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Cloud Computing Security Issues and Solutions

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Abstract— Cloud Computing is constantly emerging as a major commercial infrastructure, since it does not require businesses to maintain expensive computing hardware. This not only reduces overall cost of capital, but also eliminates the maintenance costs spent by traditional businesses to keep their computing infrastructure up and running. A prime benefit of this technology is that it gives access to the same set of shared resources to a larger user base that has different user-requirements. It does so by means of virtualization. Hence, cloud computing holds a great deal of significance for businesses and enterprises, whether they are technology-based or consumer based. The paper highlighted several problems and complications that could arise in Cloud computing and cause severe damage to the data security, physical security, logical security and administrative security. The paper explores several problems/issues that could arise in Cloud computing including data security issues, logic security and administrative security issues. The paper evaluates several solutions in the areas of Cloud computing including Cryptography-based solutions, data Partitioning-based solutions, multi-agent based solutions and machine-learning solution. These solutions in Cloud computing ensures data is completely safe and protected from unauthorized access by using Cloud Computing technology for individual use and industrial use.

Key Words—Administrative security, cloud computing, cloud computing security, data security, logical security.

I. INTRODUCTION

Now more than ever, business computing has diversified to a greater extent both in terms of size and scope. Particularly with increasing globalization of businesses, storing, managing and sharing information and other organization-specific resources across the globally spread offices has become a major challenge. Cloud computing, in this dilemma, has turned out to be a major problem solver. What powers Cloud Computing is its 'Cyber infrastructure' alongside years of research and development in the areas of grid, distributed & utility computing and software development services. More recent additions to the Cloud Computing portfolio are networking and web[1] [2].



Cloud computing has become highly convenient and on-demand network access for their users where they can utilize several computing resources with much ease and comfort through minimum managerial efforts. It has become the need of time which provides complete solutions to their users through technology driven platform. It is considered to be highly convenient for hosting services and storage services on the internet and users can share their ideas conveniently using Cloud computing [3]. The main objectives of cloud computing is to ensure that highly inexpensive services are offered to their customers with on-demand computing infrastructures and best quality goods and services. Some companies in the areas of Cloud computing have constantly developed products and services in the areas of cloud computing to successfully process, store and access data in a shared and virtualized environment. In fact, many developers of this latest technology have used cloud-based applications to enhance the security and efficiency of their products and services. It is reality that developers working on different software technologies are unable to ensure safety and security with currently affordable technological capabilities they have[4] [5]. The research paper evaluates that Cloud computing can be successfully used on the large scale to enhance the cost-effectiveness and location independence of their users than other computing frameworks. Clients can conveniently use different resources available on the Cloud by deploying vendors like Google, Amazon, Sales force, Microsoft and Rackspace etc. By using Cloud Computing, users can successfully share resources and on-demand tools depending on their requirements while working in different industries. By applying Cloud Computing, users can enjoy enormous benefits including their convenience of using this technology without buying its resource from outside resources like the third party vendors. They can utilize it and pay for it in their effort to help the customers to save their time and money. Cloud Computing can be successfully used by different users including small and medium size companies and multinational corporations depending on their requirements[6].

The architecture of Cloud computing is based on several components that could interact with each other by using different types of data and helping the user to get an access to data on a faster rate. The Cloud computing technology is much more focused on the development of front end and back end services. The front end indicates the user who can use the data at his wish, whereas backend of the Cloud computing is based on numerous devices of data storage



meeting client needs, depending on the server which makes the Cloud[7]. The Cloud computing technology is based on three important services including the private, public and hybrid Cloud computing. The private Cloud computing is the type of Cloud computing which is owned and managed by single organization while public clouds are those clouds that are owned and managed by large sector organizations. Private Cloud is associated with better control and flexibility that an organization enjoys while using cloud computing to meet their specific business needs. On the other hand, public Cloud is more frequently used by large industries. The basic advantage of using Cloud computing is that it is very appealing to their users and it could facilitate their needs more genuinely. But, the paper evaluates that Cloud computing is associated with several security issues that need to be addressed properly. Without doing so, companies can lost their confidential business data and suffer huge loss at the hands of their customers. The paper explores the problems that are associated with safety and security issues of the Cloud computing for small & medium enterprises and large level multinational organizations. Cloud computing could face several issues like privacy issues of their data, privacy, data infection issues and security issues. The paper elaborates how effectively these security risks and problems can be reduced and organizations can succeed in meeting their desired objectives[8].

