



Evaluation of Cloud Computing Model: Software as a Service (SaaS) and Platform as a Service (PaaS)

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Abstract – Cloud Computing possesses service models which give users access to cloud. The models are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). These technologies give users several advantages: cost effectiveness, efficient resource utilisation, collaboration, disaster recovery and high performance. This research aimed at evaluating two of the cloud computing service models: SaaS and PaaS. This research employed positivist stance and quantitative analysis. Survey was carried out in form of an online questionnaire. This research also investigates Usability of the Service Models depending on occupational Status of individuals. Features used in differentiating SaaS and PaaS were: description, characteristics, security, advantages and disadvantages. The parameter used for comparison was Goal, Customisation, Paradigm Shift, Programming Skills, Security level, Ownership, Resource, User Friendly, and Examples. The results obtained reveal that SaaS users are much more to PaaS, and the most used cloud computing storage is Google Apps. The most inhibitors of SaaS adoption all over the world is security and privacy issues, while PaaS is the platform development programming language. Therefore, cloud service providers (CSPs) should take note of these deficiencies.

Keywords – Cloud computing, Service Oriented Architecture(SOA), Software as a Service(SaaS), Platform as a Service(PaaS), Infrastructure as a Service(IaaS).

I. INTRODUCTION

Cloud computing is one of the emerging computational paradigms which outburst the distributed computing technology [1], [2]. There are several computing resources which made up of the cloud, which are networks, servers, storage, applications and services.

The major acceptance of cloud computing in the academic and business world is the ability which cloud possesses, e.g. collaboration, high storage capacity; accelerate development work, reduced hardware and maintenance cost, accessibility around the globe and greening of the data centre, but with this benefits, Some individual and organization are not fully aware of this robust technology, while some use cloud services without even knowing what is really mean. However, increasing companies and organisations are becoming aware of the huge benefit that a cloud computing service provides [3].

Cloud Computing can provide huge cost savings and more efficiency in large areas of the public sector including hospitals and healthcare (especially to provide information and technologies in remote or poorer locations), education (especially for e-learning and universities) and the activity of government agencies with periodic spikes in usage [4].

The introduction of cloud computing can also create multilateral network effects between businesses and increased productivity within businesses, and it can promote entry and innovation in all the sectors where ICT costs are relevant and are drastically reduced by the adoption of cloud computing [4].

The computing world has been introduced with a number of terminologies that are cloud base services, which are hierarchically built from bottom to top in the order of abstraction and physical layer, namely Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) [5].

This paper evaluated and reviewed two of the cloud computing service mode: Platform as a Service (PaaS) and Software as a Service (SaaS), their application, advantages, disadvantages, security issues, characteristics, underlying technologies and method of use.

The following research questions were posed in this study:

- i. The Usability of SaaS and PaaS?
- ii. To what extent does Users Occupational Status effect how they used the Service Models (SaaS and PaaS)
- iii. To what extent does Educational attainment effect how they make used of this Service Models (SaaS and PaaS)?
- iv. What is the Most used Cloud Storages?
- v. Have there been any Security breaches in Cloud Storages?
- vi. The Awareness of Cloud Computing Service Models (SaaS and PaaS)
- vii. The year of usage of SaaS and PaaS?
- viii. The Purpose of using the Service Models?

II. BACKGROUND TO THE STUDY

A. What Is Cloud Computing?

Definition: The first challenge cloud computing has to face is its definition, presenting clear and concise delineation encompassing its features and functional elements [6]. Numerous experts in the business and scholarly circles have endeavored to characterize precisely what cloud computing is and what interesting aspects it shows. Many authors and researcher present their own definition of cloud computing which goes as follows,

[7] have characterized it as accompanies: Cloud is a parallel and disseminated computing framework comprising of an accumulation of between joined and virtualized computers that are alertly provisioned and introduced as one or more brought together computing resources dependent upon administration level understandings (SLA) created through transaction between the administration supplier and buyers.

[8] defined cloud computing as a TCP/IP based high development and integrations of computer technologies such as fast microprocessor, huge memory, high-speed network and reliable system architecture. They also further dividing cloud computing into five layer including clients, applications, platform, infrastructure and servers.

[9] described cloud computing as the use of fast, high-bandwidth internet connections to deploy services that are centrally maintained, often by third parties, and thus minimize cost and difficulty of IT administration and support for the organisations that consume those services.”

[10] postulates it to be a distributed computing paradigm allowing virtualized applications, software, platforms, computation and storage to be rapidly provisioned, scaled and released instantly through the use of self-manageable services that are delivered over the web in a pay-as-you-go manner.

However, The United States National Institute of Standards and Technology (NIST) has developed a working definition that covers the commonly agreed aspects of cloud computing. The NIST definition summaries cloud computing as a model for enabling a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned by a minimal management effort and service provider interaction [11].

