# Cloud Computing Technology; a Secured and Cost Effective Data Storage System

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***Abstract*** **- Cloud computing has become the top thing in the mind of fast growing industries especially those that consider dealing with big data and providing highly reliable and fast data backup and recovery. Cloud computing is a concept where a computing service is provided to the user from a hosted site on demand through the internet. This paper investigated the cloud computing, its service and deployment models. Industrial activities in the cloud were also examined in order to understand the growth and occurrence of these activities which were attributed to the Data-storage-as-a-Service (DaaS) capability of the cloud. The results show that banking recorded the highest with 64% while social media recorded second with 58%, online games recorded third with 45%, photos recorded forth with 29% and file sharing recorded lowest with 19% occurrence in the industrial cloud activities. Comparing the overall cloud users to non-cloud users, the average length of downtime per disaster recovery event was 8 hours for non-cloud users, and 2.1 hours by cloud user standards (nearly four times faster). It was therefore concluded that the cloud can provide a reliable and faster disaster/data recovery storage system for every industrial activities using the cloud. Hence, it was recommended that the government agencies, academic institutions and other establishments such as the small and medium enterprises, especially in the developing nations should focus their attention towards deploying their services in the cloud to secure their services with cheaper cost, higher reliability and availability.**

***Keywords - Cloud Computing; Cloud Services; DaaS; Data Storage; IaaS; PaaS; SaaS***

## I. INTRODUCTION

When an individual or firm store photos online instead of on home computer, or use webmail or a social networking site that person or establishment is using a cloud computing service. If an organization uses an online invoicing service instead of updating the in-house one that organization have been using for many years, that online invoicing service is a cloud computing service. Hence, today individuals, private, public and government owned establishments are knowingly or otherwise resorting to cloud computing technology for a better and more secured storage of data.

Cloud computing is a term used to describe the Internet as a method of delivering information, software and other services i.e. keeping computing resources on-line rather than on-site, such as software and storage [1]. Cloud computing is a computing technique that enables the delivery of computing services over the Internet. Cloud services allow individuals and businesses to use software and hardware that are managed by third parties at remote locations. Examples of cloud services include online file storage, social networking sites, webmail, and online business applications. The cloud computing model allows access to information and computer resources from anywhere that a network connection is available. Cloud computing provides a shared pool of resources, including data storage space, networks, computer processing power, and specialized corporate and user applications [2]. Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models [3]. In general, the concept of cloud computing incorporate web infrastructure, Web 2.0, virtualization technologies and other emerging technologies. With the cloud computing technology, users use a variety of devices, including PCs, laptops, smart phones, and PDAs to access programs, storage, and application-services offered by cloud computing providers. Advantages of the cloud computing technology include cost savings, high availability, and easy scalability [4].

In recent times, data security has become a major issue in most establishments and government agencies, private companies etc. especially in most developing nations where millions of naira has been lost due to account information misappropriation as a result of data insecurity. The wired and wireless networks used in most establishments have been functional in terms of availability in providing networking services. However, the security issues recorded as a result of unauthorized connections into the physical network by hackers, and the continuous attack to the files by computer malware of different kinds have contributed to the reduced trust most people have on their physical storage systems. The cost of providing good security to the physical computer network is very high due to the high cost of anti-virus programs and their continuous updates, regular scanning and servicing of the network

components against intruder software. Furthermore, due to the incessant failure of power supply in the offices which has prevailed in most developing nations, huge amount of official data have been lost, damaged or compromised as a result of improper shut down of the physical computer systems. Therefore the option of relying on the physical computing services has also been reduced drastically. The possibility of physical system breakdown must be considered as an issue in the data/services security.

Cloud computing is an emerging computer paradigm where data and services reside in massively scalable data centers in the cloud and can be accessed from any connected devices over the internet [5]. The main objective of cloud computing is to provide Information and Computer Technology (ICT) secured data/services over the cloud. The service models provided by the Cloud are as follows: Software-as-a-Service (SaaS) model, which allows users to run applications remotely from the cloud. Infrastructure-as-a-service (IaaS) model refers to computing resources as a service. This includes virtualized computers with guaranteed processing power and reserved bandwidth for storage and Internet access. Platform-as-a-Service (PaaS) is similar to IaaS, but also includes operating systems and required services for a particular application. The Data storage-as-a-Service (DaaS) provides storage that the consumer is used including bandwidth requirements for the storage.

