Enhancing E-Learning Architectures
A Case Study

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Abstract

This paper discusses the design of an e-learning architecture at Princess Sumaya University for Technology. The approach is to start with a simple design suitable for e-learning startups, and then enhance it at three levels. The objective is to improve e-learning systems and their level of services while preserving flexibility, scalability and optimization of available resources. The approach followed makes it easy for other institutions to implement the design at its level of choice according to its requirements and needs.

Keywords: e-learning, architecture, web services, YouTube, load balancing, learning outcomes

1. Introduction

E-Learning is just-in-time education integrated with high velocity value chains. It is the delivery of individualized, comprehensive, dynamic learning content in real time, in order to aid the development of knowledge communities and link learners and practitioners with experts [1].

It has become a common supplement to traditional face-to-face education widely used worldwide and Princess Sumaya University for Technology (PSUT) [2] is no exception.

With the usage of e-learning systems over several years now, practitioners have come to expect several benefits and services of them, some of these include:

- Providing access to a range of multimedia resources [1].
- Higher levels of service, faster delivery time at reduced costs and risk [3].
- Generic design which is also scalable.

Unfortunately many of these benefits are currently absent at the current e-learning system at PSUT, and this is what arises the need for redesigning.

2. Environment

Before discussing the design of the e-learning system at PSUT, we must first realize the environment which we should comply with. PSUT is a university specialized in information and communication technologies (ICT) education which means that it has a community of practitioners (educators and learners) who are computer literate and can easily deal with different software tools used to prepare learning content and then study it, but this feature should not be taken into account to make sure that the design can be easily adapted by other institutions where computer literacy could be of high variance, keeping in mind the fact that PSUT is continuously developing new degree programs which are very likely to attract different backgrounds, in addition to a rapid growth in the number of people interacting with the system.

PSUT already has a local network in place connecting all departments together including student computer labs and instructors' individual machines. Internally there is a Computer Center which takes care of administering and maintaining both the local network and servers hosted locally for different purposes.

A locally-hosted online course offering registration and grading system is available and accessible through the internet with user credentials for each user such as students, instructors and administration.

Looking broader, the university is connected to the internet via a leased line and we will consider this as a scarce resource that has to be used economically especially when considering its relatively low bandwidth and the fact that it is shared among all beneficiaries.

3. Initial Design

This initial design is borrowed and adapted from Blackboard on Sun Reference Architecture Optimizing eLearning White Paper [3] with some modifications and generalizations. The architecture consists of the application, database, and storage tiers. Figure 1 shows a logical representation of the small campus configuration that is designed to support a user community of 1,000 to 10,000 active users when using the appropriate hardware.

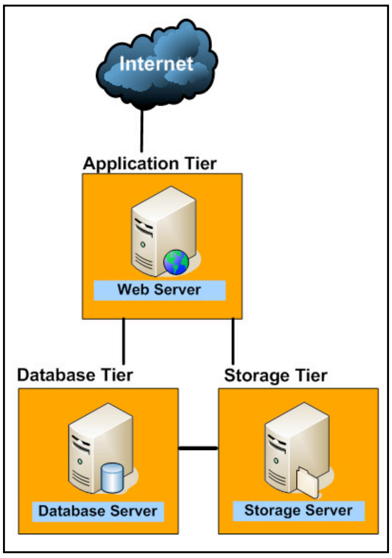

Figure 1: Logical representation of the small campus configuration

4. Design Enhancements

This section discusses enhancements to the design explained. Each enhancement is about an existing problem of concern.

4.1. Using Web Services

The current architecture does not provide any integration or communication between the online registration system and the e-learning system. As a result, actions within the registration system such as courses for a semester and students' enrollment into courses and unenrollment from them is not reflected onto the e-learning system, but is done manually by the students themselves.

This has caused several problems:

- Students are exchanging their e-learning accounts. This has affected statistics of students' activities on the system, and severely degraded the informative value of analysis performed on this data.
- Students have been enrolling themselves into the wrong courses due to similarities in courses' names.
- Graders have been grading assignments of students who had dropped the course but are still enrolled into it on the e-learning system.
- Course grades are being moved manually from the e-learning system to the registration system, which is highly prone to error, not to mention the redundant time and effort needed.

To integrate the e-learning system with the registration system, it is being suggested to develop a web service especially for this purpose. A web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the web service in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards [4].

