Responsive Web Design for Distributed Resource Sharing and E-Learning among Universities using Fixed and Mobile Devices

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Abstract

e-Education architectures have gained popularity in recent years within the scientific community. The grid technology enables software and services to aggregate distributed resources to provide integrated learning process from various organizations that can be attainable on any single system. However, most applications developed and used by the scientific community are not integrated or combined from various Universities and there is a rising need to integrate such applications into a single service-based application. Nonetheless, it is observed from the literature that the potential of grid resources for educational purpose is not being fully utilized yet. In this paper, we develop a grid enabled learning system that allows students, faculty and researchers to share and gain knowledge in their area of interest by using e-learning, searching and distributed repository services among universities from grid portal anywhere, anytime using desktop, laptops, tablets and mobile phones. Globus toolkit 5.2.5 (GTK) software is used as grid middleware that provides resource access, discovery and management, data movement, security, and so forth. The project provides various graphical user interfaces to discover and interact with application services.

Keywords — *Grid Computing, Globus Toolkit, Searching, E-learning, Distributed Repository.*

I. INTRODUCTION

The availability of commodity networking and com-puting infrastructure has helped the grid to boost up the technology and has reduced the effort required to participate in distributed collaborative science. Subsequently, the development of Internet makes it cost effective means of driving knowledge shar-ing and encourage the collaboration. Besides, there is more to be done to improve the availability of distributed education applications for the scientific community. Today’s interconnected education environment is flourishing on global scale, characterized by adoptability and rapid changes and has led to an important learning paradigm. E-learning is an extension of distance education supported by electronic and hand-held devices (e.g., smart-phones, tablets etc.). It is an emerging learning model and pro-cess which requires new forms of teaching, learning, contents, and dynamics between users [1]. The large collaborative environments, potentially composed of multiple distinct organizations, uniform controlled access to data has become a key requirement if the organizations are to work together [2]. In order to pro-vide access to a wide variety of data information, it is required to access and communicate with a different and wide range of information sources. The data trade-off between many universities requires data file management systems to manage operations like data storage, transfer access and replication. Therefore, grid computing provides various possibilities to support innovative educational and scientific applications.

In parallel to the evolution of computing infrastructure, we are witnessing the consolidation of a new generation of social networks, which are characterized by greater levels of user participation and ease of content sharing [3]. In order to encourage the development of grid services, web services (WS) have become widely accepted as a way of providing language and platform-independent mechanisms for describing, discovering, invoking and orchestrating collections of networked computational services 4. The appearance of service oriented approaches on grid platform has transformed the prospect of educa-tional and scientific communities and has expanded the support for the development of distributed application in e-science, e-education, and e-commerce. The principal strengths of web services and grid middlewares are complementary, with web services focusing on platform-neutral description, discovery and invocation, and the later focusing on the dynamic discovery and efficient use of distributed computational resources. This complementarity has given rise to the service-based grids which make the functionality of grid middleware available through web service interfaces [4]. These appliances allow learners to teachers to find new ways to collaborate and interact.

The easy access to distributed data information at one place has motivated to switch the significance of learning system from the isolated information pro-cess to an active acquisition of skills and knowledge. It is believed that the research in traditional learning system has obtained less attraction than the research in a special e-learning system [5]. However, yet to date, few universities in the world have managed to exploit the aggregate power of this seemingly infinite grid of resources for educational purposes. The data produced by such learning places requires heterogeneous resources which is not available on single computer. As observed, some educational institutes (learning spaces) do not have proper infrastructure (resource/network) available to them at all and those have, the study content used by institute is not shared or utilized by other institutes to the full extent. Grid provides stable and commonplace for educational, scientific and industrial settings that create a demand for porting such applications onto the platform. Our previous works [6] [7] focused on establishing a real-time grid test bed to test the grid functionalities through command line interfaces and conducted manual uploading, download and transferring various format documents among repositories. The proliferations of mobile devices have witnessed considerable accomplishments in the design, development and deployment of wireless and mobile networks. This paper presents graphical user inter-faces for a grid based learning system that allows easy searching and sharing education content of different universities and also facilitates better collaborative and learning environment, given the resource restriction of a university locale and it offers a solution for both distribution of educational content and application supportive computing environment. The platform allows users to connect and access the grid based system through provided portal by using PCs, portable or mobile devices via the Internet regardless of place and time. This proposed model is conceived to be used in a single virtual organization integrated by multiple providers and consumers of education services within the context of a grid.

