# **Cloud Computing Applications for Higher Education**

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### Abstract

Cloud computing is a new internet technology which describes computation, software, data access, and storage services. It does not require end-user information of the exact location and configuration of the system that delivers the services. The primary cloud services to date are Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a service (SaaS). After the dot-com bubble, Amazon has first demonstrated a success cloud computing realization by modernizing their data centers, and it is proved that the new cloud architecture resulted in significant internal efficiency improvements. In 2008, Gartner has observed that organizations are switching from company-owned hardware and software assets to per-use service-based models, which result in dramatic growth in IT products in some areas. In general, resources can be utilized with greater efficiency, and there is considerable upside potential for higher growth. In fact, cloud service was selected by CIOs the most often and among the top-two technologies in 2011.

After joining WTO, Taiwan higher education institutions not only face international competition, but also are threatened by the few-generating of the change of population structure. Formulating some effective and appropriate strategies can increase the revenue for the university and maintain the sustainable value of the school. The adaptation of external and internal environment change and formulating the appropriate strategy may lead universities to the direction of sustainability. The potential advantages for cloud computing are easy access, lower cost for the implementation of hardware, software, and License for all. The authors argue that the emergence of cloud computing as a new potential remedy for higher education application. In conclusion, it is believed that cloud computing opens a new window for future higher education; it will surely improve education quality at an affordable cost and hence enhances the competitiveness of higher education institutions.

In this article, the authors first briefly introduce the history and essence of cloud computing, followed by the background of current situation of Taiwan higher education. Some possible cloud applications for higher education and some of notable examples of education use are discussed in the following section. In the fourth section, a cloud computing architecture for campus is proposed. In conclusion, the authors believed that cloud computing opens a new window for future higher education; it will surely improve education quality at an affordable cost and hence enhances the competitiveness of higher education institutions.

**Keywords:** Cloud Computing, Higher Education, Hybrid Cloud Service Architecture, c-portfolio

# 1. Introduction

The first scholarly use of the term "*cloud computing*" was in a 1997 lecture by Professor Ramnath Chellappa, in which he defined it as a computing paradigm where the boundaries of computing will be determined rationale rather than technical limits. In 2006, Google's CEO Eric Schmidt gave prominence to this term, which refers to an important and long term trend for computing over the internet. Amazon has first demonstrated a success cloud computing realization by modernizing their data centers after the dot-com bubble, which was using as little as 10% of their capacity at any one time, just to leave room for occasional spikes, and it is proved that this new cloud architecture resulted in significant internal efficiency improvements. In 2006, Amazon initiated a new product development effort to provide cloud computing to external customers, and launched Amazon Web Service (AWS) on a utility computing basis. Due to its elasticity implementation, better support for the software and hardware, and cost consideration, cloud computing has became on of the most prevalent information technologies.

In 2008, CIO Research reported a cloud computing survey results for which it polled 173 IT executives regarding their opinions on cloud computing and its application to their enterprises. 58% of the respondents agreed that cloud will cause a shift in the way enterprises use IT, and 54% felt that it is an evolving concept which may take years to mature. A Gartner report also identified that cloud computing as the primary source growth in IT spending, increasing over 20% year-on-year to global of \$56B in 2009 and surging to over \$130B by 2013. In January 2011, a survey of 2,000 chief information officers released by Gartner indicated that cloud computing is their number one technology priority for the coming 12 months. Cloud computing plays a vital role not just in the Smart Economy, but also in the higher education. The main advantage of the cloud computing is that it gives the low-cost implementation for infrastructure and

some higher business units like Google, IBM, and Microsoft offer the cloud services for free of cost for the education system, so it can be used in proper way which will provide high quality education. In this paper, we discussed the background in section two. In section three, some possible applications for higher education and notable examples of high education use were discussed. Section four presented a cloud computing architecture for campus is proposed. In conclusion, it is believed that cloud computing opens a new window for future higher education; it will surely improve education quality at an affordable cost and hence enhances the competitiveness of higher education institutions.

## 2. Background

Based on the statistical data from the Ministry of the Education, from 1981 (ROC year 70) to 2009 (ROC year 98), Taiwan annually Newborn has decreased from 414,069 to 191,310, with the crude birth rate dropped from 2.30% to 0.83% (Figure 1). In 2009, Taiwan has the world's lowest fertility (0.91). Newborn for the first 11 months of 2011 are only 150,000, which are roughly half of that in 2000, indicating that Taiwan is suffering a serious population structure problem. After joining WTO in 2002, Taiwan higher educations now not only face international competition, but also are threatened by the few-generating of the change of population structure. Figure 2 is the average student populations for Taiwan higher education institutions from 2001 to 2010. In 2010, there were 162 higher education institutions in Taiwan. The average student population for the first 10 schools is 22,835 while for the last 10 schools is 1,074 only, which implies that lots of Taiwan higher education institutions encounter great difficulties in management and operation. Formulating some effective and appropriate strategies can increase the revenue for the university and maintain the sustainable value of the school. The adaptation of external and internal environment change and formulating the appropriate strategy may lead institutions to the direction of sustainability.