B. History of Cloud Computing

The idea of providing a centralized computing service dates back to the 1960s, when computing services were provided over a network using mainframe time-sharing technology. In 1966, Canadian engineer Douglass Parkhill published his book “The Challenge of the Computer Utility”(Parkhill, 1966), in which he describes the idea of computing as a public utility with a centralized computing facility to which many remote users connect over networks [12].

In the 1960s, the mainframe time-sharing mechanism effectively utilized computing resources, and provided acceptable performance to users; however, mainframes were difficult to scale and provision up-front because of increasingly high hardware costs. Accordingly, users didn't have full control over the performance of mainframe applications because it depended on how many users utilized the mainframe at a given moment. As such, with the introduction of personal computers users loved the idea of having full control of their computing resources, even though these resources are not as effectively utilized.

With the change in the semiconductor industry, personal computers became affordable, and business abandoned mainframes. A new challenge was then introduced: how to share the data.

Client-server systems were supposed to address this data-sharing challenge by providing centralized data management and processing servers. As business computing needs grew and the Internet became widely adopted, the initially simple client-server architecture transformed into more complex two-tier, three-tier, and four-tier architectures. As a result, the complexity and management costs of IT infrastructure have skyrocketed – even the costs of actual software development in large organizations are typically lower than costs of software and infrastructure maintenance.

For many enterprises, the long-standing dream has been to background information technology issues and concentrate on core business instead. Although the effect of the cloud computing adoption is yet to be seen, many companies believe that cloud computing may offer feasible alternative model that may reduce costs and complexity while increasing operational efficiency [12].

The idea of providing centralized computing services over a network is not new – mainframe timesharing technology was popular as far back as the 1960s, but was replaced by personal computers and client-server architecture. Until around 10 years ago, typical enterprise computing infrastructure consisted of powerful and very expensive servers. Infrastructure architecture was monolithic, and each of these powerful machines could easily host 20-30 enterprise applications. This market was dominated by only a few hardware vendors, such as IBM, Sun, HP, and Dec, whose servers were expensive to purchase and maintain, took considerable time to install and upgrade, and in some cases were vulnerable to server outages that could last several hours until a vendor representative delivered proprietary replacement parts.

C. The Service Models (SaaS and PaaS)

The service models we are considering to examined are Software as a Service (SaaS) and Platform as a Service (PaaS), its description, characteristics and security issues will be discussed here.

D. Description of Software as a Service Model (SaaS)

In this Model, Cloud service provider (CSPs) are responsible for running and maintaining application software, operating system and computing resources, the main advantages of SaaS are Multitenant efficiency, configurability and scalability. Examples of SaaS provider are Microsoft, Google and Salesforce etc. examples of SaaS Apps are Google Doc, Google Calendar, Zoho, salesforce.com etc. [13].

E. Characteristics of Software as a Service (SaaS)

1) *Customisation*: Customisation is very limited in SaaS application, user may have slight access in changing the interface of the application, and the cloud service provider is the responsible for customizing SaaS application which the end-users use.

2) *On Demand Self Service*: End-users must be able to use the service with minimal management effort or cloud provider interaction.

3) *Accessibility*: Application should be accessible on the user any network device (laptops, mobile phone or PDAs).

F. Security issues on SaaS

1) *Application Security*: *Web Browser Application are used to access these application in the cloud, Attackers have been using the web to compromise user's computers and perform malicious activities such as stealing sensitive data [14]. Security challenges in SaaS applications are not different from web application technology, but traditional security solutions do not effectively protect it from attacks, so new approaches are necessary [15].*

2) *Data Security*: Data security is very crucial for any technology, but it becomes a major challenge when SaaS users have to rely on their providers for proper security [15]. In SaaS, data and files are stored in cloud, it is the responsibility of the cloud provider to ensure security of data and files while being processed and stored. In the world of SaaS, the process of compliance is complex because data is located in the cloud service provider's datacentres, which may introduce regulatory compliance issues such as data policy, segregation and security, which must be enforced by the provider [1].

3) *Accessibility*: Accessing files and application over the internet via web client browser makes access from any network device easier; however, it also exposes the service to additional risks. According to [5] – security breach can occur while transmitting data from the cloud server to the clients' computers.

G. Advantages of Software as a Service (SaaS)

1) *Automated software*: all functions in SaaS Application are all automated, users just need the accessible devices to access the Services

2) *Scalability*: One of the most unique and distinct advantage of SaaS is its Scalability also known as Elasticity and

3) *Others advantages includes cost effective*

H. Disadvantages of Software as a Service (SaaS)

1) *Customisation*: User has little or no Customisation power over the SaaS infrastructure.

2) *Performance*: A browser-based application hosted remotely and accessed via an internet connection is likely to worry some businesses when compared to software running on a local machine.

I. Description of Platform as a Service Model (PaaS)

In this model, PaaS provides an operating system, development application and/or database platform, PaaS implementations allow organisation to develop applications without having to worry about building the infrastructure needed [16].

J. Characteristics of PaaS

1) *Customization*: With PaaS, users have complete control over the customization of the application due to the user's influence of building the software applications.

