

# Cloud Computing Framework for Yemeni Universities

## إطار عمل حوسبة سحابية للجامعات اليمنية

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### ملخص البحث:

ومشاركة المصادر والواجبات بين المدرس والطالب، ويتعدى النفع لموظفي وأعضاء الجامعة، حيث يمكن توفير ذلك كله عن طريق طرف آخر يمكن الاستئجار منه والدفع بحسب الاستخدام مثله مثل الهاتف والكهرياء، كل ذلك يمكن الوصول إليه عبر الإنترنت باستخدام أي جهاز اتصال مثل التلفزيون أو اللابتوب أو الجهاز اللوحي.

لذا فإن هذه الرسالة تناقش فوائد وإيجابيات تبني الحوسبة السحابية وماهي العوامل والعوائق التي أدت إلى التأخر في استخدام الحوسبة السحابية في الجامعات اليمنية، وتحتوي الرسالة على الاستراتيجيات العلمية وخارطة طريق للانتقال الآمن للحوسبة السحابية في الجامعات اليمنية، ومن ثم بناء مودل لآلية الدخول إلى موقع الجامعة في الحوسبة السحابية. استفادت الرسالة من النموذج TOE لتبني تكنولوجيا المعلومات.

لقد تم اخذ عينة للدراسة وتحليلها عن طريق استبيانات لثلاث جامعات يمنية وهي جامعة صنعاء، وجامعة الأندلس للعلوم والتقنية، وجامعة العلوم والتكنولوجيا، وتم تحليل تلك الاستبيانات باستخدام برنامج SPSS وكذلك عمل مقابلات لثنتين في الثلاث الجامعات، وكذلك تم عمل

وفقاً لتقرير مؤسسة جارتنر للأبحاث، تعتبر الحوسبة السحابية ثالث تكنولوجيا من أصل عشرة تقنيات حديثة منذ العام ٢٠١٤، وهي أحد الحقول الجديدة لكثير من الباحثين والمهتمين في تكنولوجيا المعلومات لتطوير مسار التعليم العالي.

لقد أصبحت الجامعات في الآونة الأخيرة ومع تطور الحاسوب والشبكات تعتمد اعتماداً كبيراً على تكنولوجيا المعلومات في تسيير كثير من الأمور التعليمية والإدارية من حيث التواصل وتقديم المادة العلمية وكثير من المتعلقات الإدارية.

وبالرغم من الزيادة السريعة والمزايا الكبيرة في الحوسبة السحابية إلا ان استفادة الجانب التعليمي من هذه التقنية المتزايدة فقط ٤٪، بينما الباقي في القطاعات الصناعية والشركات الخدمية الأخرى، مما يعني أنه لم يتم اعتماد استخدامها في المؤسسات الأكاديمية إلا النادر اليسير.

إن تبني الحوسبة السحابية للجانب التعليمي يمكن أن يوفر كثير من الفرص مثل الحد من مراكز البيانات والسرفرات وتوفير كثير من الأمور المالية في البناء التحتية، واعطاء فرص للطالب والمعلم للوصول السريع للتطبيقات والخدمات الأخرى في الجامعة في أي وقت ومن أي مكان

التقني والموظفين بشكل عام ورغبة الإدارة العليا والدولة في تبني هذه التقنية وكذلك الاهتمام الرئيسي الأولوية لاستراتيجيات الخصوصية والأمن لتجنب أي هجوم من البيانات، من خلال اتباع خارطة الطريق المقترحة والإطار الذي يحتوي على السحابة الهجينة.

مقابلة لشركات ذو علاقة بالتقنية مثل مزود الخدمة في اليمن ISP، وعمل مقابلات لشركات بدأت العمل في هذه التقنية مثل شركة ناتكو للتقنية للاستفادة من التجارب السابقة. وأوصت الرسالة بأن الجامعات اليمنية يمكن أن تعتمد الحوسبة السحابية، ويمكنها التغلب على معظم المعوقات، إذا اهتمت الجامعة بتدريب الكادر

## ABSTRACT:

Cloud computing is considered in three out of ten top strategic technology trends for 2014 year according to Gartner[1]. It is the green field for all IT researcher to develop our Higher Education (HE). The Universities in this time is becoming completely dependent with the IT on their teaching-learning, communication, service delivery, and business requirements. Although the rapid growth of Cloud Computing, It is only 4% of cloud computing used in education and the other 96% is related to industrial sectors and services. [2]

The adoption of Cloud computing in educational settings can provide great opportunities for reduction of in-house data centers and the delegation of a portion or all of the Information Technology infrastructure capability to a third party, whereby shared resources, software and information, are provided to computers and devices on-demand, like the electricity grid, in addition of giving the opportunity for students and teachers to quick access to various applications, systems and resources through the Internet - any time anywhere -, and share files and documents, and the exchange of duties and projects among students "improving their learning outcomes". Meanwhile, all of services on Cloud

Education can be accessed using any devices such as mobile phones, computers, and tablet computers. Despite all of advantages of cloud, computing it still not fully adopted in academic institutions sector.

Hence, this thesis discussed the advantages of cloud computing for higher educations, and it identifies the reasons for the slow rate of adoption of cloud computing in Yemeni universities, discussed the challenges of cloud computing and proposed five stages as a roadmap to help the universities to do self-assessment before adopted the cloud computing and finally design Framework called CCFYU (Cloud Computing Framework for Yemeni Universities) for the successful entrance to the portal of universities cloud computing. The technology-organization-environment (TOE) framework has been used as the technology innovation adoption.

The case study of the thesis are Alandalus university, sana'a university and Science and Technology university, and the data sources are interview in Yemen net that is the ISP for Yemen, and the researcher engaged the heads of the various companies selected for this study likes Yemen soft and Natco companies to establish relationship with them and get benefit from them, and

makes interview with the IT support for university and make offline questionnaires of some employees and teachers, and is analyzed through SPSS statistical Software. All that for Evaluation the readiness of Yemeni universities to use cloud computing and to help overcome the challenges of transition for secure cloud computing or safety migration through CCFYU.

The thesis recommended that Yemeni universities can adopt Cloud Computing, and can overcome most of

the limitations, if they are be attention about the side of IT human resource through training, the desire of top management and the country to cloud computing technology adoption, and the main priority attention of the privacy and security strategies to avoid any attack of data, through following the suggest roadmap and framework which is hybrid cloud.

Keywords: *cloud computing, Adoption, Framework, Roadmap, CCFYU, Higher Education (HE).*

## 1- Introduction:

With the improvement in information technology, it has become a great challenge in academic institution to have necessary information and communications Technology (ICT) infrastructures.

In addition, the updating of ICT infrastructures in academic institutions for education process, research and development of training activities is becoming a big issue in this crucial financial crisis facing by every national economy.

As we know, we can't avoid the information technology and the new techniques in the academic institutions, so One of the techniques that academic institutions must adopt is cloud computing.

The cloud computing is a model that is depending on transfer the processing, storage, services, application and data own to which is called the cloud, which is one or more servers can be accessed via a high speed internet connection from any devices (e.g., computer or mobile), that can be rapidly provisioned and released with minimal management effort or service provider interaction.