Web Services are based upon three technologies: Web Services Description Language (WSDL), Universal Description Discovery and Integration (UDDI), and the Simple Object Access Protocol (SOAP). XML is used to tag the data, SOAP is used to transfer the data, WSDL is used for describing the services available, and UDDI is used for listing what services are available [5].

This web service is to be scheduled to run periodically to synchronize data between the registration and the e-learning systems.

Since the data on the registration system is very sensitive, the web service must be secured with reliable techniques such as those recommended by the National Institute of Standards and Technology [6].

Having the environment of PSUT as discussed earlier, this web service can be developed and hosted internally with minimal extra cost. When this web service is in place, it will additionally act as a prototype for expanding the e-learning system with the introduction of new services to be added and integrated easily and flexibly, especially that the web service and all its underlying technologies comply with the World Wide Web Consortium (W3C) standards [7].

Figure 2 shows the integration of the registration database with the e-learning system.

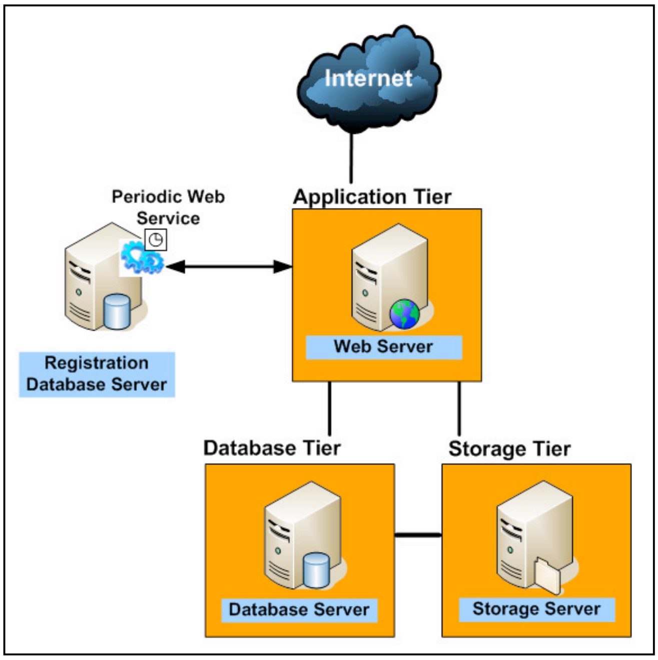

Figure 2: Integrating registration with e-learning over web services

4.2 YouTube Data API

Many agree that video content has become an essential component of e-learning systems, but its big size makes it the highest bandwidth consumer. Meanwhile, bandwidth at PSUT is a shared scarce resource and therefore its usage must be optimized, therefore the YouTube Data API can be utilized.

The YouTube Data API allows a program to perform many of the operations available on the YouTube website. It is possible to search for videos, retrieve standard feeds, and see related content. A program can also authenticate as a user to upload videos, modify user playlists, and more [8].

Using the YouTube Data API, a program can be developed to automatically upload videos from the storage server onto YouTube and return the video link. This uploader will be scheduled to run at internet usage off-peak times. Now there are two copies of educational videos, one on the local storage server and another on YouTube.

Additionally, and similar to content delivery networks (CDN), a virtual-CDN (V-CDN) implemented in software can be used. The role of the V-CDN is to detect the origin of video requests; if the request is originated from the university LAN it will be directed to read videos from the local storage server, otherwise it will be redirected to read videos from YouTube. This way, two students –one on the LAN and the other over the internet– could be watching the same video material at the same time, but each student is obtaining it from a different source.

This will add video content to the e-learning system at PSUT while carefully using bandwidth, and still maintain statistics of user activity since all requests arrive at the local server first before being redirected to the appropriate source. And since the videos will be available to the public, this will encourage tutors to produce high quality material and benefit from feedback, with an opportunity to contribute to education, research, and the community at a global level in addition to promoting the university.

Figure 3 shows an e-learning system enhanced with the YouTube Data API and the V-CDN.