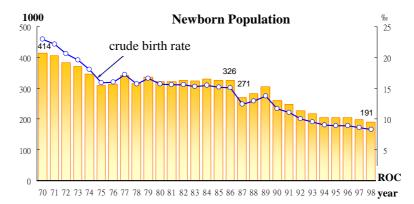


Figure 1. Taiwan Newborn Population from 1981 to 2009.

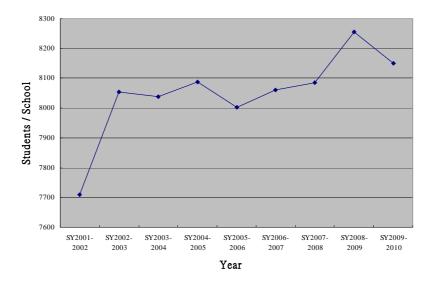


Figure 2. Average Student Population for Taiwan Higher Education Institutions from 2001 to 2010.

# 3. Cloud Computing and Higher Education

The population structure crisis and the high rate that IT progresses will continue to place significant pressure on Taiwan higher education organizations. Budgets for continuous upgrade and maintenance of hardware and software will become one of the major concerns for these organizations. This situation is more likely to be get worse in the current economic conditions, which may accelerate the adoption of cloud computing for higher education. In this section, we first discuss possible potential cloud computing application for higher education, followed by some notable examples.

### A. Potential cloud computing application of higher education

Management System usually consists of following modules: School administration and management, records and profiles management, distance learning education and e-learning system, library management etc. The potential of cloud computing for improving efficiency, cost and convenience for the educational sector has been recognized by a number of US educational institutions. The University of California at Berkeley, for example, found cloud computing to be attractive to use in one of their courses which was focused exclusively on developing and deploying SaaS applications. Cloud computing made it easy to create realistic assignments such as having students saturate a large database server. For their typical application, it requires about 10 servers, so it would have needed to commandeer 200 servers to allow each team to do their own measurements. With cloud computing, they acquired the 200 servers only in a few minutes, and released them after then. Similar surge demand can happen during the first few days of each semester in campus that administration management system may be saturated by thousands of students, when they all rush to login the system for some preferable elective courses. Hours purchased via cloud service can be distributed non-uniformly in time; which is already known as usage-based pricing. In addition, the absence of up-front capital expense allows capital to be redirected to core education investment. Therefore, for example, even though Amazon's pay-as-you-go pricing could be more expensive than

buying and depreciating a comparable server over the same period. Armbrust et al (2009) argued that the cost is outweighed by the extremely important cloud computing economic benefits of elasticity and transference of risk, especially the risks of underutilization and saturation. In their studied example for Elasticity, the authors pointed out as long as the pay-as-you-go cost per server-hour over years is less than 1.7 times the cost of buying the server, they can save money using utility computing. Another concern is that most of the higher education institutions may not use their PCs for more than half of the total working hour in an average.

Another possible application of cloud computing on higher education is the e-portfolio system, which usually consist of two types. Student e-portfolio can support student advisement, career preparation, and credential documentation, even for alumni credential documental. Whereas teacher e-portfolio is a database for faculty member's accomplishments for career-related purposes, and also can be a collection of course/ discipline related plans to be shared with colleagues. These two e-portfolios can be aggregated into an institutional c-portfolio (cloud-portfolio) containing wide variety information through internet that provides evidence for self-study and accreditation purposes. Finally, with more reliable, flexible, and cost-efficient infrastructure of cloud computing environment, an e-learning ecosystem can be evolved to a c-learning ecosystem to guarantee the better quality for teaching and learning activities. Lots of higher education institutions, for example, University of Maryland, University of California at Berkeley, and Harvard Medical School etc., also accommodated cloud computing their courses activities and have good customers experience.