2) *Multi-tenant architecture*: This architecture maintains a trust relationship between the users in security, access, distribution of source code, navigation history, user profiles, interaction history and application usage [17].

3) *Integration with web services and databases*: PaaS offers to create composition of multiple web services. These services access databases and re-use services maintained inside private networks (Khurana and Verma, 2013) [17].

K. Security issues on PaaS

1) *Development Life Cycle*: Developer have to keep it in mind that PaaS applications should be upgraded frequently, so they have to ensure that their application development processes is flexible enough to keep up with changes [18].

2) *Third-party services*: PaaS users have to depend on both the security of web-hosted development tools and third-party services. Some of this third-party service combine more than one source element into single integrated unit, whereas this third party seldom have data and network security issues [1].

3) *Underlying technology security*: In PaaS, developers do not usually have access to the underlying layers, so providers are responsible for securing infrastructure as well as the application services [19]. Even when developers are in control of the security of their applications, they do not have the assurance that the development environment tools provided by a PaaS provider are secure [1].

L. Advantages of Platform as a Service (PaaS)

1) *Customisation*: User has more Customisation power in PaaS infrastructure than SaaS.

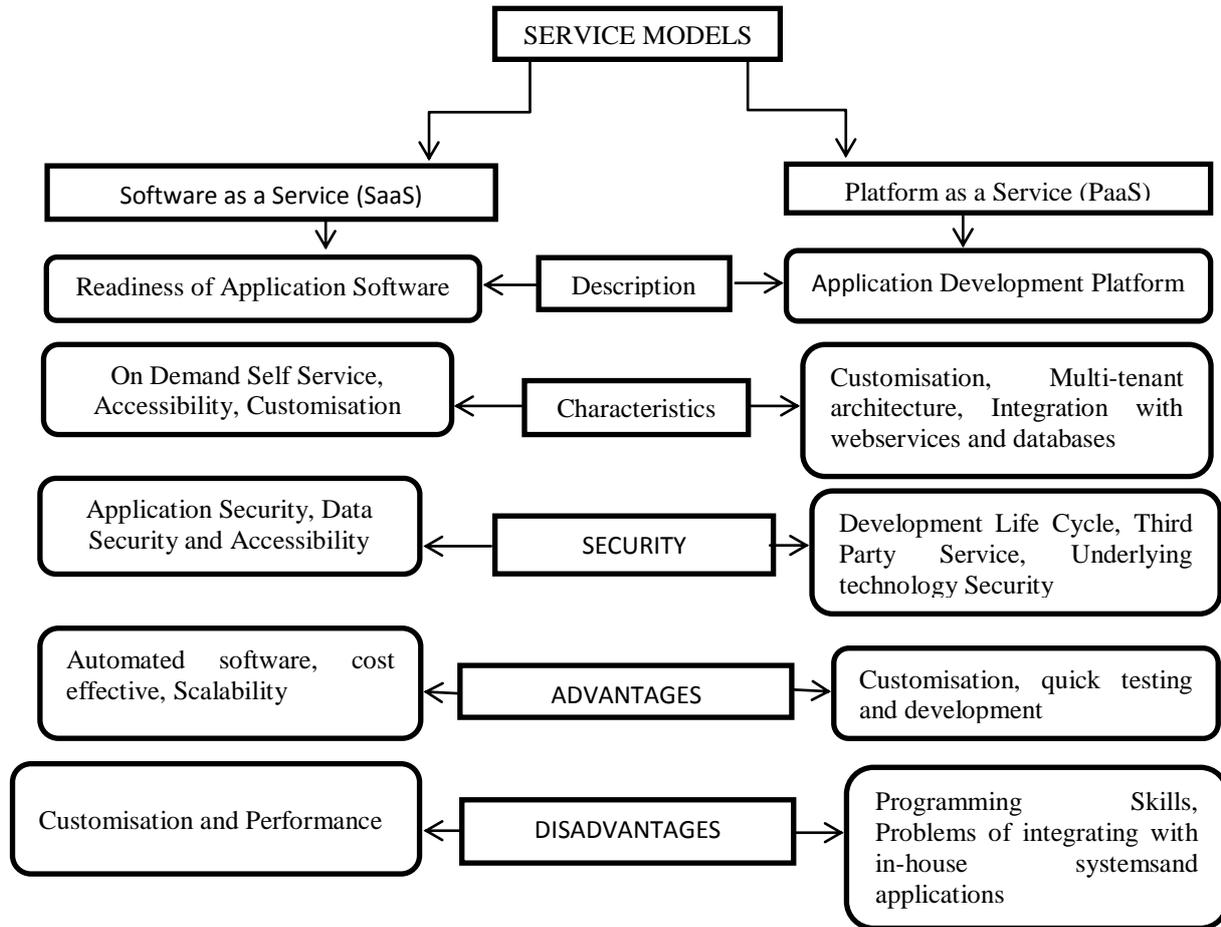
2) *Quick Testing and Development*: With PaaS, development teams can try different configurations, multiple machines and different location to run stress tests and access performance, compatibility and response. With quick testing of applications, deployment too becomes faster.