II. CATEGORIZATION OF CLOUD COMPUTING TECHNOLOGY

There are different types of Cloud computing that needs to be properly identified before exploring the advantages and disadvantages of the Cloud computing services. Different categories of Cloud computing are:

A. *The Public Sector related Cloud Computing*

It indicates the Cloud computing that anyone can use and get an access by using the internet connection at their home or office. It can also be accessed by using the credit card without making any subscription. These are considered to be virtualized infrastructures that can be used by several internet users, easily accessible and managed considering self-services portal.

B. *The Private Sector used Cloud Computing*

The private Cloud computing network is based on the infrastructure that can be managed and controlled on a private network. Unlike public Cloud computing, the private Cloud computing can be owned and managed on private basis and their access can be limited to only a single business to whom it belongs in the private sector organizations. The private Cloud computing is considered to be



quite safe in terms of stability, security, privacy and data persistence for their users.

C. The Mixed Cloud Computing

The mixed type of Cloud computing is also known as Hybrid Cloud computing and it can be effectively used and managed by same company. It could be either private cloud computing or public sector cloud computing.

D. The Community Cloud

The community based Cloud computing is specifically dedicated to the community that includes partners, sub-partners or contractors and can be used on collective basis or by the institutions of government Cloud computing.

III. ADVANTAGES & DISADVANTAGES OF CLOUD COMPUTING TECHNOLOGY

A. Advantages

Cloud computing is considered to be highly effective and useful for public and private sector organizations. There is possibility that they can be accessed by extending the information system of an enterprise that can be obtained on the request of the latter considering their intended use. Cloud computing is very useful because it provides services that can be extended from one place to another place. A company operating in the public sector or private sector can benefit from Cloud computing because it could enhance the capability and capacity of the organization to process desired information, infrastructure, capacity of storing the information and storing the computer applications[12].

B. Disadvantages

Along with advantages, Cloud computing is also associated with some disadvantages. Cloud computing provides greater promises of the future, but in fact it could not assure of future achievements of the organizations adopting this system to share their business information on daily basis[13]. Many people or companies don't like Cloud computing because it could trap them without providing effective solutions to their business problems. Cloud computing is often considered to be insecure and un-safe for their users. The security of Cloud computing applications can never be guaranteed and it is one of the major disadvantages of the system. Broadly speaking, Cloud computing often leads to their users with less control over the lifecycle of the applications. It can be operational through this technological development in the areas of Cloud computing technology to be used in public and private sector organizations more conveniently [14].



IV. CLOUD COMPUTING SECURITY ISSUES

Public and private sector organizations can suffer from Cloud computing issues due to increased utilization of this technology to store and exchange confidential business data. Hackers or large numbers of attackers can hack and steal information regarding Cloud computing on new technologies and cause severe damage to the reputation of public or private sector organizations using Cloud computing as their most preferred technology. Among these potential challenges, the organizations using Cloud computing can also face security issues due to increased industrial and commercial utilization of this new technology. The main concern of these companies was the concern of security of their database and needed to be properly addressed to improve their trust and satisfaction [15].

A. Data Security Issues in Cloud

Individuals and organizations can also observe data security issues when they share confidential business data to their colleagues, friends and others using Cloud Computing. Major security problems in Cloud computing can be classified and represented in four major areas of concern including security of data, logical security, physical security and the security of administrative basis of the organizations operating in different industries. The security concerns presented in the areas of data security should be addressed properly to ensure data stored, shared and exchanged is completely safer to use. It would also be helpful to keep data away from hackers and unauthorized data users in today's business world.

