important factors that a company should consider when it comes to data protection is ensuring that its employees are protected from unauthorized access and use. Due to the outbreak of the coronavirus epidemic, many employees had to work from home, which made it necessary for them to have remote data protection. This can be done through the use of various techniques. Another important aspect of data protection is ensuring that the privacy of the information is protected. Although the terms personal and privacy are often used interchangeably, they are very different. p[32]. The concept of privacy is based on the ideals of human dignity and the rule of law. In Europe, the terms "data protection" and "personal privacy" are often used interchangeably. However, they are very different. The former refers to the conditions that allow the processing of a person's personal information, while the latter refers to the constraints that prevent the unauthorized access and use of that information.[33]

#### Data Protection and Privacy Laws

There are various regulations and laws in different countries that affect the privacy and protection of your personal information. The Chinese Data Protection Act took effect on June 1, 2017. The European Union's General Data Protection Regulation took effect in 2018. In the US, the Consumer Privacy Act of California provides individuals with the right to control their own information. Getting the proper information handling and protection set up is a huge undertaking. Doing so can involve coordinating all of the regulations and laws in different countries. Failure to comply with these laws and regulations can result in costly

fines and the need to cease doing business in the affected region. Experts recommend that organizations have a comprehensive strategy and a set of procedures that are designed to comply with the strictest standards. The principles of data protection and privacy are designed to ensure that the information collected is secure and that the company can comply with the laws and regulations in the country where it is located. This includes getting the consent of the individual who is providing the information, ensuring that the security measures are in place, and training employees on how to handle and protect the data.[34]

### GDPR (General Data Protection Regulation)

After four years of planning and campaigning, the European Union's General Data Protection Regulation was finalized on April 27, 2016. It will be implemented on May 25, 2018. The regulation was published in the official journal of the European Union. It will have a two-year transition period following its implementation. It also applies to everyone whose data is held in the European Union, whether they are EU residents. The GDPR has six data protection principles i.e., lawfulness, fairness, and transparency, purpose limitation, data minimization, accuracy, storage limitation, integrity and confidentiality (security), accountability.[35]

The principle of transparency, fairness, and legality is very important when it comes to the collection of data. Businesses must ensure that their methods are legal and that they are not hiding anything from the data subjects. Understanding the GDPR and the other laws related to data gathering will help you stay compliant. You should also be upfront with the data subjects about how you collect their information. [35]

The purpose limitation is also important when it comes to the collection of data. It should be clear to the data subjects what the organization wants to collect and how long it will take to do so. Additionally, the processing of data in the public interest for scientific or historical purposes is allowed. [35]

When it comes to the collection of data, one of the most important steps that businesses must take is to ensure that they only collect the necessary details to perform their operations. This

method can prevent unauthorized individuals from accessing and using the information. It also helps in maintaining the data by ensuring that it is secure. [35]

The accuracy of your personal data is very important to ensure that it is secure. The GDPR states that every possible step should be taken to correct or remove erroneous or incomplete information. Individuals have the right to request that this information be deleted or adjusted within a month. [35]

When it comes to the storage of personal data, it is important that organizations remove it when it no longer needs to be. This is because, according to some companies, they should be allowed to keep the data for as long as it is necessary to identify the individual as a customer. However, this is not the case for every industry. For instance, if a company collects data for marketing purposes, then it might be necessary to retain the information for a long time.[35]

When it comes to Integrity and confidentiality can be referred as security because it is directly associated with security. According to the GDPR “processed in a manner that ensures appropriate security of the personal data, including protection against unauthorized or unlawful processing and against accidental loss, destruction, or damage, using appropriate technical or organizational measures”. Due to the continuously changing nature of technology and organizational practices, the GDPR is not yet clear on what steps businesses should take to ensure that their customers' personal data is secure. For instance, they should encrypt or pseudonymize their data whenever possible.[35]

The GDPR adds a seventh principle, which is referred as accountability, which serves as an umbrella for all other principles. Accountable organizations show that they have the necessary records in place to prove that they are fulfilling their guidelines.[35]

#### Czech Data Protection Act (DPA)

The Personal Data Processing Act 2019 (No. 110/2019 Coll.; henceforth ZZOU) is the Czech Republic's second data protection law, and it implements the EU's new legal framework: GDPR, Data Protection Directive 2016/680 (LED), and PNRD. Both GDPR and ZZOU modernize data protection to guarantee that it remains functional in future. The Data

Protection Authority is re-created by ZZOU as a supervisory authority (SA) for data protection. It makes way for the Czech DPA to take on a new role: the right to information. The Czech Data Protection Act of 2000 was enacted as a stand-alone law. All EU member nations, including the Czech Republic, are now subject to the GDPR.[36] The GDPR lays out the majority of legal responsibilities, but it also gives member states some leeway in determining how it will be implemented in their country. As a result, it is critical to read the GDPR and the ZZOU beside each other. The ZZOU features a section that deals with procedures which is outside from EU law, such as when comes to immigration it adheres to GDPR criteria but tweaked towards account that would be ineffective in a national setting. It translates the LED into local law: the LED supplements the GDPR. Because it is critical that intelligence services adhere to internationally recognized data protection standards, these measures are based on Council of Europe norms.[36]

### 3.10 Security and Privacy

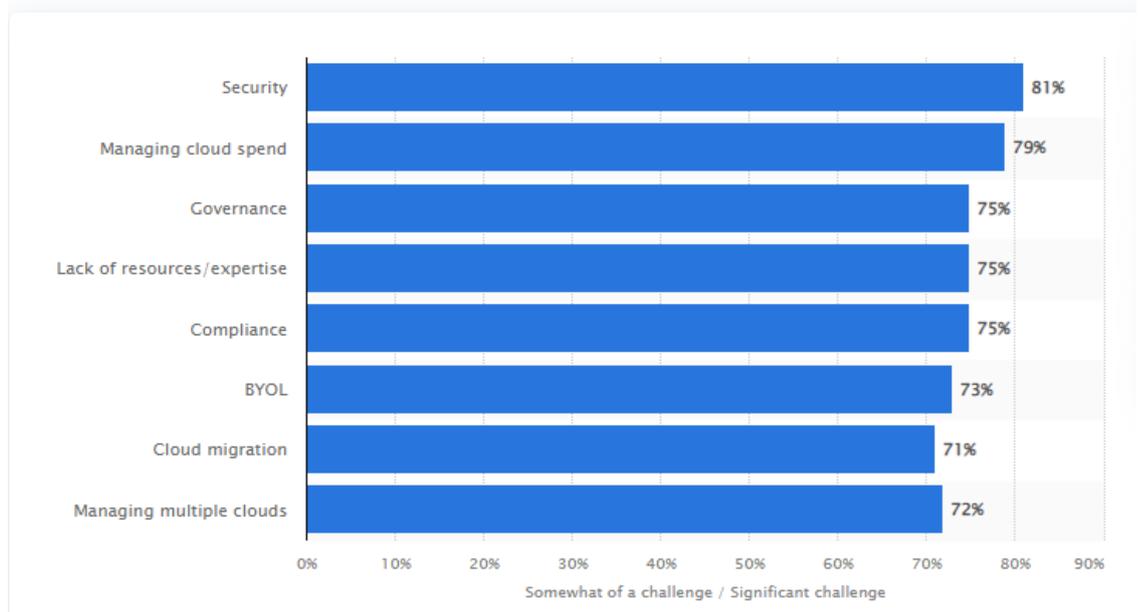


Figure 4: Challenges in cloud computing [37]

After studying various research papers, articles, meeting with the employees who is working on the cloud the security is the main issue while adopting the cloud services.

A significant portion of computer, network and information security is cloud security. It points to a collection of guidelines, instruments, and measures that are employed to protect data, programs, and the cloud services. To protect the data over the cloud it must be encrypted. Encryption helps the data to be protected from unauthorized access. The employees who are working on the cloud technology strongly recommended encrypting the data over the network, or on backup data. It is noted that not only the data on the cloud is to be encrypted but also the access to the data is to be protected from the cloud system administration. Only the encryption and decryption of the data is not provided that much protection so Cryptographic encryption is to be employed. The other thing is that there is also a number of security and privacy attacks.

Security Issues : - As the number of users in a public cloud system grows, security vulnerabilities become more intense and diverse. The attacks that are vulnerable to security threats must be identified. Adopting a private cloud solution is safer due to the numerous data breaches that affect public clouds, with the option to switch to a public cloud in the future if necessary.[38]

Issues in Public Cloud : - In a public cloud there are numerous users on a single platform and the security is taken over by the cloud service providers. Same platform is available for a lot of tenants, which is risk of data leakage between them in a public cloud. on the other hand, use a multitenant infrastructure by cloud service provider. To avoid such a risk, thorough research should be carried out while selecting a service provider. To safeguard data throughout its lifecycle, basic security requirements of integrity, and availability should be met. Many steps of creation, sharing, archiving, and processing, data must be safeguarded. However, in a public cloud, when there is no control over security policies, things become more problematic.[30]

To prevent insider attacks, an access control strategy based on client and provider has been developed. There is few key steps to accomplishing is creating a policy's it using a security policy module, enforce the policy by enforcement module. NIST's Guidelines on Security and Privacy provide an overview of cloud computing's security, privacy, availability threats. The NIST guidelines list the following dangers associated with enterprises' usage of cloud computing, among other things.

Trust: - One concern is the possibility of insider access to the information, which might result in both purposeful and unintentional data loss or corruption, as well as significant cloud service unavailability. Another concern is a lack of clarity about data ownership, particularly in border circumstances like transaction data generated by the usage of cloud services.[6]

Data Protection: - Data availability and data access control are two components of data protection that are explored.[6]

Data availability - The first component is determined by the client's choice of CS type and its migration and backup capabilities.[6]

Data access control – It's more challenging due to the unique characteristics of the shared multi-tenant environment in which cloud services are deployed.[6]

Governance: - Because of its widespread availability and, in many cases, high use, cloud services can easily ignore the organization's security, privacy, and software use restrictions. While it is possible to ensure that systems are secure and risk is handled when using in-house systems, it is significantly more challenging when using cloud services.[30]

Issues in Private cloud: - Customers have complete control over the network in a private cloud. The customer can use the private cloud to deploy any typical network perimeter security strategy. Although the security architecture in a private cloud is more trustworthy, there are several issues to consider. Areas of the cloud can be managed by users. When creating a web interface, there are two methods to choose from: Constructing an entire application stack, or Creating the web interface using common application stacks like Java, PHP, and Python.[30]

Virtualization techniques are widely used in private clouds. Machines may be able to interact with any other virtual machines in a virtual world, including unauthorized machines. To guarantee that they only connect with those with whom they are supposed to speak, appropriate authentication and encryption mechanisms should be established, such as IP level Security.[30]

Existing solution

Encryption Algorithms – At this time also, encryption is the main solution in order to overcome data privacy concerns in cloud computing. Information is encrypted using encryption techniques and only authorized person who have the encryption keys can use it. There are a variety of encryption types to choose from

Symmetric encryption - The regulation defines a symmetric encryption method as a type of encryption that uses a single key for both its encryption and decryption operations. This type of encryption is very simple to implement and is named "symmetric" due to how it uses a single key. As a result, symmetric encryption techniques is quicker than asymmetric encryption, no need a lot of resources and not slow down the speed of internet. So, to secure the data symmetric encryption is a great choice. [39]

Asymmetric encryption uses two different keys for its data encryption and decryption. These keys are known as the public and the private keys. Since the former is used to encrypt the data, it prevents it from being stolen by unauthorized individuals, while the latter is used to decrypt it. One of the most important factors that sets this type of encryption apart from other types of encryptions is its authentication. This ensures that only authorized users can decrypt the data.[25]

Any cloud service user is dependent on the cloud service provider for the encryption that they need. Let take an example that by default Amazon S3(Simple Storage Service) encrypts a user's data. Now the problem is that the user completely lose the control over the safety of their data. Cloud service providers is now having complete access to the data of user. Even though the service provider has no intention of harming the data of the user, there is a possibility that any employee of the service provider can always leak the user's data's confidentiality, integrity, and privacy.

Users can additionally encrypt their data using any encryption method they want and manage their own encryption keys. This strategy is currently being used by many CSUs to protect their data. Homomorphic encryption is important in this context because it allows cloud service provider to handle users data without having to decode it by offering services like searches, correctness verification, and error localization. Homomorphic encryption, while promising, has its own drawbacks, such as rise of bandwidth costs or attackers can discover specific patterns in communications connected with operations that use homomorphic encryption.

In terms of key management, newer cloud encryption approaches go a step further. They don't allow a single party to have complete control over an encryption key. As, they

divide the key into several parts, which are stored separately by the cloud service user, cloud service provider, and a third-party data encryption service.

An access control system is a set of procedures that prevent unauthorized individuals from accessing a company's data. It includes various steps such as authentication and authorization. A number of studies were conducted to develop a strategy that can identify the rules and roles that are required to implement this type of security.