### B. Notable examples of higher education on cloud computing

A case study of cloud computing application of the University of Westminster was done in a recent research by Sultan. This university, which consists of six schools and has more than 22,000 students, is one of a handful of UK higher education to embrace cloud computing. The cloud application was initiated by a survey that indicated that 96% of students were setting up their email accounts so that received emails were automatically forwarded to their external third party accounts. In 2007, the University started to look for an alternative option in order to address this issue. Google Apps was one of the options. The applications were deployed to all students and staff by January 2009. Gmail provides a whole campus with 7.2 GB of storage, protects against spam and viruses, stays connected with built-in IM, voice and video chat, IMAP and POP message access. Furthermore, it enables users to retain their domain names in the email. Google Calendar provides share calendars and schedule people, groups, and resources easily, even from their mobile device. To encourage use, each month a different Google application is publicized to the student body through promotional campaigns. Although Google claims that it is" No cost, no advertising, and no hardware maintenance mean time and money saved", optional Optional Postini email archiving and security services are available with a 66% education discount.

The University of Westminster faces similar challenges to many higher educational institutions in the UK and worldwide: catering to the IT needs of a very large number of people with limited resources. In addition to providing a good student experience, economic issue is one of the major concerns which lead the University decided to adopt Google Apps. The cost of using Gmail was literally zero. Based on consideration of installation, ongoing maintenance, upgrades, etc., "As important as the estimated £1 million saving by moving into the cloud with

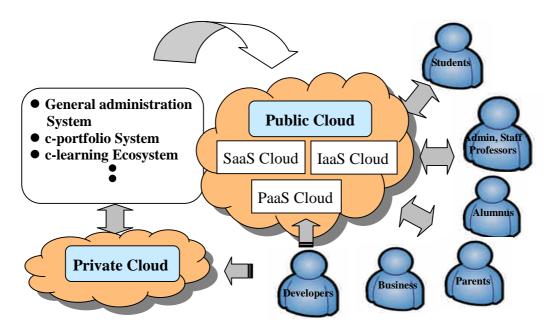
Google is, the new system also promotes creativity and collaboration among students." says Professor Roger James, Director of Information Systems. In addition, the spam issue associated with students' personal email accounts was no longer going to be a problem. Google Apps also provided the University with the option to use friendly names for email rather than use the traditional student ID number. Furthermore, an additional benefit has been the reduced time spent in systems and user support with a minimal number of calls for support of such a significant system.

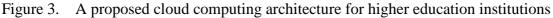
In the light of this example, user's familiarity with Google was one of the most important driving factors in ensuring take-up across the university. Despite the fact that Google Apps for Education is free, all relevant policy guidelines are followed before the University can adopt the cloud system. For example, University Records and Intellectual Property policy required that all calendar, teaching, research, legal and employment information be maintained on university-owned systems. Staff Gmail is provided for the purposes of collaborating with colleagues or students in the Google environment. However, the university's original email system remains the official staff email system, which was obviously a conscious decision by the University that was concerned about the legal implications of transferring the safe keep of their data to a third party. After the adoption of the cloud computing service, not only university students have used Google Apps to find new ways of working, forward-thinking staffs are also seeing the benefits which collaborative cloud technology can bring to the university environment.

# 4. A Proposed System for Higher Education

According to above discussions and characteristics of higher education in Taiwan, a proposed cloud computing architecture is depicted as Figure 3. In this hybrid cloud service architecture, the higher education institution builds a private cloud solution to handle of its IT work where data confidentiality and auditability, and data lock-in problems are important issues. The institution also uses a public cloud solution to provide education support for low-sensitivity applications and surge service demands. Regional or national public cloud alliance can be forged by different higher education institutions to share the educational expenditure.

Compared to current education system, in the proposed cloud computing architecture, the general administration system will be able to provide considerable extent of similar service, but the c-portfolio and c-learning systems are superior because better access and interaction for students, administer, staff, and professors, even for parents, can be guaranteed. Furthermore, alumni are provided a better platform for portfolio management and it is much easier for business to recruit employees. Finally, complete evidences provided by theses systems will definitely play significant roles in the future higher education evaluation process.





# 5. Conclusion

Cloud computing is an emerging technology which promises to provide opportunities for better teaching and learning experience for higher education. It was argued in this research that cloud computing service is a potential remedy for serious population structure problem and competitive higher education environment Several potential cloud computing applications for higher education are in Taiwan. discussed, along with a practical case of the University of Westminster. A hybrid cloud service architecture which consists of private cloud and public cloud services is proposed in this article. According to Alford and Morton (2009), these institutions are more likely to be part of the second wave of cloud adopters because of the inherent complexity of this kind of hybrid scenario. Like many other new internet technologies, cloud computing may encounter problems. Although there are still many concerns regarding its security, reliability, privacy, and performance, the cloud computing application for higher education is an inevitable trend in the future.

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