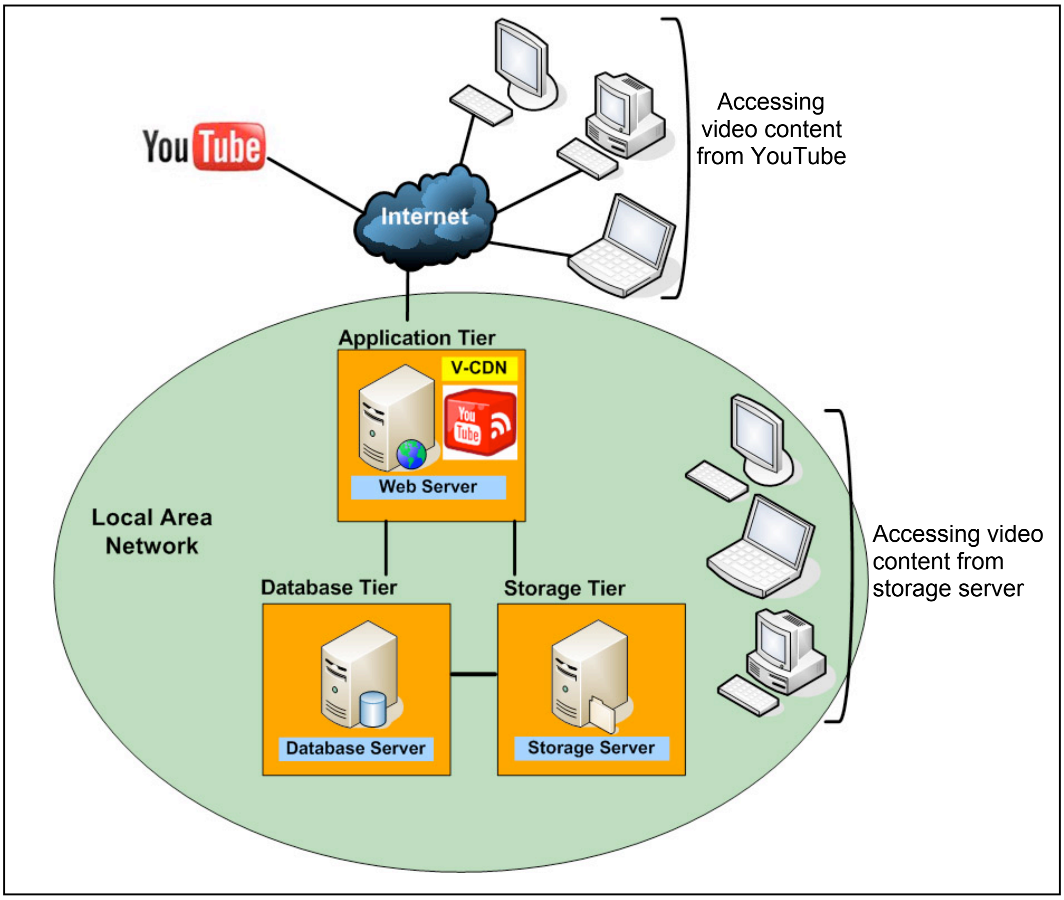

Figure 3: Enhancing e-learning with the YouTube Data API

4.3 Internet Connection and Server Replication with Load Balancing

The problem with the current design is that it suffers from the bottle neck effect; all external requests come over the single connection to the internet, and all requests (both external and internal) are handled by a single application server. But what if the internet connection fails? Or if the application is overloaded with requests and therefore takes a long time to respond, or totally fails?

It is a common practice to replicate resources for the purpose of backup, reliability, and improved performance. It is suggested to connect the application tier with at least two internet links from different internet service providers. This will result in reducing the average response time because the work load is apportioned among the two links while the bandwidth is doubled. And in case one of the links fails, the e-learning system will still be accessible over the other.

When the design is adopted by a university with a larger number of students (more than 10,000 students), replication will be needed at some or all tiers (application, database and/or storage). With server replication a load balancing mechanism is needed. Server replication with load balancing will also enhance performance and availability.

Figure 4 shows an architecture utilizing resource duplication and load balancing.