The concept of role-based access control (RBAC) allows users to access a company's data based on their tasks. It is commonly used to implement minimum access regulations that restrict the access of certain individuals to only the resources that they need to complete their tasks. In this study, the authors present a data-attribute-based access policy that allows the owner of the data to delegate the majority of the tasks that are required to maintain the security of the data.[24]

Information system (IS) auditing is the process of reviewing an organization's checks, balances, and controls. In this section, the third-party audits, in which cloud service users and providers aren't involved in the auditing process other than to provide data and information to auditors. Third party audits (TPA) can be used to address data integrity, confidentiality, availability, and privacy concerns. Third party audits can examine data integrity in at least two ways: when it is in transit and while it is stable. TPA's key focus in terms of data confidentiality is how data is encrypted.

Governance - A full collection of actions connected with developing and implementing controls is referred to as governance. Although few hints of a cloud-specific security governance framework emerging. There are attempts underway to expand existing security standards. The ISO/IEC 27000 series is a global information technology (IT) security governance framework that primarily specifies general IT security standards and how to certify enterprises for compliance. ISO/IEC is working on a new standard that will enhance the existing ISO/IEC 27000 series and address cloud-specific information security controls. This new standard will be called ISO/IEC 27017 and will be part of the ISO/IEC 27000 series. One of these organizations is the Cloud Security Alliance (CSA). In the sense that they are targeting automated audit, statement, and certification, CSA's purpose differs slightly from ISO/IEC 27017's. Although new standards are evolving, there is currently nothing accessible in terms of what practitioners may embrace and apply. Individual cloud

security experts are mostly responsible for acquiring cloud computing and security knowledge and applying it to different parts of their cloud security. It is a necessary component of the cloud maturation in order to reach the next level of acceptance.[32]

### 3.11 Use of Cloud Computing Services

**Use of cloud computing services, 2020 and 2021**  
(% of enterprises)

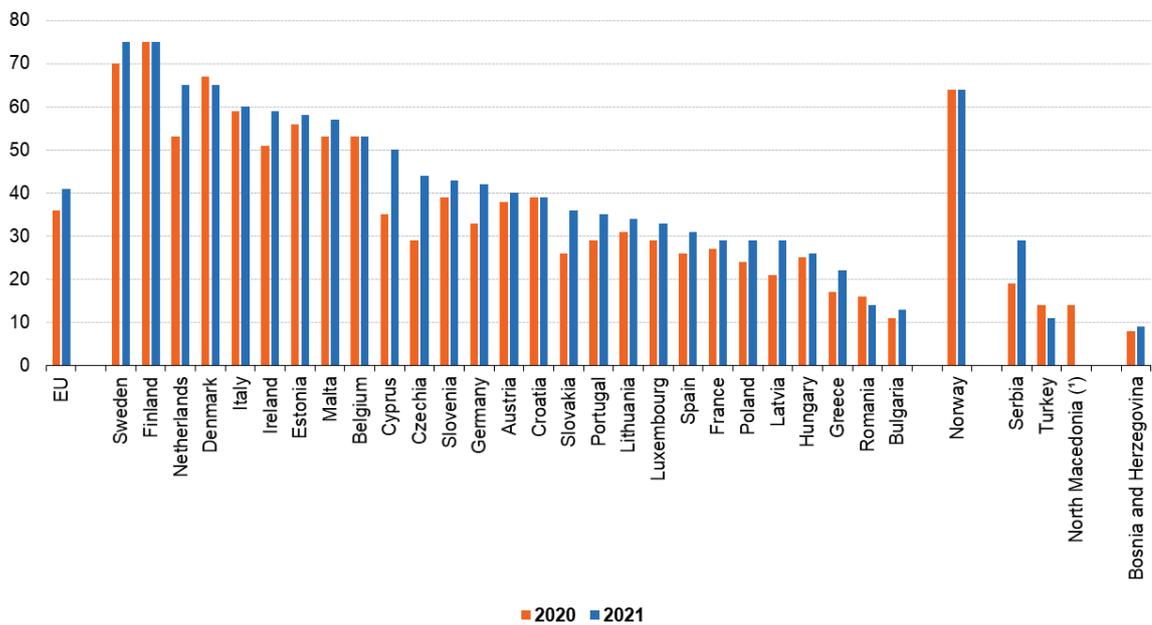


Figure 5: **Percentage of Enterprises using Cloud computing in different Countries**[40]

The above graph shows the use of cloud services in the European countries. It is clearly shows that average in EU the use of cloud services in 2020 was 36 % whereas in 2021 it was rise to 41 %. Also, it is interesting that in Czech Republic the use of cloud services among enterprises in 2020 was 29% which was below average in European countries but in 2021 44% of enterprises was using cloud services. This huge rise within one year is great and the factor maybe the coronavirus pandemic because most of the companies make their employees work from home. [40]

**Use of cloud computing services in enterprises, by type of cloud service, EU, 2020 and 2021**

(% of enterprises using the cloud)

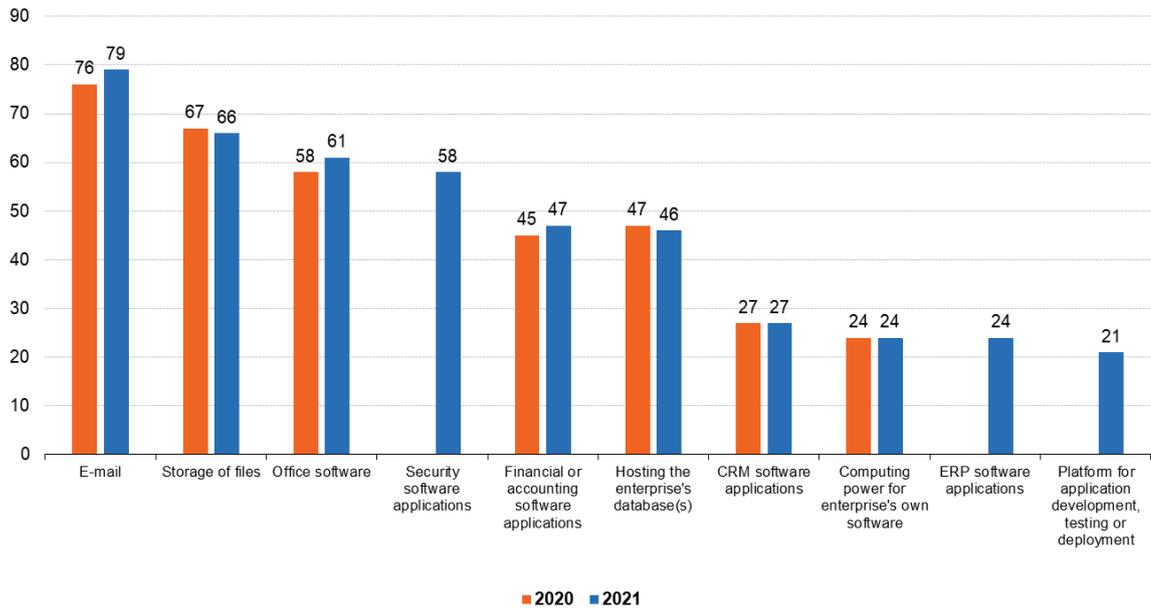


Figure 6: **Use of Cloud Computing Service in terms of Type of Service**[40]

The above graph shows that the enterprises mostly use cloud services for e-mail which was 76% in 2020 and rise to 79% in 2021. Also, to store the files on the cloud it's the second priority for the companies to use cloud storage. 67% of the companies in the EU was using cloud storage in 2020 whereas in 2021 it was drop to 66 % and least used for the application development or testing or deployment in 2021 and no data is available for 2020.[41]

**Use of cloud computing services, by size, EU, 2020 and 2021**  
(% of enterprises)

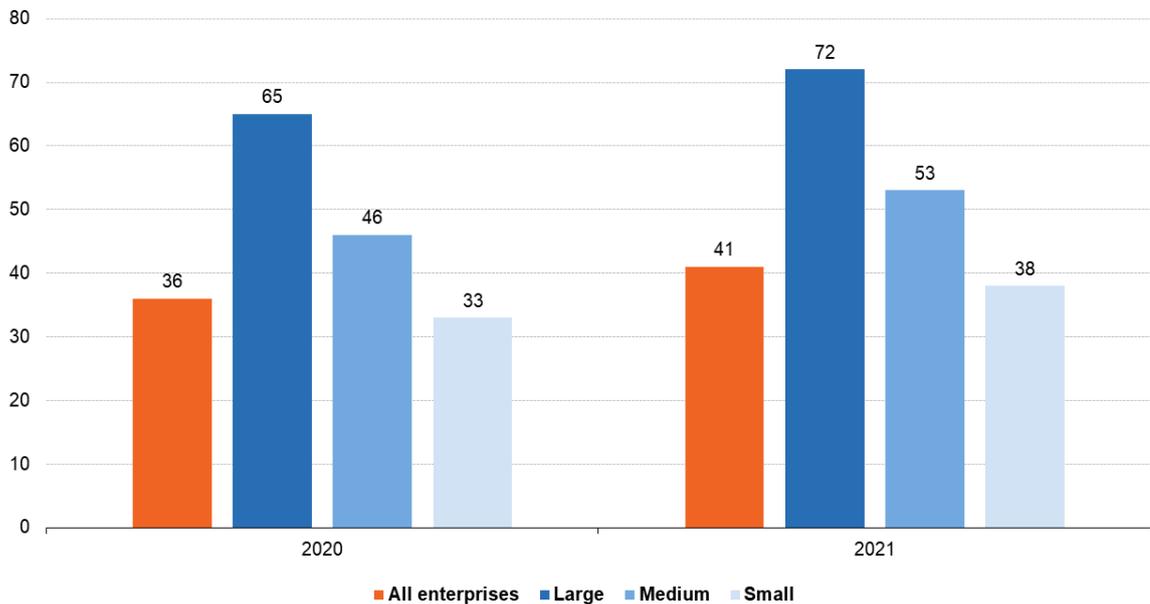


Figure 7: **Use of cloud computing services, in terms of size of enterprises**[40]

According to the above graph in 2020, in EU among all small sized enterprises only 33% of the companies was using cloud services whereas among medium sized enterprises only 46% was using cloud services. But it is also interesting to know that in 2021 the medium sized enterprise who was using cloud services was more than half. One out of two medium sized enterprises were using cloud services whereas the small sized enterprises in 2021 has also increased as compare to previous year. Almost four out of ten small sized enterprises using cloud services in 2021.[40]

### 3.12 ICT security in Enterprise

ICT security in enterprises, 2019  
(% enterprises)

	Use at least one ICT security measure	Have documents on measures, practices or procedures on ICT security	The enterprise's ICT security documents were defined or reviewed within the last 12 months	Make persons employed aware of their obligations in ICT security	Affected by ICT related security incidents in 2018	Have insurance against ICT related incidents
<b>EU-27</b>	<b>92</b>	<b>33</b>	<b>24</b>	<b>61</b>	<b>13</b>	<b>21</b>
Belgium	94	34	27	57	22	25
Bulgaria	85	18	13	51	16	3
Czechia	94	32	26	76	21	8
Denmark	97	56	42	70	10	56
Germany	97	37	27	68	11	20
Estonia	86	27	18	55	8	7
Ireland	93	54	42	76	18	39
Greece	74	15	10	33	7	25
Spain	92	33	25	54	12	33
France	94	26	18	55	15	39
Croatia	90	41	25	47	19	7
Italy	93	34	28	73	10	13
Cyprus	83	32	24	59	11	13
Latvia	98	42	25	68	12	12
Lithuania	93	36	22	67	16	4
Luxembourg	93	27	22	52	17	26
Hungary	86	17	13	48	15	4
Malta	92	32	25	59	24	29
Netherlands	96	42	32	56	11	26
Austria	91	36	28	63	12	18
Poland	87	23	18	49	13	11
Portugal	98	28	21	54	8	10
Romania	73	17	11	49	11	5
Slovenia	84	35	26	53	14	4
Slovakia	90	28	22	64	15	8
Finland	97	44	35	66	18	28
Sweden	95	52	39	66	35	39
United Kingdom	94	48	40	69	6	46
Norway	94	32	22	61	11	33
Montenegro	69	14	11	48	17	18
Serbia	94	27	16	51	17	15
Bosnia and Herzegovina	88	9	7	43	17	17

Figure 8: ICT security in Enterprises[40]

The above table shows that in 2019 in the EU 92 percentage of the enterprise has use at least one ICT security measure whereas 33 percentage of the organisation have documents on measure, practices or procedure on ICT security. 61 percentage of the organisation make their employees aware about their obligation in ICT security. There was about 13% of enterprises which was affected by ICT related security incidents in 2018. It is also shocking that only 21 percentage of organisation in EU has insurance against ICT related incidents.

