THE ARCHITECTURE OF CLOUD COMPUTING FOR EDUCATIONAL ENVIRONMENT IN INDONESIA

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ABSTRACT
Information and Communication Technology (ICT) based Education has become a new trend in education of Indonesia. Nowadays, the number of educational institution have implemented this practice for their environment as supporting educational processes is more increasing. However, there are several factors inhibiting this implementation such as: inadequate infrastructure, not well integrated service, lack of competence in managing, and the standardization of the implementation strategy was needed. At the same time, Cloud computing has been a hot topic and a new business paradigm for education. Cloud computing is closely related to provision large resource computation which can provide added values for educational environment. In this paper, we introduce the architecture of cloud technology for educational environment to accommodate all interests and needs in this area. The architecture was designed based on Cloud taxonomy that provide flexibility, customizability, extensibility, and reusability that fit the dynamic educational environments.

Keywords: architecture, cloud computing, ict-based education

1. INTRODUCTION

Geographically, Indonesia comprises of many islands which consist of more than 200 million people in around 2 million km^2 (National Portal, 2010). In 2010 (Education Statistic Centre), there are approximately 3011 higher education spread across in 12 regions where around 50 % of them located in Java. Their qualification of lecturers was still poorly. There were only 5% Doctoral degree, 32% in masters degree and 56% of them earned a bachelor degree. Dramatically, most of them (59%) work in Java. The spread of students were not balanced yet, almost 64% of them build their knowledge in Java and others outside, and meanwhile the availability of academic programs at each higher education was also still limited. These was indicated that only available 1.99% PhD Programs, Master Programs 8.69%, and 58.55% bachelor level (Sailah, 2011).

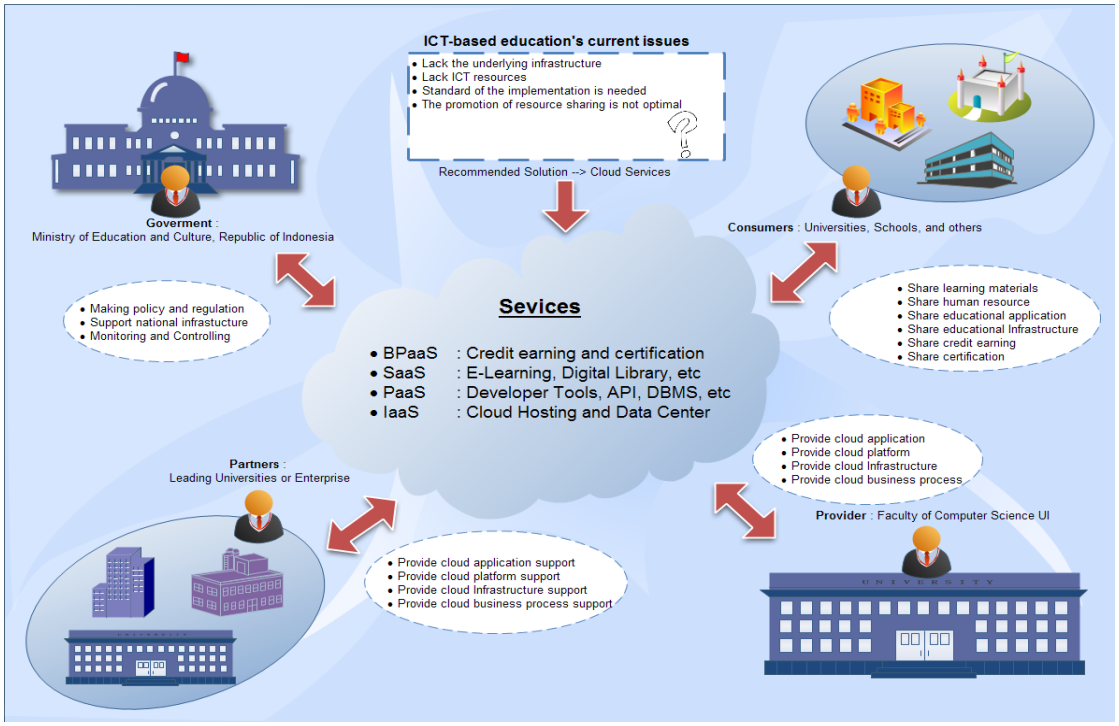

Figure 1. Rich Picture of Cloud Computing for Educational Environment

This condition reflects how resource persons to some degree centralized in Java. It also means that access to quality education is still becoming a major issue in Indonesia and definitely will impact the quality of human resource development.