Cloud computing supplies customer with the ability to use resources that exceed the capacity of their own devices, such as internet applications and storage space, at lower prices than if they had purchased these resources. It provides anyone can access internet the opportunity to use resources whenever they need them without having to install new software or buy new equipment.

It turned information technology from products to services, also it supports maintenance, solving, developing, and update all owns software. So cloud provides computing resources on demand on a pay-per-use such as

water, electricity and telephone, in opposite of traditional computing that produces many loss of resource.

Cloud computing offers opportunities to improve the quality of education by offering flexibility, availability and accessibility through the Internet. This can enable more dynamic and interactive learning experiences and allow students and teachers in multiple locations to collaborate and communicate more effectively[5].

There are many application used by the students such as Facebook, Twitter, Gmail, and Flickr, are cloud-based technologies.

In addition, cloud-based services can offer users and academic institution cost savings and access to scalable computing power.[6][7]

Research highlighted by Forbes outlines that by 2020 large American corporations can “achieve annual energy savings of \$12.3 billion” and small to medium sized companies could reduce their energy consumption by “90%”. [8]

At this time, many universities are trying to update their IT infrastructure and data, but they are facing few challenges which can be solved by cloud computing. Students will have access to all software anytime, anywhere and any technological devices connected internet by suggested cloud structure. Also, students will have access to development platform, and develop their applications, and store on university infrastructure. So, lecturers will focus their basic tasks and not lose their workforce.

The thesis aims to suggest a Cloud Computing Framework scenario and roadmap to help the universities in Yemen to migrate to the cloud in safety manor. It has taken Alandalus University, Science and Technology University, and Sana’a university as a case study of this research and make interview with some companies interested to cloud computing. The results of the interviews were used to build the questionnaires.

## 2- Problem Statement:

Although the predictions on the increase in the rate of adoption of the cloud technology, the acceptance level for higher education is still very low.

Up to now higher education infrastructure is traditional and often unable to face the demand of rapid changes in technologies in an interactive learning environment, nowadays a lot of universities or users need to process a long amount of information data or need to do some complex operations, for example some mathematical models calculations, and they

need a high amount of process power to resolve it. May be the power of a personal computer can be not enough to finish in a determinate time one task. Also sometimes a user wants to use a program for few times, for example for making some practices in university, and maybe it's pointless to make install this user a program, so for both we have to bring to the user the necessary tools to be able of executing a problem in the cloud of the university.

Every day that goes by, the research and educational needs of universities' change with developing technology; All the software and hardware of universities' must be renewed in accordance with the changes.

Accordingly, the process of purchasing, maintaining, and administering computing assets requires a large investment of financial and manpower resources for university, and make all that is in an availability or accessibility.

This research is intended to build a framework and roadmap for Yemeni University to drawback some of the above limitations and challenges by utilizing of Cloud Computing services. Currently, many universities are interested in using cloud computing capabilities, but they do not know how can be moved. So this research attempts to answer the following research questions:

1. What are the factors which universities take into account when deciding about adopting Cloud Computing and how important are these factors?
2. To what extent Yemeni Universities are aware of Cloud Computing?
3. Is it suitable for Yemeni Universities to adopt of Cloud Computing?
4. What measures can be put in place to ensure a safer and more reliable transition to the cloud?
5. What is the roadmap and framework for the successful adoption of cloud computing?

### 3- Research Hypotheses:

There is a significance effect between independent variables and dependent variable or response variable which is Cloud Computing Adoption in Yemeni universities (at level of significance  $\alpha= 0.05$ ).

#### 4- Motivation and Significance of the Research:

Cloud computing is a modern technology that is currently rapidly being adopted around the world in many education institution, businesses, organizations and also by the home consumer, So this study will:

1. contribute of the development of technical services for the Yemeni universities, which will reduce the technical and economic costs for university institutions, and minimize the waiting time for students to get the various services.
2. Provide the Yemeni university by recommendations, roadmap and framework for the adoption of Cloud Computing.
3. Helping to keeping the university services available so it can be accessed at any time, 24 hours a day from anywhere, and make them work efficiently.
4. Increase the level of cooperation between the learners, teacher, and others staff in the academic institution with each other's.
5. Support to the Yemeni university libraries with study in the Cloud Computing technology.
6. Contribute to draw the attention of researchers and interested to do many of the studies and research in the Cloud Computing.

#### 5- Research Variables:

The dependent variable: Cloud Computing Adoption.

The independent variable:

1. Higher management support.
2. Integration of the current services with Cloud.
3. Skills of the IT human resources.
4. Security Impact.
5. Cost reduction of the Yemeni universities.

## 6- Related Works:

- 1- Adoption of Cloud Computing By Higher Education Institutions in Maharashtra India: An Investigative Study,2016, by Avinash Appasha Chormale and Sunanda Arun More. The theoretical foundation of this research is based on the technology–organization–environment (TOE) framework. In this study, the factors that affect the cloud adoption by higher education institutions were identified and tested using SPSS software, a powerful statistical analysis tool for structural equation modeling. Three factors were found significant in this context. Relative advantage, complexity and data concern were the most significant factors. The model explained 48.3% of the total adoption difference. The findings offer education institutions and cloud computing service providers with better understanding of factors affecting the adoption of cloud computing
- 2- In a study on Cloud Computing in Higher Education in Jordan by Massadeh and Meslah (2013) suggested that Jordanian universities consider adopting cloud computing as a way of meeting the growing demands of IT services and managing the tight budget due to very limited financial support from the government. The researchers believe that implementing cloud computing will be a strategy to offer good business models for the Jordanian universities as they do not have sufficient resources to manage the required IT support for development, educational, and research activities that should be provided in an ideal higher education environment.
- 3- In article “Cloud Computing Adoption Model for Universities to Increase ICT Proficiency”,2014, by Safiya and others identifies the reasons for the slow rate of adoption of cloud computing at university level, discusses the challenges faced and proposes a cloud computing adoption model that contains strategic guidelines to overcome the major challenges identified and a roadmap for the successful adoption of cloud computing by universities. The model was tested in one of the universities and found to be both useful and appropriate for adopting cloud computing at university level. the article proposes a cloud computing adoption model consists of:
  1. Strategic guidelines to overcome security and privacy Concerns.
  2. Strategic guidelines to overcome reliability concerns of the Cloud Service Providers.

### 3. A roadmap for the successful adoption of cloud Computing.

The proposed roadmap has seven stages: planning, choosing the right deployment model, choosing the most suitable service models, vendor selection, negotiating the SLA, migration, and integration.

- 4- In the research "The "Adoption of Cloud Computing Technology in Higher Education Institutions: Concerns and Challenges (Case Study on Islamic University of Gaza "IUG" )", 2013, by Ahmed Jameel This research aims at showing the concerns and challenges of the adoption of Cloud Computing technology in Higher Education Institutions, case study Islamic university of Gaza (IUG).