The rest of the paper is organized as follows. In Section II, the backgrounds about e-learning models are reviewed. Section III briefs on components of globus toolkit. In Section IV, case study on connecting Universities is discussed. The system design and methodology are presented in Section V. Experimental setup and results are presented in Section VI. Finally, concluding remarks and future directions are given in Section VII.

II. BACKGROUND AND MOTIVATION

The idea of creating educational portals such as those described requires the integration of many technologies and organizations from different field. As technology advances, the world has witnessed the changing over the learning process in acquire knowledge, interaction and collaboration of learners, and accessing the shared resources. The recent widespread adoption of mobile computing devices and the availability of wireless access in most learning spaces have greatly impacted the learning process. This is the new paradigm shift of teaching and learning practices in education system through e-learning services. These services are mainly based on information transfer and sharing paradigm that can more focuses on new learning strategies with appropriate software tools and environments. The more effort has been put to establish the ELeGI project [8] (European Learning Grid Infrastructure). The project focuses on developing software technologies for effective human learning and promoting and supporting a learning paradigm shift. Within the context of web based education system, the PEDC [9] system provide a grid file system to manage educational resource files and to build a writable, server-less data grid with large scale. The e-learning grid in [10] discusses peer-to-peer technologies for content distribution among independent institutes/universities. It introduces a collaborative computing platform framework that supports the creation of multi-user collaborative sessions, allowing users to self-organise and communicate, share tasks, workloads, and content, and interact across multiple different computing platforms. The work in [11] proposes a service oriented e-learning systems that include assessment, course management, grading, registration and reporting web services. e-framework in [12] is a service-oriented approach for education and research, the methodologies used helps to identify shared and common services that form a part of the information environment. Further, [13] accomplish a blended e-learning grid framework that includes the multi-agent system that can integrate with other e-learning grid systems. Science gateway [14] is a user-friendly intuitive interface between scientists (or scientific communities) and different software components including various distributed computing infrastructures (DCIs), web ser-vice based model enables solution for complex scientific workflow management. An ontology-driven semantic web education learning system [15] has proposed to implement the Felder-Silverman learning style model in addition to the learning contents, to validate its integration with the semantic web environment. In [16], presented the architecture of an ICT system that able to enhance the development pro-cess of e-learning contents and focused on collaborative environment as a unique access point. However, the other projects found to be more commercialized and made utilization of grid technology at its best. The proposed education based e-learning grid system provides a platform and services for academicians and researchers to collaborate and share the data knowledge in their respective domain using grid technology.

III. GLOBUS COMPONENTS OVERVIEW

The base level interfaces of Globus toolkit [17] [18] allow mappings to commonly used grid services. The base level components of globus includes (1) Grid Security Infrastructure (GSI) [19] enable secure single sign-on mechanism to authenticate grid credential of user, (2) Monitoring and discovery service (MDS) [20] provides access to information of the structure and state grid resources and services by querying MDS contents to server, (3) Grid Resource Access and Management (GRAM) [21] allows manage and schedule computational jobs like locate, submit and monitor the status of the submitted jobs (pending, active, failed, done, and suspended). This component maintains the synchronization with GSI and GridFTP [22]. (4) GridFTP provides a secure mechanism for high performance data/file transfer directly between two machines. It also provides standard interfaces for file movement such as transfer, uploading and down-loading by referring machine’s domain name, ad-dress and file location.

IV. CASE STUDY: CONNECTING UNIVERSITIES

Consider a real-time example of education system environment that enables students, faculty and re-searchers to store, search and share academic, ad-ministration and research data through a portal of respective Institute. The community (students, faculty and researchers) may also require to access data of academic and research happening around the location by searching in different repositories. This outline requires provisioning and communication of data available through the PCs, laptop and handheld devices of mobile users with wired and wireless connection. The data generated from this system will be complex to analyse for different objectives queried by various authoriser may include a range of mechanisms which are unattainable to perform on single machine of individual Institute.