1. Problems of Data Security in Cloud

Several studies have shown the problems of data security in Cloud computing and risks that could threaten the security of datasets stored in the Cloud. Security can play an important role in the areas of Cloud computing and assuring datasets are properly protected by adopting effective security measures. Kuyoro, Ibikunle & Awodele [4] identified some of the major problems that need to be addressed in the security of data storage on the hard disk of other person. It could cause huge damage to the security of data, loss of data and the problems of privacy associated with datasets utilized in different organizations. They would be helpful in offering free or cheaper prices to fulfill their attacks. Other researchers also explored that the utilization of Cloud computing is often associated with security threats. Planning is considered to be highly important to reduce such losses and to ensure protection of



complicated business data from hackers and illegal data users. Company data often include the data of their customers, their business data, products and services data and confidential data that need to be protected and secured carefully. The protection of data and datasets are mainly referred to as the integrity, confidentiality and availability of the data at the time of need. They also determine the problems that the organizations can face in the areas of getting an access by their users, the transmission and the location of data that can be secured by using IP Security, Secure Socket Layer and other possible security arrangements to ensure that the data is properly protected from illegal use.

Different researchers also explored that data security has become the major issue for organizations utilizing Cloud computing for storage of data. Padia & Parekh [6] and Parakh & Kak [7] identified that organizations can face several security threats in the areas of Cloud computing and these concerns need to be properly addressed in the recent years. The major problem of data security is the unauthorized access to data without the consent of the organization or the person responsible for running the data. The data sets are expanded across different systems of the organization and these datasets can be simple and less complicated for most of the users. Under such conditions, there is possibility that such datasets can be attacked by hackers and illegal data users. If the data is stolen or data security is breached, it could damage the reputation of the person or the organization utilizing data sets for their personal or organizational use. The researchers in the areas of data security also suggested that organizations can adopt traditional data security approaches whose data is stored in a single server and can be accessed by using the password associated with that data. When the data is spread across different systems of the organization, it becomes easier for illegal data users can get an access to the data and breach the security of the datasets for the organization.

Subashini & Kavitha [17] explored how data security has become an issue for fast growing business organizations in the areas of multi-tenancy. The intrusion can be exercised either by hacking the data from the company datasets or by loopholes that exist in the application of databases. It can be stolen by hackers by adding the client code into the SaaS system and the execution of code without giving importance to the verification of data can cause huge potential loss to the organization.



2. Problems of Logical Security

Individuals as well as organizations can face logical security issues and need to be resolved to effectively store, share and exchange highly confidential business data. Their management needs to be proactive to reduce the issues and to make sure the problems can be properly addressed. Different researchers like Subashini & Kavitha [10] identified that virtualization are considered to be one of the major components of Cloud computing that need to be addressed properly. It could cause major security risks in the utilization of Cloud computing when different instances are operated on the similar physical machine and isolated from each other considering the task of virtualization. The other issue associated with logic security is the administration concerns of major tasks virtualization which is needed to be properly addressed in the daytime scenarios. Some vulnerability can be found in the areas of virtualizing the software that can be exploited by local users or malicious control of the systems. It becomes highly risky when the local users bypass some certain security measures or gain privilege.

Baniah & Brohi [12] identified different types of virtual machines that can be used by the Cloud computing users to have a control on the virtual memory as well as on the central processing units of the operational computing machines. It is considered to be the major source of managing the virtualized Cloud computing systems and hackers can target them to get an access to these virtual machines and the physical hardware associated with these computing machines. Prevention systems and intrusion of Cloud can be reduced by adopting an effective detection and prevention system that the organizations can adopt to detect malicious activities at different levels of virtual machines.

3. Problem Administrative Security

The problem administrative security determines how administrative problems in all cases can play an important role in determining the type of provider and type of account to be used. Padia & Parekh [6] explored how duplication of web pages can be used to entice users by giving them financial particulars or the passwords.