Using the descriptive analytical method to study the effects of the main five dimensions (Top management support, Support and integration with university Services, Skills of IT human resources, Security effectiveness and Cost reduction) on the adoption of Cloud Computing technology. This research focuses on IUG as a case study of the academic institutions of Palestine which is the first from among other universities in terms of modern technology utilizing in its operations.

Moreover, it's used several services of Cloud Computing technology for example IUG Gmail, Facebook, Fliker, and IUG Tube ...etc.

The researcher used a questionnaire as a data collection tool. The results showed that there is a significant relationship between the adoption of Cloud Computing and the five independent variables at level of significance  $\alpha = 0.05$ . The research recommended that IUG can adopt Cloud Computing technology in its operations, if it is interesting on the side of IT human resource through training, scientific missions, and innovations,..etc.

- 5- In research "Cloud Computing: Strategies for Cloud Computing Adoption", 2010, by Faith Shimba, Dublin Institute of Technology this research project aims at developing a roadmap called ROCCA (Roadmap for Cloud Computing Adoption), which provides organizations with a number of steps for adopting cloud computing and building trust. An associated framework called ROCCA achievement Framework (RAF) is also proposed. RAF is a framework that uses the criteria in the ROCCA to build a framework for measuring the adherence level to the proposed roadmap. It presents in detail the technological factors key to a successful cloud computing adoption, and it introduces

The technology underlying cloud computing, and describes different cloud computing delivery and deployment models.

6- Saidhbi (2012) in the research Cloud Computing Framework for Ethiopian Higher Education Institutions proposed the implementation of a central hybrid cloud computing infrastructure that combines both the current local infrastructure of the universities as the private cloud and public cloud to enable the sharing of educational resources and collaboration within all universities in Ethiopia and the global educational community, so that Ethiopian higher institutions can enjoy the benefits of ICT in an efficient and affordable way (Saidhbi, 2012). The research further states that by deploying the proposed hybrid cloud model, the risks of privacy and other security challenges can be avoided as critical and sensitive data will be housed in a private cloud.

#### 7- Cloud Computing Service:

There are three main cloud computing service; Software as a service (SaaS), Platform as a service (PaaS) and Infrastructure as a Service (IaaS) [9].

- A. Software as a service(SaaS): This type of services focus on the software and service of IT systems such as recording applications, financial applications and reports applications in various domains. Therefore, SaaS provide online user's interfaces as connection points between end users and organization services.
- B. Platform as a service (PaaS): The main purpose of PaaS is to manage, control, process and operate the gather information between different applications and systems storages and infrastructures. Thus, PaaS considered cloud computing operating system to operate the gather information between SaaS and IaaS sides. There are many bold PaaS examples such as online programming language debugger, tasks interruptions management and automated daily operations.
- C. Infrastructure as a Service (IaaS): It is the higher services layer in cloud computing services structure; SaaS represent the infrastructure that responsible about store systems operating systems, applications, data and information and the network requirement to connect between cloud services. Therefore, SaaS considered as systems hardware and storages resources. Figure 1 illustrate the structure of cloud computing services.

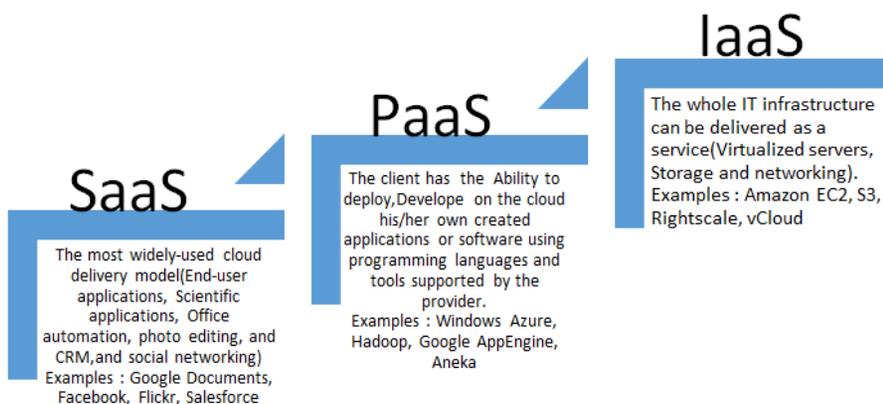


Figure 2.4: Basic Service Layers of Cloud Computing with some selected Cloud service providers for each layer (author)

## 8- Cloud Deployment Model "Types of clouds"

There are four different types of cloud and each of cloud computing deployment approach has its own characteristics such as costs, security and availability, and the organization can decide the suitable deployment approach for its businesses based on working environment.

### A. Public Cloud:

Public cloud is deployment approach that allows organizations or users to use the cloud resources. Therefore, public cloud uses WWW networks as infrastructure to communicate between customers and cloud resources. The main advantage of this approach is globalizing the business markets which give the organization the opportunities to maximize their consumers and publish their products widely.[10][11][12]

### B. Private Cloud:

In this model the cloud resources are not shared by unknown third parties. The cloud resources in this model may be located within the client organization premises or offsite. In this model the clients security and compliance requirements are not affected though, this offering does not bring the benefits associated with reduced capital expenditure in IT infrastructure investments.[13] For example, a company may host email in their own private cloud, but archive email in a provider's public cloud.

### C. Hybrid or heterogeneous cloud:

It is a combination of public and private cloud models or more clouds that try to address the limitations of each approach, but are bound together by standardized or proprietary technology that enable data and application portability. In hybrid cloud, part of service infrastructure runs in private cloud while the remaining part runs in public clouds. Hybrid cloud offer more flexibility than both public and private clouds.[10][11][12]

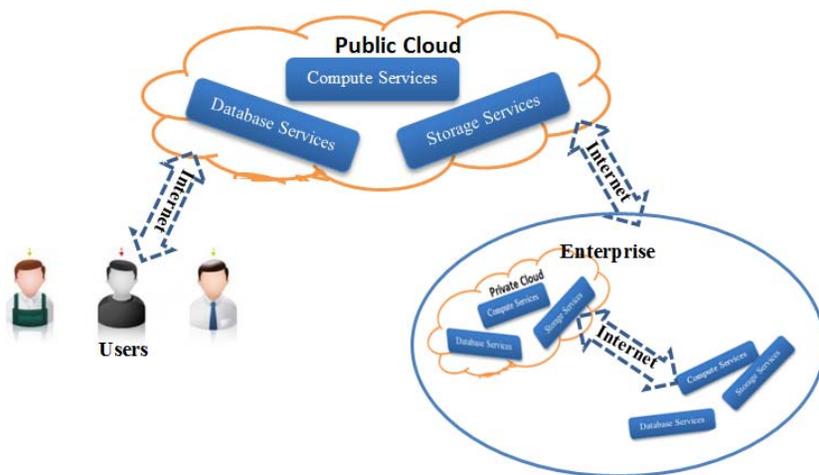


Figure 2.7: Hybrid Cloud (author)

### D. Community Cloud:

A community cloud contains features of both the public and private cloud models. Like a public cloud, the community cloud may contain software, data storage, and computing resources used by multiple organizations. Where this model differs from the public model is that the infrastructure is used exclusively by a group of organizations known to each other. [10][11][12]