In this scenario, it is desirable to have a better service assurance in order to share the data among multiple universities (i.e., distributed repositories). For instance, depending upon the area of interest in variety of information and importance of the results required, one would look for searching for better and more results rather than in a single repository. Therefore, in order to solve this problem moving this scenario to grid environment that supports large numbers of distributed resources sharing and provide a good platform for the long-life, online and educational mobile applications to achieve quality data, high availability, reliability and scalability for education system.

V. SYSTEM DESIGN AND ARCHITECTURE

There are many aspects can be considered to have the greatest technological enhancement in order to provide the quality learning experience. Among them, the major aspects are (i) the system must able to connect the education community through compound systems with easy and affordable con-figuration (ii) the system must be seamless and flexible enough towards distributed resource sharing and adaptability. By considering these requirements, it is possible to construct an effective grid enabled education based framework architecture that provides promising platform to enables sharing of learning materials/contents which are geographically distributed and it allows academicians and re-searchers to involve in sharing the academic and re-search related data materials by using the services such as searching, e-learning and distributed repository from different universities connected over grid network. This prototype model combines the academic and research data of the educational institutes and universities to support the educational com-munity. The multi-layer mechanism employs ser-vice abstraction and provides a clear specification of each layer. The proposed system consists of re-source layer, middleware abstraction layer and application layer. The application layer supports for implementing content retrieval and e-learning ser-vices. The grid middleware environment holds web service layer, service architecture layer and middleware components. These components maintain transferring application’s information as stateful ser-vice to the underlying layers. Grid resource layer includes system software

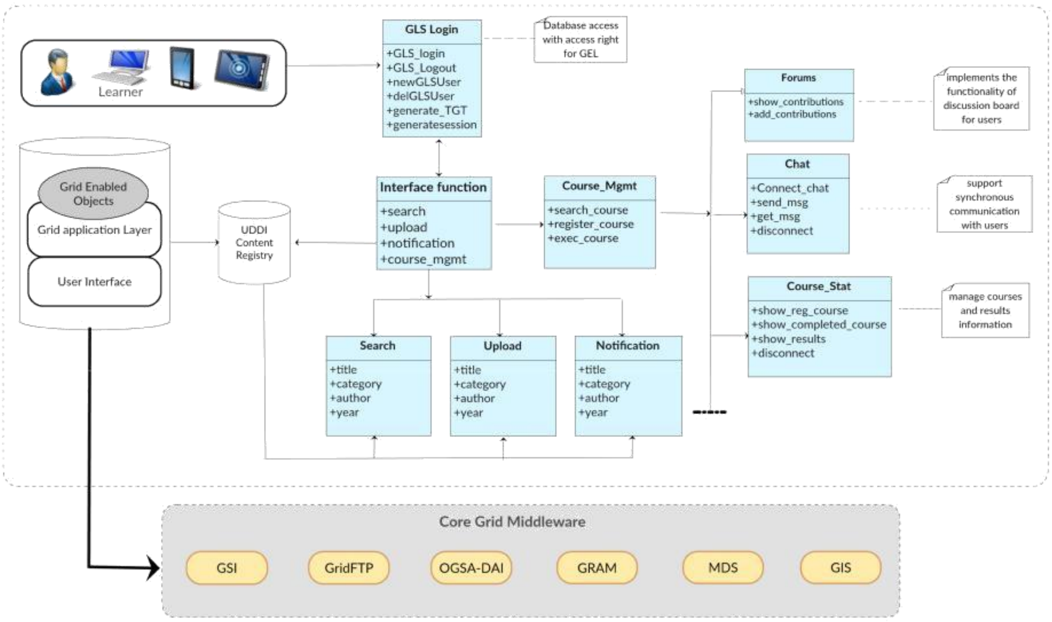

Fig. 1: Architecture of Proposed System.

represents the hosting environment, and deals with computing devices like high-performance computer, file server and compute cluster. The communication protocol of system soft-ware exchanges the data between grid middleware and end resources. The proposed model eases the implementation process and improves the prospective of component reuse.