## II. REVIEW OF LITERATURE

Information and Communication Technology has brought about technological revolution globally. All over the world, individuals, enterprises and countries are beginning to compete and fight over control of information rather than natural resources. Nowadays, it appears easier and more reliable to save information in the soft-copies rather than on physical items which were usually placed and preserved in shelves, on tables, in the banks etc. Saving information in electronic soft forms provides a faster means of retrieving the information and also makes it more portable to convey huge amount of data. In recent times, it has been all about e-platform, this implies offering financial services through electronic media to various customers irrespective of place, time and distance. In response to the demands for quick, efficient and reliable services, players in the banking industries are increasingly deploying technology as a means of generating insights into customers' behavioral patterns and preferences [6]. Well developed outsourcing support functions (technology and operations) are increasingly being used to provide services and manage costs e.g. Automated Teller Machine networks, Cards processing, Bill presentment and Payments, Software Development, Call centre operations and Network management [7] and the proposed cashless banking in Nigeria. According to Ankrah [8], contemporary technology in banking comes in the form of computer based application and information technology.

According to Tunmibi and Falayi [7], despite the positive impact of technology on society, it has on the other hand led to unintended use in criminal activities like cybercrime. It has therefore become easier to steal a penny from millions of bank account owners using the internet than through conventional bank robbery [9]. Hence, the risk of hackers, denial of service attacks, technological failures, breach of privacy of customer information and opportunities for fraud created by the anonymity of the parties to electronic transactions have become IT security issues.

*Related Works*

Udhayakumar et al [10] carried out a survey on cloud computing. According to them Cloud computing is a concept where a service is provided to the user from a hosted site on demand. Here the word 'cloud' is used as a metaphor to denote internet which we represent as cloud drawings. Cloud computing customers do not own the physical infrastructure. Therefore reducing the capital expenditure incurred in receiving the services provided. Here the resource provided by the host is considered as a service. The customers shall pay only for the resource they have used. These therefore make the cloud computing economically viable. Cloud computing technology has been used in many areas to improve ICT infrastructural services and many proposals are still coming up to utilize the potentials of the technology. Trong et al [11] worked on the optimization and evaluation of a multimedia streaming service on hybrid Telco cloud where they characterize a class of competitive cloud services that telecom operators could provide based on the characteristics of telecom infrastructure through applicable streaming service architecture. In their work, they compared different deployment strategies for cloud computing services. Tin and Thinn [4] developed a PC-Cluster Based Storage System Architecture for Cloud Storage. They suggested that Cloud Computing is an emerging computing platform and service mode, which organize and schedule service based on the Internet.

**Characteristics of Cloud Computing**

The characteristics of cloud computing include on-demand self service, broad network access, resource pooling, rapid elasticity and measured service.

**On-demand self Service:** On-demand self service means that customers (usually organizations) can request and manage their own computing resources.

**Broad network access:** Broad network access allows services to be offered over the Internet or private networks.

**Pooled resources means:** Pooled resources means, that customers draw information from a pool of computing resources, usually in remote data centers. **Measured Service:** Cloud service can be scaled larger or smaller; and the use of a service is measured and customers are billed accordingly

**Cloud Computing Service Delivery Models**

In practice, cloud service providers tend to offer services that can be grouped into three categories: software as a service, platform as a service, and infrastructure as a service. These categories group together the various layers. The cloud computing service models are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS).

**Software as a Service (SaaS):**

In Software as a Service model, a pre-made application, along with any required software, operating system, hardware, and network are provided. Software as a service features a complete application offered as a service on demand. In this SaaS model, cloud providers install and operate application software in the cloud and cloud users access the software from cloud clients [12]. A single instance of the software runs on the cloud and services multiple end users or client organizations. Some widely known example of SaaS is salesforce.com, and Google Apps which offers basic business services including email and word processing.

**Platform as a Service (PaaS):**

In PaaS, an operating system, hardware, and network are provided, and the customer installs or develops its own software and applications. Platform as a service encapsulates a layer of software and provides it as a service that can be used to build higher-level services. PaaS offerings can provide for every phase of software development and testing, or they can be specialized around a particular area such as content management. Some commercial examples of PaaS include the Google Apps Engine, which serves applications on Google's infrastructure. PaaS services such as these can provide a powerful basis on which to deploy applications, but they may be constrained by the capabilities that the cloud provider chooses to deliver. Application developers can develop and run their software solutions on a cloud platform without the cost and complexity of buying and managing the underlying hardware and software layers. With some PaaS offers, the underlying computer and storage resources scale automatically to match application demand so that the cloud user does not have to allocate resources manually. The latter has also been proposed by an architecture aiming to facilitate real-time in cloud environments [13].