### 9- Cloud Computing in Higher Education HE:

The educational cloud computing industry is still in the beginning. Nevertheless, cloud computing has potential to play a wide and significant role in education technology in the near future. It is because now cloud computing spreads fast in all industries.[14] In recent days, many research institutes are struggling to adapt Cloud Computing for solving problems that

are continuous increasing computing and storage. There are three main factors interests in Cloud Computing[15]:

- 1- Rapid decrease in hardware cost and increase in computing power and storage capacity, and the advent of multi-core architecture and modern supercomputers consisting of hundreds of thousands of cores. The education industry now faces a new set of challenges that is driving a fundamental transformation across the education. Their customer demographics, behaviors and expectations have changed. They face revenue pressures along with increasing sensitivities from their customers on the return on investment for dollars spent on higher education. [16]
- 2- The exponentially growing data size in scientific instrumentation/simulation and Internet publishing and archiving.
- 3- The wide-spread adoption of Services Computing and Web 2.0 applications. The Cloud Computing trend of replacing software traditionally installed on campus computers (and the computers themselves) with applications delivered via the internet is driven by aims of reducing universities' IT complexity and cost [17]. Cloud Computing could be a technological innovation that both reduces IT costs for the college and eliminates many of the time-related constraints for students, making learning tools accessible for a larger number of students [18]. There are many benefits of cloud computing for educational institute and below are listed a few of them:
  - With cloud computing, universities can open their technology infrastructures to businesses and industries for research advancements.
  - The efficiencies of cloud computing can help universities keep pace with ever-growing resource requirements and energy costs.
  - The extended reach of cloud computing enables institutions to teach students in new, different ways and help them manage projects and massive workloads. When students enter the global workforce they will better understand the value of new technologies [19].
  - Cloud computing allows students and teachers to use applications without installing them on their computers and also allows access to saved files from any computer with an Internet connection [20].

## 10- A proposed work:

The research suggests five phases or stages as One of solution for ensuring a successful transition to the cloud, as shown in figure (4.1), it will be discussed below.

This five stages are like a roadmap help the universities and any organization to do self assessment before adoption to the cloud computing.

When undertaking any major technology initiative, it is necessary to carefully define objectives and requirements, aligning them with the business needs as well as the technology architecture and strategy. It is also imperative to understand the risks and develop plans for mitigating them. This approach is critical in order to maximize success and return on investment.

As mansion The five (5) stages in the adoption of cloud computing project are: feasibility study, planning, integration, migration and management.

### Stage1: Feasibility study:

- In this preparation or initial stage, management support and decision makers will start by discovering how much cloud computing is already taking place in their education institution, and understand cloud service offerings, benefits, the risks, and best practices. The university should evaluate the costs, benefits, project scope, and operational changes to successfully migrate to a cloud computing technology. so as to analyze the strengths, weakness, opportunities and threats of existing systems a SWOT matrix is useful. [21]
- It good idea for ensuring a successful transition to the cloud is to turn to a professional services group” University IT experts” for assistance in developing a strategy that best suits your college or university’s needs. This team of experts will work with university IT teams to create a wish list for making the transition to the cloud easier, like:
  - Choice of provider, partners, and cloud-computing solutions.
  - Alignment with business strategy and goals.
  - A comprehensive, architectural approach.
  - A full service and solution offering with robust security.
  - Measurable benefits such as time-to-market.

This idea will save a lot of costly mistakes from happening, and the university can call at least one external cloud expert who will give professional, expert, and practical advice as that is their area of expertise.

University IT experts should evaluate their cloud services and architecture security risks, focusing on protecting access and providing on-demand security options within a services catalog for their users. □

- The university should work with experts who have extensive experience in multiple technology areas, such as virtualization, service orchestration, automated provisioning, and the security that underpins network architectures, so it should think about formal and informal training to introduce cloud concepts, where possible, tied to early projects. In other word, the human pillar is very important for the framework to work; so the management of university should take it upon themselves to develop the personnel that will be specialized to work in the university cloud.
- The personnel should be trained in all the aspects of datacenter technology, in most of the operating system and any technology related to cloud. The training will enable the university employees to support the cloud computing efficiently. Training also should be diversified to vendor specific platform; it should be the responsibility of all vendors to train the personnel on the specific products they install in the datacenter.
- Existing Web workloads are ideal candidates for this early phase of adoption such as web applications that are not linked to sensitive institutional data, as an initial step to experience and measure the effectiveness of cloud computing and a candidate cloud computing service provider.

## Stage2: Planning and Design:

After the university decides to start adopting cloud computing technology, practical steps must be taken to explore more about technology, its mechanism, how to use it, then the university IT supports build a plan proposed, detailed architecture design, data-center-specific expertise, and security designed from end to end.

The University IT experts build prototype for [22]:

- 1- Election the right deployment model, so As it is recommended, the hybrid model is the best deployment model because it combines the strengths of the public and private clouds and handles their weaknesses more efficiently. The hybrid cloud provides scalability without boundaries; it is more cost-effective, gives the needed security, and offers great flexibility by giving its users the opportunity to explore different operational avenues.
- 2- Choosing the most suitable service models: For instance, using IaaS delivers everything: servers, storage, space, and networking equipment as a service. PaaS provides the platform for application developers to build and host their applications whereas SaaS provides complete applications to the end user of the cloud service; it only requires that the user has a web browser and is connected to the Internet.
- 3- Vendor or provider service selection: it is extremely important to investigate into the selected vendor before outsourcing.

After Guarantying the reliability of the vendor, the next step is to know where the data will be stored; this is important because different countries have different laws on the right to information in the land, information security, privacy, data protection, and different levels of restrictions; therefore, it is important to understand the local data protection requirement of the country or location where the data will be housed before commitments are made.

4- Negotiating the service level agreement (SLA): The SLA is a very important document; it is a binding contract between the university and the cloud service provider. The terms of the SLA should be negotiated and agreed upon by the university and chosen vendors before the deal is signed. Among other things, the agreements should include the following:

- Planned downtimes by the vendor to check bugs, do maintenance, and updates should be scheduled at times when the impact will be least felt. For example, at midnight of the university's location and preferably over the weekends; such times should be communicated to the university beforehand.
- In the case of service transfer to another vendor, a seamless transfer without delay, downtime, and data loss should be assured.
- Besides the service costs, all hidden costs within the documents for extra charges of any kind and terms and conditions written in tiny

fonts should be made clear and properly understood by the university before the SLA is signed to avoid any misunderstandings in the future.

- The chosen vendor should assure 99.9% availability and have an immediate data recovery plan in case of any disaster.

The university decide the services that needs migration and the services that needs to kept with the institute are decided.

The resulting of this stage is including an end-to-end architecture for example a migration roadmap, a common control framework, a security technology framework, physical safety and security, and the future cloud services evolution, particularly with respect to integration with internal systems.

