Highly Available and Dependable E-learning Services Using Grid System

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Abstract

The development of the web-based technologies had great impact on the E-learning systems. Developing pervasive, highly available and economical educational systems are so difficult or impossible in the client-server and web service architectures. The grid computing system can be used as a good platform for the low cost, online, highly available and mobile educational applications. The possibility of the failure/unavailability of resource in the grid during an e-learning service is not negligible and should be taken into consideration.

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1. Introduction

E-learning services can be made available when is demanded even in remote places and without the traveling to the classroom (Pankratius, 2003). Nowadays, with respect to the development in the network and web technologies, e-learning become one of the most popular teaching methods in the educational organizations and communities. E-Learning is the use of computer technologies to deliver teaching and learning services anytime and anywhere. E-learning offers self-paced, self-directed and on demand learning services. Many schools, universities and educational systems are using e-learning as their common training method (Tucker, 2002). Many e-learning platforms and technologies like client-server, peer-to-peer and web services architectures have been used by many educational communities.

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Several service oriented methods have been proposed to overcome these problems (Fox, 2002), (Fox, 2003). One of the best infrastructures to overcome these limitations is the grid system. It is a suitable framework for executing many applications like long mission and distance learning-applications (Foster, 2002), (Gannon, 2002). Grid system as a large distributed environment integrates diverse and heterogeneous resources and services. It enables the aggregation and sharing of geographically distributed resources and services for many applications efficiently and inexpensively (Foster, 2001), (Jacob, 2003). The grid system provides a better platform to offer pervasive, highly available and stable e-learning services. On the other hand, because the grid resources are highly heterogeneous and can leave/join dynamically, the failure and unavailability in each resource of the grid system must be considered as a common event. Therefore, the availability and dependability of the needed resources for a requested e-learning service must be improved in the grid resource management system (RMS). The resource in this paper refers to the educational resources in the grid system. Delivering highly available and dependable e-learning services by using minimum number of resources in the grid system is the main purpose of this study. In this paper, we propose a dependable model for managing the e-learning resources in the grid system.

2. Related Works

Availability, dependability, stability and the cost of e-learning services are the significant drawbacks in the peer-to-peer, client-server and web-service architecture (Pankratius, 2003), (Booth, 2003). Some of the previously published papers like (Fuji, 2002) proposed reusable distributed learning activities based on the CORBA technique. Several methods have been proposed using the grid services to attain dependable and economic e-learning systems (Pankratius, 2003). Some of other studies have proposed a framework based on the Globus to develop a grid based e-Learning system (Reklaitis, 2002), (Reklaitis, 2003) and (Towards, 2003). In (Li, 2003) the author has proposed a continuous pervasive learning system that integrated different types of e-Learning platforms into a pervasive environment. The proposed method in (Gaeta, 2002) used grid technologies to integrate learning resources. In this study, we propose a resource management model for delivering highly available, dependable e-learning services in the grid system. The minimization of the resource consumption and consequently the cost of requested services is the other merits of this work. The proposed dynamic resource management model leads to improve the availability and dependability of the e-learning services in the grid system.

3. Proposed Model

3.1 System Architecture

The grid based e-learning architecture is composed of different services which are shown in Figure1. Providing the communication facilities is the main function of the infrastructure layer. Creating and managing the distributed virtual organization (VO) and handling the needed resources are the other role of this layer in the grid based e-learning platform. The other layer is web services layer which is responsible for the basic web services and related protocols such as XML and SOAP and provides quality of services like connectivity and reliability for the layers on top of it. The grid middleware is the next layer on top of the service layer and has a significant function in the grid based e-learning platform; the file distribution, database synchronization, load balancing and security service are the main facilities of this layer. The e-learning management layer is the other layer which sits on the top of the grid middleware. This layer is composed of the distributed e-learning resources and services. Discovery, composition and management of the e-learning resources are considered as the main functions of this layer. E-Learning basic services are the main components of grid based e-learning platform. This layer composed of the basic services for e-learning applications which rely on the grid core services. This layer allows users to access and share all types of the resources like papers, magazines and e-books. The grid portal provides the required facilities to access the corresponding learning resources by the learners and teachers. Figure 1 illustrates an overview of the e-learning system in the grid.
3.2 Proposed Model

The main role of a resource management service is discovering, selecting and allocating the needed resource for delivering the requested e-learning services. Fig. 1.b describes the abstract architecture of the proposed resource management system (RMS). The resource manager, after receiving an e-learning request, analyzes the request to exclude some information including the needed resources and their needed quality. The optimal RMS selects resources with hopes that the e-learning services will be completed with respect to the required quality. Hence, the availability and dependability of the selected resources must be considered in the resource management process. Proposed model consists of monitoring and recovery services. Monitoring service monitors the status of allocated resources during an e-learning service. Unavailability and failure detection are the main role of the monitoring service.