Officially, the government has released several projects related to the implementation of ICT-based Education in Indonesia. For example, the distance education projects in various levels such as: Edukasi Net, PJJ PGSD, and Rumah Belajar. To support the distance education, the government has also released INHERENT project; development of a network infrastructure which connecting the variety of higher education in Indonesia to promote resource sharing culture. In Addition, in early 2010 the government also initiated the integration of research publication from various universities in GARUDA project (Garba Rujukan Dijital). However, the utilization of all projects has not been optimal.

ICT-based Education supposed be a tool that provides a quality education, equally, and economically reasonable. In fact, the practice is still facing many obstacles, including:

Educational Services – There are so many business processes in higher education. It starting from administrative services likes student admission, financial services, until the learning process. Each service has its own application and each of them is almost certainly are not well integrated. If related to the theme of resource sharing, definitely not an integrated environment will make the process of resource sharing is so difficult.

IT Governance – This is responsible for managing all matters relating to the implementation of ICT-based Education. In technical area, educational institution should have qualified technical capabilities to manage the implementation. Ironically, there are still many educational institutions force the implementation without a qualified technical people, so the results are not optimal and do not in line with the goals of the implementation. Therefore, we need collaborative governance in which each institution can be mutually responsible to managing the implementation nationally.

Infrastructure – Infrastructure is one of essential component in the provision of ICT-based Education. However, investment cost for purchasing and managing (e.g., operations, upgrades, etc.) the infrastructure is relative expensive. Consequently, the implementation often use inadequate infrastructure, whereas we need high computational resources, large storage capacity, and high speed access to conduct this practice.

Exactly, this condition was a constraint, particularly on carrying out the vision of Ministry of Education and Culture that related to educational equity and implementation of Indonesian Qualification Framework which has launched recently. Knowing these issues, we need a different concept on its implementation; how it provides educational environment easier technically (e.g., operating, managing, maintaining, and expanding the implementation), requires lower budget so educational cost is more decreasing, can be integrated with various educational environment to realize the resource sharing, automated system to support self managing, and standardized in educational processes to avoid disparities in educational quality rather than ongoing practices.

At the same time, Cloud Computing has become a research hotspot among future technologies. Cloud Computing is closely related to Grid Computing technology that utilizes the computer resource through improving utilization rate, decrease energy consumption (Zhang, 2010) and increase of reliability. Researchers have studied of the application of Cloud Computing in various fields. The implementation of ICT-based Education using cloud technology is one of hot topic in cloud research area.

With the emerging concept and technology of Cloud Computing, we believe that it can be an alternative solution on conducting ICT-based Education. Cloud Computing for education or also called Cloud Education (See Figure 1) provides the required information technology, excellent compatibility and also supplies the basic for integration of platform and technology environment for a variety of scattered of educational resources.

This paper introduces the architecture of cloud technology for national education environment that complements the work of Nugroho and Suhartanto (2010) which proposed some networks topologies for the whole nations. The remainder of this paper is organized as follows. Section 1 elaborates the motivation of ICT-based Education implementation, its current issues, and describes the goal of study. After that, in section 2 we explain the concept of Cloud Education. In next section we overview current Cloud Education architecture. In section 4, the proposed architecture is presented. Final, we provide conclusion and future work in section 5.

2. CLOUD EDUCATION AS A FUTURE TREND

The appearance of Cloud Education along with the growth of cloud technology in business areas which driven by IT companies (e.g., Amazon, Google, IBM, Microsoft, and others). Cloud Education is optimize information technology resources and provide collaboration to enhance educational services by offering various services (e.g., software services, platform services, and infrastructure service, and others) to support educational environment. Cloud Education tends to be a ubiquitous technology where users break the bonds of the constraints of time. It means they can access educational environment at any place, anytime, and anyway using any device.