In Czech Republic, In 2019, 94 percentage of the organisation has use at least one ICT security measure which is above the average of EU. Another point is that 32 percentage of the organisation have documents on measure, practices or procedure on ICT security. 76 percentage of the organisation make their employees aware about their obligation in ICT

security which is above the average of EU. There was about 21% of enterprises which was affected by ICT related security incidents in 2018 which is higher than the average of the EU. Only 8 percent of organization in the Czech Republic has insurance against ICT-related incidents.

### **3.13 Challenges of cloud service adoption by SMEs**

It's not that much easy for a small or medium sized organization to adopt the cloud services. With the benefits, there are also some challenges which an organization has to face during the adoption. Cloud service provider has the control over these technology and SME did not have the control over the cloud server. If anytime the cloud server is down or some other issue the SME have anything to do as they didn't have any control. So, for this it is very important to use multiple servers connected to the organization and should available 24\*7. [42] It is also very important to hire ICT specialists as services like PaaS, IaaS are quite complex so to deal with such type of services an expert is needed. Company has to provide the training to its employees which is expensive and possible to face difficulties due to limited financial fund. Because a network is required to reach the cloud, using it promotes dependence on the Internet especially in the areas where internet connections are seen as being of poor quality.[43]

Because of data hacking by cyber action, using the cloud also exposes the consumer or corporate web user to a potential risk. Data encryption and data backup on servers with multiple geographic locations, however, can improve security measures. Because of data hacking by cyber action, using the cloud also exposes the consumer or corporate web user to a potential risk. Data encryption and data backup on servers with multiple geographic locations, however, can improve security measures. Dependence on the internet is one of the key concerns associated with adopting cloud services. Because internet-connected services are not secure, ICT teams occasionally have to deal with loud security attacks and fingerprints. [26] The concern around migration for SMEs includes a number of problems, such as the variations in how using older technologies to provide new services. Then there are challenges with manpower that will be reduced because of the cloud technology. The difficulty of moving very huge amounts of data as business is successful because it has a huge number of customers. As opposed to building own infrastructure, smaller businesses can use the cloud to access more services and the most secure system possible for a lower cost. They can obtain the same service at the lowest cost by paying for maintenance and

obtaining a license from several service providers, which further aids in their ability to expand their business. The cloud saves a lot of money on hardware upgrades and software license purchases, and also releases the user from routine system maintenance tasks. Additionally, using the cloud offers a high level of security and transparency.[39]

### **3.14 Method used for Selection of Cloud Service Provider**

Cloud service evaluation methods are very important to consider because they should be used for the most appropriate cloud service provider. For the selection of a method, there should be consideration of various decision-making methods. A decision-making method is effective that helps to decide on the best cloud service. Then, it helps to find an appropriate cloud service provider that provides that service the best. [44]

The method for selecting a cloud service provider should be based on a multi-criteria decision-making process. In this method, different criteria play their role in the selection of an appropriate cloud service provider. These criteria include security, compliance, Architecture, manageability, service levels, support, and costs of the cloud service.

Security is the most important criterion in the selection because there must be tight security measures. A cloud service provider must provide complete security without the possibility of any risks. The client might differ in terms of needs for security criteria; therefore, the selection process must be strict to their needs and requirements. Compliance is the second criterion that service providers must follow the industry standards and frameworks so that the application of cloud computing is aligned with the industry standards and frameworks. Architecture is a very important criterion in the selection of an appropriate cloud service provider. Storage needs, alignment with the existing services, and similar factors play their instrumental role under this criterion. Manageability should also be smooth and sound, and there should be no risks or problems in managing the cloud service. Manageability is more supportive of the management of cloud services, under which they should face no difficulty in managing cloud services.[45]

Service levels, support, and costs are other criteria that can be part of a multi-criteria decision-making model. Service levels include different requirements, including availability, response time, support, and capacity to choose a cloud service provider. Service level agreements for cloud services are important in this regard. Another important parameter is the support that must be timely, perfect, and efficient from the cloud service

provider. Costs are also instrumental though this criterion has been placed at the end of all criteria. Costs should be in line with the client's needs and financial position. This is how; these are criteria to make the multi-criteria decision-making method for choosing a cloud service provider.[45]

### **3.14.1 Analytic Hierarchy Process (AHP)**

Analytic hierarchy process (AHP) is commonly used multi criteria procedure. It is worth explaining when this analytic hierarchy process (AHP) approach is applied. This approach is aligned with the multi-criteria assessment or decision-making technique in which different criteria play their role. There are six criteria representing appropriate situations to have AHP applicable. They include financial, performance, usability, agility, security and privacy, and assurance[46]. It is financially viable to use AHP because of its ability to be aligned with goals or decision-makers. Its ability to convert information and even experiences into numerical values makes it an attractive option for application[47]. It enables AHP to ensure usability, performance, and agility, which is not possible without intelligence and efficient use of information and subjective data. The assurance offered by AHP removes uncertainties and enables cloud computing or technology applications to be predictable and effective[48]. This technique combines the various methods used to find and evaluate alternatives. It then ranks the most relevant ones according to a set of criteria. The objective of the ranking process is to find the best possible alternative. This strategy emphasizes categorizing problems into several categories before prioritizing alternative solutions, and it has essential components.

1. To figure out what the relative criteria are and what the options are
2. Define the Problem and Criteria
3. Establish Priority amongst Criteria Using Pairwise Comparison
4. Check Consistency
5. Get the Relative Weights

Intensity of importance	Definition
1	Equally preferred
3	Moderately preferred
5	Strongly preferred
7	Very strongly proffered
9	Extremely preferred
2,4,6,8	Intermediate values
Reciprocal	if one factor of above “i” numbers are placed in it the adjacent diagonal factor will be the reciprocal value when compared with i.

Table 1: Comparison Scale AHP[49]

### 3.14.2 Row Geometric Mean

The priorities ( $\psi$   $I = 1 \dots n$ ) can be obtained in conventional-AHP, by solving the eigenvalue problem  $A\psi = \lambda_{max} \psi$ .

Where A is an n-dimensional positive pairwise comparison matrix,  $\lambda_{max}$  is the major eigenvalue of the matrix, and  $\psi$  is the priority vector. Prioritizing technique, Saaty established the consistency index (CI), which is a measure of consistency in judgment.

$$CI = (\lambda_{max} - n) / (n - 1)$$

The principle eigenvalue of the judgment matrix is  $\lambda_{max}$ , and its order is  $n$ . If the reciprocal matrix comparison is consistent,  $\lambda_{max} = n$  and the CI value is zero; otherwise, this value will always be positive. Saaty created a normalized metric CR, which is supplied by to lessen the reliance on CI.

$$CR = \frac{CI}{RI}$$

Where  $RI(n)$  is the Random Index of the  $n$ th order of the matrix's consistency. It is defined as the expected value of CI corresponding to matrices of  $n$  order ( $RI = E[CI(n)]$ ), where the judgements are simulated in sets of  $(1/9, \dots, 1, \dots, 9)$ , and the EVM is utilized for prioritizing.

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Table 2: Index values of RI [50]

The CR provides us with metrics for pairwise comparison judgment; the matrix is completely random and consistent. When  $CR=1$ , the  $CI = E[CI(n)]$ , and judgment is made at random (Low Precision). Higher CR values produce greater inconsistency; thus we're interested in finding a way to reduce CR to make it more consistent. Saaty proposed a criterion of 10% or less ( $CR < 0.1$ ) for admitting matrix consistency.[51]

### **3.15 Today's application and usage**

There are numerous application areas within the cloud and for cloud services at this time. With the rising use of the Internet and the high expenses of gear that isn't being used to its full potential, interest in resource sharing via cloud services has grown. As a result, the cloud has been used to construct everything from programming tools to image and video sharing services, and new cloud services are introduced on a regular basis. The flexibility of cloud services, in which clients only pay for the resources they use, accounts for a substantial part of this variance and development. It should be simple to gain access to additional resources as needed, and to pay only for what you need.

The opportunities for establishing elastic services have been limited only by the actors' ability to innovate because many different actors have seen the possibilities. This enables the cloud to be used by the customer for the purposes described above. Because the customer's servicing and hardware purchases are handled by the provider, the customer can save money. Because you only pay for the capacity you utilize, the costs for temporary "highs" in computer use drop as well. You can also get mobility in your organization by accessing your work from anywhere as long as you have Internet access.

Another aspect contributing to growing organizational mobility is that everything from laptops to cell phones, as well as Internet use in general, has become less expensive, resulting in a lower investment to maintain the business more mobile rather than purchasing expensive servers. There are a variety of services available to keep your company mobile and adaptable. Office 365 is one of these examples. Microsoft offers this cloud service to businesses who want their employees to be able to utilize Office programs (Word, Excel, PowerPoint, and OneNote, for example) from anywhere in the world. The only need is internet access[4].

Exchange, an email and calendaring service is also included in Office 365. The service can be shared inside the company, allowing employees to schedule meetings when it is convenient for them. Lync, a conversation function in Office 365, is also available.[4] SharePoint is another feature of Office 365 that allows employees to share files or documents within the business by uploading them. Employees can choose to share files or documents with themselves, everyone, or a select few within the organization. [4]

### 3.16 Issues of cloud transition

With time, changes in technology let everyone adopt new technology in the market. This adoption is in light of the requirement and needs of users regarding its effectiveness. In case, users do not adopt changes over time, they can lag behind. As a result, they cannot maintain their customer-centric image and cannot provide desired services to them. It is the reason why adoption of technology is there across different industries whether they are modern day business or traditional businesses. In turn, they waste time, money, and resources because technology makes processes more efficient and workable for them. It is also in line with the need and inevitable nature of change in any business so that changes remain there considering customers and their needs.[52]

As a result, every organization aims at achieving information technology return on investment and in this effort, cloud computing is one of the most crucial components in their strategy. Small and medium enterprises have learned the way to compete successfully with large corporations. It is because of the efficiency of time and money achieved through technology. There are some requirements and prerequisites for cloud computing implementation which are needed for SMEs to effectively implement it. Every problem has its solution and SMEs have learned how to make effective use of cloud computing. Therefore, it is worth considering steps and options for SMEs before implementing cloud computing.

#### 1. **Cloud Security:**

Security is very delicate and crucial issue nowadays that has emerged as very critical. It has become important with the popularity of technology and the use of information through it. During the transfer of data from the service to the cloud, a security breach can cause loss of data. Public clouds are multi-tenant in nature because many members share them. Any flaw and vulnerability to their neighbor's code can also cause issues and serious challenges to their security. During the migration process as well, familiarity with the cloud must be the priority and focus. Therefore, there is an increasing importance of data security during data migration that can be time consuming and requires high expertise.

**Solution:** - Solution to this issue on cloud security should be well-thought so that there is no collapse of security. Seeking security service providers' assistance can be effective that can be provided by different cloud providers like Amazon AWS, Microsoft Azure, Google Cloud

Platform, etc. In so doing, a business must ensure that there is a policy-driven approach to let implementation go on automatically. [25]

## **2. Management of the Devices**

Device management is another challenge on the way of cloud migration that organizations face. There are many gadgets and devices, and management of devices should be crucial. SMEs can face issues in management of devices mainly because of lack of technical assistance. Therefore, getting the assistance from a company can be suitable and workable.

**Solution:** - Again, management of devices involves security of devices and data. In this regard, encryption and data wiping can be instrumental and can bring considerable change. [38]

## **3. Recovery**

Recovery is one of important issues in the use of cloud computing by SMEs. Cloud computing and cloud apps can face failure more than traditional systems. There is the way to avoid these failures to these systems, but loss of data caused by humans should also be controlled and avoided. Small and medium enterprises must use paper documents and data to let investment to work in recovery and backup.

**Solution:** - The use of encrypted file system is worth following when data is transferred from one service to the cloud server. As a result, data remains protected and safe from getting in the hands of unwanted elements and individuals. It also prevents data from being spied and intercepted by unwanted individuals. Even after careful security and protection, disaster might happen, and data can be lost. To preventing such situation, it is advised to keep data as the backup remotely or in-house so that data remains accessible. [24]

## **4. Storage**

Time and resources crucial for fulfilling IT duties and small firms and SMEs must ensure having time and resources to meet their needs.

**Solution:** - In case of storage, time, and resources issues, outsourcing should be the option to let other parties overcome this shortage. Services and platforms like Dropbox and Microsoft SkyDrive can be used to overcome scarcity of time and resources. These platforms are employed to replicate files across different computers and systems. [39]

## 5. Subscription Plans

The issue of time and resources can be solved through subscription option. Sometimes, SMEs do not have resources to have cloud computing platform therefore, subscription can be used to overcome this deficiency. For this to work, an SME should adjust to the new cloud system.