After determining the needed resources of an e-learning service, the resource discovery service is invoked. In order to discover the needed resources/services the MDS in the Globus toolkit is used and it finds out the set of candidate resources (Baker, 2002). The needed degree of dependability of the requested e-learning service is important to discover the candidate resource. The resource manager tries to find out and allocate the dependable and highly available resources which satisfy the Quality of Service (QoS) of e-learning service. But with respect to the dynamic structure of grid systems, which every resource can enter and leave the grid at each time, this is so complex task. In order to satisfy the dependability and availability of e-learning services over an erroneous platform, we propose a resource-redundancy technique. In this model, the resource management allocates three replicas of the needed resources for the requested e-learning services. Each replica resource is selected from a different site in the grid. The redundant resources are used when the candidate resources is failed or unavailable during the e-learning service. Hence, this model optimizes the dependability and availability of the e-learning services on the grid system. The other significant point that must be taken into account is to attain a trade-off between cost and QoS. Users must pay the cost of requested services in the economic grid. Using redundancy technique increases the QoS of an e-learning service.

The unavailability detection service exploits monitoring service to detect the corresponding resource failure and unavailability. The monitoring service uses a two layer error detection technique to improve detection coverage and consequently improves the dependability of e-learning services. Using two-layer detection service decreases the probability of false alarms and consequently improves the reliability of RMS. In the proposed model, voting service is exploited periodically in the unavailability detection service. The unavailability-detection service uses the Globus toolkit services like MDS, GRIS, GIIS and GRAM (Baker, 2002). The proposed unavailability detection service covers both timing and content failure. In order to cover timing failure, checking deadline-constraints is an important factor. In order to timing-failures detection, the detection service monitors time thresholds or checks time-out and deadline constraints of the e-learning services.
At each predefined time-intervals the monitoring service returns the state of the e-learning service. In order to store the state of the running service, the check-pointing service is invoked. Indeed, the check-pointing service is invoked periodically to save the current status of the replicas. This model focuses on the system level check-pointing which is supported by some middleware like Condor (Baker, 2002). The information saved at the checkpoints includes the state of the e-learning service during execution. An error state is detected when the monitoring service detects resource unavailability. In this step, the recovery service recovers the failed e-learning service by continuing the service from the last stored state using redundant resources. The saved state of an e-learning service at the time intervals avoids restarting the failed e-learning service. Restarting the failed service from the beginning in some of e-learning services is impossible.

If the monitoring service detects an error, the recovery service which includes rescheduling, task migration, resource migration is invoked. There are need to attain trade-off between the frequency of checkpoints and performance overhead. Hence, one of the main parameters that affect the dependability and performance is the granularity. Granularity is considered as the time interval between checkpoints. To determine the graining size, the following factors must be considered: transparency, performance-overhead and detection-latency. Transparent check-pointing process does not require the users of e-learning system efforts (students or teachers). Fine grains increase the number of checkpoints and consequently it leads to high performance-overhead and low detection latency. Increasing of the diagnoses frequency leads to increase the performance-overhead and decrease error-detection latency. (Sayori, 2003) have proposed an equation to calculate the optimal check-pointing intervals.

\[- T: \text{Check-pointing Interval} \]
\[- C : \text{Check point overhead} \]
\[- \lambda_i : \text{The constant rate of resource unavailability/failure in the machine } i \]

\[ T^* = \frac{C}{2} \left[ \frac{1}{\lambda_i} + \frac{C}{AC} - 1 \right] \]

4. Evaluation

In this section, we use an analytical approach to evaluate the effectiveness of proposed model to improve the availability and dependability of the e-learning services in the grid system. Markov model and fault tree are the well known approaches to dependability analysis of software and hardware systems (Shooman, 2002). We have used the Markov model to analyze the availability of the proposed GRMS model. The results of analysis show that the proposed model has higher availability and Mean-time-to-Failure (MTTF) than the basic resource management services which are used in Globus toolkit. Figure 4 shows the availability of the e-learning services in the proposed model. Dynamic architecture of the proposed model improves the resources efficiency. Higher rate of MTTF in the proposed model leads to higher availability and dependability of the e-learning services in the grid system. On average, this model needs lower degree of resources and this feature improves efficiency and reduces the service cost in the economic grid.

![Fig.2. The MTTF in the proposed GRMS, the basic GRMS and NMR based GRMS](image-url)
MTTF: Mean time to failure,
MTTR: Mean time to repair,
Availability of Service = \frac{MTTF}{MTTF + MTTR}
Reliability of Service = e^{-\frac{t}{MTTF}}

Regarding the results of analysis, the MTTF and consequently availability, reliability and also dependability of the e-learning services in the proposed model is higher than the availability of e-learning services in NMR based and basic GRMS.

5. Conclusion
In this study, we proposed a dynamic resource management model in order to improve the availability and dependability of the e-learning services in the grid system. In the proposed model a dynamic replication technique is used to tolerate resource failure/unavailability during the execution of an e-learning service in the economic grid system. Using a lower degree of resource redundancy in the proposed model leads to the lower cost in the market based grid. Using two layered unavailability-detection service improves the dependability of the delivered e-learning services. An analytical method has been used to evaluate the effectiveness of the proposed model to improve the availability and dependability of the e-learning services over the grid system. Regarding the results of analysis, the availability of the e-learning services in the proposed model is higher than those of the NMR based and basic GRMS. This model maintains a trade-off between cost and the degree of quality of e-learning services.

References