Cloud Education is a great solution for both educational institutions which only have low budget to move from traditional practice to ICT-based Education paradigm and also for educational institutions which do not have ICT governance and infrastructure required to run ICT-based Education effectively.

This practice provides the scale infrastructure, large of computational resource, dynamic data storage, and high speed internet access is used to maximize investments on educational processes.

There are some characteristic of Cloud Education, among others:

Integrated - Cloud Education is expected to provide centered educational environment, so that each institution in this environment can be integrated at both the strategy and implementation as attempt to promote resource sharing culture.

Ubiquitous Access - The initial concept of ICT-based Education is to enable all of educational stakeholders get educational services without the limited space, time, and how to get it. It means that all of the educational services offered can be accessed through any devices (e.g., mobile device, computer, TV, etc.), from various places (e.g., campus, houses, offices, etc.), and regardless of time.

Efficient - By using the concept of Cloud Computing, the investment cost to conduct ICT-based Education would be cheaper and users can save time in the making, using, managing, and updating of educational services offered.

On-demand Services - On Cloud Education, all of educational services offered can be used according to user's need where they can use it simultaneously or partly.

Elasticity and Scalability - The services offered has to provision the computational resources that can meet consumer needs.

3. CURRENT CLOUD EDUCATION ARCHITECTURE

Several Cloud Education architecture has been proposed by researchers, but they are different each other. To better understand about their architecture, we make comparisons between them (See Table 1) which is based on the layers of cloud computing architecture that is inspired by cloud taxonomy (Prodan, 2009). For each layer we divide it into several blocks, the following layers of the architecture and their blocks, including:

Service Offering – What services are offered by the system based on certain levels; software services, platform services, infrastructure services, and other services.

Operational Management – How does the system managing daily activities. It related to Quality; how does the system ensure the services offered in line with user requirement, Security; how does the system emphasizes the protection of an information asset, Administration; how does the system organizing the activities related to business model to add revenue, Services; how does the system managing their services offered, User; who are the people involved or have a special interesting to the system and what are their roles there, and Resource; what assets are available in the Cloud.

Infrastructure Management – What are underlying facilities needed to support the operational activities. There are three categories of infrastructure, include: Interface Infrastructures; how does the system getting in touch with the users related to the delivery of products and services, Functional Infrastructures; what are software needed to support cloud environment and how does technology and services available on the system interlinked each other, and Physical Infrastructures; what are hardware needed to support cloud environment.

Table 1 show the existing architectures do not meet the cloud taxonomy which is explained in early section. Following our conclusions, including:

- All of architecture has not several blocks such as Administration and Quality, whereas they are essential part must be owned by Cloud architecture.
- Some architecture describes their users commonly, so we do not look the role and responsibility of them.
- Resource management is crucial in the Cloud. Some of them have described how to managing any resources, but they do not explain in detail what resources are.
- To interact with the Cloud environment, we need set of device. Unfortunately, most of them do not explain what any device used are.
- Most of them just explain their services offer in general.

From our discussion above related to existing architectures issues, then we propose a new architecture and we will elaborate it in the next section.

Table 1. The Comparison of Cloud Education Architecture

Architecture Layer	Architecture Block	(Yang, 2011)	(Wang and Huang, 2011)	(Liu and Chen, 2010)
Service Offering	Software Services	E-Learning System	Course Management	Google Apps
	Platform Services			Google Apps Engine
	Infrastructure Services			Google Machine Instance
	Other Services			
Operational Management	User	Schools and Learners	User Management	
	Quality		Management System	
	Security	Security and Identity	Security System	Security Management
	Administration			
	Services	Service Engine, Monitor, and Scheduler		Service Management
	Resource		Resource Management	Data Management
Infrastructure Management	Interface Infrastructure	Notebook, Mobile, and PC		
	Functional Infrastructure	Middleware and Virtual Machine	Virtual Server, Database, and Storage	Memory, Storage, and I/O virtualization
	Physical Infrastructure	Storage	Server, Storage, and Network	Storage and Server