3) *Increased focus on business and boost to internal entrepreneurship*

M. Disadvantages of Platform as a Service (PaaS)

1) *Programming Skill:* To use PaaS, it requires at least one programming Language, if a user doesn't know any programming language, she/he will not be able to operate PaaS.

2) *Problems of integrating with in-house systems and applications:* Integration of PaaS services with the rest of your systems and applications could trigger an increase In complexity



III. METHODOLOGY

This section explains the methods used in evaluating the service models. An online survey in form of questionnaire was carried out at Olabisi Onabanjo University community to address the research questions. The URL link to the Questionnaire form is goo.gl/RtSuPq. The Questionnaire contained six (6) and twelve (12) research questions making 18 questions. Quantitative data were collected by using a Questionnaire which was divided into sections as presented in Table 1.

Section A captures the relevant background information of the Individuals completing the question information such as Name, Sex, Occupation, Qualification, Age and Email

Section B deals with the respondents acquainted with the Internet (Cloud) and Cloud Storages. Table I showed the questions together with the respective summarisation variables.

Section C consists of the SaaS and PaaS questions which will be used in comparing the Service Models according to its usability, year of experience and purpose. Table I showed the questions together with the respective summarisation variables.

Table I Research Questionnaire Variables (SaaS and PaaS)

Question	Variable
How long have you been using the internet (Cloud)?	Awareness with the Cloud and Cloud Storages
How Many cloud account do you have?	
Do you use Cloud Storage?	
Which Cloud Storages do use?	
Do you use Software as a Service (SaaS)?	Comparing Techniques and Cognisance of SaaS/PaaS
How long have you been using both services?	
What do you use the services for?	
Before now, Did you know that Software as a Service (SaaS) and Platform as a Service (Paas) are Cloud Computing Models?	

Also, the service models were paralleled against the following criteria: Goal, Abstraction, Customisation, Paradigm Shift, Programming skills, Application software, Security level, Ownership, Resource, User Friendly, Transparency, Client, service Provider and Examples. The parameters were explained as follows:

1) *Goal*: An observable and measurable end result having one or more objectives to be achieved within a more or less fixed timeframe.

2) *Abstraction*: This is a technique for managing complexity of computer systems. It works by establishing a level of complexity on which a person interacts with the system, suppressing the more complex details below the current level. The programmer works with an idealized interface (usually well defined) and can add additional levels of functionality that would otherwise be too complex to handle.

3) *Customisation*: allows you, as a user's, to tailor the application to better suit your reading and editing style. Your customisation affects only how pages look in your web browser, not the reading or editing experience of other editors.

4) *Paradigm Shift*: A major change in how some process is accomplished. A paradigm shift can happen when new technology is introduced that radically altered the production process of goods.

5) *Programming Skills*: Programming skills is the craft of writing useful, maintainable, and extensible source code which can be interpreted or compiled by a computing system to perform a meaningful task. Programming a computer can be performed in one of numerous languages, ranging from a higher-level language to writing directly in low-level machine code (that is, code that more directly controls the specifics of the computer's hardware) all the way down to writing microcode (which does directly control the electronics in the computer).

6) *Application software*: This is where the owner of the software deployed the application, the CSPs or the Platform Developer may deploy it.

7) *Security level*: This are assigned to an individual document, file, or record based on the sensitivity or secrecy of the information. Four common security classifications are:

- Top secret: Highest degree of protection for information that is paramount in national defense matters and whose unauthorized disclosure may cause extremely grave danger or damage to the nation.
- Secret: Unauthorized disclosure of which may result in serious damage or danger.
- Confidential: Unauthorized disclosure of which may undermine the defense or government operations.
- Restricted: Unauthorized disclosure of which is undesirable.

8) *Ownership*: The ultimate and exclusive right conferred by a lawful claim or title, and subject to certain restrictions to enjoy, occupy, possess, rent, sell, use, give away, or even destroy an item of property.

9) *Resource*: This is systems and tools required to effectively produce or create a product or service. These include energy, information, people, tools, machines, capital and time. Technological resources aid production processes and service delivery in companies and organisations [20].

10) *User Friendly*: Refers to anything that makes it easier for novices to use a computer. Menu-driven programs, for example, are considered more user-friendly than command-driven systems. Graphical user interfaces (GUIs) are also considered user-friendly. Online help systems are another feature of user-friendly programs.

11) *Transparency*: In computers, transparent means something a little different than its general meaning of having the quality of being easily seen through, coming closer to meaning in visible or undetectable. Computer programs and procedures that are said to be transparent are typically those that the user is - or could be - unaware of. Transparency is considered to be especially desirable in situations where users that are not particularly technically inclined would tend to be confused by seeing or having to interact directly with programming components. Transparent is also used to refer to a change or upgrade of hardware or software that is undetectable in subsequent uses of the system. A secondary meaning of transparent refers to complete predictability, as, for example, in a transparent computer system or program, output is entirely predictable from knowing the input [21].