**Infrastructure as a Service (IaaS):**

In the most basic cloud-service model, providers of IaaS offer computers - physical or (more often) virtual machines - and other resources. (A hypervisor, such as Xen or KVM, runs the virtual machines as guests. The IaaS model provides just the hardware and network; the customer installs or develops its own operating systems, software and applications. Infrastructure as a service delivers basic storage and compute capabilities as standardized services over the network. Servers, storage systems, switches, routers, and other systems are pooled and made available to handle workloads that range from application components to high-performance computing applications. Commercial examples of IaaS include Joyent, whose main product is a line of virtualized servers that provide a highly available on-demand infrastructure. IaaS clouds often offer additional resources such as a virtual-machine disk image library, raw (block) and file-based storage, firewalls, load balancers, IP addresses, virtual local area networks (VLANs), and software bundles [14].

**Network as a Service**

A category of cloud services where the capability provided to the cloud service user is to use network/transport connectivity services and/or inter-cloud network connectivity services [15]. NaaS involves the optimization of resource allocations by considering network and computing resources as a unified whole [16]. Traditional NaaS services include flexible and extended VPN, and bandwidth on demand [15]. NaaS concept materialization also includes the provision of a virtual network service by the owners of the network infrastructure to a third party (VNP – VNO) [17].

**Cloud Client Access**

Cloud clients or users access cloud computing using networked client devices, such as desktop computers, laptops, tablets and smartphones etc. Some of these devices used by cloud clients rely on cloud computing for all or a majority of their applications so as to be essentially useless without it. Examples are thin clients and the browser-based Chromebook. Many cloud applications do not require specific software on the client and instead use a web browser to interact with the cloud application for their services. With Ajax and HTML5 these Web user interfaces can achieve a similar, or even better, look and feel to native applications. Some cloud applications, however, support specific client software dedicated to these applications (e.g., virtual desktop clients and most email clients). Some legacy applications (line of business applications that until now have been prevalent in thin client computing) are delivered via a screen-sharing technology [12].

## III. CLOUD COMPUTING DEPLOYMENT MODELS

There are many considerations for cloud computing architects when moving from a standard enterprise application deployment model to one based on cloud computing. The considerations are mostly based on the level of privacy required to be achieved in the data storage and application preservations. There are public and private clouds that offer complementary benefits and there are three basic service models to consider in the implementation of cloud computing. Establishments and IT organizations can choose to deploy applications on public, private, or hybrid clouds, each of which has its trade-offs. The terms *public*, *private*, and *hybrid* do not dictate location of data or services. But they can denote the level of security or privacy or authenticity needed. While public clouds are typically "out there" on the Internet

which could be hosted in the service provider's premises elsewhere, private clouds are typically located on premises, and a private cloud might be hosted at a colocation facility as well.

**Public clouds**

A cloud is called a 'Public cloud' when the services are rendered over a network that is open for public use [12]. Public clouds (figure 1) are most often hosted away from customer premises but mostly in the premises of the cloud service provider and they provide a way to reduce customer risk and cost by providing a flexible, even temporary extension to enterprise infrastructure. If a public cloud is implemented with performance, security, and data locality in mind, the existence of other applications running in the cloud should be transparent to both cloud architects and end users. Indeed, one of the benefits of public clouds is that they can be much larger than a company's private cloud might be, offering the ability to scale up and down on demand, and shifting infrastructure risks from the enterprise to the cloud provider, if even just temporarily. Also, the third party has the responsibility to secure the data and applications of their clients thereby cutting down the security cost for the clients. Generally, public cloud service providers like Amazon AWS, Microsoft and Google own and operate the infrastructure and offer access only via Internet (direct connectivity is not offered) [18].

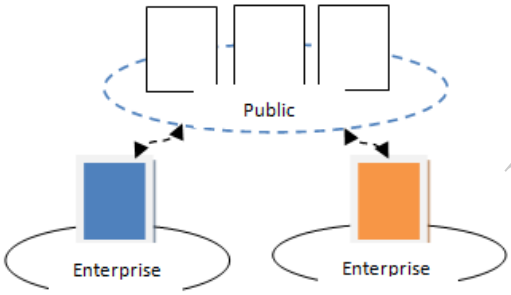


Figure 1: A public cloud provides services to multiple customers.