The system collaborates the individual virtual organization (Institute/University) into the grid and establishes the proper communication between each organization's fabric resource. Every single education application/service hosted by individual will be ex-posed to service registry using WSDL.

The outline architecture of the proposed model is presented in Fig. 1 consisting of grid learning system (GLS) and grid middleware as well, which are both based on grid services and web services respectively. The grid learning system interacts transparently with grid middleware, which holds abstraction layer between user and system so that user is unaware of the grid. The proposed system offers both content that utilizes grid functionalities and the content that does not grid functionalities. All ser-vices of the grid learning system accessed through dynamic web pages, therefore users only required of web browser to utilize the system.

A. Operations and Functionalities

This section coordinates the services related to learning activities and are provided as a web services to the end user. Some of the high level services are required core grid functionality services to accomplish the requested task and some services does not required. The services of GSL are accessed via web pages, hence, the user required only web browser to access this system. The GSL login operation allows authenticated users to use services hosted by the connected universities. The ticket granting ticket is received upon successful authentication of the user. Following, user can look for suitable options and operation such as course management, notifications, forums, and searching (academic/research data/any other information) as provided in the web page. The course management has the search Course where learner can search for respective field, the requested service will be first searched in the content Registry. The register Course operation is called to enrol for a course. User can take part into the course by calling exec Course operation. The course Assessment manages the assessments/tests for courses which user enrolled and course Stat service holds the statistical information, status and result of all courses attained by an individual.

Similarly, the system allow users to search for the academic class notes, question papers and re-search publications published from connected universities in the network. The search operation enables user to search and sort the contents by specific options provided in the interface. Further, the listed items are either viewed or downloaded to personal device, this is performed by calling the download operation which uses GridFTP protocol to transfer the file by coordinating with OGSA-DAI component. In addition, upload operation allows the authorized users to upload the verified and validated document. The user has to provide details of up-loading document such as domain, title, authors, keywords, etc. Then, the document is stored in the respective local repositories and local index is constructed for the stored data along with required meta information. The deliverFromGFTP activity is invoked by the remote server to update the global index and this is repeated when local indexes are added with new entry or any new update on previously stored document. The Commodity Grid Toolkit [23] is used to implement the grid middleware components and it supports for mapping and inter-faces between grid middleware and framework. The architecture in the Fig. 1 for grid enabled learning system, the architecture is kept as simple as possible in order to demonstrate the technical feasibility which includes both web and grid technologies respectively.

B. Web Services

Web Services are designed as standard reference architecture in order to promote interoperability and extensibility among the web applications, as well as to allow them to be combined in order to per-form more complex operations [24]. It expresses a standardized way of integrating web based application using the open standards specifications such as

Extensible Markup Language (XML) as to tag the data, Web Services Description Language (WSDL) is used to specify the operations supported by web service, Simple Object Access Protocols (SOAP) is used to exchange the data over the web and Universal Description Discovery and Integration Protocol (UDDI) is used to list and discover the new service available on the web.

C. Service Creation and Accessing

Standard web server technologies are used to transfer the information between users and main server. Using web technique, like SOAP [25] which provides basic messaging frame work to carry-over messages between HTTP server and grid functionalities. Upon user authentication to the network/portal, a context is created for that user session. User can locate the available services that each have a user interface and some back-end logic that execute in the portal server. The user can only view services/applications which are registered in the ser-vice registry in order to access the service. By adopting the web technologies into the system, it allows the integration existing web service and e-learning systems into the virtual classroom. From visualization prospect, custom Javascript and CSS information are used to enhance the browser view. There-fore, the GLS is capable to deliver the modified CSS web pages to the respective device screen.

D. Service Publishing and Discovery

The proposed system uses centralized service directory that enables users to publish and discover the new and existing service hosted by the other virtual organization. This operation is performed using monitoring and discovery service (MDS4) from globus toolkit. The index and trigger services of MDS4 make use standards and mechanisms such as WS-Resource Propoerties, WS-Base Notification and WS-Service Group to discover resources and ser-vices. Due to centralized based approach of this sys-tem, however, hosting applications or services will be assumed to be within central server proximity. The existence of super node can be actively broad-casted without interference on the network. The MDS4 is coded in Java, and runs on top of the SOAP over HTTP protocol stack used by GTK WSRF core, which allows MDS to be closely integrated with core GTK functionality.

