International Journal of Engineering Trends and Technology
ISSN: 2231 – 5381 / https://doi.org/10.14445/22315381/IJETT-V70I6P231

Volume 70 Issue 6, 300-307, June 2022


*Original Article*

# Cost-Benefit Analysis of Public Cloud Versus In-House Computing

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Received: 29 April 2022 Revised: 11 June 2022 Accepted: 14 June 2022 Published: 29 June 2022

***Abstract*** *- The transformation of the Information Technology world has been evolving exponentially in the last couple of years. The technology gives many choices, enabling businesses, educational institutes, health, and industries to have the computational power and monetary performance, which is highly affected by their routine work. Many business companies are trying to move to the cloud for computing and storing their information on the system and decide which is cost-effective for in-house computing and Public Cloud. The objective of this study is to compare and calculate capital expenditure (Capex) and operational expenditure (Opex), which focuses on cost-benefit analysis of public cloud versus in-house computing, and develop a decision tree diagram that shows the benefits of cost-effectiveness, privacy, and data confidentiality, service level agreement, and real-time application. According to the Cost, the study shows that the public cloud is less expensive than in-house computing; most of the cost incurred by in-house computing is a power consumption cost. However, in-house computing is effective on the benefits side.*

***Keywords*** *- Cloud Computing, In-house, Cost-benefit, Capital expenditure, Operational expenditure.*

## 1. Introduction

The transformation of the information technology world has been evolving exponentially in the last couple of years. The technology gives many choices, enabling businesses, educational institutes, health, and industries to have the computational power and monetary performance, which is highly affected by their routine work. Several technologies have emerged with the need for this computational power and monetary performance. Cloud computing is among emerging technologies. As defined by (Marston et al., 2011); Mell and Grance (2011); (and Wang et al., 2008), cloud computing is a model for allowing ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, applications storage, and services) that can be quickly controlled and released with care or service provider interaction. Cloud computing is the long-held dream of computing as effective. It has the potential to transform a large part of the Information age industry, creating software even more attractive as a service and modelling the way IT hardware is designed and purchased (Nieuwenhuis et al., 2018). Cloud computing – a composition of a variety of online services – is a smart suggestion for small to medium businesses (SMBs) looking to make most of the technology currently used at possible costs and slighter risk (Gao & Meng, 2021; Qasem et al., 2019; Widyastuti & Irwansyah, 2018). The upfront investment is low. No need to invest in software/hardware, authorizing and renewal costs are saved and reduced to the lowest total cost of ownership so that they only pay for their usage. Whereas many companies continue to worry about the security of the system's redundancy, robustness, and the accessibly to the data in the cloud, that are the issues, the cost benefits very often to be more important than these considerations (Parast et al., 2022; Sharma et al., 2021). Small and medium enterprises (SMEs) usually meet a confusion about going for a hosted or an on-premises solution (Abdullahi et al., 2021).

The question remains unanswered, but enterprises evaluate their work-related desires and infrastructure before moving and deciding. The essential thing is that all solutions are not interchangeable to work with one another in the public cloud or in In-house computing. The selection regularly needs to optimize both security and costs to improve incomes. Companies should have the experience of migrating to the cloud and not be opposite to the benefits instead of gaining. At the same time also, when the situations change, there are occasions where an on-premises solution is more useful long-standing in as much as; moreover, there comes a time when a Cloud-based service is the one preferred. Finally, cloud computing offers many advantages for investment firms. For example, Kondo et al. (2009); (and

Nanath & Pillai, 2013) concluded that hosting a server on a cloud is likely cheaper than conducting a project on one's own. There could also be disadvantages, such as big data management as well. However, this study explores the cost-benefit analysis of public cloud versus in-house computing analysis.

Nowadays, a new technology called cloud computing has emerged. As it appeared, cloud computing simplifies and changes how technology is used, such as storing data and providing computing functionality. The cloud brought infrastructure as a service, platform as a Service, and Software as Service Manuel (2015). Subsequently, there are two terminologies of classes in server-based computing: (1) In-house server computing and (2) Cloud Computing. With the technology advancement needs and the increases in organization's business process complexity, many businesses and educational sectors seek to avail the In-house server and cloud computing, but the issue of choice, in which one is more cost-effective, either In-house or cloud. To assure and facilitate the decision-making process of selecting either In-house or cloud, this study will compare In-house computing and public cloud in terms of costs. It will facilitate how the news organizations, as well as the existing organization, may decide to move to the cloud or not.