**Solution:** - It is very necessary for SMEs to manage expenses; therefore, they should make huge upfront payment. Subscription plans allow SMEs to choose gradual and step by step payment plans that are less costly. [24]

### 3.17 Why to adopt cloud services

While researching and going through a number of research papers or articles available on the google scholar, scoups, ResearchGate, etc. the author comes to the point that there are a number of reasons why the organization has to go for the cloud services. Author investigated the findings of past research and came up with a collection of scientifically proven cloud adoption drivers.

What factors influence cloud adoption in businesses? A collection of cloud adoption factors in enterprises because of the two-step literature review. In addition, a collection of cloud adoption determinants in organizations, which included elements that had previously been experimentally confirmed.

The factors that influence adoption

**Advantage in terms of price** – The expense of cloud adoption is one of the most concerning factors. As a result, the organization is not having to pay high costs for storage, servers, and their upkeep. The only services that the organization must pay for are those that will be utilized. If our imaginary SME (i.e., Gilla Info) are worried about the costs associated with moving to cloud computing. The starting cost of using a cloud-based server is a barrier. Although, people attempting to weigh the advantages and disadvantages of adopting the cloud must take into account not only the starting cost but also all expenses, companies must also take into account the business value.

When starting a project, quick access to the company's data on the cloud will save time and money. Pay-as-you-go cloud computing services are the norm, which is great sign for customers worried about spending too much for unnecessary or unwelcome items. This

implies that a business won't have to invest money on the cloud even if SMEs don't exploit its benefits. [53]

**Implementation in a hurry** - One of the qualities that contributes to a company's success is control. There will always be things beyond your company's control, however how in control its internal processes are. In current economy, even a small amount of pointless delay can have a significant impact. Failure in services affects productivity losses, lost revenue, and company image, among other things. Although there is little things to stop or even detect disasters that could harm the business, there are things to improve the recovery process. In a number of crisis situations, such as natural disasters and power outages, cloud-based services provide speedy data recovery. Almost half of the IT leaders, wants to invest in enhance cloud-based backup and recovery services.[54]

**Innovation possibilities** - The fact that using cloud services gives an organization new chance is another reason to do so. In a competitive market, every business aspires to be a step above and wants to offer a variety of services to clients so they can draw in more customers. Therefore, by using cloud services, an organization will have more options to save money and time for other services or projects as the majority of what the company used to spend on servers, storage, backup recovery, etc. maintenance is now avoided.[55]

**Flexibility in strategy** - Enterprises have more flexibility when hosting on the cloud as opposed to on a local server. Additionally, if any organization demands bandwidth, a cloud-based provider might be able to give it right away without upgrade to IT infrastructure. The total productivity of business may be significantly impacted by this enhanced liberty and adaptability. Another reasons for a corporation to move to the cloud, is "the flexibility to quickly fulfill business demands.".[56]

**Concentrate on core competencies** - Despite the growing popularity of cloud computing, several SMEs still choose to save their information on their own servers. It is drawback of the organization in comparison to others who can take advantage of the cloud. Also, the organizations which are adopting the cloud services have better growth and a step further as compared to the organizations which still didn't adopt the cloud services.[57]

**Accessibility** - SMEs only spend a certain amount of time to each of its tasks. An firm won't be able to concentrate on achieving its goals and delighting its clients if current IT solutions require it to spend too much time and effort on computer and data-storage difficulties. If SMEs depends on an outside company to handle the IT hosting and infrastructure, they will have more time to spend to the parts of their business that directly impact their bottom line.[58]

**Advantage in relation to others** - In other ways cloud helps is various ways like the organization can save a lot of cost on maintenance of the server. Client's experience will also change as the services will be also accessed on the mobile phones, notepads, laptops etc. Use of cloud services is also provided easily accessible information readily available to sales workers who travel, independent contractors, or remote employees. It is not strange that organizations that place a high priority on employee happiness are likely to increase their cloud utilization.[59]

### **3.18 Summary from the literature review**

The literature has started with types of cloud computing, and it has reviewed four different types of cloud computing, which are public cloud, private cloud, hybrid cloud, and community cloud. They perform functions and fulfill responsibilities according to what their name suggests. Each cloud computing type follows a specific cloud service model.

There are three major service models such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). The focus of these major service models focuses on infrastructure, platforms, or software in providing respective services. For the objective of comparing cloud computing service providers, the literature review has studied and reviewed local and global service providers of cloud computing. The literature review has covered these two areas of service providers.

Local Service Providers can also be global service providers as they provide their cloud computing services to the local market. In the Czech Republic, global cloud service providers offering services locally include Microsoft Azure, Amazon Web Services (AWS), and Google cloud platform (GCP). Apart from these global players and service providers, specifically local cloud service providers in the country include Algotech Cloud, Forpsi Cloud, and T- Mobile. They cover the market locally and provide cloud computing services to clients for cloud computing.

There are global service providers of cloud computing services as well in the country, and they have broader and more comprehensive expertise, abilities, and capabilities. They include Amazon Web Services (AWS) from Amazon and Microsoft Azure from Microsoft. They offer cloud computing services according to local needs, which puts them ahead of local competitors for their global-level expertise.

The advantages and disadvantages of cloud computing are an important part of the literature review that help to follow and achieve the objectives of this diploma thesis. It has several advantages for any organization. They improve coordination among groups that improve access to data via a cloud server. Another useful feature of cloud computing services is their ability to back up and restore data after storing it in the cloud. The accessibility feature is important globally as well as an organization has got the access and ability to preserve information from anywhere in the world without limitations of time and internet service type and quality. A well-developed and systematic cloud-based infrastructure of an organization improve the company's quality and performance.

There are various Disadvantages of cloud computing which focus on limitations and drawbacks. One of these disadvantages is the possible conflict between the cloud service provider and the client receiving these services. It happens due to cloud customers having less influence over service functions and execution. Another limitation or disadvantage of cloud computing services is accessibility. In this system, all kinds of data are stored in the cloud, and it requires an internet connection to access data. Another significant downside of cloud computing is vendor lock-in. Thus, any effort to switch services from one vendor to another may run into issues.

Two important aspects of cloud computing services focused on in the literature review are security and privacy. Cloud security is a joint duty between the cloud provider and the client. It makes cloud security a shared responsibility model, and generally, there are three types of responsibilities. Cloud computing services have joint or shared responsibilities. First, it is the responsibility of the provider to ensure cloud security. Then, there is the responsibility of the customer to abide by cloud security. The third very important cloud computing service depends on the chosen service model. There are three service models, which are Infrastructure as a Service (IaaS), Platform as a Service (PaaS), or Software as a Service (SaaS).

The second important aspect of cloud computing is its protection and privacy. Cloud computing services must ensure the protection and privacy of information or data shared,

stored, and transferred using cloud service. Protection of data is effective in preventing data tampering, data compromise, and data loss. It is strongly pertinent as the cloud computing service attribute when data is collected and stored at a high rate. It makes data protection increasingly important. Protection of data is the responsibility, and privacy is the right of clients as an important aspect of a data protection strategy. For the protection and privacy of data, cloud computing services follow laws and regulations like Data Protection and Privacy Laws, GDPR (General Data Protection Regulation), and Czech Data Protection Act (DPA).

Another important objective of cloud service adoption is for SMEs to implement cloud computing services. However, the literature review has noted some challenges of cloud service adoption by SMEs. In the case of small and medium enterprises, challenges arise from the control of these cloud computing services. Overall, SMEs must make a strong and error-free strategy to adopt cloud computing services. The first is the control issue that the service provider has got strong control over cloud computing services. It can hurt SMEs in exhibiting control over the technology and its application on cloud computing services. As a result, at the time when cloud services are down, SMEs must be dependent on the cloud computing service provider. The literature review has hinted at a solution that is to hire ICT specialists to offer services like PaaS and IaaS. There should be a sound and effective decision to ensure which type of service and ICT specialist is needed.

Considering the security and privacy aspects of cloud computing services, there should be a focus on appropriate methods used for the selection of cloud service providers. In this context, the selection of an appropriate cloud computing service provider should be based on a multi-criteria decision-making process. Various criteria should be considered in this process, including security, compliance, Architecture, manageability, service levels, support, and costs.

The objectives of this research focus on the cloud services adoption approach for SMEs. The methodology has described using the analytic hierarchy process in choosing an appropriate cloud computing service. Being part of the methodology, the research focuses on the analytic hierarchy process (AHP) approach. Therefore, it is relevant to present findings related to this chosen methodology. First, it is in line with the multi-criteria decision-making technique when different criteria come into action. For the selection of an appropriate cloud computing service, six criteria should be there, including financial, performance, usability, agility, security and privacy, and assurance. Another important criterion is the ability to convert information into numerical values, where any type of

information can be converted into numerical data and information. AHP also ensures usability, performance, and agility to make data useful and effective. Thus, the literature review reflects all objectives developed for this diploma thesis and guides the research for further application.

## **4 Practical Part**

The practical part of the diploma thesis pursues research objectives set in the first chapter. The purpose of this part is to implement the chosen cloud computing service for a company. Though the chosen company is not real, it has depicted all factors and aspects of a real company to know the implementation of an appropriate cloud computing service. This part starts with the background of the organization and then presents the SWOT analysis of a cloud computing service for the SME. It has been of great value to consider cloud service providers and the criteria behind choosing one. As the name suggests, this part implements all processes needed to choose a service considering all requirements of the chosen company. A very important part here is the SWOT analysis of the company, which must explain the needs and requirements of the organization. This section has also helped to explain the objectives of this research and where the most relevant cloud computing service provider should be selected. The implementation of the practical aspect of this diploma thesis is the most important part that guides readers on the implementation of the service and service providers. It has the following criteria for the whole process, and it is the backbone of this research.

### **4.1 Background of the Organization (SME)**

For this diploma thesis, the chosen company is Gilla Info, which is a small and medium enterprise in the computer components industry. It supplies different computer components like networking devices and electric components in the Czech Republic and globally. Many small and medium enterprises have chosen cloud computing services to fulfill their business needs. The company is in an industry that is technology-intensive; therefore, it must be in line with technological innovation and transformation. For this purpose, it must evaluate its present market standing and other companies adopting cloud computing services in their domain and jurisdiction. Research studies on SMEs and their adoption of cloud computing services have noted different factors playing a crucial role in

the adoption of cloud computing services. These factors include relative advantage, uncertainty in the environment, compatibility of cloud computing services with other the business, top management support, size of the organization, external computing support, and supplier efforts[56]. Gilla Info has some of its factors to let cloud computing services be part of its processes and functions.

Gilla Info is one of the leading companies in its working field and provides other services to its customers and retailers. The company also gives its components, for example, modems, routers, switches, etc., for rent to its customers or retailers. The company does not accept cash transaction but accept all other modes of payments like online transfer, credit/debit card payment, and cheque transaction. Its area of operations and doing business is local as well as global. However, it is a small and medium enterprise that is focused on technology equipment and components. It has been working well and doing its best over the years. Still, there are several challenges on the way to being successful. One challenge is the pace of change that might cause its components and equipment to be less relevant to the market. It can invite more competitors to offer competition and further challenges. Therefore, it is worthwhile to switch to cloud computing services so that it can ensure digital transformation and innovation in its practices and functions. Information about the company is as follows.

Employees (Currently Working)	40-50
Number of branches	1 (Prague, Czech Republic)
Number of Customers (2022)	5000 (per year)
Number of Retailers (2022)	50 (per year)
Assets	1 Million (euro)
Area	Networking Components and other electronic devices.

Table 3: Key facts of Gilla Info

Switching to cloud computing by Gilla Info is due to its needs and pressure to ensure sustainability. Strengths, weaknesses, opportunities, and threats should be known before justifying the application of cloud computing in the company.

The parameter for the cloud server is CPU 8 GHZ, RAM 16 GB, HDD/ SSD 500 GB, hosted applications, operating system, network security, cloud server and storage, data center.

The company has business in the major cities of the Czech Republic, and it is important to carry out market research to find the best cloud solution for the company and in the current market solution. SWOT analysis will be conducted so that one can find the suitable condition of the market.

#### 4.1.1 SWOT Analysis for Cloud computing

It has four dimensions, where two dimensions investigate the internal environment of the company, and two dimensions consider the external environment[60]. It is workable and implementable in any business or situation because of its adaptability and flexibility. It is suitable for the planning of an IT project as well as to know when the application of information technology is required in the company. Strengths and weaknesses address the internal environment to let the company know about the positive and negative aspects of the business[61]. Opportunities and threats belong to external environmental factors, which are more serious. Within this analysis, a company can reach the best strategy for an IT project for the company[62].

SWOT analysis has been used to find the current situation of the Gilla info and upcoming opportunity, which is to be used in strategic planning and decision making. Before moving further with the SWOT analysis, the following matrix summarizes the points included in the analysis.