E. Collaborative Learning

Due to the distributed nature of grid, the system is able to expand beyond the traditional learning methods and environment that enables the collaborative learning to students, researcher, and faculty etc. Learning Collaboration includes both synchronous and asynchronous communications among different parties. Synchronous communication includes instant messaging/chat, shared white-board, or teleconferencing, etc. Asynchronous communication holds discussion forum, email and news group, etc. Based on the technology various institutions or universities are collaborated and establishes network between each other. This aspect is particularly useful for students who are jointly working projects or group work from different universities where they can combine, discuss and manage their work. In addition, it also enables the computing power to perform complex real-time simulations and experiments. One can search for the academic study material, research documents and other information among the connected university repositories anywhere, anytime using fixed and mobile devices. The proper user interfaces are designed to list the searched content/documents. Later, the user can opt for download or view option provided in the user interface.

F. Web Based Communication

The system is designed to implement as much of the required functionalities as possible using web technologies and implemented around the centralized servers hosting applications and contents. For interactive web applications AJAX 5 web technology is used to provide the communication between the users (learners) and applications. The principal strength of AJAX resides in the classifying static web

Host	CPU Type	Processor Cores	Clock (Ghz)	Memory (GB)	Storage (TB)	NIC (Gbps)	Linux Kernel
IBMServer	Intel Xeon X5670	12	2.93	48	4	1	3.19.0-25
HpEliet01	Core i7-3770	8	3.4	4	1	1	3.19.0-25
HpEliet02	Core i7-3770	8	3.4	4	1	1	3.19.0-25

HpProbook01	Core i7-4702	8	3.4	4	1	1	3.13.0-48
HpProbook02	Core i7-4702	8	3.4	4	1	1	3.13.0-48

Table 1: Specification of hardware Resources on the Test Bed

page and their dynamic contents. AJAX is designed with asynchronous mechanism which supports to keep learner's interaction with server though requests are still pending. Upon the requested data are ready, it loads the dynamic contents on it static web page. The requests remain ineffective until one of the learning material such as presentations (slides), notes, chat-room communication etc., altered. This reduces the workload on server at many time periods between data refreshing requests. Upon the changes occurred on data item, the response is assembled by the server and returns to the user's dynamic screen. User side Javascript parse the re-turned data and modify the page contents.

VI. EXPERIMENTAL SETUP

The experimental environment is set up using desk-top machines and laptops with high end dedicated server. The details are given in Table 1. A grid test bed is established to experiment grid operations using Globus toolkit 5.2.5 version. Each ma-chine in the test bed consists of GTK which includes GRAM, GridFTP and GSI components with Ubuntu 14.04 Lts operating system. All machines are connected via local area network and assigned static IP addresses. The essential necessity of defined ser-vices should be compatible with other components of GTK. The components of the framework are developed using the libraries provided by Globus Alliance. Each machine is configured by static IP ad-dress with its unique host name. The user can create other accounts to use client applications along with GTK functionalities.

Configure the necessary files to form grid:

1. In order to establish the communication between individual systems in the network, the /etc/hosts file is edited with different IP addresses and hostname as specified in the GTK configurations.
2. The web application and services approaches required to install Java (JDK) for programming language and Apache tomcat web server with its latest version which provides HTTP server environment for interaction of web pages. The Ubuntu OS has different methodology to get install these software toolkits for example export CATALINA HOME and apt-get install CATALINA HOME.
3. Next, the Globus RPMs repositories need to be installed before low level GTK components. These RPMs are base repositories for GTK which includes the Globus software packages and yum configuration file with verified packages using public key mechanism. The globus site contains various repositories with respect to their OS release codenames.
4. Using the operating system packaging tools (apt-get, aptitude), we have installed the GTK components such as GSI, Myproxy server Myproxy-admin, GRAM and GridFTP. Standard CLI commands can be performed in order to insure the established network and proper working of components. Later, the programming approaches and low level component interfaces can be mapped to check the basic GTK services. The Fig. 2 shows the initial programming samples illustrates accessing basic grid core services such as submitting program, uploading/downloading, searching etc.