**Community Cloud**

Community cloud shares infrastructure between several organizations or individuals from a specific community with common concerns (security, compliance, jurisdiction, etc.), whether managed internally or by a third-party and hosted internally or externally. The costs are spread over fewer users than a public cloud (but more than a private cloud), so only some of the cost savings potential of cloud computing are realized [19].

**Private clouds**

Private cloud is cloud infrastructure operated solely for a single organization, whether managed internally or by a third-party and hosted internally or externally [19]. Private clouds are designed and built for the restricted use of one client only, providing the supreme control over data, security, and quality of service as illustrated in figure 2. The company or establishment owns the cloud infrastructure and has control over how applications and services are deployed and managed on it. Private clouds may be deployed in an enterprise datacenter, and they also may be deployed at a colocation facility. Private clouds can be built and managed by a company's own IT organization or by a cloud provider. In this "hosted private" model, a company such as Sun can install, configure, and operate the infrastructure to support a private cloud within a company's enterprise datacenter. This model gives companies a high level of control over the use of cloud resources while bringing in the expertise needed to establish and operate the environment.

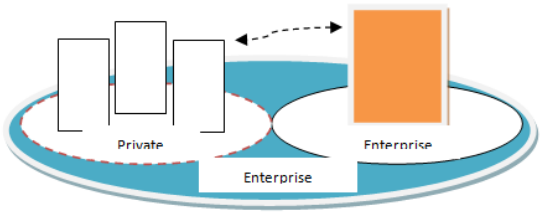


Figure 2: Private clouds located at the enterprise premises

**Hybrid clouds**

Hybrid cloud is a composition of two or more clouds (private, community or public) that remain unique entities but are bound together, offering the benefits of multiple deployment models [19]. An enterprise can consider deploying hybrid cloud depending on the objectives of the management towards the data or applications to be housed in the cloud. Hybrid clouds combine both public and private cloud models as illustrated in figure 3. The clouds can help to provide on-demand, externally provisioned scale. The ability to augment the capacity of a private cloud with the resources of a public cloud can be used to maintain service levels in the face of rapid workload fluctuations. This is most often seen with the use of storage clouds to support Web 2.0 applications. A hybrid cloud also can be used to handle planned workload spikes. Sometimes called "surge computing," a public cloud can be used to perform periodic tasks that can be deployed easily on a public cloud.

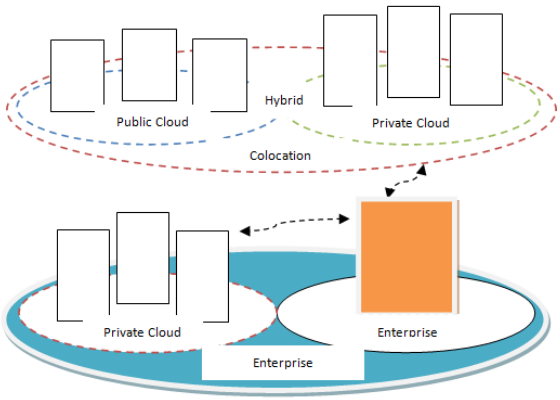


Figure 3: Hybrid clouds combine both public and private cloud models

**Access Authorizations, Authentication Methods, and Identity Management**

Cloud services are typically based on the concept of a high level of accessibly to the service and stored information from any physical location. The identity management, access authorization, and authentication mechanisms used

by the cloud service must enforce appropriate protections and utilize government approved cryptographic mechanisms. The identity management and access authorization functions of a cloud service may either be managed directly by the cloud provider or delegated to one or more individuals from the customer organization that are given special access rights. If management is retained by the service provider, a robust mechanism for remotely validating the identity of individuals presenting themselves as from the customer organization must be in place to prevent successful social engineering attacks. This same structure must be in place for the authorized customer account managers if delegated to the customer [20].

Authentication mechanisms must be separately evaluated from standard service functions to ensure compliance with Federal Information Processing Standard (FIPS) in the handling and transmission of user credentials, as well as the storage of user data within the account database. Information within the account database of the service provider beyond the user credentials may constitute sensitive information as user data may provide all the information necessary to execute a spear-phishing attack on key individuals. Some cloud services may publish user data in formats or within the web service to enhance user search features, but may use mechanisms that are accessible by non-organizational users.