### **Stage3: Integration:**

The main activities in this phase or stage are:

- This phase will mark a growing acceleration to cloud adoption. The IT experts will begin to integrate The systems application to ensure that the candidate applications will be able to function with the internal applications that are not migrated to the cloud and also with the cloud infrastructure of choice.
- This phase will see the initial development of university structures, as well as service design and development to support the growing needs of cloud environments. Outsourcing strategies are decided upon and the benchmarks developed in the planning stage. collaboration with service provider is crucial in establishing SLA agreements and different security policies and best practices to ensure compliance and trust as it is palned in the second stage. The last thing in this stage is contract development and signing that meets the user requirements for using cloud services.

### **Stage4: Migration:**

It is the migration of the data and applications to cloud, where the migration or transition to the cloud may be achieved gradually starting from testing a pilot project in cloud and the finalizing the application chosen for the cloud “smooth migration from your existing environment to a cloud utility computing architecture, while helping ensure adherence to plans and enabling on-time delivery of a fully implemented cloud-computing model”. This stages has include of other activities like:

- According to above, the universities determine which applications to move into the cloud first, which applications to move later, and which applications should remain in-house, sometimes we need to Categorize databases to determine what can move as a service. Moving a collection of applications and their associated databases may be easier than moving component parts of the service. Migrating systems without evaluating or adjusting resource needs will limit the financial benefit of migration[23].
- University might replace a technology that does not support public cloud deployments[23].
- There will be services that don't make sense to move to the cloud or that need to have at least some on-premises component (e.g., DHCP, DNS, and Authentication).
- The university should consider the sensitivity of their data, and decide if and how they will encrypt their data while it is in transit and while it is at rest. The university can set highly granular permissions to manage access of a user within their university to specific service operations, data, and resources in the cloud for greater security control. Security should be designed in at every layer of the environment. Institutions should require the use of two-factor authentication where possible and use a least privilege design model.
- Selecting the vendor based on set benchmarks as it is planned in second stage, and put the plane stage into practice.
- One of the very important activities in this stages is supporting and providing adequate training to all users for successful migration.
- It may be need to contract development and signing that vendor that meets the user requirements for using cloud service. It is also important to understand these important basics regarding cloud providers.[23]

### **Stage5: Management, Optimization & Maintenance:**

The project now should be fully ready in the cloud. There are some points should take it in this stage:

- This stage is for contact management, vendor management, Ongoing maintenance, user support, architectural reviews, security audits and process improvements.
- Monitor and control the project to ensure successful migration.

- University will need to understand how backups, snapshots, and data restores to development and test systems map from current practice to the cloud.

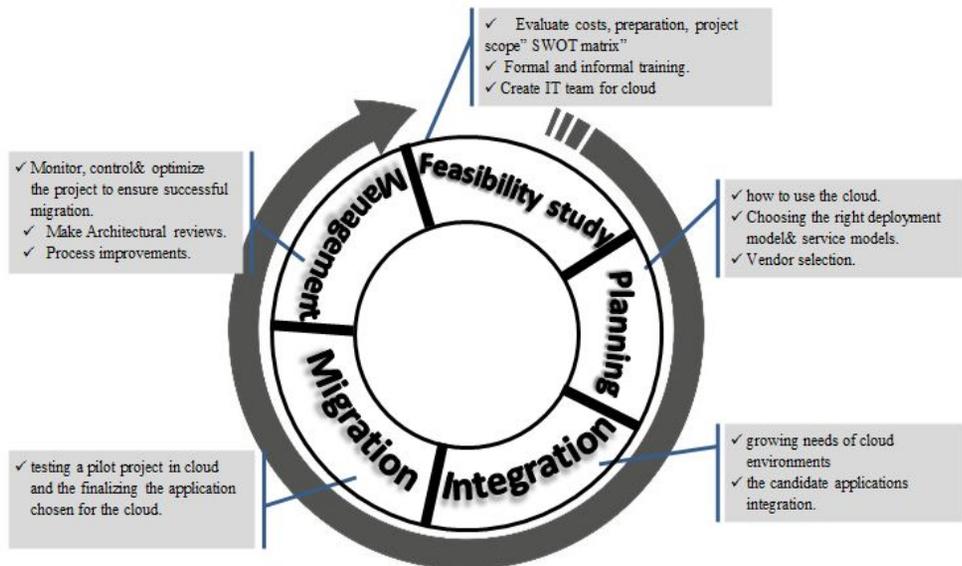


Figure 4.1: Roadmap to Cloud Computing Adoption (author)

## Overcoming Concerns of Cloud Adoption:

### 1- security and privacy concerns:

the greatest barrier to cloud adoption continues to be security. In fact, a recent poll shows that 65% of universities list security[24]. There are Five Steps for Building a Secure Cloud:

#### Step 1: Plan:

The best way to approach cloud security is to integrate it with your overall cloud planning early in the process(understand your risk tolerance, identify the best deployment models for your specific needs, and detect potential exposure points for sensitive data and processes. With a private cloud implementation, since you own the infrastructure, security is under your own control. You establish security and compliance standards, as well as enforce and measure them[24].

## Step 2: Protect your hardware and infrastructure:

A best practice for cloud implementation is to layer technologies to develop a strong security net that protects your data, applications and platforms, and network at all levels.

## Step 3: Secure your data:

Of course, as you move workloads to the cloud, your priority is to keep your data out of the wrong hands. The main targets to hit when you implement a data security plan are Data Loss Protection, Email Encryption, and Data Encryption as the following:

**Encryption:** Encryption is an effective, well-established way to protect sensitive data. This is the process of changing or transforming information into a form that cannot be understood by any unauthorized person. In another words, the data are translated into a secret code that cannot be understood by anyone else except those who have the code or password to decrypt the encrypted information[22].□

The provider and vendor allows you to encrypt your data in your owns private environment, after that you can upload the data, so nobody can decrypt or see your data even the provider itself.

Encryption is the main method used to ensure the security of data stored in the cloud[22].

**Digital signature:** an electronic signature used to authenticate the identity of the user of the services provided over the cloud, by using this technique, the user must provide the appropriate login or access credentials before they can have access to the information or application they want to use. This will help to ensure the authenticity, accountability, and integrity of data in the cloud[22].

## Step 4: Gradual sequence of migration:

The migration toward cloud should not be done all at once, as much as the cloud offers cost savings, increased agility and efficiency caution should be taken and the movement gradual with low risks applications going first. This will give the university time to see whether the cloud project or the chosen vendor is worthy if so, then the other applications can be moved step by step.

## Step 5: Choose the Right Cloud Service Provider:

The chosen cloud provider(s) security measures and the kind of security mechanisms, infrastructure and configuration in place to ensure the safety of data stored on their cloud, should be thoroughly investigated. Also, the plan for security events by the service provider detailing the responsibilities and actions to be taken in the event of a security breach should be understood, analyzed, and ensured to be in line with the required standards set by cloud computing bodies like the NIST (National Institute of Standards and Technology) and the CSA (Cloud Security Alliance) to ensure that the right level of security is provided by the cloud vendors to their clients and there are appropriate backups in place in case of any problems or the occurrences of disasters like fire, flood, or earthquake[25].