B. Existing Solutions to Protect Cloud Computing

After evaluating the security risks and problems that are associated with Cloud computing, the paper explores the solutions to protect this technology from



possible hacking or illegal utilization of data. The Cloud computing solutions are often based on several techniques that need to be properly addressed including the following points:

1. Cryptography based Solution

Organizations can adopt cryptography based solutions in the areas of utilizing Cloud computing. Different researchers have suggested that Cloud computing is often based on computing environment which is built on trustworthiness and secure utilization of data and application in the areas of Cloud computing services. In the proposed network, three distinct networks can be used as the backup sites for protecting the data. The backup sites are successfully located on the remote server locations and if one path of the remote location fails, the alternative path starts working. The encrypted files can be used as the backup sites where data can be compressed and decrypted during the recovery operations model.

2. Data Partitioning based Solutions

The data portioning-based solution is considered to be a traditional approach to secure the data to successfully store it and back it up to the single server. It would allow the users to have an access to the secure data by applying a password which is needed to be changed on frequent basis to ensure safety and security of the portioned data. The researchers, Parakh & Kak [7] found that there is tendency among data users that they keep the password memorable to overcome the possibilities of brute attacks on the data sources. Karkouda et al. [8] also proposed that portioning-based solution is considered to be highly effective and useful to protect data used in warehouses. It is helpful to limit the Cloud computing risks and ensure that the data used is complexly safer for their users. It would provide complete confidentiality and availability of data without any interruptions and users can successfully store, share and exchange data with others through the sharing secret algorithms. These algorithms share the data without any possibility of data loss or data theft from illegal data users. The data shared and exchanged in this way can never be exploited and understandable by a malicious user in case of the intrusion and not depends on the one provider.



3. Multi-Agent System Solutions

Multi-agent system is another possible solution for Cloud computing security issues and it allows their users to build a secure Cloud computing platform to facilitate Cloud data storage. The architecture can be specifically used as the autonomous agent to specifically secure services and allow their agents to interact and to facilitate security of their Cloud data storage. The researcher also described the approach that users can adopt in their effort to build a secure Cloud computing platform[17]. The main objective is to ensure the security of the data usage through proposed framework that could be used in two layers to protect the data storage and the functionality of these layers can be summarized as given below:

These two layers include agent layer and Cloud data storage layer. In agent layer, one agent has been used known as User Interface Agent and he is responsible to effectively bridge the gap between the user and the rest of the agents. The second layer is the Cloud data storage layer and it is associated with two different network entities including the Cloud user who stores the data in the Cloud and the Cloud security platform which is associated with significant resource expertise to successfully build and manage distributed Cloud data storage servers and operates successfully on Cloud computing systems[18].

4. Machine Learning Solutions

Machine learning solution is another possible solution of the Cloud computing systems and it could be helpful in meeting the challenge of intrusion severity analysis. This analysis is considered to be highly effective and useful and ensures the overall safety and security of Clouds. It is associated with a novel method to ensure the safety and security of data in accordance with specific requirements of Clouds considering the importance of intrusion severity analysis[19]. The proposed solution is used to solve the severity problems that the Cloud computing networks can face and treats the problems according to their specifications. Furthermore, the machine based solution or learning technique can be effectively used to perform the classification of data. In this frame, unsupervised technique can be used as the most effective learning technique that could be suitable to offline classifications and tend to



show the variation over the data set analysis length[20].

Through an integration of these components, Cloud Computing promises low technology overheads for businesses, increased flexibility, provision of service oriented architecture, on-demand services, low ownership costs and several other perks (Vouk). Thus, by incorporating Cloud Computing, businesses become capable of ensuring readiness of information / resource availability across various locations without the need for maintaining expensive hardware and servers on each of those locations (Iosup et al). This is elicited in the figure below;