This research aims to find out the cost-benefit analysis of cloud computing, especially public cloud and In-house computing, also known as On-premises computing. This study will also compare their service cost, including upfront cost, maintenance cost, staff training cost, compute power cost, and data storage cost. Also, focus on the following points:

- To compare public and in-house computing to implement cloud or server in terms of cost.
- To decide the type of server (cloud or in-house) that has less cost for business sectors
- Design a decision tree to facilitate the desired public cloud or in-house computing.

The remainder of this article sequentially discusses the theoretical foundation, the types of the cloud computing, and inhouse computing, demonstrates the proposed work, such as the cost-benefit analysis mechanism and parameters used, also be demonstrated the proposed model of calculating the capital expenditure and operational expenditure of public cloud versus in-house computing, contributions and future work related with this study

## 2. Literature Review

### *2.1. Cloud computing*

According to Shivi and Narayanan (2014), depending on the kind of cloud deployment services model the organization prefers, such as networking, platform, storage, and software infrastructure, the company will be provided a service that scales up or down liable to the needs of the customer. The cloud computing model has three main deployment models, and they are classified into Public, Private, and Hybrid.

Cloud computing offers several benefits. The cloud provides services that made many small to medium businesses migrate from their in-house-based server to cloud computing. Cloud computing increase the capacity or add capabilities dynamically without investing in new infrastructure, training new personnel, or licensing new Software (Babu et al., 2015; Ita & Manglani, 2017; Modisane & Jokonya, 2021; Saini et al., 2019; Subashini & Kavitha, 2011; Talib et al., 2010). In the cloud, small to medium business was drastically attracted by the elastics, which reduces many costs. In the literature on the cloud, three main services are infrastructure as a service, platform as a service, and software as a service:

#### *2.1.1. Infrastructure as a Service IaaS*

This service IaaS, is a machine virtualization service. This service provides renting small to medium business complete or partial hardware resources, such as CPU, Storage, etc. Small to medium-sized organizations can obtain required server services (virtualized servers) for their business based on their need. IaaS completely changes the way developers deploy their applications (Manvi & Shyam, 2014; Shahzadi et al., 2017; Subashini & Kavitha, 2011). Depending on their economy, they can scale up or down for the virtualized server capability.

#### *2.1.2. Software as a service SaaS*

This service offers to small and medium businesses and personnel to get any software as a service. In SaaS, applications are remotely hosted by the application or service provider and made available to customers on-demand over the internet (Seethamraju, 2015; Tsai et al., 2014). Traditionally, organizations have to purchase software for each computer they need to use for that software; therefore, this service answered the problem of purchasing a complete software.

#### *2.1.3. Platform as a service (PaaS)*

Unlike the other cloud services, this service is intended for the developers. PaaS offers an integrated set of developer environments that a developer can tap to build their applications without having any clue about what is going on underneath the service (Beimborn et al., 2011; Yasrab, 2018). In systems development, some tools facilitate the entire application development. This service provides Application Development platforms and APIs. This service can also support web services that are needed for web applications(Krancher et al., 2018).

*2.1.4. Types of cloud computing*

- The public cloud is a pool of shared network services from vendors like Amazon People use economies of scale since infrastructure costs expand to all users; therefore, every client will be allowed to operate on a low-cost, "pay-per-use" model. Alternative to public cloud infrastructures advantages is that they are typically larger in scale than an in-house enterprise cloud, which offers customers whole, on-demand scalability. Moreover, to know that all customers on public clouds share a similar infrastructure pool that is limited to configurations, security protections, and availability consistencies, let's say service providers are under the control of this issue (Hofmann & Woods, 2010; Shivi & Narayanan, 2014).

- A private cloud is built for a single enterprise. And may host applications in the cloud. Meanwhile, it concerns data security and control that the public no longer has. Private clouds are divided into On-Premises - Private Cloud, also called "internal cloud," which is accommodated inside the company's data center. It has security but is limited in size and scalability. It has to earn its capital and operational costs for the physical resources. When the whole application controls and configurability of the infrastructure and security, on-premises private clouds are better solutions. Externally Hosted Private Cloud: This cloud model is hosted externally, unlike the On-premises private clouds. It is an external cloud computing provider. The service that this private cloud provides is more secure. It is intended for an organization that needs to share with other companies the resources (Basmadjian et al., 2012; Davidovic et al., 2015).