This investigation is necessary by adopters of the cloud technology in the educational sector to ensure constant availability and confidentiality because of the level of privacy that is required to preserve research results and other confidential information.

Finally, in another word Cloud providers must maintain confidentiality, integrity and availability (CIA) by establishing security requirements to satisfy educational cloud computing systems. Some of these requirements are identification and authentication accounts for students, faculty members and administration staff to verify and validate each individual by username and password. Some need control permissions, priorities and resource ownership (authorization). Encryption techniques should be employed to protect sensitive data of institution such as exams, grades, etc. from tampering or unauthorized access. There is also need to ensure non-repudiation in some circumstances which means the transactions cannot be denied using time stamps, digital signatures and confirmation receipts [26][27][28][29].

### 2- Reliability of the service provider concerns:

The reliability of the service provider -in other words trust - is a major obstacle and barrier to the adoption of cloud computing.

Reliability has also been an issue for cloud users. For example, in february 2008, Salesforce.com customers were without service for 6 hours while Amazon's S3 simple storage service and EC2 experienced 3 hours outage in the same month a few days later and 8 hours outage in July[30].

Cloud service providers needed to be reliable and trusted so that adopters of the cloud technology can be confident to entrust their vital information to

them for safekeeping. The need to look up, properly research, and make a comparison between different cloud vendors to ensure reliability of the chosen vendor cannot be overemphasized.

This is because information is the live wire of universities, and all efforts should be put in place to ensure that moving to the cloud brings true relief, solutions, and improved services. These can only be achieved, and the promises of the cloud enjoyed if the cloud vendor used is reliable and trustworthy. To achieve this and overcome the barrier posed by lack of trust and reliability of cloud service providers, the following guidelines should be followed:

**Reliability and availability:** To ensure that the services in the cloud are reliable and up and running well at all times, reliable cloud vendor is required. The chosen cloud service provider should be one that guarantees service level, uptime and availability 99% of the time. It was mentioned that an 100% availability is impossible[28][29].

The chosen vendor should have redundancy of power, cooling systems, security system, servers, storage, excellent Internet connection, and fire suppression systems among other things to ensure that the required services are consistently and constantly available.

**Reputation of good track record:** The chosen cloud vendor should be one with good track record; this can be ascertained by how well their services function properly without frequent downtimes and when they occur, how long they last before service is fully restored. The reasons behind downtimes and frequency of occurrence should be considered, this information can be gotten by finding out who their customers are and how well they have enjoyed or not enjoyed the services of the vendor. This should be carefully considered before data are moved to any vendors' data center.

**Providing security in the cloud:** The university must be assured of tight, well-defined security services in the cloud before they employ the services of any vendor. These security services include identity management, access control as well as authorization and authentication mechanisms to ensure the right level of control within the cloud environment and that only authorized personnel can make any changes or additions to the data and applications in the cloud as a way of ensuring the security, privacy, and confidentiality of data. The service provider should have a comprehensive security infrastructure in place at all levels of the services they provide.

**Service Level Agreements SLA management:** The cloud vendors should give guarantee by providing service levels for all services they are offering and ensure to meet the requirements of the SLA. The SLA should be negotiated to meet the expected level of service quality and should include refund guarantees or some kind of penalties if the promised service level is not delivered. This will keep the service providers on their toes to meet up with the terms and requirements of the SLA and the clients assured of quality service delivery. Also, the copyright laws as contained in the vendors' SLA and that of the location where the vendors' infrastructures are located should be carefully considered before commitments are made.

Moreover, the choice of the cloud vendor should be one that is transparent in their dealings with clients and follow the code of practice unique to them as university and also that provided by cloud regulatory bodies to ensure the provision of highly secured and efficient services to their customers and be willing to explain any ambiguities and provide clarity to their clients when needed. The service provider's chosen should be ones that are accountable and live up to their claims and promises.

### **3- Bandwidth:**

Internet bandwidth is the backbone of the internet-based educational services. The quality of service relies on the connection speed, which can require investment in the network infrastructure[27][29].

### **4- Lack of Skills, Knowledge and Expertise:**

It's different in the cloud, and many IT universities may not have the necessary tools or resources to implement, monitor and manage cloud solutions. It's not what they are geared to do. Educating staff about new processes and tool sets, or hiring staff with new skills, may be necessary. increasingly so as more of your operations and applications move to the cloud over time. Selecting the right service provider will definitely help ease the transition and fill gaps.

**Integration with Existing Infrastructure:** This is a difficult yet essential piece of maximizing the value of cloud services. Frankly, after time it will be not a problem because we need with time to develop the university's software and hardware and also not problem gains to the benefits from cloud services into university.

## 11- Cloud Computing Framework for Yemeni Universities CCFYU:

Hybrid Cloud is one of the Cloud Computing deployment models. It provides the ability to access, manage, and use third-party (vendors) resources from multiple Cloud Service Providers (CSPs) and combines them within in-house infrastructure the framework needs to deploy a hybrid cloud as the most suitable deployment model for universities. Deploying the hybrid cloud will offer cost benefits to the management of the university. with the hybrid model, the fear of privacy and other security-related issues are avoided, as very critical and sensitive data whose confidentiality cannot be compromised will be hosted on premise in the university's datacenter, which serves as a private cloud, and the private cloud is owned and managed by the university and its accessed is limited only to students and faculty, staff of the university.

The research proposed that the public cloud should combine the services of different cloud service providers or third-party to serve students and staff of the university more efficiently as well as avoid the problem of vendor lock-in.

Thereby Using such a model allowed us to avoid lock-in and was blocked with one CSP by allowing mix and match services from different CSPs[31].

The framework's candidate is an open-source project called OpenNebula which can support on-demand VMs provisioning, pre-configured, and manage groups of interconnected VMs; thus, OpenNebula enhances the integration of external providers (CSPs) to enable the selected model of deployment. OpenNebula is growing very fast to meet the industry and developer requirements.

Using OpenNebula gives the ability to manage the local infrastructure and establish the first step toward hybrid Cloud solution by interfacing with a remote Cloud site.

OpenNebula's main role is to manage the VMs[32].

The following figure shows the architecture of OpenNebula:

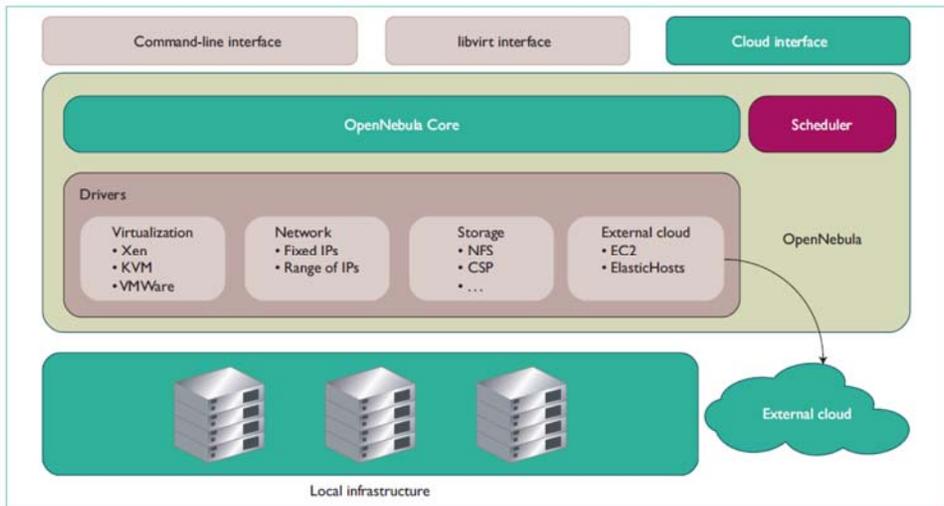


Figure 4.2 OpenNebula virtual infrastructure engine components.