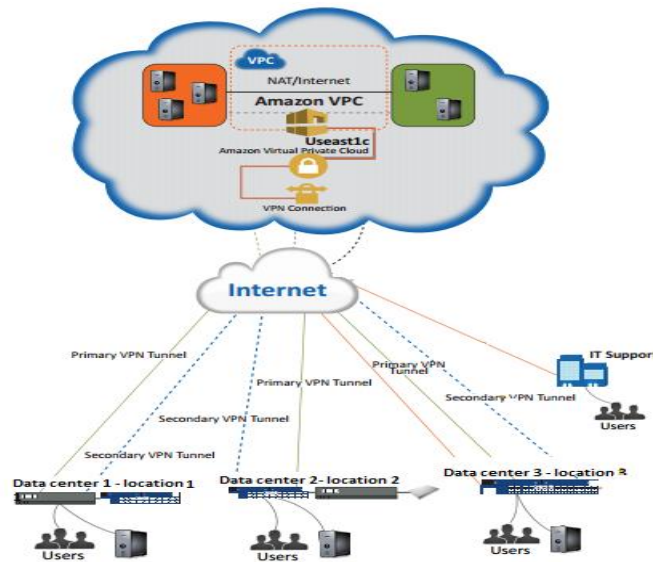


Figure 1: Cloud Computing Technology with multiple Users[13]

In the above image, it can be seen that through cloud computing hosted by Amazon Virtual Private Cloud, a company is enabled to share its resources across three data centers on different geographic locations

V. ANALYSIS AND DISCUSSION

Core components of Cloud Computing architecture include the following;

- The End-User: This is often the client organization who appoints cloud computing services. The end-user utilizes hardware, application and all the other attributes of cloud computing.
- The Service: Adoption of cloud computing for businesses is usually centered on improving business processes.
- The Application: The cloud computing application is developed by a



developer through coding, and is the component through which the service is realized.

Additionally, core components of cloud computing include the platform, the storage and the infrastructure (Exforsys, Inc). The concept of cloud computing is not as simple as its title, and involves rather complex attributes. In essence, the cloud computing platform is not universal across every business / organization, and varies depending on the need and technical requirements. For this purpose, cloud computing includes a total of eleven patterns or categories which are highlighted in the hierarchical presentation of the figure below;

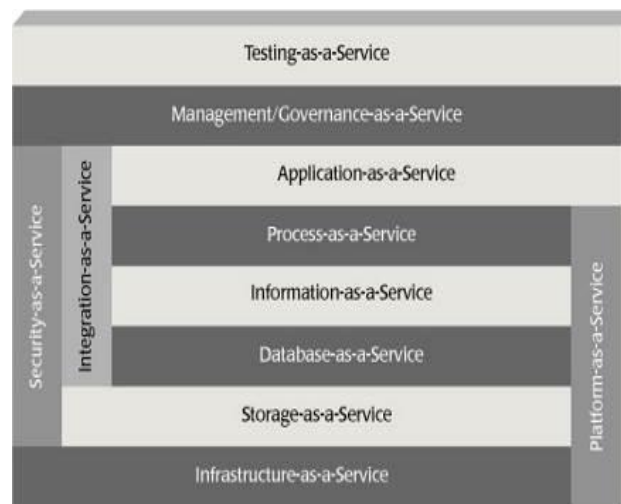


Figure 2: Cloud Computing Security-as-a-Service[8]

While explaining each of these 11 categories of cloud computing is not possible in this paper due to certain restraints, it is clear that each of these categories serve a specific purpose. Each of these 11 categories provides businesses with myriads of compelling business opportunities. Some of these opportunities have been listed below;

1. Ability to reap the benefits of the 'Connected Experience' across suppliers, customers, partners and employees.
2. Opportunities to reduce time to market and maximize customer / stakeholder engagement by interactive ways.



3. Opportunities to boost operational efficiencies by ensuring prompt sharing of resources across departments, branches and plants. For instance, major companies have boosted their sales force efficiency by virtue of the cloud.
4. Ensure substantial cost-savings by eliminating the need for maintenance and ownership of hardware, giving companies the opportunity to utilize the savings more effectively for developmental purposes[19].

A. How Cloud Computing Security can be ensured

By using the cloud computing security risks should be ensured in the enterprises. To proceed with cloud computing some concerns related to security must be considered by the enterprises:

1. Enterprise should make sure the understanding of the overall structure that affects the security issues of receiving and sending data within the enterprise.
2. Transparency of required information by the providers should be what he/she demands in the enterprise using same architecture. To insure that issue an audit from a federal agency must be conducted on regular bases.
3. To insure the internal security of enterprise, that what technology is used, how client computer are equipped with security software like firewalls.