<b>Strengths</b>	<b>Weaknesses</b>
<ul style="list-style-type: none"> <li>• Excellence in online sales</li> <li>• Low processing and handling fee</li> <li>• The staff is skilled and knowledgeable in information technology</li> <li>• It has advanced technology for its operations and processes</li> </ul>	<ul style="list-style-type: none"> <li>• Higher prices for products shipped from overseas</li> <li>• Problems in inter-banking network services</li> <li>• The company did not accept cash transactions.</li> </ul>

<ul style="list-style-type: none"> <li>• Gilla Info supplies computer components like networking devices and other electric components locally and globally.</li> <li>• Gilla Info is a leading company in its industry</li> <li>• It also has the option to give electric and computer components for rent to its customers or retailers.</li> </ul>	<ul style="list-style-type: none"> <li>• Innovation and technological transformation in the company are slow and need to be increased.</li> </ul>
<p><b>Opportunities</b></p> <ul style="list-style-type: none"> <li>• The sharp increase in the number of SMEs</li> <li>• Plans to open branches in other countries in Europe</li> <li>• Technology-intensive company</li> <li>• Gilla Info is a leading company in its industry. It can excel further by being focused and dedicated to its business model.</li> <li>• The company can bring transformation and innovation to its components.</li> <li>• It can find cloud computing services to exploit the opportunities present in the industry and market.</li> </ul>	<p><b>Threats</b></p> <ul style="list-style-type: none"> <li>• Security and privacy issues</li> <li>• Competition from large companies</li> <li>• High prices for customers</li> <li>• The company faces many challenges, and one of the challenges is the pace of change and intensifying competition in the market.</li> <li>• Lack of innovation and transformation can make the company less relevant to the market.</li> <li>• In case the company does not adopt cloud computing and other innovation, it can invite more competitors to offer competition and further challenges to the company.</li> </ul>

Table 4: SWOT analysis of Gilla Info regarding cloud computing

### Strength –

The corporation follows Czech Republic regulations and pays taxes to the government. It sells all of its products and services entirely online, and it is one of the few companies in Prague that does so. And its processing fees, such as handling fees and shipment fees, are lower than those of its competitors since it has a long-term deal with the shipping agency. It provides computer-based services and is a paperless organization, thus its staff have good and skilled computer and IT knowledge. It has solid infrastructure and high-speed Internet, allowing data to be transported quickly.

### Weakness –

The company has the higher service price because of some products that are shipped from overseas (for example China, India, Latvia), and the shipping charges for those products would be greater. It offers extra expenses for different forms of delivery, such as fast shipment, cargo, or regular product delivery. Sometimes the consumer who does not want to pay extra, for the fast delivery and normal delivery takes a lot of time. Sometime there is also the problem in the transactions like the amount is debited from the customer's account but didn't credit into the company's account this is because of the inter banking network services.

### Opportunity –

There is a rapid increase in the Small and Medium sized enterprise from last few years. And also, there is numerous opportunities in this field of area. There is a great market of the networking devices in all the sectors as internet is available globally. There is hardly any country without internet. So, the devices should be also needed to run the internet. As the Internet is available in the home as well as the workspace so these networking components is being used in every field of work. Also, the working culture of the company is great and have skilled worker. The company is also going to open the new branches in the Europe to expand its business and to provide the better services and resources to its retailers and the customers.

Threats –

The company is small and medium sized and have the security and privacy issues. The authorized users or hackers can breach their security. It is the most important for the organization to secure their data and provide the best services to its customers. Also, there is a great competition in this market, a number of large companies is a competition for small and medium sized organization and to compete with them a small and medium sized company have to be best in its service with the minimum price to its customers.

## **4.2 Current State Analysis**

Gilla Info must tailor its strategy considering its current state. From the SWOT analysis, strengths and weaknesses reflect the company's current internal environment. Overall, the company is a leading one in electric and computer components and has been selling these components locally and globally. However, there is a need for more integration of internal affairs. It is the main feature of cloud computing adoption as well because it integrates and connects computer system resources. Currently, the company has the strength of low shipping costs, but simultaneously, it faces higher shipping costs for items shipped from overseas. It indicates a gap to fill through cloud computing that can better integrate and connect with overseas suppliers.

Employees are working in the company, and their management is very important. It is an online company, but the workforce helps to fulfill tasks and responsibilities. Integrating and providing them with capacity-building techniques is also the objective to be fulfilled through cloud computing services. Currently, the company needs a server, domain, and hosting to better serve its clients and customers. It is also to make things streamlined within the organization. Data storage and information management must be a priority because of the online operations and activities of the company. Cloud computing can offer these benefits to the company and its various stakeholders. It is one of the prime features of cloud computing services that the company can have zero failure rate in its operations and processes. The current state analysis is helpful in choosing the best cloud for the company as per the following criteria.

### **4.3 Selection Criteria for cloud**

For the selection of the cloud for the company, certain criteria must be there. The following criteria have been set for this purpose:

- Price
- Cloud Security
- Data Centers
- Support
- Cloud Storage
- Manageability

These criteria have been selected because of their relevance and importance to the decision. The price must be in control while security is a priority concerning the interests of customers. Data centers and support are further important criteria to assist the company and its business model. Cloud must provide broader and expanded storage capacity along with presenting manageable solutions. Price criterion is especially required because of the need to lower the prices of services. A more detailed explanation based on these criteria is in the following.

The analytical method for the selection of cloud is Saaty's method. It is the multicriteria decision-making analysis method to achieve objectives as it has used the multicriteria decision approach for making the strategy that involves the usage of the Analytic Hierarchy Process (AHP) to produce the most appropriate and reliable decision. The chosen analysis method is suitable for the case because of its relevance to the requirements of the company. These methods can focus on all chosen criteria under which the company needs. For instance, it requires better functionality as well as low-priced solutions for cloud computing. These objectives are met by selecting the suitable cloud for it.

#### **4.3.1 Price:**

A smaller investment in Cloud services allows a corporation to earn a larger profit. With the new technology and newer thinking of the generation the organization is reaching new goals. There's no doubt that price will factor heavily into the decision. It's beneficial to consider both the sticker price and the accompanying charges which includes data backup, security, upload and download costs, as well as maintenance expenses. It suggests the organization is

looking for a cloud service provider that can deliver all its needed services at a minimal cost. " By shifting to the cloud, businesses may save an average of 15% on all IT costs.[63]

#### **4.3.2 Cloud Security:**

It is to be understood what our security goals are; each cloud service provider offers security measures to its clients or customers and has different mechanisms to protect the data on the cloud. Data security means protecting data from unauthorized users or can say unauthorized access. A company's biggest goal and challenge is to protect its data and use the most secure way to protect its data. At the same time, security measures and costs go side by side. A cloud higher in terms of security features is more costly as well. However, it is a matter of priority if the company should have a more costly and securer cloud. Ironically, the effort to make the system securer can be less convenient and flexible for users. Gilla Info must reach a balance between these two priorities. Gilla Info needs a security solution against system failure, data backups, platform misuse, unauthorized access, third-party access, etc. It means that the company must focus on security, but it should make the cloud more functioning and smoother to work. [64]

#### **4.3.3 Data Centers**

The location plays a significant effect in whether you use the services. In terms of geography, it is also critical to be aware of the regulation that states that if a provider is not physically present in your nation, you must use services from other countries. Many organizations provide services all over the world, but they don't have a physical presence in any one location. It is not a severe issue in terms of IT infrastructure, but customers want to be concerned about maintenance, connectivity, and data security. [65] As Gilla Info is located in Czech Republic and have the EU customers so it complies with the EU's GDPR. It is also important to appoint a Data Protection officer usually known as DPO but as Gilla info is a small enterprise, so it is not that important to appoint any DPO. It is better to learn and understand the principles of GDPR and if have possibilities, then data collection can be minimized. Privacy policies of the company with the checkbox "I Agree" which will make that the customer is giving the consent to company to use its data which can published at company's website. After collecting the data, to make it fully secure data protection impact assessments (DPIA) is performed and need to register with the Czech Republic Data Protection Authority.

Choosing a cloud service provider cannot be without consideration of data centers. Regulations and legal perspectives are relevant regarding data centers because they have a physical presence. Gilla Info has an online presence, and cloud services must be in line with its online presence. Cloud service providers have to deal with big data, lots of information and data, and processing of that data and information. Gilla Info will have information and data about customers, suppliers, and its general operations and processes. The service provider will provide the space through data centers, and it also affects the processing ability of data and information. Data storage is a big area in cloud computing that is very sensitive and delicate to ensure effective utilization of cloud computing.

#### **4.3.4 Support**

Support from the cloud service providers or can say IT helpdesk of the service provider is also important. In some scenario there is only chat service or the call center. Sometime is acceptable and sometimes its not. It's better for a cloud provider to give services or support 24\*7 as the cloud market is rapidly increasing and to provide best services to its customers and have a great impact to its clients. To improve customer satisfaction, service providers could provide emergency services, receive and act on feedback quickly, and become more personalized to their customers. Before choosing a cloud service, it is better to know about the level and type of support which will receive. [66]

#### **4.3.5 Cloud Storage:**

It is also very important how much cloud storage is provided by the service provider to store and backup the data. The company have a huge data and the price of the the memory is depend upon its size for e.g. – 100 GB,1 TB, 10TB etc. Also, there will be different for the backup storage. A company have to keep in mind about the backup storage and its size that how much there data will expand and how much memory allocation they will need.

#### **4.3.6 Manageability**

The SME also need to understand cloud platforms will require in terms of management. Each service interfaces with a variety of other services and supports multiple strategies of solving. If the cloud provider have any services that are critical to company's business, the cloud provider have to integrate them or the organization should move over to

a similar type of the services service that can be supported. It is important to figure out the time and effort needs for an organization to handle components of cloud infrastructure.

#### 4.4 Comparison of Cloud Service Providers

The table below is showing the services provided by the Amazon Web Service (AWS), Google cloud platform (GCP), Microsoft Azure, and local service providers. It is easily see the difference between the most common cloud providers. The following criteria have been used for the comparison.

- Price
- Cloud Security
- Data Centers
- Support
- Cloud Storage
- Manageability

	Amazon Web Service (AWS)	Google Cloud Platform (GCP)	Microsoft Azure
Market Share	32%	8%	21%
Support	Elastic container service Elastic compute cloud (EC2) Simple storage service (S3) Elastic container registry Auto scaling Amazon Lambda Amazon CloudFront Simple Notification Service (SNS)	App Engine Kubernetes Functions Container Security Graphics Processing unit (GPU)	App Service Azure CycleCloud VMware solution Linux virtual machines Azure functions Azure Kubernetes services Batch Azure Service fabric

Database	Amazon Aurora Amazon RDS Amazon Redshift DynamoDB Amazon Neptune	Cloud Bigtable Fire store Memory store Cloud Spanner Cloud SQL Firebase Realtime Database	Azure cache for Redis Azure SQL database Azure SQL edge Azure Data Factory Azure Cosmos DB
Serverless Computing	AWS Lambda AWS Fargate	Cloud Function Cloud Run	Functions
Data Centers	Over 77 availability zones within over 25 geographic regions	24 regions	60 regions
GDPR Compliance	AWS GDPR DPA (Data Processing Addendum) AWS Service Terms AWS Privacy Notice	Google Workspace Data Processing Amendment. Google Workspace EU Standard Contract Clauses. Google Cloud Data Processing and Security Terms. Google Cloud EU Standard Contract Clauses (SCCs).	Azure Policy. Compliance Manager Azure Information Protection Azure Security Center Azure Security and Compliance GDPR blueprint.
Storage	Simple storage service (S3) Data transfer server Elastic file system Snowball	All storage product Cloud storage File store Persistent Disk	Archive Storage Azure Backup Azure Files Azure Data Lake Storage Data Box Azure Data Share
Security	AWS IAM	Cloud IAM	Azure Security
Manageability	Largest provider Global reach Unlimited server capacity Reliable encryption & security	Better price Private global fiber network Redundant backup Improved performance	High Availability Speed of service Security Recovery

Disadvantages	AWS service limits Technology limitation Technical support fee	Few service Few global data centre Complex transition	Complex Data transfer fees Complicated price
Price	US\$69 per month	US\$52 per month	US\$70 per month

Table 5 : Comparison of Cloud Service Providers against the set Criteria [67]

	ForpsiCloud	Algotech Cloud	T-Mobile
Price	4725 CZK + VAT	2199 CZK + VAT	2499 CZK +VAT
Cloud Security	ISO 9001, ISO 27001	ISO 27001	Managed Security Box
Data Center	Ktis, CZ Milan, ITA London, UK Warsaw, POL Frankfurt, GER Paris, FRA	3 data center all in Czech Republic	Czech Republic Slovakia Republic
GDPR Compliance	YES (CISPE code of conduct)	YES (100 % compliant with GDPR and Other Standard)	YES (T-Mobile Privacy Dashboard Global Privacy Control)
Support	Cloud VPS Cloud PRO Private Cloud DataBase as a Service	Enterprise System (ERP) CRM System Accounting System	T-Cloud VDC T-Cloud 365 T-Cloud Azure Hybrid Cloud
Cloud Storage	Starts from 100 GB	Starts from 20 GB	Starts from 100 GB
Manageability	Online Backup Infrastructure.	Better Price.	Collaboration with Microsoft. Good Service.