4. THE PROPOSED ARCHITECTURE

Cloud Education is a transformation of cloud computing technology in educational area. It is a future educational paradigm which provision computing resources to virtualization, so that they can be afforded in the form of services for educational institutions, learners, instructors and businesses to utilize computing resources. The proposed architecture (see Fig 2) we called Nan Cenka (National Cloud Education for expanding Knowledge Accessibility) Architecture. It is the development of cloud taxonomy which is provides flexibility, customizability, extensibility, and reusability that fit the dynamic educational environments. Each layer of the architecture includes:

4.1 Cloud Service Offering Layer

Based on the proposed architecture, the four models of services in Cloud Education are:

CCaaS - In this paper we also introduced the Credit and Certified as a Service (CCaaS). CCaaS is the extension of Business Process as a Service (BPaaS) where these services provide a set of policy and regulation that can be used to improve the quality of education. We provide two services in CCaaS block; credit earning and certification. For each services, their policy and regulation is different each other. For example, if learners want to obtain credit earning at a university, they then have to follow the policy and regulations of each institution which provide these services. If all of them are fulfilled, then learners are entitled to a credit that recognized nationally. Meanwhile, related to certification, instructors and learners can also acquire certificate which provided by each certification institution that is incorporated in the cloud environment. Certificates can be obtained in accordance with policy and regulations of each institution and have to compatible with their competencies.

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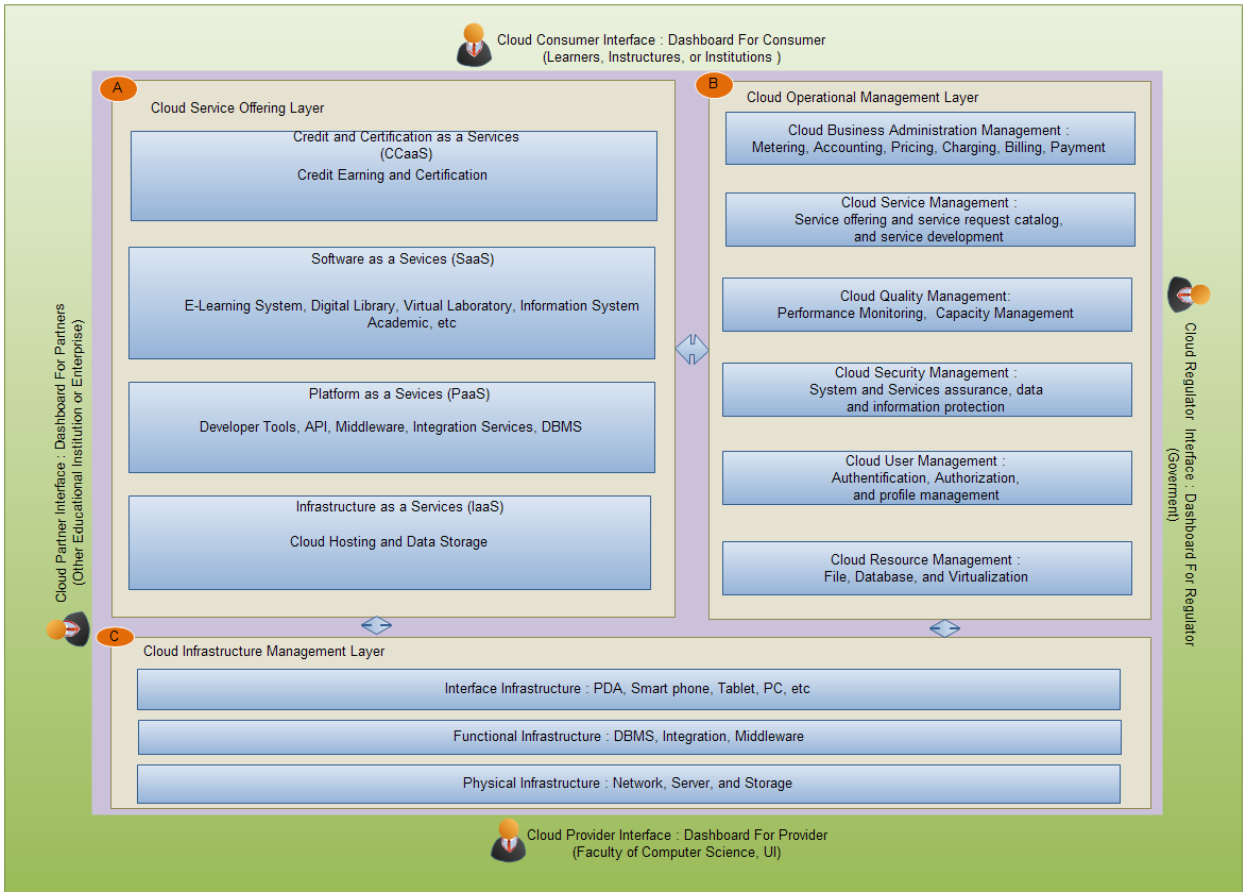