(Peng, J., Zhang, X., and others, 2009).

using Aneka as a reference platform, It supports a collection of programming abstractions for developing applications and a distributed runtime environment that can be deployed on heterogeneous hardware (clusters, networked desktop computers, and cloud resources)[34].

Aneka provides software infrastructure for scaling applications using broad collection of APIs for the developers to design and implement applications. Aneka gives developers the ability to run their application on a local or remote distributed infrastructure which supports the hybrid Cloud deployment model. The figure shows Aneka framework architecture:[34]

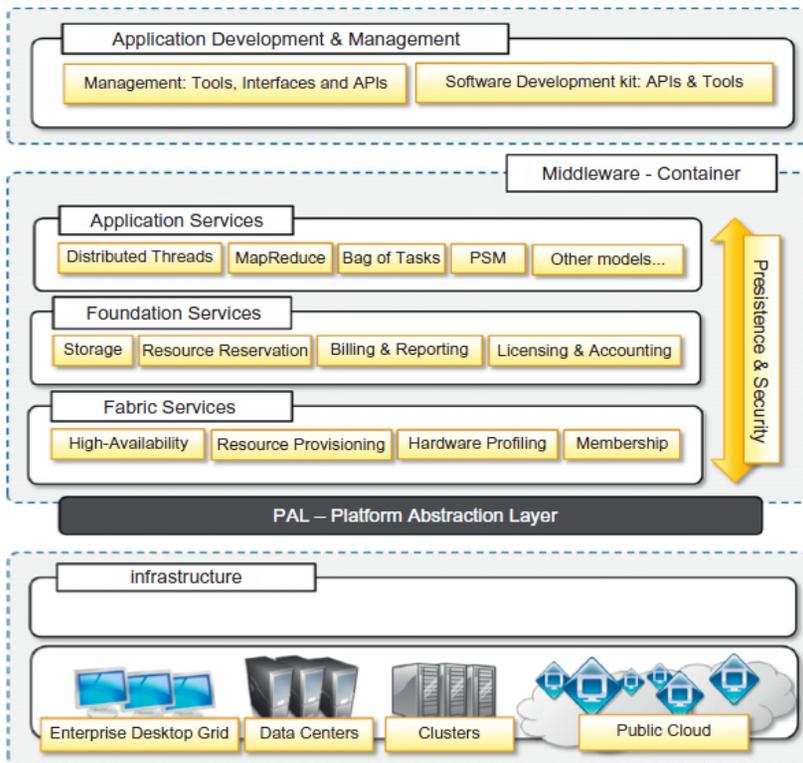


Figure 4.3 Aneka framework architecture[34]

As shown in the above figure, the Aneka framework architecture contains three different layers corresponding to the basic service layers of the Cloud Computing easily integrated with the external Cloud. Aneka enables the execution of the application on its runtime environment by using the underlying Cloud infrastructure for either private or public Clouds. It provides management tools; administrators can easily start, stop, and deploy any application. The Aneka platform contains three classes of services which characterize its middleware layer:

1. Execution Services: Their primary responsibility is scheduling and executing deployed applications.
2. Foundation Services: They represent the collection set of management services, such as metering applications and resource allocation and updating the service registry whenever needed.
3. Fabric Services: They present the lowest level of middleware services classes. They provide access to Cloud resource management to enable resource provisioning which will scale the allocated resources to the applications to achieve the required QoS[31].

Layer of proposed cloud:

### **1- The Software as a service (SaaS) layer:**

The SaaS layer represents the top layer of the cloud. It offers its services in a software model of web-based applications and serves a large number of users.

User will connect to internet and has many services such as e-learning systems, admission process, ERP systems, research, faculty and student corners, admin, digital library, email, account and financial processes, student life cycle and information system, classroom management system, and other administrative processes can be hosted on the SaaS layer for easy access and convenience for students, academic as well administrative staff of the university.

With SaaS, the user does not need to install or run any applications on their devices or worry about maintenance, upgrades, and support.

This layer divided into two sections that are the public cloud and private cloud, the most sensitive applications such as the admission process, account and financial services, and any other services considered critical and requires very high confidentiality should be hosted on a private cloud.

The SaaS services on the public cloud can be provided by cloud vendors such as Salesforce.com, Google, and Sky-Drive. Using SaaS will help to overcome the problems of limited modern teaching and learning resources and lack of e-learning scalability.

Using Microsoft Word or Microsoft Access, for example, as a hosted application on the Cloud by SkyDrive or Google Apps is considered as a component for this layer.

### **2- The Platform as a service (PaaS) layer:**

The PaaS layer is the middle layer between the SaaS and IaaS. Universities member can Develop, test, deploy, and manage applications hosted in The PaaS layer.

The PaaS layer facilitates the development and deployment of applications without the developers worrying about Provisioning and management cloud infrastructure and middleware for the platform consumers and provides development, deployment, and administration tools to platform consumers because it is provided by the cloud vendor.

This layer provides access to different platforms and programming languages, thereby making it possible for developers and programming students to easily do their work by simply connecting to the cloud.

This layer provides access to different platforms- programming language, distributed systems, net centric systems and similar platforms. For example for candidates taking Distributed Systems, building a distributed system or simulation needs control of the number and the IPs for the VMs with a platform to host the developed application. For the Information Systems Management and DB systems, they are able to build more sophisticated systems and distributed DBs using different tools to manage these systems and DBs. In the PaaS level, the user can access the VM level with some limitations, and with this access, they are able to control part of the networking issues, such as IPs and routing mechanism which help in teaching Net-Centric computing courses for the beginner. For the Computational Science course, they can build a temporary multiprocessing system using multiple VMs to solve an existing problem quickly and efficiently. Researchers and developers use PaaS for their work simply by connecting to the cloud.

This layer also divided into two sections private and public cloud, many public services can be hosted on a public cloud using Force.com, Microsoft Azure, Google App Engine, and other and the private system to the university is required to authentication and control access.

### **3- The Infrastructure as a service (IaaS) layer:**

It is the bottom layer. It is referred to everything as a service layer provides basic computing resources including servers, storage, hardware, and networking equipment. University Creates/installs, manages, and monitors services for IT infrastructure operations.

The IaaS layer gives more flexibility when dealing with the Hardware layer but through the virtualization.