- Hybrid clouds are the combination of public and private clouds and are the best of both. In this model, the company can control third-party cloud providers, which increases the flexibility of computing. This kind of cloud environment can provide on-demand, externally controlled scalability. Enhancing a traditional private cloud using a public cloud resource and managing any unexpected rushes in workload (Hoenisch et al., 2015; Kashef & Altmann, 2011).

***2.2. In-house computing***

The enhancement of technology has transformed the usage of computers to entail a large amount of storage capacity. Smaller personal computers derived the cost and permitted everything to be done In-house. Within a single room, owners could house all their data and networking equipment, enabling more employees to access information at any time (Chen & Chang, 2020; Elragal & El Kommos, 2012). Although in-house computing has some major problems simultaneously, cloud computing has emerged with a new solution delivering remote IT services that are more flexible, efficient, and cheaper than a business-owned data center (Prabhakaran & Lakshmi, 2018). Businesses now have a wide array of solutions which they can choose. Small and large business firms adopt moving their services to the cloud due to economic matters, accessibility of data on different devices, and increased cyber security. There are plenty aims that organizations should retain their services running in their own datacenters (Ali & Sujarae; Nayar & Kumar, 2018).

Direct access to all the infrastructure components like hardware, software, and networking allows a better overview and the possibility to know if any problem is happening. Once your data is under your regulation, and the services in your data center enable, greater control over the infrastructure and resources and access to the platforms can be restricted to direct or internal connections. In-house is less complex since running the services in the own data center assures the safety of your data and, therefore, fewer interactions between them; moreover, all physical components are in the same place. Having an own data center allows purchasing and sharing existing places, i.e., having the IT department working close to the data center floor for a low cost. Usage of knowledge: Datacenters are normally run by professionals with experience and expertise (Birke et al., 2012). A public cloud disheartens many organizations in building and maintaining their data centers. There are views organizations rely on cloud computing. Owning a data center without having core expertise encounter problems that may result in operating inefficiently. According to Shojaiemehr et al. (2018), service providers have to provide enough resources to deal with peak times, then the average utilization rate of data centers ranges from just five to twenty percent. The following cost is predicted that the cost of data center facility and energy usage will become significantly larger than the actual server procurement costs. Talking about scalability by running an application or service in your data center makes it difficult to handle a rapidly growing burden. Finally, the impact of data centers on the environment is currently receiving negative attention.

***2.3. Cost-Benefit Analysis***

Kondo et al. (2009) Explain the comparative cost-benefit analysis of cloud computing over desktop grids using Amazon EC2 and BIONIC (Berkley open infrastructure for network computing) based Desktop for the scientific community, ranging from storage to computational size. (Kondo et al., 2009); Maresova et al. (2017) (Martens et al., 2012) determined how many volunteers are required before VC becomes more cost-effective than clouds. Also, determine the minimum project age needed to achieve that number of volunteers. Chandra and Borah (2012) Discussed that the cloud handles complex IT infrastructure management and maintenance and leads to huge cost savings. In the case of an In-House server, all computing infrastructure lies on the shoulder of the user, such as Databases, server software,

server hardware, storage & networking (Aoshima & Yoshida, 2022; Salindeho et al., 2021).

## 3. Research Methodology

Since there can be several ways of comparing public cloud and In-house computing, this study focuses on comparing the cost-benefit analysis of both public cloud and In-house computing. According to the model of the two different scenarios, Public cloud and In-house computing, it comes to the question of how to evaluate both systems using cost-benefit analysis to decide which of the two has a better advantage over the other in terms of cost. Cost-benefit analysis is an assessment method that is quantified in monetary terms (Boardman et al., 2017; Maresova et al., 2017; Nanath & Pillai, 2013). It is an analytical way for organizations to make decisions about complicated issues. First, the study discusses the cost-benefit analysis of In-house computing. Then, with a cost-benefit analysis of public cloud computing, the study analyzes the capital and operational expenses for five (5) years. Fig 1 shows the process model for calculating Capex and Opex: collecting input parameters, passing values to parameters, and calculating Capex and Opex. The figure illustrates the steps that the user sequences and finally shows the total Cost of In-house computing and public cloud.