Cloud services may provide a limited ability to audit the roles and permissions assigned to all accounts within the customer's portion of the cloud service. The service providers will typically not provide customers with information regarding administrative roles held by the service provider or third party service providers responsible for some elements of the cloud service. Audit record retention, content, and availability may be limited with cloud services. Cloud service providers may not be able to enforce particular password rules or lifespan. The combination of username and password alone is generally insufficient protection of sensitive information that is accessible from anywhere on the World Wide Web. Additional protections in the form of Internet Protocol address restrictions or multi-factor authentication mechanisms may not be available from many cloud service providers.

**Cloud Data Storage**

Among other advances, cloud computing has brought advantages in the form of online storage [21]. This type of cloud service is referred to as Storage-as-a-Service or Data Storage as a Service (DaaS). The range of service offerings in this space is remarkable, and they continue to grow. Storage as a Service is a business model in which a large company rents space in their storage infrastructure to a smaller company or individual. In the enterprise, DaaS vendors are targeting secondary storage applications by promoting DaaS as a convenient way to manage backups. The key advantage to DaaS in the enterprise is in cost savings, in personnel, in hardware and in physical storage space. For instance, instead of maintaining a large tape library and arranging to vault (store) tapes offsite, a network administrator that used DaaS for backups could specify what data on the network should be backed up and how often it should be backed up. A company would sign a service level agreement (SLA) whereby the DaaS provider agreed to rent storage space on a cost-per-gigabyte-stored and cost-per-data-transfer basis and the company's data would be automatically transferred at the specified time over the storage provider's proprietary wide area network (WAN) or the Internet. If the company's data ever became corrupt or got lost, the network administrator could contact the DaaS provider and request a copy of the data. Storage as a Service is generally seen as a good alternative for a small or mid-sized business that lacks the capital budget and/or technical personnel to implement and maintain their own storage infrastructure. DaaS is also being promoted as a way for all businesses to mitigate risks in disaster recovery, provide long-term retention for records and enhance both business continuity and availability [22].

Data security for such a cloud service encompasses several aspects including secure channels, access controls, and encryption. When the security of data in a cloud is considered, the security triad must consider: confidentiality, integrity, and availability. In the cloud storage model, data is stored on multiple virtualized servers. Physically the resources will span multiple servers and can even span storage sites. Among the additional benefits of such generally low-cost services are the storage maintenance tasks (such as backup, replication, and disaster recovery), which the CSP performs. The most notable provider in this space is Amazon with its S3 (Simple Storage Service). A common aspect of many cloud-based storage offerings is the reliability and availability of the service. Figure 4 depicts an abstracted view of how many individual disks in many aggregated storage devices are composed into a virtualized unit of storage [21].

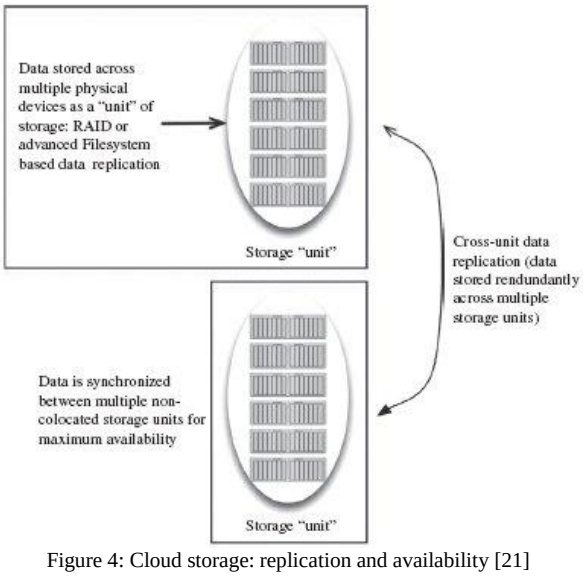


Figure 4: Cloud storage: replication and availability [21]

Cloud storage solutions may allow end-to-end encryption using user held cryptographic keys. This may preclude any portion of the stored files, with the exception of document titles and possibly document metadata to be fully secure at any resource layer. However, this would preclude the use of some services such as virus detection and potentially complicate disaster recovery. Some cloud storage options may allow for end-to-end data encryption, but maintain backup copies of the encryption key to perform some system operations and data recovery at client request. In that case, the key escrow or storage mechanisms may require evaluation if that function is selected for use.