A. Experimental Results

A set of experiments are performed using mobile phones and desktop computers to evaluate the pro-posed system in the laboratory. The objective of this approach is the validation of user interfaces on relative sizes of handheld devices, user experiences and configurations. A prototype is been deployed on a physical server with specific IP and domain name. Before hosing the services some of the laboratory experiments have been done to test this infrastructure. Along with infrastructure test, carried test for the operations like uploading, searching and downloading the documents. Next, the reliability and utility of the proposed system is tested by performing number of experiments by setting up a group of students' batch in a web browsing laboratory at the cam-pus. The students were given chance to check and have an experience on provided functionalities and simple instructions were given to utilize the functionalities. Later, the researchers and higher level students to test the system (no instruction was provided). It was quite interesting to observe the results for both batches.

```
// Initialization
String mdsServer = "mds.globus.org";
MDS mds=new MDS(mdsServer,"579");
// Search for an available machine to submit job
result = mds.search ("o=Grid","&((objectclass=
GridComputeResource)(freenodes=4))","contact");
//Select a machine
machineContact = <select the machine with minimal
execution time from the contacts that are returned
in result>
//Search for the document and return & the attributes:
server,port ,directory, file
dn = mds.search("(objectclass=documentNumber)
(year=2015)","dn", MDS.SubtreeScope);
result = mds.lookup (dn, "server port directory
file");
//Download the data to the machine
filename = result.get("filename");
sourceURL = result.get("server")+":"
+ result.get("port")+"/"+ result.get("directory")+"/"
+ filename;
destinationURL = "gsi-ftp://"
+ "machineContact"              // destination
+ "~/"                          // directory
+ filename;                    // filename
UrlCopy.copy (sourceURL, destinationURL);
//Submit the program
GramJob job = new GramJob(rsl.toString());
job.addJobListener(new GramJobListener() {
public void stateChanged(GramJob job) {
// react to job state changes
}
});
try{
job.request(machineContact);
} catch (GramException e) {
// problem submitting the job
}
```

Fig. 2: Sample Examples using Grid Services

Graduate students are engaged with course materials and academic notes and few of them searched for technical project stuffs which supports academic goals. Subsequently, majority of the students have shown interest in studying the documents published by native universities than their own as presented in Fig. 3. Unlike students, researchers and others involved in both grid functionality and education services; moreover, they searched data or documents that support to research goals.

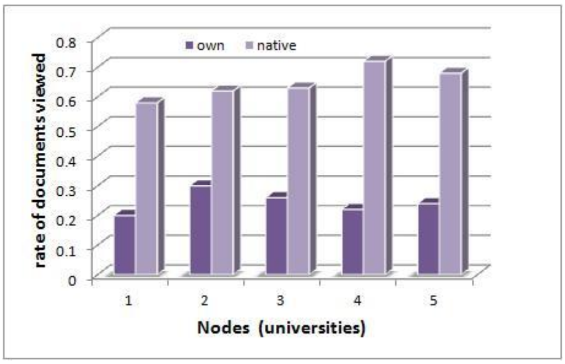

Fig. 3: Documents Searched and Viewed by Student Group

As the infrastructure has one central node (i.e super node) where the business logic deployed and runs. The Fig. 4 shows the resource utilization at different nodes where super node has maximum resource utilization rate compared to other nodes because of its frequent request processing. Besides, the test is conducted to analyze the resource utilization at different case i.e by

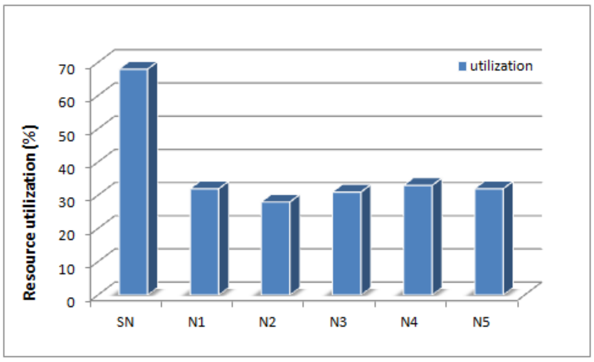

Fig. 4: Resource Utilization at Different Nodes (machines)

performing or hosting the online workshop on programming in collaboration. It is ob-served that the variations pattern of total number of resources utilized at different nodes as shown in Fig. 5.