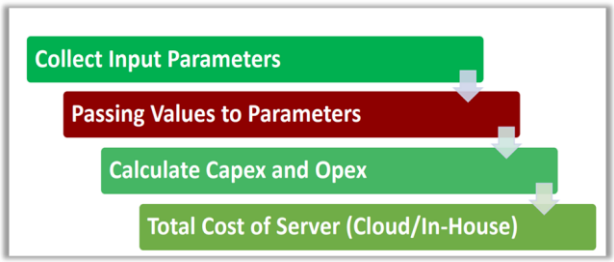


**Fig. 1 A process model for calculating Capex and Opex**

Making useful evaluations is essential to estimate the cost of purchasing and maintaining large servers. The right number of servers usually depends on the financial model of the capital expenditure and operational expenditures for the servers. The study also considers the costs of the in-house server's cost benefits, including maintenance and infrastructure costs. The study answers how much it costs to organize, operate, and maintain an organization's dedicated set of servers. The research model will suggest that the initial financing is applicable to assemble and work on their servers.

### *3.1. Parameters of In-house Computing*

Buying servers is a crucial aspect when companies decide to launch a new server-based system. They weigh more on several items and their parameters that help them classify the suitability of in-house servers or prefer other alternatives. The following are formulas for calculating Capex and Opex of In-house computing costs with their respective parameters:

***Cost for servers*** *= Number of servers × Cost per server*
***Cost of electricity for servers*** *= Number of Servers × Cost of electricity × Power Consumption per server*
***Cost of Electricity for AirCon*** *= AirCon × Cost of electricity × Power Consumption per AirCon*
***Cost of other Electricity*** *= Number of Hours per day × Cost of electricity × Power Consumption of other electricity*
***Cost of Operating System*** *= Number of Operating systems × Cost per Operating system*
***Cost of Database*** *= Number of Database × cost per database*
***Cost of antivirus*** *= Number of antiviruses × cost per antivirus*
***Cost of Network Equipment*** *= Number of Network equipment × Cost of Network equipment*
***Cost of Staffs*** *= No of Staffs × Cost per month*
***Cost of Space Rental*** *= Space Rental × cost of space*
***Infrastructure Maintenance of servers*** *= Number of Servers × Cost per server × Cost of Ratio*
***Infrastructure Maintenance of Networks*** *= Cost of Network Equipment × Cost of Network Equipment*
***Software maintenance*** *= Cost of Ratio × Cost of Software*
***Cost of Bandwidth*** *= Number of leased lines × cost per leased line*

### *3.2. Parameters and Calculations of Public Cloud*

The public cloud usually takes less capital expense than in-house computing when it comes to buying upfront costs; instead, it is used immigration charges in detail, classified Subscription fees, Consultation charges, and the Number of training staff. This section will explain how we calculate the Capex and Opex of Public cloud computing.

***Migration Cost*** *= Subscription fee × Consultation charges × staff expense*
***System Administration cost*** *= Salary per month × Number of a System administrator*
***Computing power*** *= Number of users × Hours per day × Rate per hour*
***Cost of Storage*** *= Usage GB/Hour × Hours per day × Rate per hour × GB Per hour*
***Bandwidth Cost (IN + OUT)*** *= Rate GB/Hour IN × Rate GB/Hour OUT × Working hours*

The decision tree of cost-benefit analysis classifies the benefits of cost-effectiveness, privacy and data confidentiality, service level agreement, and real-time application, as shown in figure 2.

