RELIABILITY ASSESSMENT OF USERS' VIRTUAL LEARNING QUEUE SYSTEM

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Abstract

In this paper we consider Virtual Learning Systems (VLSs) in which users utilize educational programs. Regarding the role of each system, some infrastructure as software and hardware exist. While several users exist in the VLS, a queue of users is configured. Fault would break down the system and cause learning defects being more serious in virtual learning environment. We consider the queue of users to determine system reliability and propose an alarm system to warn non-reliable services of the system for improvements. The validity of the proposed reliability assessment model is presented in a numerical illustration.

Keywords: *virtual learning system, reliability, queue system*

ACM Classification: K.3.1

1. Introduction

Information technology (IT) has the potential to transform the means by which we learn and access information in two important ways. First, IT enables us to do many of the things we already do faster, more flexibly, more efficiently and with greater access for all (Heo and Han, 2003). Second, IT enables us to do things that we cannot now do, or to do them in ways that are significantly different (Hsu and Chiu, 2004). IT enables users to find a new atmosphere for learning that goes well beyond the classrooms, curricula, and text-based formats to which we are accustomed (Jiang et al., 2002). Virtual learning system (VLS) is a kind of education that is much more than a talking head regurgitating traditional training courses broadcast over INTERNET. Virtual learning is a convergence of training, knowledge management, collaboration, mentoring, publishing and customer support. Ease of use, users' online collaborations, online advice of instructors, and personalized learning leading to replace traditional classroom with virtual learning system. A configuration of virtual learning system is shown in Figure 1.

The success of virtual learning depends on user friendliness of the system and other parameters being effective to increase users' intention to continue using it (Venkatesh, 2000; Shih, 2004). For analyzing user satisfaction in VLS, Mahdavi et al., (2008), designed a heuristic methodology for multi-criteria evaluation of web-based e-learning systems based on the theory of multi-criteria decision making and the research results concerning user satisfaction in the fields of human-computer interaction and information systems. Virtual learning system (VLS) is an internet based service like the application system or the internet based virtual course study service. Fazlollahtabar and Mahdavi (2009) proposed a neuro-fuzzy approach based on an evolutionary technique to obtain an optimal learning path for both instructor and learner in a VLS. The neuro-fuzzy implementation helped to encode both structured and non-structured knowledge for the instructor. On the other hand, for learners, the neural network approach has been applied to make personalized curriculum profile based on individual learner requirements in a fuzzy environment.

Implementing virtual learning requires technical, financial and cultural commitments. Requirements include technology, infrastructure and content. Configuring the system with these elements needs significant investment. Therefore, having a reliable system is of importance due to large amount of investment. Here, a reliability model is developed for the users for utilizing the services provided by VLS. The remainder of our work organized as follows. Next, we give the literature review. Section 3 presents the proposed problem, assumptions and the mathematical notations. A numerical illustration of the proposed model is given in Section 4. We conclude in Section 5.

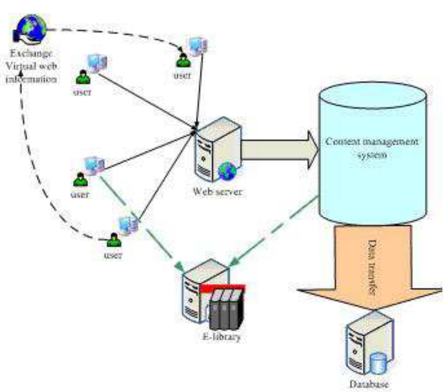

Figure 1. *A configuration of virtual learning system*

2. **Literature review**

In any virtual learning system two main elements are significant. Technology and content are the elements that are important for configuring a virtual learning system. Technology required providing virtual learning in a combination of hardware and software. Personal computers with Internet connections are already available in most locations. Content must be up to date designed by experts to be engaging for the user and achieve maximum value. Virtual learning content should be divided into easily searchable modules, so the user can quickly find material relevant to the task at hand. Reliability is considered as a substantial segment of implementing virtual learning systems. Therefore, special attention should be concentrated on reliability. Increased financial and regulatory pressures have driven equipment reliability to a top priority.

In a study by Carchiolo et al. (2009) an approach to address the problem of the choice of most suitable learning resources was presented by exploiting the idea of trustworthiness associated to both learning objects as well as to peers in a Peer 2 Peer e-learning scenario. An existing defect classification and analysis framework, orthogonal defect classification (ODC) was adapted by Ma and Tian (2007) to analyze web errors and identify problematic areas for focused reliability improvement.