The results indicate that there is no significant tendency in resource utilization as increasing the users' number. With a increasing number of nodes, the peak resource utilization remains 60-70 % range which is an acceptable state. As tests are conducted, the configuration of the system is set to encourage that any node in the network is never more than 0.25 seconds out of sync with the super node. Therefore, some experimentations are conducted by increasing nodes connected to revise the phase, however, it is noticed that no substantial changes occurred in the overall performance in utilization of resources with updated change. In this sense, the GLS holds the positive response from learners and noted that learner is able to find the need for improved learning method.

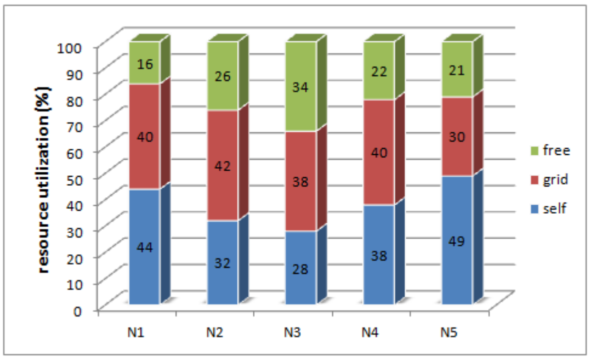

Fig. 5: Distributed Resource Utilization at Nodes

B. *User Interfaces*

The system has several graphical user interfaces that enable easy access to the functionalities provided.

1. Graphical display: The model represents responsive design that determines the resolution of the screen on which a page is being viewed using HTML5/CSS3 media queries, then adjust the size and layout of the page appropriately as shown in Fig. 6.

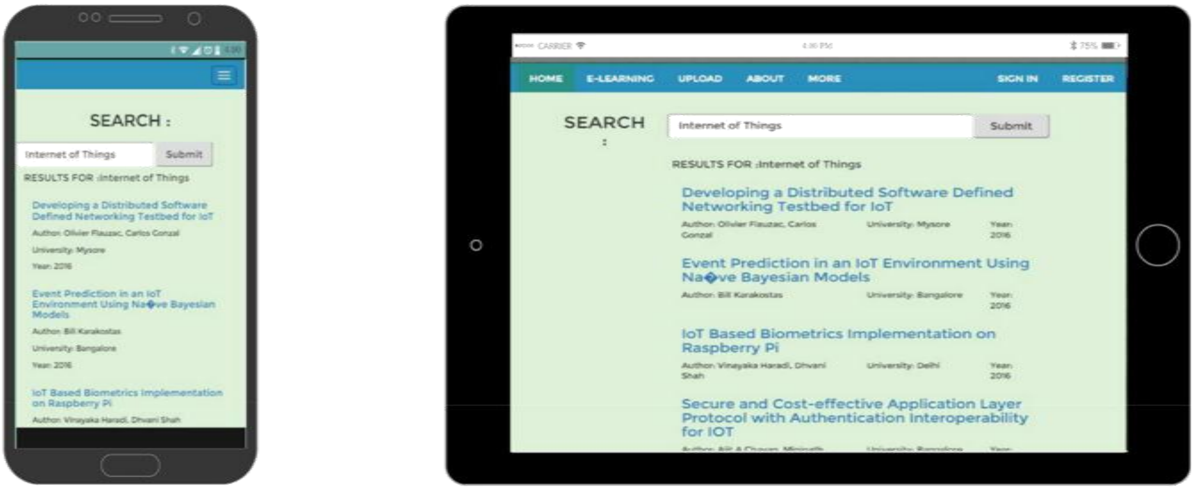

Fig.6: Graphical Display view for Searched Documents in Both Smart Phone and iPad

2. User profile page: The individual user is provided his own learning space on successful registration. It maintains user's usage, personal information and configuration. User is allowed to change personal configuration through this page.
3. Admin page: The page enables super access to grid learning system where admin can customize service functionalities and events. Ad-min has all/partial privileges on the system and manages all participants within this plat-form and configures the overall setting.
4. Home page: This page gives quick overall information about the portal and display re-cent articles, news, activities and events on the board. This page facilitates navigation on provided links, search box and other options are presented in Fig. 7. It enables minimal services for guest users such as searching on repositories, activities, forum lists, etc.