This layer includes the operating system, bandwidth, and virtualization technology needed to manage the resources. Universities can deploy and run arbitrary software. The users of IaaS can be system developers, system administrators, and information technology(IT) managers who are interested in creating, installing, managing and monitoring services for IT infrastructure operations, thereby this layer is sensitive need to access authentication.

One of the key players in the IaaS layer is Amazon E2C (Amazon Elastic Compute Cloud), it reduces the time needed to get and boot up new servers to minutes, it allows quick scaling capacity back and forth as demands change and provides a computing environment and resources that quickly and cost-effectively process large amounts of research data. Other providers of this service are HP, GoGrid, Rackspace, and so on[22].

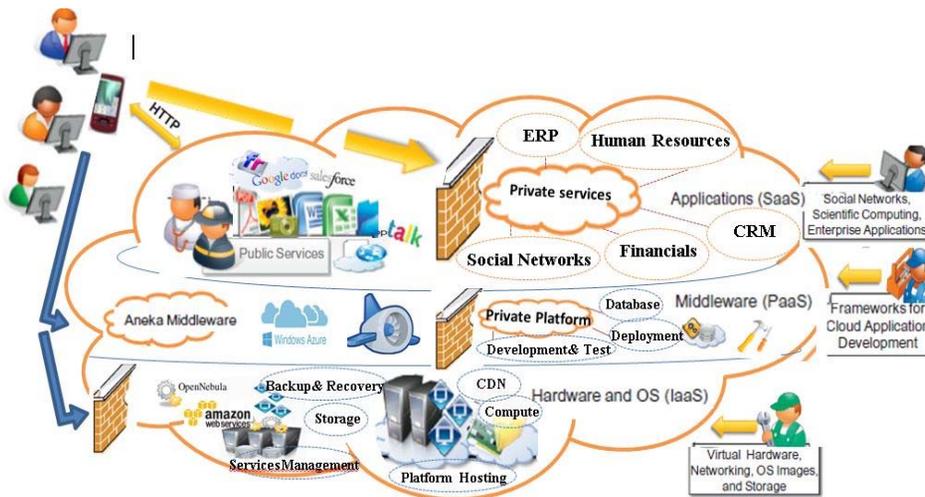


Figure 4.4 Web services Framework for University environment in cloud. (author)

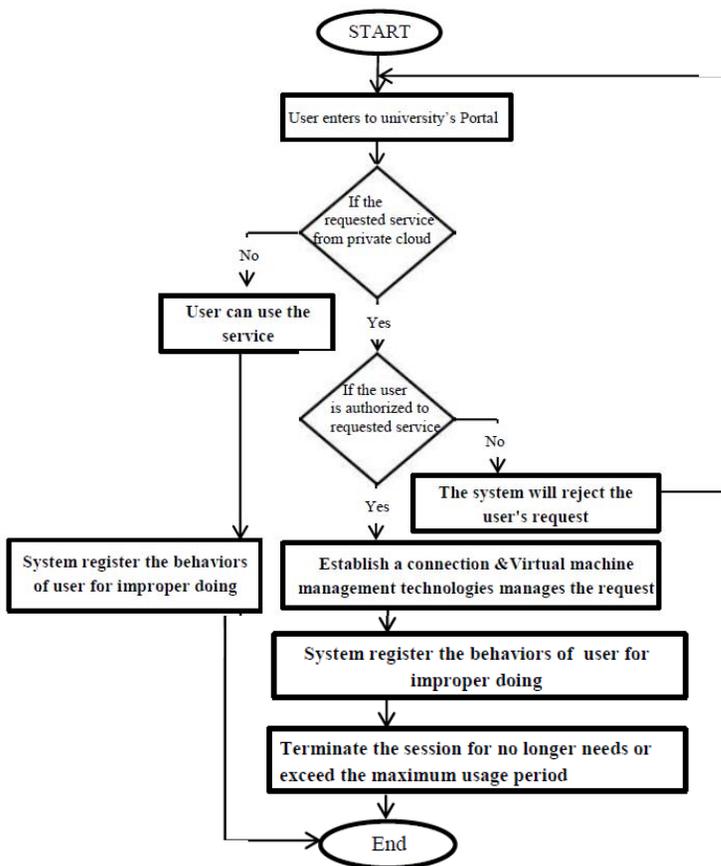


Figure 4.5 Cloud Computing Structure Flowchart for University environment. (author)

As shown in the tow figures above shows an overview of how the content could be in the Cloud:

- 1- The user sends a request using the University portal.
- 2- If the user request is for public service the user can enjoy with service.
- 3- If the user request is for private service, The verification of the authorization level will be checked using the user profile private Cloud.
- 4- If the user is unauthorized to request such services, the system will reject the user's request; otherwise, the request will be sent to the virtual infrastructure manager (OpenNebula) or Aneka to redirect the request to the appropriate service.

- 5- The system will establish a connection between the requested service from the Cloud and the user.
- 6- As long as the user needs the resource and does not exceed the maximum usage period, the system synchronizes the service delivery between the user and the resource.
- 7- When the user is done and no longer needs the requested resource, the system will terminate the session and disconnect the user from the target Cloud.

## 12- Conclusion

Cloud Computing paradigm is a new approach to produce a solution for old problems.

In a NY State CIO Conference in July 2009, the Vice President of Educause, Richard N. Katz, spoke about “The Tower and the Cloud: Higher Education in the Age of Cloud Computing.”[30]. He cited a poll that sensed how people felt about the role of cloud computing. In a nutshell, 74% of those polled thought that cloud services will have a great effect on higher education while 75% thought the same for their IT organization. [30]

It will become an essential source of e-learning in order to give the opportunity for students and teachers and the whole university department to quick access to various applications, systems and resources through the Internet, and share files and documents, and the exchange of duties and projects among students, a challenge that must overcome the comprehensive coverage of the service and fast Internet access, to enable the student to take advantage of this technology applications.

Cloud computing is an excellent alternative for educational institutions which are especially under budget shortage in order to operate their information systems effectively without spending any more capital for the computers, network devices and others.

From the points of advantages provided by cloud, there is a great advantage for university IT staff to take them away the responsibility of the maintenance burden in the university.

As any new technology develops and becomes popular, new issues have to be faced.

Cloud computing is not an exception, however Security, privacy and service-level agreements issues continue to be the biggest concern on cloud computing that limits its adoption in practice.

This condition poses challenges for confidential data, which organizations can't afford to reveal.

They continue to raise many questions for their CSPs such as where is their data located and who manages and accesses it, why is their personal information requested and who uses it and what is the fate of their data in case of disasters or when the CSP went out of business.

It is not surprising that much of the future work in cloud computing will focus on developing approach that are able to address its security issues.

It is very important to Make sure that the vendor has adequate staff that possesses legal and contracting skills to control your risk.

However, it is strongly recommended that early adopters plan the transition carefully and have a planning team in place to plan and oversee the cloud project, in order to ensure a uniform and smooth transition.

The research shows that hybrid cloud computing is a better choice for deployment in the universities since it gives the combined benefit of private and public clouds.

We have proposed roadmap and framework for adoption to cloud computing smoothly.

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