Pickering (2005) described some of the issues affecting reliability and performance of applications served through the Internet environment and highlighted typical sources of unreliability and performance problems and showed pragmatic ways of dealing with these to achieve improvements in end user experience without requiring disproportionate investment. That work classified the basic factors affecting reliability with a static web-site to be: Internet connectivity to the servers, stability of the server hardware systems, stability of the server software systems, and environmental and power stability within the hosting facility. Each of these factors needs to be considered when attempting to assure or improve the overall reliability and resiliency of the service.

Also, the concept of duality in web services reliability presented by Abramowicz et al. (2006). The authors claimed that the Web services technology allows for easy creation of complex applications consisting of smaller components – Web services and they performed an in-depth analysis of a Web services' reliability problem for both atomic and composite web services. For composite web services, Sasikaladevi and Arockiam (2010) designed a reliability evaluation framework.

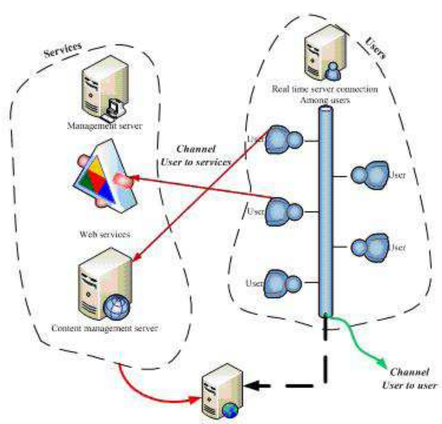

Figure 2. *A configuration of the proposed queue system*

3. The proposed problem

Here, we consider a virtual learning system (VLS) in which several users receive services. Due to existence of numerous users, organizing a queue of users to make use of different services is possible. Services are classified into two main groups: software and hardware. Software services are such as learning management system, content management system, e-library, e-bank for paying the tuition, and e-shop. Hardware service is concentrated on servers. Since we consider multi users, multi services, and two types of internet connections (channels) namely: internet connection to VLS center and internet connection among users to exchange knowledge and information, we consider M/M/s=2 queue system. A configuration of such queue system is shown in Figure 2.

Some parameters are important to be computed for our proposed system performance evaluations. Below are the mathematical notations for assessment parameters of VLS and their corresponding equations:

Mathematical notations for assessment parameters of VLS:

P_0	The probability that the system is empty
L_q	The expected number of users in queue
L	The expected number of users in system
W_q	The expected time in queue
W	The expected waiting time
λ	Inter-arrival time of users to the VLS
μ	Expected service time
s	Number of channels

$$P_0 = \frac{1}{\sum_{n=1}^{s-1} \frac{\left(\frac{\lambda}{\mu}\right)^n}{n!} + \frac{\left(\frac{\lambda}{\mu}\right)^s}{s!}\left(\frac{1}{1-\left(\frac{\lambda}{s\mu}\right)}\right)}, \tag{1}$$

$$L_q = P_0 \left[\frac{\lambda^{s+1}}{\mu^{s-1}\,(s-1)!\,(\mu s-\lambda)^2}\right], \tag{2}$$

$$L = L_q + \frac{\lambda}{\mu}, \tag{3}$$

$$W_q = \frac{L_q}{\lambda}, \tag{4}$$

$$W = W_q + \frac{1}{\mu}. \tag{5}$$

These parameters are effective on the reliability of the system, since internet connection among users beside software and hardware is the third element of our proposed VLS model.

4. **Reliability assessment model**

Management systems in VLS require reliable software and hardware to provide proper services to the users. In statistics, reliability is the consistency of a set of experiments used to describe a test. The service reliability can be understood as the probability of a successful execution of a Web service. A successful service execution in this case should be understood as the state when not only the Web service provided the desired result, but also that no execution errors appeared and overall agreed-upon quality of service was maintained. As a probability measure, it is in range [0,1]. It is one of the attributes that are a part of Quality of Service model (Abramowicz et al., 2006). Here, as stated above, a two channel queue of users utilizing provided services of VLS is considered. We aim to propose a reliability alarm system to report different status of VLS including the reliability of the system to service the users. While the number of users is effective on the total reliability of the system our alarm system reports the queue computations. It is necessary to incorporate reliability into the model to ensure the level of service for each VLS element. The reliability is defined as the probability that the system functions until time t. If an element is broken down, it can be regarded as a failure. A desired level of reliability can be achieved by limiting the failure probabilities. This approach for handling reliability is called the method of chance constraints. It is assumed that the reliability of each element is independent according to Exponential processes. In the followings we discuss the reliability based model. Consider,

$R(t) = 1 - F(t)$.