VII. CONCLUSION AND FUTURE WORK

The increasing significance on educational e-learning process gained the attraction of new generation learners. The information technology has its vital role to change over the methodology of the system. Understanding the challenges and difficulties faced by institutions in the developing countries compared to developed ones in order to drive the academicians and researchers of towards new e-learning system. Grid technology provides promising platform to access distributed shared resources and information. This platform can be well suited for many areas where information is required to be collaborated and shared. In this paper, the system described and graphical user interfaces developed for grid based learning system enable users to discover the educational services offered such as easy searching, content sharing and distributed repository by connected institutions of different Universities.

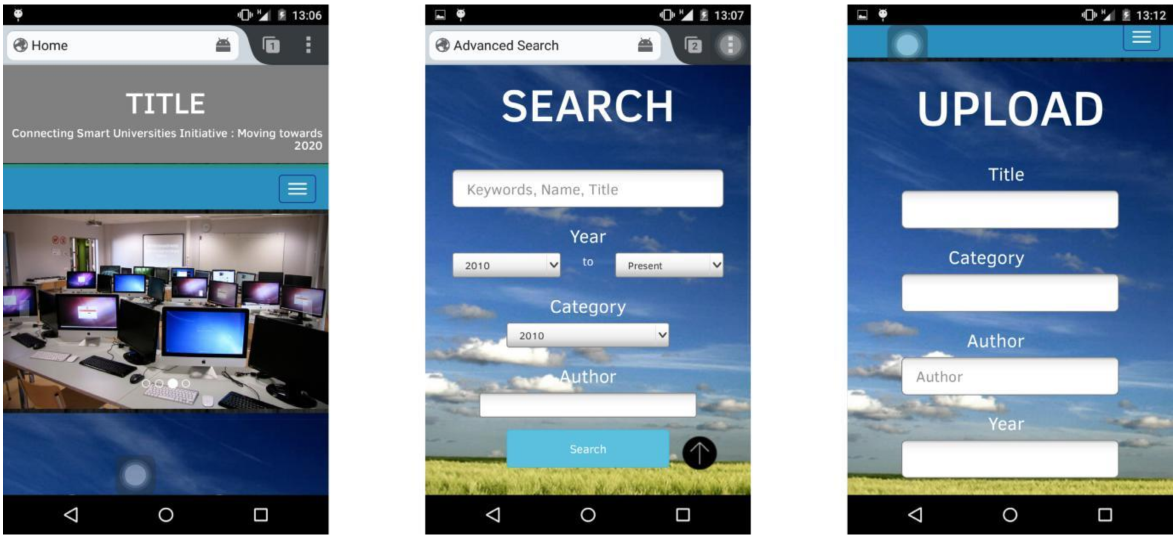

Fig. 7: Screenshots of Graphical user Interface in Android Mobile Phone

Furthermore, the designed GUIs are easy to operate and offer a flexible interactive learning sessions from distributed repositories. The responsive web pages with varying display size on respective fixed and mobile devices make enriching comprehensive learning experience. The experimental results shows screenshots of various learning services at different screen sizes. The system has the potential to expand learning spaces through the use of mobile technology. This serve as a prototype for developing education and knowledge based applications for Universities.

The system may further create enhanced GUIs for course management and new services based on the learner experience and feedback. We are also investigating on integrating the cloud platform to have flexible operations and intended to develop efficient resource utilization and scheduling techniques in order to balance the system against large number of requests within restricted resource capacity. In addition, the system needs optimized security mechanism in securing the integrity of data than basic provided mechanism.

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