	Easy and quick to activate. User friendly and pre-configured.	Best tools for in Formation and communications	Accountability for Network.
--	--	--	-----------------------------

Table 6 : Comparison of Cloud Service Providers against the set Criteria [8][16][18]

## 4.5 Saaty’s Method

This is the approach for ensuring that the relevant data and calculations are used in the selection process. The multi-criteria decision approach is employed in this strategy, which may include the usage of the Analytic Hierarchy Process (AHP) to produce the most [18]appropriate and reliable decision. Many small businesses choose for cloud service providers to provide a more secure and cost-effective infrastructure investment, and they continually seek out the best options available in the IT market. For any company, security may be the most significant factor in gaining confidence and establishing a reputation in the marketplace, followed by pricing. Other variables, such as storage and support, are also critical for the company's success. After analyzing the decision alternatives used in AHP, it assigns a priority rating to each of the aspects for selecting cloud service providers and determines the most acceptable criteria. [68]

## 4.6 Criteria Prioritization

The design of the selection model play the most crucial and critical part in selection decision-making process. Main purpose of the selection procedure to select existing alternatives for the SME option using a set of criteria for evaluation. It must also consider the primary and sub-criteria that aid in the production of more helpful or great output in order to attain the aim. Price, data security, storage, data center, support, and manageability are among the characteristics listed here. Gilla Info's hierarchical problem structure is as follows:

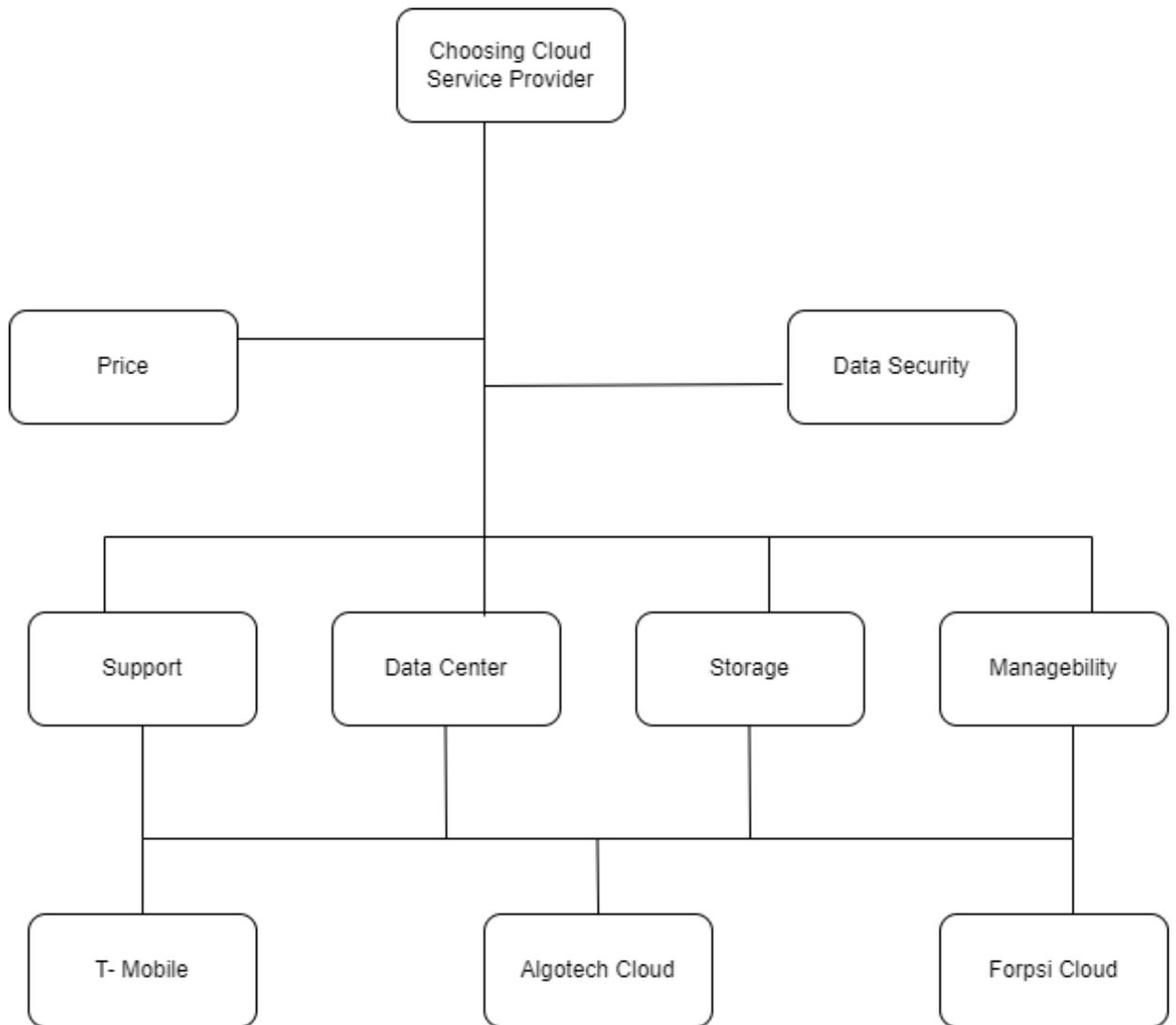


Figure 9: Hierarchical Problem Structure of Gilla Info model according to [68]

In the comparison, global cloud service providers have not been included because they are priced high. Local cloud service providers are more in line with the requirements faced by Gilla Info. They can provide a greater level of freedom, control, and efficiency for the company to ensure cloud computing services. Moreover, the company is doing extraordinary at the national level; therefore, the cloud computing service should be local as well. It will provide better service in terms of support, manageability, storage, and security of data and information stored there. This is the reason why local cloud service providers have been given priority over global cloud service providers. Gilla Info has one purpose at the top of its services to customers, and it is customer-centric services. They should have the

ability to contact the company in case they have any concerns or issues. Local service providers are better equipped and prepared to provide the required level of services to clients. Therefore, local service providers have been preferred over global cloud service providers. The following criteria guide why these service providers have been chosen.

	Price	Security	Storage	Data Centre	Support	Manageability	GM	Weights
Price	1	3	5	7	5	9	4.10	0.433495
Security	0.33	1	3	5	7	9	2.61	0.276038
Storage	0.20	0.33	1	5	5	5	1.42	0.150679
Data Centre	0.14	0.20	0.20	1	3	5	0.66	0.070268
Support	0.20	0.14	0.20	0.33	1	3	0.42	0.044745
Manageability	0.11	0.11	0.20	0.20	0.33	1	0.23	0.024774
						Sum	9.45	

Table 7: Pairwise Comparison and Normalization between criteria

consistency_index (CI)	0.13
consistency_ratio (CR)	0.0995
	cr<0.1

Table 8: Consistency index and consistency ratio

#### 4.7 Evaluation of alternative cloud service providers

Pairwise comparison and Normalization between the Alternatives

For Price

	Forpsi Cloud	Algotech Cloud	T-Mobile	GM	Weight
Forpsi Cloud	1	0.33	0.14	0.36	0.08
Algotech Cloud	3	1	0.2	0.84	0.19
T_Mobile	7	5	1	3.27	0.73
			Sum	4.48	

Table 9: Pairwise Comparison and Normalization between Alternatives by price

For Data Centre

	Forpsi Cloud	Algotech Cloud	T-Mobile	GM	Weight
Forpsi Cloud	1	5.00	7.00	3.27	0.73
Algotech Cloud	0.20	1	0.20	0.34	0.08
T_Mobile	0.14	5	1	0.89	0.20
			Sum	4.51	

Table 10: Pairwise Comparison and Normalization between Alternatives by data centre

For Assistance

	Forpsi Cloud	Algotech Cloud	T-Mobile	GM	Weight
Forpsi Cloud	1	5.00	0.20	1.00	0.26
Algotech Cloud	0.20	1	0.33	0.41	0.10
T_Mobile	5.00	3	1	2.47	0.64
			Sum	3.87	

Table 11: Pairwise Comparison and Normalization between Alternatives by assistance

For Security

	Forpsi Cloud	Algotech Cloud	T-Mobile	GM	Weight
Forpsi Cloud	1	3.00	5.00	2.47	0.65
Algotech Cloud	0.33	1	0.33	0.48	0.13
T_Mobile	0.20	3	1	0.84	0.22
			Sum	3.79	

Table 12: Pairwise Comparison and Normalization between Alternatives by security

For Storage

	Forpsi Cloud	Algotech Cloud	T-Mobile	GM	Weight
Forpsi Cloud	1	0.20	0.20	0.34	0.09
Algotech Cloud	5.00	1	3.00	2.47	0.62
T_Mobile	5.00	0.33	1	1.19	0.30
			Sum	3.99	

Table 13: Pairwise Comparison and Normalization between Alternatives by storage

For Manageability

	Forpsi Cloud	Algotech Cloud	T-Mobile	GM	Weight
Forpsi Cloud	1	0.20	0.20	0.34	0.08
Algotech Cloud	5.00	1	0.14	0.89	0.20
T-Mobile	5.00	7	1	3.27	0.73
			Sum	4.51	

Table 14: Pairwise Comparison and Normalization between Alternatives by manageability

All weights

	Price	Security	Storage	Data Centre	Support	Manageability	Total
Forpsi Cloud	0.08	0.65	0.09	0.73	0.26	0.08	1.89
Algotech Cloud	0.19	0.13	0.62	0.08	0.10	0.20	1.32
T-Mobile	0.73	0.22	0.3	0.2	0.64	0.73	2.82

Table 15: Calculation of total utility of each alternative

## 4.8 Estimation of costs

### 1. Forpsi Cloud calculation

There is a calculator on Forpsi cloud website. Price has been calculated to pay for the services SME will going to use. According to above mentioned parameter the calculated price will be approx. 4725 czk + vat per month. Also, if the SME want to increase CPU GHZ or RAM, the SME must pay extra. For vCPU to increase 2GHZ the price will be 500 czk + vat for 30 days and for RAM to increase 2GB the price will be 200 czk + vat fro 30 days. [69]

### 2. Algotech Cloud

There is a price list on Algotech cloud website. Price has been calculated to pay for the services SME will going to use. According to above mentioned parameter the calculated price will be approx. 2199 czk excluding 21% of vat per month.If the SME wants a cloud sever vCPU 4x, SSD 100GB,and RAM 8GB total cost will be for private cloud hosting will be 2199 czk + vat per month.All the specification mentioned in algotech cloud is less than the specification which Gilla Info is looking for. According to the company's requirement

the SME have to pay more. Also, for the cloud storage the plan mentioned on algotech cloud website is about 640 czk per month excluding vat. In this they provide 1000 GB of space and unlimited number of users with support in Czech language.[16]

### 3. T-Mobile

In T-Mobile cloud there are only three services provided by the company  
 Microsoft office 365 - The most expensive T- Cloud office 365 plan is of 519 czk which gives the possibility to install up to 5 computers, 5 tablets and 5 phones for one user.

Xopero cloud - The price for T-Cloud team backup starts from 399 czk from 100 GB to 2499 czk for 1000 GB.

PhoneCopy - is a service that provides management and backup of data from a mobile phone to cloud storage. The storage is maximum upto 100 GB which will cost around 149 czk.[18]

Forpsi Cloud	4725 czk + vat
Algotech Cloud	2199 czk + vat
T-Mobile	2499 czk + vat

Table 16: Estimation of price for local provider

### **Location of Data centers:**

The location of the datacenter where cloud data is housed is crucial. It's because each country's legal system is unique. Rules are always changing. Because nothing is certain in such situation. That is why it is critical to select a cloud service based in Czech Republic.

Datacenter of the Forpsi cloud - Its datacenters are located in Ktis, Czech Republic, Milan, Italy, London, UK, Warsaw, Poland, Frankfurt, Germany, and Paris, France. It shows its Europe-centric operations, which make it aligned with the decision to choose a local cloud service company.[70]

Datacenter of the Algotech Cloud – Algotech cloud have three data centers and all of them are located in Czech Republic[16]

Datacenter of the T- Mobile – T-Mobile has its data centers to Czech Republic and Slovakia Republic[18]

## Cloud Security

### 1. Forpsi Cloud

According to words of Forpsi cloud mentioned on their website, they meet the standards for a system that manages information security. Their parent company is one of the founders of the CISPE Code for Data Protection, indicating that data protection is a top priority for Forpsi cloud.” It follows the ISO 27001: 2014 and CISPE- Service Complaint – Aruba for data security. [17]

### 2. T - Mobile Cloud

Corporate e-mail, electronic banking, and sensitive client information are all at risk. Hackers will find all of these to be simple targets. Modern generation cyberattacks are becoming more complex as computer networks become more diversified. As a result, it's critical that SMEs network is well-protected.