Figure 2. Nan Cenka Architecture

SaaS - Software block comprise of several applications to support educational processes, among other: E-learning system, Digital Library, Virtual Laboratory, Information System Academic, and others. Fortunately, each of them can be integrated both on internal or external institution in Cloud Education environment.

PaaS – Each platform in Cloud Computing provides API, middleware, developer tools, DBMS, and integration services which allow consumer and partners to develop educational services, such as: e-journal, web portal, online recruitment, and others.

IaaS –Infrastructure contains servers, storage, and network to support educational processes. We have two services offering in the block, include: cloud hosting; a cloud service that enable consumer to develop and run educational application, and data storage; a service that allow consumer keep their data on internet.

4.2 Cloud Operational Management Layer

Operational layer is area of management concerned ensuring that business, physical and/or technical functions are efficient in terms of using as few resources as needed, and effective in terms of meeting consumer requirements. Following six components in the layer:

Cloud Services Management – The block provide service offering and service request catalogue. Commonly, consumers using service offering catalogue to list of their services, meanwhile service request catalogue is used by provider to manage the order and then deliver the services for consumer. In addition, service development mechanism is also available in this layer which is guideline for programmer to develop services in cloud.

Cloud Quality Management – There are two important activities in this block. The first is performance monitoring. We must ensure the performance of all the services in the cloud environment is not disturbed by anything. Secondly, capacity management; It is the processes that ensure ICT infrastructure is provided at the right time in the right volume at the right price, and ensuring that ICT is used in the most efficient manner.

Cloud Security Management – Security management is an essential mechanism to convince the users in using their services. System and services assurance, also data and information protected are main activities in this layer. For example, we can use encryption and decryption mechanism to protect data and user information from various attacking (e.g., back-door, spoofing, replay, password

guessing, Trojan horses, malware, Man-in-the-Middle) and from various resource (e.g., device to access the cloud, learning material, or a deliberate attack).

Cloud User Management – In Cloud environment this block is responsible for the authentication and authorization processes and also profile management. This environment includes all involved stakeholder, among others:

Consumer – Through the dashboard, the consumer allows to sign in, operate, maintain, and update their own services. For instance: Teachers and students can utilize their services by using the e-learning system. Another example, librarian can use digital library to manage their collection.

Regulator – In Cloud Education, the government acts as regulator. By using the dashboard, the regulator allows to monitor and control the implementation. For instance: the number of educational institution, the number of instructors and learners for each educational institution, the quality of learning materials, and other information that available on the cloud environment. Based on this information, the government enables to make policy and decisions to optimize the implementation.

Provider – It is responsible to supply overall that related with the implementation of Cloud Education. By using the dashboard, the provider enable to develop, operate, maintain, update, or delete their services offered to others.

Partner – In this practice, the partners is the educational institution or enterprise in collaboration with the provider to offer services for the consumers. Cooperation may include the provision of infrastructure, application development, content creation, and others. Partner enable to running their service using their dashboard, for example: interaction with the provider and costumer.

Cloud Business Administration Management – This block is responsible for managing the accounting process that starts from the identification of what services are used by consumers, register the service, set the accounting records, determine the pricing formula, get the charge record, and then payment process. Some of the functions involved in the accounting process including: metering function, mediation function, accounting function, and so on.

Cloud Resource Management – One of the characteristics of Cloud Computing are resource pooling. This means that the cloud will be made available a variety of resources. Hence, this block is required to manage all the resources available on the Cloud Education, for example: database, file, software, and hardware virtualization.