B. Cloud Computing Security Issues & Possible Solutions

- First solution of Cloud computing is to find the right Cloud provider to overcome possible security threats. Different vendors have different Cloud security arrangement and need to be selected very carefully by determining their experience, standards and regulations.
- In order to avoid Cloud security issues, the users must have a clear contract with their Cloud services provider. Under such conditions, if the vendor closes before the end of contract, the user can claim any security breach issues.
- The users must ensure that the Cloud computing service provider has good recovery facilities available with them. If data is lost due to fragmentation or other issues, the user can claim recovery and continuity of data[21].
- The user must ensure that the vendor has better enterprise infrastructure which provides complete facilitation of installing and configuring hardware components like proxy servers, firewalls, and software like operating system and thin clients etc.



- Another possible solution would be the best use of data encryption technique to ensure the security of data from possible hackers and illegal data users. Under such conditions, additional security from the enterprise would not be required as all the security burdens will be placed on the Cloud vendors[22].

VI. SECURITY ISSUES

Nonetheless, cloud computing also encompasses several challenges when it comes to its use by businesses. The first and foremost challenge of cloud computing is data security and privacy. With the constantly increasing number of cybercrimes, business vulnerability to data-theft and confidentiality breach has also increased as more companies are adapting the cloud for business process optimization. A second major challenge of the cloud is that it gives access to all employees – good or bad – which mean ex-employees who did not leave on a good note may exploit business information. Another key challenge facing the cloud is insufficient responsiveness over network, a problem experienced more frequently by companies today. Many companies have reported the inadequacy of SLAs provided by cloud service providers, which is a major challenge (IBM). Finally, cloud computing troubles businesses – especially IT companies – when it comes to integration of applications. For instance, enterprise applications and data structures of many companies are complex, and thus give a hard time integrating with the cloud (IBM).

VII. CONCLUSION

In this paper, we have observed an overview of the Cloud computing and determined how it has become useful for individuals and institutions in the recent world. It can be more effectively used for storing, sharing and exchange of data among individual users and institutional users. But, Cloud computing is always associated with some security problems and they need to be properly addressed. The paper explored that there are several data security threats that are associated with Cloud computing. These security threats need to be properly addressed and it can only be achieved by creating the trust between the user and the service provider. The paper explored that it could be helpful to protect the data storage and data sharing through Cloud computing from unauthorized access, data loss and poor utilization of data from the service providers by the Cloud and protection from different hardware hacker attacks and intrusion.



The paper explored how Cloud computing technology can be made more secure through proposed security solutions that are based on cryptography and other possible ways in the areas of Cloud computing security for their users. The Cloud has several security problems and anyone can exploit the use of Cloud computing into unauthorized hands in the forms of access to data, theft to data and intrusion to data. The paper proposed some necessary and effective solutions including cryptography-based solution, data portioning solution, multi-agent and machine learning solution that users and institutions can adopt to overcome possible data security threats. The paper proposed these solutions to the control the user in getting an access to the data sources and storing it in Cloud network by using two of the most important security policy roles that are based on access control and multilevel. The paper also proposed a framework as the solution that could incorporate between the client and the Cloud which is a shared network into three important parts including the Cloud and client control framework.

The paper also identified layer control system the at the users of Cloud computing can adopt through RBAC model to share data according to their roles whose role is so abstract that it is associated in privileges and set rights to their duties to achieve their desired results. Multi-layer policy is associated with the role of each stage that can be adopted to provide complete security through confidentiality and integrity of data storage in the Cloud to protect it from unauthorized access of data. The paper explored that Cloud computing has become no less than a blessing to the contemporary corporate world. Its evolution has assisted business not only in minimizing costs of ownership and overheads, but also in boosting operational efficiency by allowing individual access to shared organizational resources on need basis. Although challenges of privacy, security and network responsiveness are significant, yet the benefits associated with cloud computing outweigh the challenges, making it a viable approach for business process optimization.

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