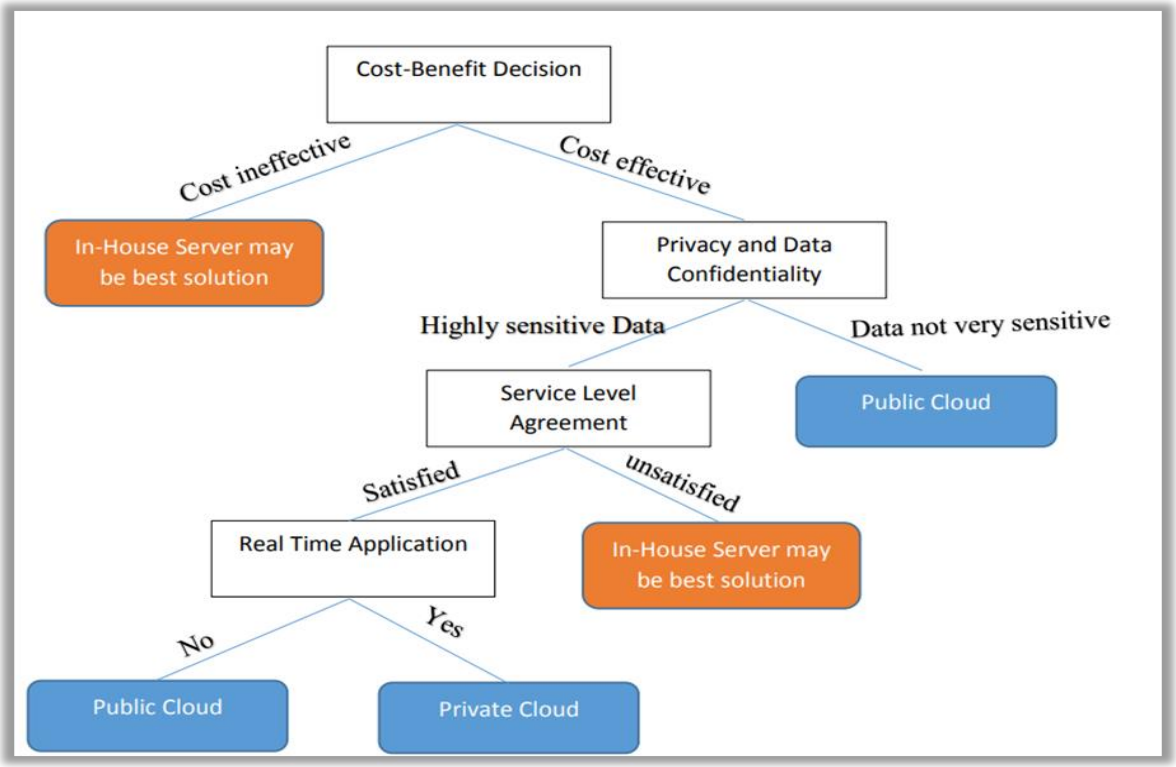


**Fig. 2 Cost-Benefit Decision Tre**

## 4. Results and Discussion

Comparing cost-benefit analysis of In-house computing and public cloud. Cloud need not think about buying or investing facilities from scratch like owned data centers; instead, you just pay immigration costs, Capital expenditure of the public cloud, like subscription fee, consultation charges, and staff expenses. While in-house needs enormous investments. Capital expenditure of the In-house computing; Server, Network equipment, AirCon, Software, Staff Expense, and Space Rental. A convenient way to evaluate the two systems, public cloud customers (organizations) can also input their metrics and derivation rules to specify their deployment model in the public cloud. In this model, we assign a way for calculations, i.e., assign a relationship between costs of two different metric items. It helps customize our model according to the organization's needs. We can indicate all aspects of expenditure, such as software, electricity, bandwidth, etc., mainly determined by the number of servers the company needs. For example, if an organization needs 40 servers, the number of network equipment and software licenses are the same. Hence if the number of servers required increases, the other costs also increase simultaneously.

Public cloud operational expenditure is the cost of running the cloud services. The system administrator cost, Computing power, storage, and bandwidth are the most used terms in a company's cloud. On the other hand, expenses of the in-house computing are like having an own datacentre means having costs for power, cooling, building, network, Storage, and Infrastructure. For investing an In- house computing, you should buy all your equipment or complete like datacentres facilities and, let's say, upfront costs you incur whenever building datacentres starting from scratch, calculating every penny spent using financial expenses of each cost factor involved, simplifying approaches to use Capital expenditure (Capex) and Operational Expenditure (Opex). Firstly, we detail the costs in terms of capital expenditure. To support this, we use financial expenses data collected. A total cost of ownership analysis would help the organizations to analyze and help them to evaluate what they need to pay to operate their systems in terms of hardware, software, and costs for upgrading, maintenance, downtime, and enhancements. After considering each and everything used in the Capital expenditure (Capex) to classify and name categories in place of repetition to give a parameter for every term mentioned as a capital expenditure (Capex), so that listing the terms may ease the user to input parameters without confusion and after you invest for the initial capital expense, the enterprise will commence running up everything and later will glance your ongoing operating costs. Finally, after taking the input parameters and a sample of five years, the public cloud is less expensive than In-house computing.