12) *Client*: A client is a piece of computer hardware or software that accesses a service made available by a server. The server is often (but not always) on another computer system, in which case the client accesses the service by way of a network. The term applies to programs or devices that are part of a client-server model.

13) *Service Provider*: is a company that offers some component of cloud computing – typically Infrastructure as a Service (IaaS), Platform as a Service (PaaS) or Software as a Service (SaaS) to other businesses or individuals. Cloud Service Providers are sometimes referred to as Cloud Service provider and

14) *Examples*: These are different kind of examples of service models examined in this project. The qualitative and quantitative data obtained during the survey were analysed.

IV. RESULT AND DISCUSSION

This section presents the result obtained its analysis and discussion

A. Result Of The Survey

The result of the survey is presented in this section in pie chart

1) *The Usability of SaaS and PaaS*: The result was obtained from the individual answer of users of SaaS and PaaS in the questionnaire Figure 1 presents the SaaS answer: 92% of respondents use SaaS, 6% of respondents did not use it, while 2% respondents haven't heard of it. The PaaS answers are that 36% respondents uses PaaS, 44% of respondents didn't use it, while 20% of respondents haven't heard of it before. This infers that the respondents whose answer this question uses SaaS than PaaS.

This result concur with Google Trend research that SaaS is used more often than PaaS as shown in Figure 2

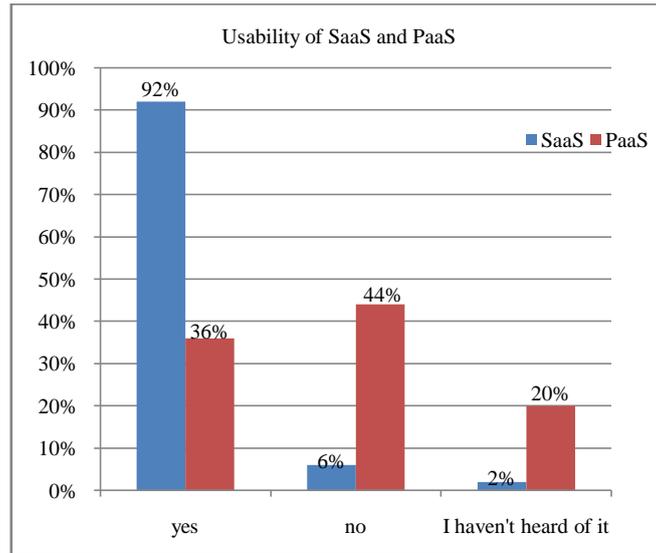


Figure 1: Usability of SaaS and PaaS

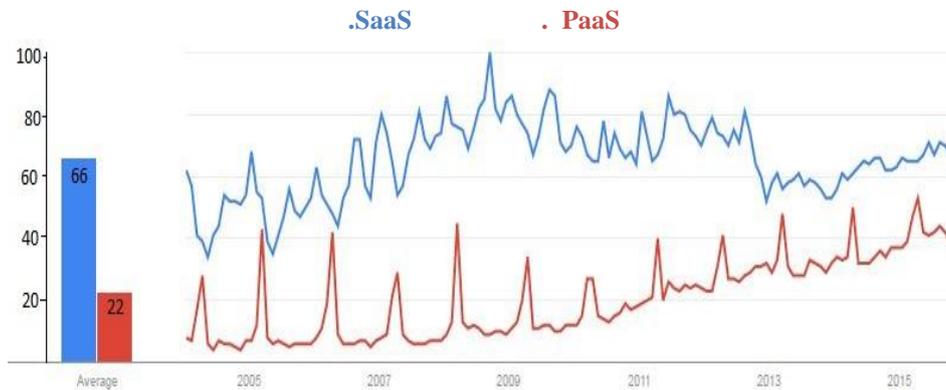


Figure 2: Google Trends on SaaS and PaaS (Google Trend, 2015)

2) *Sex Distribution*: Figure 3 shows that 82% of the respondents are male, 14% of the respondents are female, while 4% of the respondents didn't pick any option, Hence, from Figure 3 revealed that male use SaaS more than their female counterpart