$R(t) = exp(-\lambda t)$ (where λ is the failure rate)

$R_i\,(t)$: The probability of functioning element i^{th} until time t

$$R_i(t)_{system} = \begin{cases} \left(1 - \prod_{i=1}^{I}(1 - R_i(t))\right), & \text{when elements are in parallel case} \\ \left(\prod_{i=1}^{I} R_i(t)\right), & \text{when elements are in series case} \end{cases} \tag{6}$$

In our proposed problem, the VLS elements are series but the users $(i = 1, 2, \ldots, I)$ are in parallel and therefore a composite system is configured. Note that, we compute reliability of services with series equation and the reliability of users with the parallel one. Therefore, the reliability of the system is as follows:

$$\left(1 - \prod_{i \in I} (1 - R_i\,(t))\right) \geq \alpha, \tag{7}$$

where α is the lower bound for a desirable reliability of the system until time t. As previously assumed the reliability of each element is independent according to Exponential distribution:

$$R_i\,(t) = e^{-\frac{t}{\theta_i}}, \tag{8}$$

Then,

$$\left(1 - \prod_{i \in I} \left(1 - e^{-\frac{t}{\theta_i}}\right)\right) \geq \alpha \tag{9}$$

Using equation (9), we can compute the reliability of each element and the whole system. While the reliability of the system does not satisfy the lower bound for a desired reliability of the system, the alarm system functions. The element or elements which are non-reliable are determined and improved. A reliability alarm system is presented in Figure 3.

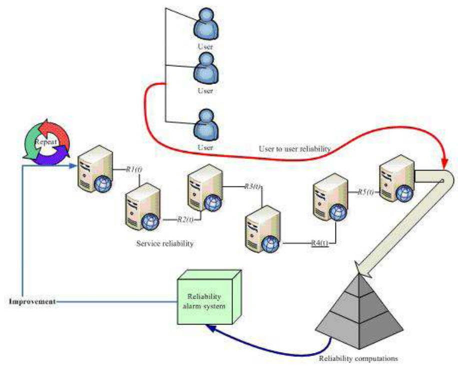

Figure 3. *A reliability alarm system*

Next, we illustrate our model in an example.

5. **Numerical example**

Here, a numerical illustration is presented to investigate the applicability of our proposed reliability assessment model. We consider software and hardware as elements of VLS. Therefore the number of users utilizes the services affecting the reliability of the system. For a service, the inter-arrival time is exponential with which implies that a new user arrives every 5 seconds on the average, since

Mean inter-arrival time $= \frac{1}{\lambda} = \frac{1}{0.2} = 5$.

We assume that channels are identical and service time is given by exponential distribution with $\mu = 0.125$. This implies that the mean service time is 8 seconds, since

Mean service time for a channel $= \frac{1}{\mu} = \frac{1}{0.125} = 8$.

The same parameters setting are done for other services considered to be 3 in our example. The required information about the users' queue for different services is given in Table 1.

Table 1. The queue computations of different services

	Service 1	Service 2	Service 3
P_0	0.11	0.17	0.23
L_q	$2.82 \cong 3$	$2.12 \cong 2$	1
L	4.42	2.95	2.25
W_q	14.1 ≅14 sec.	8.48 ≅ 8 sec.	2 sec.
W	22.1 sec.	11.81 sec.	4.5 sec.
λ	0.2	0.25	0.5
μ	0.125	0.3	0.4
s	2	2	2

Using the users in the queue, we can estimate the expected time in queue in which failure may occur. Now, we can compute the reliability of the system. As stated before, users are in parallel and therefore using equation 9 we obtain,

$R_1 = 0.828434$,

$R_2 = 0.74764$,

$R_3 = 0.63212$.

Also, services are in series, therefore

$R_{system} = 0.828434 \times 0.74764 \times 0.63212 = 0.39$

While the desired lower bound of the system's reliability is 0.5, the alarm system acts out to notify that the system is non-reliable and needs improvement in software and hardware elements.

6. Conclusions

Here, we proposed a reliability assessment approach associated with an alarm system in a virtual learning system. The aim was to achieve more reliable environment during learning process within virtual world of education. This model helps the management systems to control and monitor various elements of VLS to determine the failure. The numerical example presented the validity and applicability of our real time reliability assessment model considering users queue.

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