According to T- Mobile cloud mentioned on their website, it is said that there is ‘security box’ which helps to manage the security of the organization. Also, that “Managed Security Box” will cost 1849 czk per month.

T- Mobile Cloud services as mentioned at their website the UTM function is the implementation of full network protection using technical techniques such as IPS, Antivirus/Antispam, and web filtering. Inspection of encrypted traffic in its entirety, i.e. https: / is provided. Organization network's Internet risks, including possible attacks, are reported on a regular basis. Also, complete backup of the most recent operational service settings and customer service is available 24 \*7. T-Mobile also provide initial configuration and professional installation are provided at no cost to SMEs.[18]

### 3. Algotech cloud

According to words of Algotech cloud mentioned on their website, they provide highest standard of data security ISO 27001 certification and assistance is available for 24 hours a day in Czech language.[16]

## **Support**

If a SME has chosen the most services, the cloud service provider must give customer support to their clients 24\*7. And all of the select local service providers i.e. Forpsi cloud, Algotech cloud, T-Mobile cloud provides assistance 24\*7\*365.

## **4.9 Summary of Evaluation**

One of the objectives of the thesis is to analyze and find out the best cloud service provider for a SME. Forpsi cloud, Algotech cloud, and T-Mobile is the local cloud service provider in the Czech Republic. Gilla info, a virtual company can use the services provided by them. Main criteria on which the Gilla info select the best possible service provider is price, security, data centers, support, storage and manageability. Analytic Hierarchy Process (AHP) is used for the selection of cloud service provider and same process is used for all the alternative for each criteria. The pairwise comparison and normalization between all the alternatives is made and in last all the weightage is calculated and the cloud provider with the highest weightage is selected as the best possible alternative as per the above-mentioned parameters. As the outcome T-Mobile has the highest weightage i.e., 2.82 as compared to other alternative i.e., Forpsi Cloud and Algotech Cloud and is best option for Gilla Info. T-Mobile is best in price, manageability, and support as compared to its alternatives. As it is not best in data center but considering all the criteria it stands the best option. Forpsi Cloud also provides good services with the weightage of 1.89 it stands at second position or is the alternative for the Gilla info.

## **5 Results and Discussion**

In the theoretical part of the thesis was describe about the cloud computing and following various types of cloud computing. Also, it was discussed about different cloud service models and services which the IaaS, PaaS, SaaS are providing. It is also discussed about the various local service provider and what type of the services the local service provider is providing to their clients. Also, in what way the cloud services is beneficial for the small or medium sized enterprises and what will be the drawbacks of adopting the cloud computing. If any SME wants to adopt or cloud services what will be the security and privacy

of the organization's data. Data protection laws, the Czech data protection laws and the general data protection regulation is also discussed.

In this thesis, a fiction company is assumed, and according to its requirement a selection criterion is made. The local cloud service provider Forpsi cloud, T-Mobile cloud, Algotech cloud, is compared in term of price, location, availability, assistance, data protection, mobileability etc.. And with the multi criteria decision making the author come to the result that T-mobile has the highest weightage and is selected best cloud service provider according to the above-mentioned specification. Also, the overview of the global cloud service provider i.e., Amazon AWS, Google cloud platform, Microsoft azure is made.

The criteria through which the chosen cloud computing service has been selected include price, data centers, manageability, support, cloud security, and cloud storage. The chosen company, T-Mobile, is effective as per the needs of the case company. It has strong and well-integrated business activities and operations in Europe. It can help the company in the Czech Republic in various ways and perspectives. Data security is one of the top attributes to be there in a cloud computing service provider.

On the other hand, manageability is also possible for choosing the local provider because it can be available to the company. Therefore, in summary, the chosen service provider is excellent, and it is recommended to follow this service provider to come up with the needs of the case company, i.e., Gilla Info. This is how; the findings are in line with the security and privacy concerns of cloud computing services provided by the supplier[46]. Security ensures a threat-free solution to computing services. Privacy ensures that every individual and business will be secure in terms of his personal information. It is also in line with the previous research findings and literature review on cloud computing services and their various aspects and perspectives.[56]

The location of all three local service providers is mostly in the EU and all three have their data canter in the Czech Republic and nearby countries. For services, the price will be paid on monthly basis. All three local service provider is promising to give the assistance or customer support 24\*7.

When an SME is transiting to the cloud services there are some challenges that an SME has to face but with the issues, there are also solutions. Issues like security and privacy of the data, management of the devices, storage, backups, etc. are discussed also their solution is discussed how these issues will be solved. Adoption of cloud services for SMEs will help in the security and privacy of the data, save its cost, and server and storage or

backups are maintained by the service provider. In the Czech Republic, almost 44 percent of the organization is using cloud services and 53 percent of the medium-sized enterprises in the EU are adopting cloud services.

At the end of this section, the company must follow recommendations for effective functionality and work. The company is doing well in terms of functions, working, pricing, and manageability. However, it is witnessing increasing pressure from competitors. Therefore, it must look into this perspective that it should not lead to an increase in the price of its services. Along with this, manageability must be the top priority so that functions and services can be simple and fast. Manageability is dependent on many factors, and a strong backend and infrastructure are responsible for the better management of cloud computing services. The company needs better and focused coordination to streamline its operations from the international level. Shipping costs are high, and better streamlined and effective cloud computing services from T-Mobile can better serve the purpose and objectives of the company.

## **6 Conclusion**

The main objective of this thesis is to analyze the cloud services adoption from a view point of SME which include the security and privacy concern. This was done based on numerous findings and investigations of requirements, available and appropriate technique, interviews with experts and professionals in IT and cloud-related fields, and calculations based on their marking and weighted points on that topic. This thesis described the current condition of cloud services on the market and provided several providers in the Czech Republic. A comparison analysis of cloud services based on a set of criteria.

The research has the objective to make an overview of the current market of cloud services, digital transformation approaches, and challenges. A comparison of local and foreign cloud service providers has done this job for the diploma thesis. This analysis has been confirmed and focused on knowing the current market of cloud services, digital transformation approaches, and challenges. Security and privacy are prominent issues and challenges in the way of adoption of cloud computing services.

Another objective is to analyze cloud services adoption approaches, including security and privacy concerns. It has also been met that the chosen cloud computing service is from the local provider that is T-Mobile. The company has been selected based on security and privacy criteria. Other criteria, including price, manageability, and others, have been considered and addressed effectively. However, the most important are these two conditions which have led to achieving this objective as well.

The third objective is to summarize findings and elaborate recommendations for cloud services adoption for SMEs. This has been done in the previous section before the conclusion. It has been found that cloud computing services must focus on privacy and security criteria. A local cloud computing service is better than a foreign cloud computing service. In this perspective, recommendations have also been made to let the company keep bringing changes in its area of operations and activities

The finding is based on the research papers, articles, interviews with the person or the employee working in the organization or working on the cloud. It is also discussed why an SME should adopt the cloud services like the key points i.e., in terms of price, security, and privacy of data, storage, data center what can be estimated in the growth of the company, new possibilities for the organizations, and collaboration with the internet. The main issues

in security and privacy are discussed. The main issues in the public cloud and private cloud and the key points in both types of cloud are shown in the above practical part of the thesis.

To make the data secure from unauthorized users, the encryption and decryption algorithm should be used. As there will be a public key and private key will be created which will only be used by the authorized user. Also, role-based access control is also given to the employees who are working in the organization. Like if any employee quits the organization, then all the access control will be taken from the employees.

Data is collected from the latest survey made by Europa in which the use of cloud computing services in the European countries is described. In this study, almost four out of ten organizations in the EU are using cloud services in 2021 and if discussed the Czech Republic 44 percent of the organizations are using cloud services. Also, more than five out of ten medium-sized enterprises are using cloud services and almost four out of ten small-sized enterprises are using cloud services.

The research has achieved its objectives, but there is room for improvement and betterment. For this purpose, it is worth considering the quantitative and primary research methodology involving cloud computing services. Primary data and information can be very effective in drawing results because of their original and direct approach. Another limitation is that this research has chosen a local cloud computing service provider, while a foreign cloud computing service provider can also be considered. There is a chance for future researchers to take these limitations for researching new avenues in this direction. It is also advised to focus on findings and recommendations to conduct future research.

## 7 References

- [1] European Union, “Unleashing the full potential of European SMEs,” 2020. doi: 10.2775/218854.
- [2] D. Widyastuti and I. Irwansyah, “Benefits And Challenges Of Cloud Computing Technology Adoption In Small And Medium Enterprises (SMEs),” *Bandung Creative Movement (BCM)*, vol. 4, no. 1, Mar. 2018, Accessed: Sep. 08, 2022. [Online]. Available: <https://openlibrarypublications.telkomuniversity.ac.id/index.php/bcm/article/view/5905>
- [3] “What is Cloud Computing?,” *Amazon Web Services*, Mar. 2013, Accessed: Oct. 16, 2022. [Online]. Available: <https://aws.amazon.com/what-is-cloud-computing/>
- [4] Microsoft, “Cloud Computing Services | Microsoft Azure,” *Microsoft Azure*, 2020.
- [5] “IBM Cloud - Czech Republic | IBM.” <https://www.ibm.com/cz-en/cloud> (accessed Oct. 16, 2022).
- [6] C. A. Lee, R. B. Bohn, and M. Michel, “NIST Cloud Computing Program - NCCP | NIST,” Feb. 2020, doi: 10.6028/NIST.SP.500-332.
- [7] “What is public cloud? Everything you need to know - Cloud Computing Gate.” <https://cloudcomputinggate.com/what-is-public-cloud-everything-you-need-to-know/> (accessed Sep. 05, 2022).
- [8] “Private Cloud - Service Features | ForpsiCloud.cz | ForpsiCloud.cz.” <https://www.forpsicloud.cz/privatni-cloud.aspx> (accessed Sep. 06, 2022).
- [9] D. Catteddu, “Cloud Computing: Benefits, Risks and Recommendations for Information Security,” 2010. doi: 10.1007/978-3-642-16120-9\_9.
- [10] “Cloud Computing Services - Amazon Web Services (AWS).” <https://aws.amazon.com/> (accessed Oct. 15, 2022).
- [11] “Cloud Computing Services - Amazon Web Services (AWS).” [https://aws.amazon.com/?nc2=h\\_lg](https://aws.amazon.com/?nc2=h_lg) (accessed Sep. 06, 2022).
- [12] E. Plesky, “IaaS vs PaaS vs SaaS – cloud service models compared,” *Plesk*, 2019.
- [13] “Home | Digital & Cloud Services.” <https://www.digitalandcloudservices.com/> (accessed Sep. 06, 2022).
- [14] “Google Cloud Platform Services Summary.” <https://cloud.google.com/terms/services> (accessed Sep. 06, 2022).

- [15] “Cloud Computing, Hosting Services, and APIs | Google Cloud.” <https://cloud.google.com/gcp/?hl=en> (accessed Sep. 06, 2022).
- [16] “AlgoCloud.” <https://www.algotech.net/index.php/algocloud> (accessed Sep. 05, 2022).
- [17] “Cloud Backup - disaster recovery | ForpsiCloud.cz.” <https://www.forpsicloud.cz/cloud-backup.aspx> (accessed Sep. 06, 2022).
- [18] “T-Cloud: úložiště, antivirus a mnohem víc - T-Mobile.cz.” <https://www.t-mobile.cz/podnikatele-firmy/t-cloud> (accessed Oct. 15, 2022).
- [19] “Spolehlivý operátor pro mobilní i pevné služby - T-Mobile.cz.” [https://www.t-mobile.cz/osobni?campaign=1100a02\\_|\\_SRCH:\\_BRAND\\_-\\_broad&gclid=CjwKCAjwKmaBhBMEiwAyINuwOpCBUZQ5RbAafin95B\\_\\_dLjPmqBvw-bdMyfyXbyDk3lX6vSCOW7DxoCm\\_QQAvD\\_BwE](https://www.t-mobile.cz/osobni?campaign=1100a02_|_SRCH:_BRAND_-_broad&gclid=CjwKCAjwKmaBhBMEiwAyINuwOpCBUZQ5RbAafin95B__dLjPmqBvw-bdMyfyXbyDk3lX6vSCOW7DxoCm_QQAvD_BwE) (accessed Oct. 15, 2022).
- [20] “Introduction Cloud computing on Amazon Web Services | by INSAID | Medium.” <https://insaid.medium.com/introduction-cloud-computing-on-amazon-web-services-a58326a84b22> (accessed Oct. 15, 2022).
- [21] “12 Advantages of Cloud Computing - Simco Lab.” <https://www.simcolab.org/12-advantages-of-cloud-computing/> (accessed Oct. 16, 2022).
- [22] “ADVANTAGES AND DISADVANTAGES OF CLOUD COMPUTING SERVICES, FROM THE EMPLOYEE’S POINT OF VIEW IACOB-EMANUEL BACIU.” [Online]. Available: <http://ssrn.com/abstract=2787612>
- [23] “5 Disadvantages of Cloud Computing - Simco Lab.” <https://www.simcolab.org/5-disadvantages-of-cloud-computing/> (accessed Oct. 16, 2022).
- [24] S. Yasser hashemi and P. Sheykhi Hesarlo, “Security, Privacy and Trust Challenges in Cloud Computing and Solutions,” *International Journal of Computer Network and Information Security*, vol. 6, no. 8, 2014, doi: 10.5815/ijcnis.2014.08.05.
- [25] R. Velumadhava Rao and K. Selvamani, “Data security challenges and its solutions in cloud computing,” *Procedia Comput Sci*, vol. 48, no. C, pp. 204–209, 2015, doi: 10.1016/J.PROCS.2015.04.171.
- [26] R. Nagahawatta, M. Warren, S. Lokuge, and S. Salzman, “Security and Privacy Factors Influencing the Adoption of Cloud Computing in Australian SMEs,” 2021, Accessed: Oct. 15, 2022. [Online]. Available: <https://aisel.aisnet.org/pacis2021/7/>