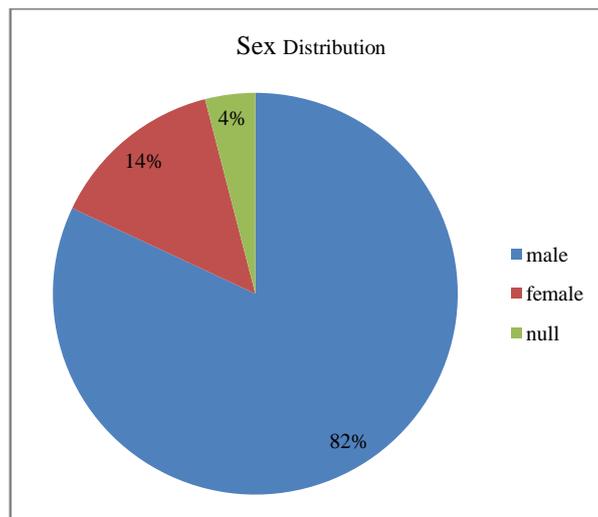


Figure 3: Sex Distributions of the Respondents

3) *Occupational Status Usage*: The occupations presented were: Students, Researchers, and Professional. Figure 4 showed that 32 respondents representing 62% are Students, 2 respondents representing 4% are Researchers, and 13 respondents representing 26% are Professional. This implies that majority of the respondents and Users of Cloud services are Students.

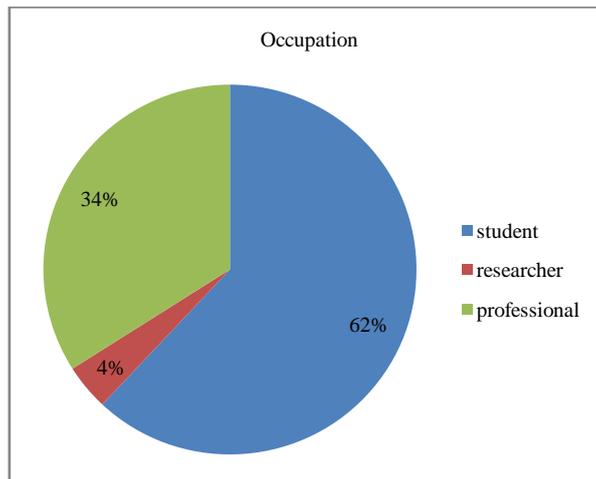


Figure 4: Occupational Distributions of SaaS and PaaS

4) *Extent of Educational attainment:* Figure 5 revealed that the number of respondent with High School certification is 5 (10%), number of respondent with first degree is 27 (54%), number of respondent with second degree certification is 3 (6%), number of respondent with professional Certification is 2 (4%), number of respondents with diploma certification is 11 (22%), while 2 (4%) of the respondents didn't partake in the question. This result shown here that respondents with first degree certification used more of cloud computing services than others qualification

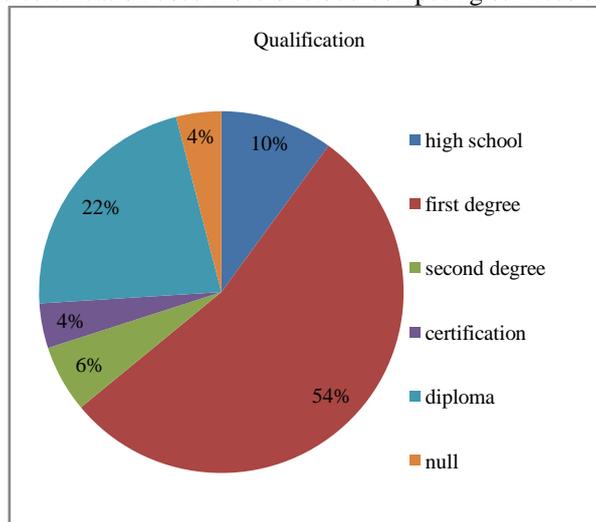


Figure 5: Qualification distributions of SaaS and PaaS

5) *What is the Most used Cloud Storages:* Figure 6 presented 21 respondents who use Google Apps owned by Google. The cloud services provided are Google drive, Goggle calendar, Google doc etc. The next one is Dropbox, then OneDrive. This result shown that Google apps own the highest niche in Cloud Storage

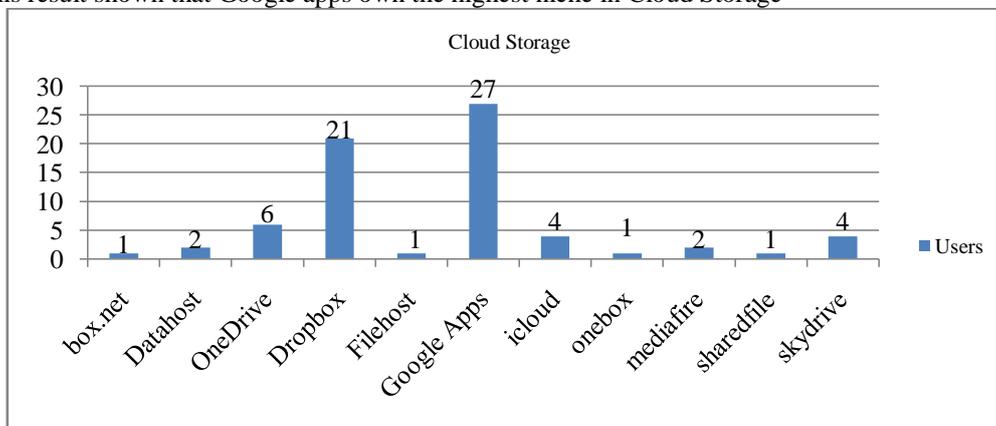


Figure 6: Cloud Storages

6) *Security Breaches:* Figure 7 showed that 4%, 70%, 26% respondent selected yes, no and not sure option respectively for the research question. With the 70% No response, Therefore, Cloud Storage is safe to use.