4.3 Cloud Infrastructure Management Layer

Infrastructures are a core in cloud environment. The Infrastructure management needed to organize underlying ICT facilities (e.g., Interface, functional, and physical infrastructures) on Cloud Education. We divide it into three categories, namely:

Interface Infrastructure – It is the connections between subsystem facilities, people and systems, systems with the system, etc. Since Cloud Education tend to ubiquitous access, so we can use any devices such as PDA, Smartphone, tablet, PC, and others to access learning environment

Functional Infrastructure – We define functional infrastructure as software used to process, manage, and exchange data, such as DBMS, connection between web servers and application servers, between application server and database server, etc.

Physical Infrastructure – It can be defined as physical facilities are connecting various devices, data storage, and computing machines. For example: network equipment, storage to save the data and files, as well as server and its operating system.

Based on our explanation about the proposed architecture, we conclude that: it clearly more complete then existing architecture and cover all matters related to Cloud Education environment, such as who are the users, what are the supporting infrastructures, how to manage their daily activities, and what are services offered.

5. CONCLUSION AND FUTURE WORK

In this era, ICT-based Education has grown into a widely accepted educational model. Through the internet, this practice increased the educational processes without restrictions on time and space. Although it is becoming a new trend in educational area, the delivery of ICT-based Education is still encountered some obstacles, including: high cost investment on infrastructure, there is no standard guideline, and lack of ICT resources to manage the implementation.

At the same time, Cloud Computing becomes hot topic in computer science research area. The essential characteristics of Cloud Computing provide a promising various resources to support integrated services, high computation, and large storage space become key factor why we should use cloud computing to support educational processes.

This paper introduces the architecture of Cloud Computing for educational environment. By combining the characteristics of ICT-based Education and approach of Cloud Computing, we allows to provide educational environment that reliable, flexible, cost-efficient, self-regulated, and quality guaranteed. In the future, we will develop the prototype of this Cloud Education.

REFERENCE

Education Statistic Center, Ministry of Education and Culture, Republic of Indonesia. (2010). *Overview of Higher Education*. Retrieved on 1 March 2012 from http://www.psp.kemdiknas.go.id/?page=statistik

Liu. Y., Chen, L. (2010). Application Modes, Architecture and Challenges for Cloud Educational System. *Second International Conference on Computer Research and Development* (pp. 331 - 334). China : IEEE.

National Portal. (2010). *Indonesian Profile*. Retrieved on 1 March 2012 from http://indonesia.go.id/in/sekilas-indonesia/geografi-indonesia.html.

Nugroho, I.B., Suhartanto, H. (2010). The Design and Simulation of Indonesian Education Grid topology using Gridsim Toolkit. *Asian Journal of Information Technology, Volume 9 Issue 5, 2010*,http://www.medwelljournals.com/abstract/?doi=ajit.2010.263.271.

Prodan, R., Ostermann, S. (2009). A Survey and Taxonomy of Infrastructure as a Service and Web Hosting Cloud Providers. In *Proceedings of 10th IEEE/ACM International Conference on Grid Computing* (Banff, AB, October 13-15, 2009). 17-25. DOI= http://dx.doi.org/10.1109/GRID.2009.5353074.

Sailah, I. (2011). *Directorate General of Higher Education, Ministry of Education and Culture : Policy of Academic Programs*. Retrieved on 1 March 2012 from http://telaga.cs.ui.ac.id/~heru/archives/sarasehan Aptikom2011

Wang, X., Huang, D. (2011). Research on the Architecture of Open Education Based on Cloud Computing. *International Symposium on IT in Medicine and Education (ITME)* (pp. 531 - 535). China : IEEE.

Yang, Z. (2011). Study on an Interoperable Cloud framework for e-Education. *International Conference on E -Business and E -Government (ICEE)* (pp. 1 - 4). China : IEEE.

Zhang, S., Zhang, Sh., Chen, X., and Huo, X. (2010). Cloud Computing Research and Development Trend. In *Proceedings of Second International Conference on Future Networks* (Sanya, Hainan, January 22-24, 2010). 93 – 97. DOI= http://dx.doi.org/10.1109/ICFN.2010.58.