## IV. RESULTS AND DISCUSSIONS OF ACTIVITIES IN THE CLOUD

This investigates the statistics of major activities in the cloud. In this work, the major activities considered are banking, social media, photos, online gaming, and file sharing. The result in figure 5 shows that banking recorded the highest with 64% occurrence in the cloud activities while social media recorded second with 58%, online gaming recorded third with 45%, photos recorded forth with 29% and file sharing recorded lowest with 19%. With remarkable growth observed in the social media, people would think that it will record the highest in the activities in the cloud. However, the dominance of banking in the cloud shows that the cloud can provide a secured environment for industrial activities and storage systems. The significant occurrence of the other activities in the cloud can be attributed to the storage as a service capability of the cloud computing service. This is because every user of activities such as social media makes use of the virtual storage systems of the cloud to store his or her account profile, photos, videos and other documents.

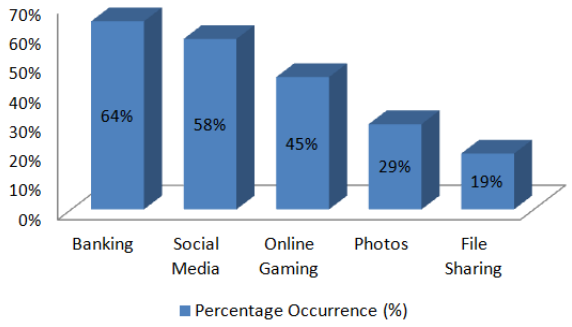


Figure 5: Percentage occurrence of Activities in the Cloud [23]

The amount of storage capacity shipped in support of file-based storage is expected to grow at a compound annual growth rate of 60.1% through 2013 [24]. IDC predicts that by 2014, 78% of all storage capacity shipped will be for unstructured data, such as documents, spreadsheets, and emails [25].

A recent survey conducted by the Aberdeen Group uncovered the IT disaster recovery trends of a range of companies using cloud computing for data storage, backup and recovery. Comparing cloud users and non-cloud users, it was found that mid-sized companies ($50 million to $1 billion of yearly revenue) were the largest group to adopt the cloud for data storage, accounting for 48 percent of the cloud users surveyed. Small companies (under $50 million of yearly revenue) were next at 38 percent and large companies (above $1 billion of yearly revenue) came in last at only 26 percent [26].

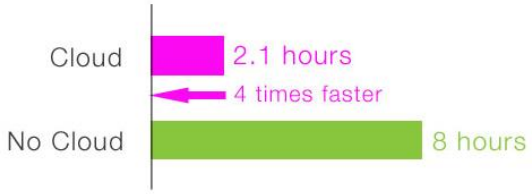


Figure 6: Average downtime for data recovery for cloud versus non-cloud users [26]

Comparing overall cloud users to non-cloud users (figure 6), the average length of downtime per disaster recovery event was 8 hours for non-cloud users, and 2.1 hours by cloud user standards (nearly four times faster). Non-cloud users may depend on traditional and time-consuming tape backup methods with complex recovery paths for their disaster recovery plan. Companies that use cloud computing for disaster recovery benefit from the elimination of tape backup, offsite tape backup and cold site DR, and making for faster online backup and recovery times [26]. The cost advantage in storing data on a cloud securely is a definite plus for Cloud services. It reduces the burden of maintaining, backups, disaster recovery and protecting data, this is done very reliably using the state of art techniques by the Cloud Service Providers (CSP), which an individual company may not be in a position to do monetarily and management wisely [27].

## V. CONCLUSION AND RECOMMENDATION VI.

Cloud computing is a concept where a computing service is provided to the user from a hosted site on demand through the internet. The service models of the cloud are in different forms such as IaaS, PaaS, SaaS, and DaaS. Cloud computing offers the potential of huge benefits for organizations that use it for the deployment and scaling of IT for business processes. The road to cloud computing begins with a foundation capable of delivering storage-as-a-service [28]. The results of the investigations show that banking recorded the highest with 64% while social media recorded second with 58%, online gaming recorded third with 45%, photos recorded forth with 29% and file sharing recorded lowest with 19% occurrence in the industrial cloud activities. The comparison of overall cloud users to non-cloud users, show that the average length of downtime per disaster recovery event was 8 hours for non-cloud users, and 2.1 hours by cloud user standards (nearly four times faster). It was therefore concluded that the cloud can provide a reliable and faster disaster recovery storage system for every industrial activities. Hence, we recommend that the government agencies, academic

institutions and other establishments especially in the developing nations should focus their attention towards the cloud to secure their services with cheaper cost, higher reliability and availability. Small and medium enterprises that do not have such high infrastructural capabilities to store and secure their data and services should plan and deploy a model of the cloud for their services.

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