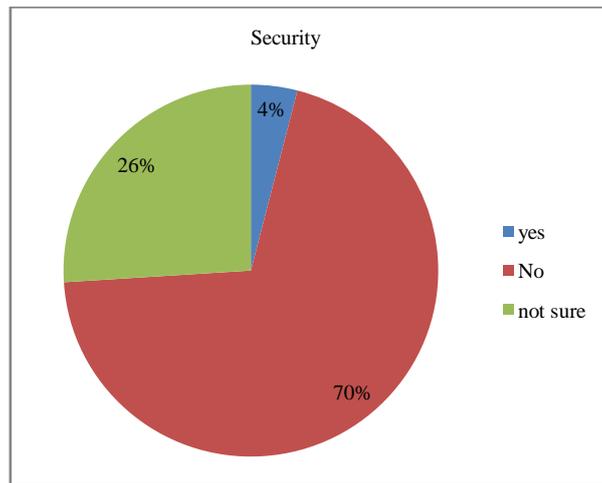


Figure 7: Cloud Account Security

7) *Awareness of Cloud Computing Service Models*: 10 respondents selected yes which resulted to 20%, 17 respondents selected No which result to 34%, while 23 students selected Not sure which result to 46%. The table and figure charted on the bar chart also show that respondent representing 34% uses SaaS and PaaS but didn't know it is Cloud Computing model, only few respondents representing 20% which are aware of that Service Model is SaaS and PaaS, while respondents representing 23% are in dilemma whether they use it or not.

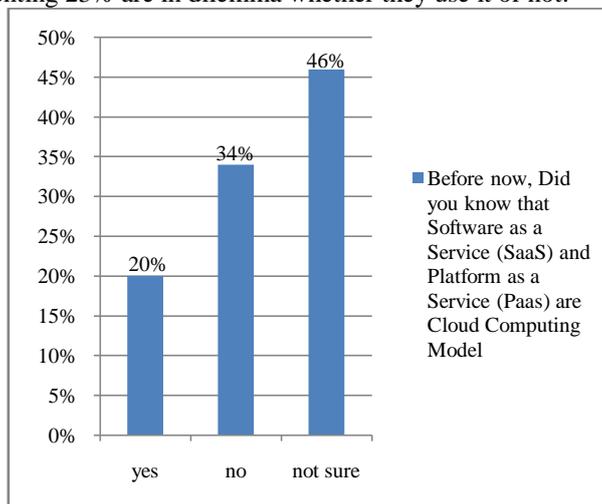


Figure 8: Awareness of SaaS and PaaS

8) *Years of Usage*: Figure 9 presented the number of respondents for the Usage of the SaaS of less than a year stand at 14%, Between the usage of 2 to 4 years followed with 25% of the total number of respondents and the Usage of 5 to 7 years has 36%, This is also followed by those in the bracket of 7 years and above was 8%, the respondents who didn't choose any option was 2%. While for PaaS, number of respondents been the Usage of the PaaS of less than a year stand at 26%, Between the usage of 2 to 4 years followed with 10% of the total number of respondents and the Usage of 5 to 7 years has 10%, This is also followed by those in the bracket of 7 years and above was 2%, the respondents who didn't choose any option was 52%.

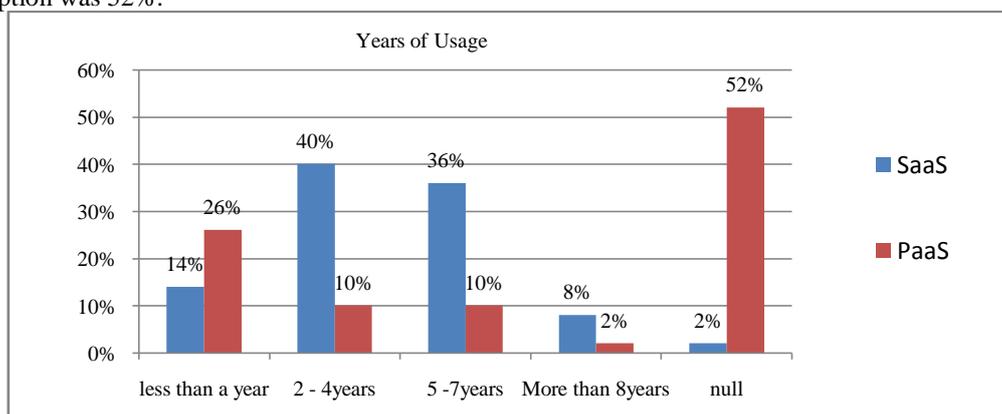


Figure 9: Years of Usage

9) *Purpose of using the Service Models:* The purpose of using the service models (SaaS and PaaS) result are chosen from a multiple choices such as by personal, Educational Services, Business and others. From the results presented and analysed Figure 10 below, for SaaS, it shows that 40 respondents represents personal purpose, 25 respondents represents Educational Services, 20 respondents represent business, 1 respondent represent Others, 3 options was not chosen, while for PaaS, it shows that 14 respondents represents personal purpose, 11 respondents represents Educational Services, 10 respondents represent business, No one chose Others, 25 options was not chosen. This implies that majority of the respondents used SaaS and PaaS for Personal purpose.