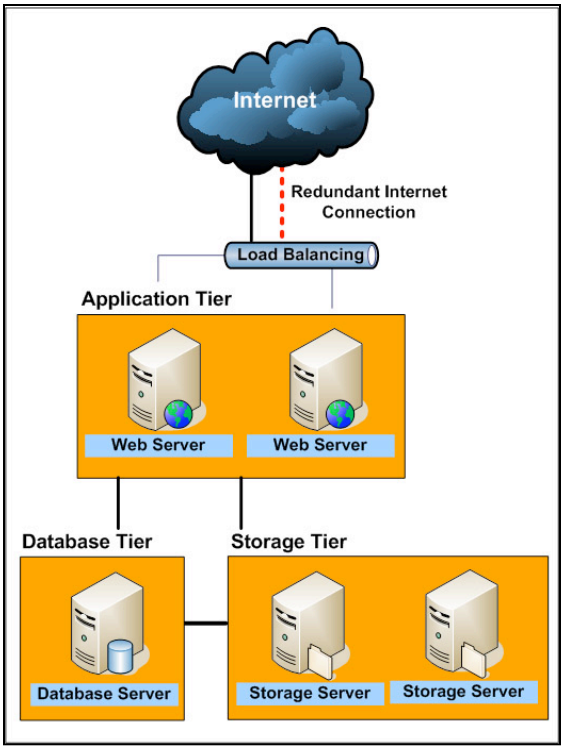

Figure 4: Enhancing e-learning with resource duplication and balance loading

5. Lessons Learned

Enhancing e-learning systems as discussed is very beneficial. Integrating e-learning with registration over web services has made many operations easier and more accurate while preserving security, and has promoted the value of statistical analysis since it now relies on real student activities. This modular and low coupled design will support expansion and scalability, and act as a prototype for future integrations with other systems regardless of their implementations, since web services are by design platform, database, and language independent.

Taking the precautions to assure availability and improve performance has increased the reliability of students on the e-learning system and their interaction with it. It has improved their academic performance because the learning materials are always available and infinitely repeatable. The continuous interaction of students with the e-learning system has clearly furbished their learning behavior and enriched it with openness to many different learning resources available online.

Within the OCW Mirror Site Program, Massachusetts Institute of Technology (MIT) has provided PSUT with a copy of the MIT OpenCourseWare website hosted locally. Educators are using it as a reference for teaching and sometimes incorporating it in their materials, and students are making use of it to enhance their learning and for individual study of topics of their interest. As a result, students are being offered better education, and they are enhancing and broadening their knowledge.

The publishing of educational videos to the public domain on YouTube -or its alternatives- not only has optimized bandwidth consumption, but also encouraged tutors to produce higher quality materials taking into consideration a wider spectrum of audience with various backgrounds, and taking advantage of feedback provided online. This level of demand for quality along with the students' new learning behavior has had the following affects on learning outcomes:

- It has moved the teaching approach from bare knowledge transfer to encouraging analysis, critical thinking, problem solving, and creativity.
- Students have developed a deeper understanding of the domains under study.
- In addition to knowledge, students are acquiring abilities and attitudes.
- Students have improved their networking skills and their realization of the importance of teamwork.

In the same method for uploading videos to YouTube, Google Docs will be utilized to provide web-based documents, spreadsheets, and presentations, offering accompanying condensed versions of video materials in some of these formats, in addition to independent educational documents.

Although assuring availability and optimizing bandwidth consumption may not be an important issue in countries where the internet infrastructure is mature and does not suffer from frequent disconnection nor from the bandwidth problem, saving costs remains a common desire. Since the discussed design and its enhancements build on existing resources with low costs to a certain level, it will strongly assist in introducing e-learning at institutions with limited budgets including high schools worldwide.

6. Conclusion and Future Work

This paper has discussed a redesign of the e-learning architecture at Princess Sumaya University for Technology (PSUT) initially designed for it, and then enhanced for better service and possible adaptability at other institutions.

Future work will include mobile learning support, assessment in e-learning, security, and further integration with other university departments.

References

[1] Zhou, D., Zhang, Z., Zhong, S., Xie, P.: The Design of Software Architecture for E-Learning Platforms. In: Pan, Z., Zhang, X., El Rhalibi, A., Woo, W., Li, Y. (eds.) Edutainment 2008. LNCS, vol. 5093, pp. 32–40. Springer, Heidelberg (2008)

[2] Princess Sumaya University for Technology official website, http://www.psut.edu.jo/, as of January 12, 2010.

[3] Sun Microsystems, Blackboard on Sun Reference Architecture Optimizing eLearning, White Paper, October 2007.

[4] W3C Working Group, Web Services Architecture, The World Wide Web Consortium (W3C), 11 February 2004.

[5] E. Cerami, Web Services Essentials (O'Reilly XML). O'Reilly, February 2002.

[6] Anoop Singhal, Theodore Winograd and Karen Scarfone, Guide to Secure Web Services Recommendations of the National Institute of Standards and Technology, NIST Special Publication 800-95, August 2007.

[7] World Wide Web Consortium (W3C), Standards, http://www.w3.org/standards/, as of January 12, 2010.

[8] YouTube, YouTube APIs and Tools, http://code.google.com/apis/youtube/getting_started.html, as of January 12, 2010.