- [27] A. Luntovskyy and J. Spillner, “Security in Distributed Systems,” *Architectural Transformations in Network Services and Distributed Systems*, pp. 247–308, 2017, doi: 10.1007/978-3-658-14842-3\_7.
- [28] “The State of Cloud Security — Insights From Eric Carrell - OpsCompass.” <https://opscompass.com/resources/blog/the-state-of-cloud-security-insights-from-eric-carrell/> (accessed Oct. 16, 2022).
- [29] O. Corporation, “National Cyber Security Centre (NCSC) Cloud Security Principles and Implementation in Oracle Cloud | Version 2.1 National Cyber Security Centre (NCSC) Cloud Security Principles and Implementation in Oracle Cloud,” 2021.
- [30] S. Nandan Kumar and A. Vajpayee, “A Survey on Secure Cloud: Security and Privacy in Cloud Computing,” *American Journal of Systems and Software*, vol. 4, no. 1, pp. 14–26, 2016, doi: 10.12691/ajss-4-1-2.
- [31] Y. Sun, J. Zhang, Y. Xiong, and G. Zhu, “Data Security and Privacy in Cloud Computing,” *International Journal of Distributed Sensor Networks*, vol. 2014. Hindawi Limited, 2014. doi: 10.1155/2014/190903.
- [32] “Data Breach and Protection against it – Lexlife India.” <https://lexlife68840978.wordpress.com/2021/07/02/data-breach-and-protection-against-it/> (accessed Oct. 15, 2022).
- [33] L. kacha and A. Zitouni, “An Overview on Data Security in Cloud Computing,” Dec. 2018, doi: 10.1007/978-3-319-67618-0\_23.
- [34] E. Politou, E. Alepis, and C. Patsakis, “Forgetting personal data and revoking consent under the GDPR: Challenges and proposed solutions,” *Journal of Cybersecurity*, vol. 4, no. 1. Oxford University Press, Jan. 01, 2018. doi: 10.1093/cybsec/tyy001.
- [35] “Personal data protection (GDPR) | CZSO.” <https://www.czso.cz/csu/czso/personal-data-protection-gdpr> (accessed Oct. 15, 2022).
- [36] “Czech Republic | European Data Protection Board.” [https://edpb.europa.eu/our-work-tools/our-documents/member-state/czech-republic\\_en](https://edpb.europa.eu/our-work-tools/our-documents/member-state/czech-republic_en) (accessed Oct. 15, 2022).
- [37] “RightScale 2018 State of the Cloud Report™ DATA TO NAVIGATE YOUR MULTI-CLOUD STRATEGY,” 2018.
- [38] D. Kumar Murala, S. Kumar Panda, S. Kumar, and S. Kumar Swain, “A Survey on Cloud Computing Security and Privacy Issues and Challenges Model based human face generation using generative adversarial networks View project Blockchain View

- project A Survey on Cloud Computing Security and Privacy Issues and Challenges,” 2019. [Online]. Available: <https://www.researchgate.net/publication/350995748>
- [39] Y. Liu, Y. Sun, J. Ryoo, S. Rizvi, and A. v. Vasilakos, “A survey of security and privacy challenges in cloud computing: Solutions and future directions,” *Journal of Computing Science and Engineering*, vol. 9, no. 3, pp. 119–133, 2015, doi: 10.5626/JCSE.2015.9.3.119.
- [40] “Cloud computing - statistics on the use by enterprises - Statistics Explained.” [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Cloud\\_computing\\_-\\_statistics\\_on\\_the\\_use\\_by\\_enterprises#Enterprises\\_using\\_cloud\\_computing](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Cloud_computing_-_statistics_on_the_use_by_enterprises#Enterprises_using_cloud_computing) (accessed Oct. 16, 2022).
- [41] “Statistics Explained.” [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Main\\_Page](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Main_Page) (accessed Oct. 15, 2022).
- [42] M. Akbari, “Cloud Computing Adoption for SMEs: Challenges, Barriers and Cloud Computing Adoption for SMEs: Challenges, Barriers and Outcomes Outcomes,” 2012. [Online]. Available: <https://arrow.tudublin.ie/scschcomdis>
- [43] K. Ghaffari, M. S. Delgosha, and N. Abdolvand, “TOWARDS CLOUD COMPUTING: A SWOT ANALYSIS ON ITS ADOPTION IN SMES,” *International Journal of Information Technology Convergence and Services (IJITCS)*, vol. 4, no. 2, 2014, doi: 10.5121/ijitcs.2014.4202.
- [44] A. Ishizaka and P. Nemery, “Multi-Criteria Decision Analysis Methods and Software: General introduction,” *Multi-criteria Decision Analysis: Methods and Software*, pp. 1–9, 2013, Accessed: Oct. 15, 2022. [Online]. Available: <https://www.wiley.com/en-us/Multi+criteria+Decision+Analysis%3A+Methods+and+Software-p-9781119974079>
- [45] H. Alabool, A. Kamil, N. Arshad, and D. Alarabiat, “Cloud service evaluation method-based Multi-Criteria Decision-Making: A systematic literature review,” *Journal of Systems and Software*, vol. 139, pp. 161–188, May 2018, doi: 10.1016/J.JSS.2018.01.038.
- [46] I. Otay and T. Yıldız, “Multi-criteria Cloud Computing Service Provider Selection Employing Pythagorean Fuzzy AHP and VIKOR,” *undefined*, vol. 1197 AISC, pp. 423–431, 2020, doi: 10.1007/978-3-030-51156-2\_49.

- [47] A. W. Khan *et al.*, “Analyzing and Evaluating Critical Challenges and Practices for Software Vendor Organizations to Secure Big Data on Cloud Computing: An AHP-Based Systematic Approach,” *IEEE Access*, vol. 9, pp. 107309–107332, 2021, doi: 10.1109/ACCESS.2021.3100287.
- [48] A. C. Mondragon *et al.*, “An AHP and Fuzzy AHP Multifactor Decision Making Approach for Technology and Supplier Selection in the High-Functionality Textile Industry An AHP and fuzzy AHP multi-factor decision-making approach for technology and supplier selection in the high-functionality textile industry,” 2019, doi: 10.1109/TEM.2019.2923286.
- [49] “Saaty, T.L. and Vargas, L.G. (2001) Models, Methods, Concepts and Applications of the Analytic Hierarchy Process. Kluwer Academic Publishers, Norwell. - References - Scientific Research Publishing.” [https://www.scirp.org/\(S\(lz5mqp453edsnp55rrgjt55\)\)/reference/ReferencesPapers.aspx?ReferenceID=1391551](https://www.scirp.org/(S(lz5mqp453edsnp55rrgjt55))/reference/ReferencesPapers.aspx?ReferenceID=1391551) (accessed Oct. 15, 2022).
- [50] T. L. Saaty and L. G. Vargas, “Models, Methods, Concepts & Applications of the Analytic Hierarchy Process,” vol. 34, 2001, doi: 10.1007/978-1-4615-1665-1.
- [51] T. L. Saaty, “A scaling method for priorities in hierarchical structures,” *J Math Psychol*, vol. 15, no. 3, pp. 234–281, Jun. 1977, doi: 10.1016/0022-2496(77)90033-5.
- [52] Y. Ou, “THE CONCEPT OF CLOUD COMPUTING AND THE MAIN SECURITY ISSUES IN IT,” 2015.
- [53] I. Khan, “WHY BUSINESSES (SMES) SHOULD ADOPT CLOUD COMPUTING.”
- [54] A. Abdollahzadegan, A. Hussin, M. M. Gohary, and M. Amini, “The Organizational Critical Success Factors for Adopting Cloud Computing in SMEs,” *undefined*, 2013.
- [55] J. Adeghe, “Exploring the Cloud Adoption Processes SMEs need to Secure their Business Exploring the Cloud Adoption Processes SMEs need to Secure their Business View project.” [Online]. Available: <https://www.researchgate.net/publication/333648605>
- [56] Y. Alshamaila, S. Papagiannidis, and F. Li, “Cloud computing adoption by SMEs in the north east of England: A multi-perspective framework,” *Journal of Enterprise Information Management*, vol. 26, no. 3, pp. 250–275, Apr. 2013, doi: 10.1108/17410391311325225.

- [57] M. P. and H. K. Jan Wollersheim<sup>1</sup>, “Factors Influencing the Adoption of Cloud Computing by Small and Medium Enterprises in Developing Economies 14,” 2014.
- [58] “MASTER’S THESIS Security Concerns on Adoption of Cloud Computing Bilal Charif 2014 Master (120 credits) Master of Science in Information Security.”
- [59] “IMPORTANCE OF CLOUD COMPUTING1.docx - IMPORTANCE OF CLOUD COMPUTING Insight: As we progress farther into the digital age, it becomes increasingly evident | Course Hero.”  
<https://www.coursehero.com/file/136362711/IMPORTANCE-OF-CLOUD-COMPUTING1docx/> (accessed Oct. 16, 2022).
- [60] A. Sarsby, “Swot analysis : a guide to SWOT for students of business studies”, Accessed: Oct. 16, 2022. [Online]. Available: <https://www.lulu.com/shop/alan-sarsby/swot-analysis/paperback/product-22932529.html>
- [61] E. GÜREL, “SWOT ANALYSIS: A THEORETICAL REVIEW,” *Journal of International Social Research*, vol. 10, no. 51, pp. 994–1006, Aug. 2017, doi: 10.17719/JISR.2017.1832.
- [62] J. Nazarko, J. Ejdys, K. Halicka, A. Magruk, Ł. Nazarko, and A. Skorek, “Application of Enhanced SWOT Analysis in the Future-oriented Public Management of Technology,” *Procedia Eng*, vol. 182, pp. 482–490, Jan. 2017, doi: 10.1016/J.PROENG.2017.03.140.
- [63] “The Real Costs of Cloud Computing | Computerworld.”  
<https://www.computerworld.com/article/2550226/the-real-costs-of-cloud-computing.html> (accessed Oct. 16, 2022).
- [64] R. Saleem, “Cloud computing’s Effect on Enterprises in terms of Cost and Security,” *Computing*, 2011.
- [65] B. Duncan, A. Bratterud, and A. Happe, “Enhancing cloud security and privacy: Time for a new approach?,” in *2016 6th International Conference on Innovative Computing Technology, INTECH 2016*, Feb. 2017, pp. 110–115. doi: 10.1109/INTECH.2016.7845113.
- [66] B. Boudreau-Trudel and K. Zaras, “Comparison of Analytic Hierarchy Process and Dominance-Based Rough Set Approach as Multi-Criteria Decision Aid Methods for the Selection of Investment Projects,” *American Journal of Industrial and Business Management*, vol. 02, no. 01, pp. 7–12, 2012, doi: 10.4236/AJIBM.2012.21002.

- [67] “AWS vs Azure vs Google Cloud - Detailed Cloud Comparison.”  
<https://intellipaat.com/blog/aws-vs-azure-vs-google-cloud/> (accessed Oct. 15, 2022).
- [68] T. L. Saaty, “Decision-making with the AHP: Why is the principal eigenvector necessary,” *Eur J Oper Res*, vol. 145, no. 1, pp. 85–91, Feb. 2003, doi: 10.1016/S0377-2217(02)00227-8.
- [69] “Cloud PRO - Pricing and Configuration | ForpsiCloud.cz.”  
<https://www.forpsicloud.cz/cloud-computing/cloud-pro.aspx> (accessed Oct. 15, 2022).
- [70] “VPS virtual server based on VMware | ForpsiCloud.cz.”  
<https://www.forpsicloud.cz/vps/virtualni-server.aspx> (accessed Sep. 06, 2022).