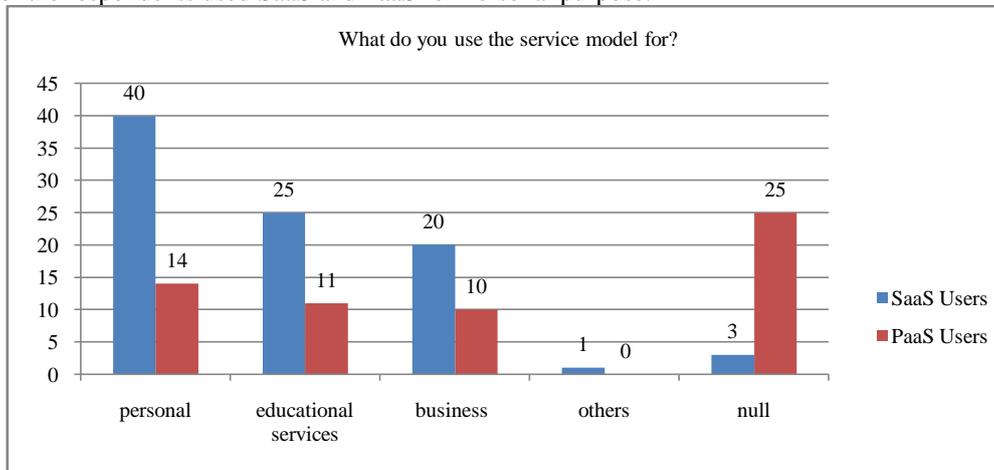


Figure 10: Purpose of the Service Model

B. Result of the Parameter

The concept of SaaS and PaaS are quite different from each other, SaaS provides all computing resources to the users, while PaaS gives application developers the capacity to builds apps on cloud. Table II show different parameter which these service models possess and differentiate both SaaS and PaaS.

Table II SaaS vs. PaaS (Parameter)

S/N	Parameter	Software as a Service	Platform as a Service
1	Goal	Ready-made application	Application development
2	Abstraction	Low	Medium
3	Customisation	Low	High
4	Paradigm Shift	Software as an asset (business and consumer)	License purchasing
5	Programming Skills	No special programming skills	Programming skill is needed
6	Application software	Cloud service provider	Customer or Developer
7	Security level	Low	Medium
8	Ownership	CSP	CSP and Apps Developers
9	Resource	Limited	Unlimited
10	User Friendly	High	Low
11	Transparency	Low	High
12	Client	Mobile, Smartphones, Laptop and Desktop computer	Laptop and Desktop computer
13	Service Provider	Google, Box	IBM, Google, Amazon
14	Examples	Google Drive, Dropbox, Box,	Microsoft Azure, Google Apps engine, Heroku

V. CONCLUSION

Cloud Computing is a concept that presents a good numbers of benefits to its users. The benefits are too enormous, especially the ubiquity, scalability and elasticity of the technology, however, One must be careful to understand the security challenges and threats these technology possesses before utilising it. PaaS and SaaS computing models appears to be a promising modelling especially focus on a single user, where user can utilise apps on cloud and even integrate apps following the PaaS provider policies with a minimal management effort or service provider interaction. The dream of rapidly using an application on cloud without maintain, upgrade or install any apps on cloud will be achieved by SaaS, while developing and integrating your own apps without worrying about the computing resources/hardware will be achieved by PaaS. Awareness and poor internet infrastructure are prevailing factors affecting the adoption of SaaS and PaaS. Knowledge and some understanding of SaaS and PaaS are important for users and organisations considering the initial adoption of SaaS and PaaS. High internet costs, low internet reliability and poor access are detrimental to the adoption of SaaS and PaaS.

There were altogether 50 responses from the survey, 92% users used SaaS while 36% users used PaaS, the Result is shown in Table 4.1 and charted in Figure 4.1. We have 82%, 14%, and 4% respondent are Male, female and null respectively. The null option is the respondents who didn't indicate their option.

The sample is too small for each individual SaaS and PaaS Sample, as well as for the combined sample, to represent the general population of Internet Users. The limitations create an opportunity to study more on SaaS and PaaS using a large sample. Besides, the third cloud computing service model Infrastructure as a Service (IaaS) may be included in the comparing service.

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