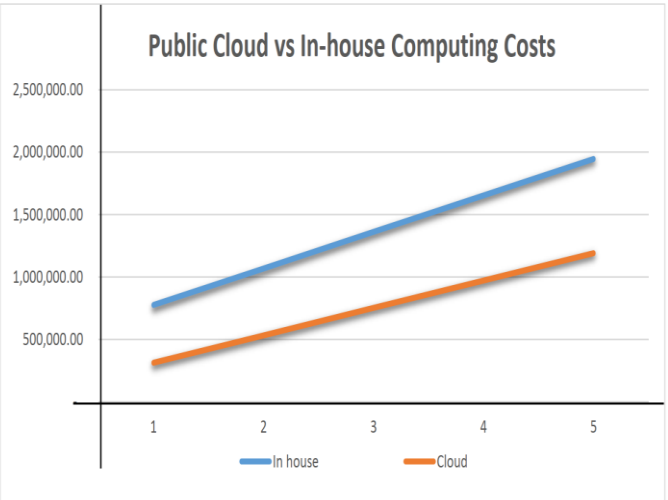


**Fig. 3 Five Years Period Analysis**

Fig. 3 illustrates the result of five years period analysis done during the research Study. The graph explains the conclusion of the two compared systems, both public cloud and In-house computing, which may come to the final decision of the customers of companies choose the choices of the two differentiated cost-benefit analyses.

## 5. Conclusion

Nowadays, many small and medium enterprises (SMEs) business companies like to deploy their data to the cloud for contracting infrastructures they need and settle on whether they allocate Inhouse computing or to the cloud to choose the one which is cost deduction and cost-effectiveness for their establishment, comparing and contrasting many factors and compared and calculated both In-house computing and cloud computing, so the author argued and demonstrated that in-house computing is more expensive than public cloud because installing in-house computing and supposed to build our own data centers equipping with hardware and software. In contrast, public cloud computing uses virtual Storage, CPUs, and bandwidths. Moreover, it is required to incur the upfront cost for purchasing all equipment and setting infrastructure of the data centers and the cost for upgrading, maintaining, and enhancing the systems. So, its upfront and operational cost is why In-house computing became more expensive than the public cloud. The authors concentrated on this study's cost-benefit analysis of public cloud versus in-house computing. They evaluated the cost of setting up all terms, whether upfront cost or Capital Expenditure (Capex) and Operational Expenditure (Opex) of both In-house computing and Public Cloud. The study has also focused on comparing public cloud versus In-house computing in terms of benefits. The study emphasized the cost-benefit analysis by observing several factors and studying the subject area literature that may touch on the benefits of monitoring the quality of services they provide, such as security, availability, and network latency. It contributed a decision tree that facilitates how a company can choose which servers of either In-house computing or public cloud are suitable. The study compared 20 in-house servers and their equivalent public cloud in terms of costs. The results demonstrated that the public cloud has less Cost than In-house computing. On the other hand, the researcher demonstrated that besides the cost, there are benefits such as elasticity and on-demand services that make the cloud to be attracted by many small to medium businesses.

## 6. Future Work

As the cloud introduces many advantages to the business and educational sectors that n incorporate various technology services, different issues need to be studied more. These two of the main issues are big data management and risk assessment. In the following sections, I will elaborate on these two issues:

### *6.1. Big Data Management*

Nowadays, big data has become a marketing term when advertising cloud services or data mining tools; however, “big data” is used to describe a huge amount of data that is growing extensively and available for usage, i.e., data analysing and retrieval. As the data increases, the computational complexity of storing and calculating data will also increase and may decrease the performance of the cloud if the institution completely moves to the cloud because using cloud computing, all storage and processing may happen on the cloud side. The institutions of business sectors have connected the cloud through the internet. So, the performance depends on how good your communication channel is. Poor internet connection tends to poor performance.

### *6.2. Risk Analysis*

Since the emergence of cloud computing, cloud service providers strive to put their utmost security services and claim that their services are risk-free for security and privacy. Organizations have less confidence that their data are secure. Using Cloud computing, the organizations outsource their services fully or partially to a third company; thus, the organization must access the cloud service through the internet, where there is a chance of security problems such as degrading malicious attacks. Besides the security, privacy is the most important issue, which makes organizations anxious about the cloud computing that their data may be sold to other third parties because one of the most valuable things of an organization is their customers, so that they may dread breaching about it their customer's personal data. However, there are still open questions such as “is the cloud risk-free?” and recommend that other researchers dig more than the “big data” and risks regarding privacy and security.

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