Research Journal of Applied Sciences, Engineering and Technology 8(22): 2290-2299, 2014
DOI:10.19026/rjaset.8.1231
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: September 13, 2014 Accepted: September 20, 2014 Published: December 15, 2014

Research Article

Optimized Grid Based e-Learning Framework

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Abstract: E-Learning is the process of extending the resources to different locations by using multimedia communications. Many e-Learning methodologies are available and based on client-server, peer-to-peer and using Grid Computing concepts. To establish e-Learning process, systems should satisfy these needs, i) high storage for storing, ii) high network throughput for faster transfer and iii) efficient streaming of materials. The first and second needs are satisfied by using Grid and P2P technologies and the third need can be achieved by an efficient video compression algorithm. This study proposes a framework, called Optimized Grid Based e-Learning (*OgBeL*), which adopts both Grid and P2P technology. To reduce the e-Learning material size for efficient streaming, a light weight compression algorithm called *dWave* is embedded in *OgBeL*. The behavior of framework is analyzed in terms of time taken to transfer files using in-use grid protocols and in networks combined with grid and P2P.

Keywords: Distributed networks, education, e-learning, grid computing, multimedia streaming, peer-to-peer networks, wireless networks

INTRODUCTION

Romiszowski (2004) defines e-Learning as a "solitary, individual activity, or a collaborative group activity (where) both synchronous (real-time) and asynchronous (flexi-time) communication modes may be employed".

E-learning (Kawamura *et al*., 2007) is a term used to refer to the computer-dependent learning. It makes use of computer dependent guidance for online meetings, teaching supplies, email, discussion forums and computer-aided evaluation. Most of the experts are concerned in adopting this technology in education as it tries to ease the process of teaching and learning. This technology has benefits, rarely found in classic learning environments, such as interaction between learner and resources, independence from time and place, supervisory capability and continuous validation. E-learning is used widely in on-line classes, because of availability of increased bandwidth and tools supporting multimedia usage in online. Although there are many merits for e-Learning, some demerits are there:

- Difference between LMS (Learning Management System) and LCMS (Learning Content Management System)
- Difference between standards and formats of creating electronic contents
- Difference between learner's and teacher's skill
- More attention to content and less attention to interaction
- Storage of e-Learning contents. Most of the current e-Learning systems are based on client-server or peer-to-peer model and they have some limitations such as scalability, shareable, accessibility, availability, distributed computing and storage

Grid technology (Foster *et al*., 2001; Nemeth and Sunderam, 2003; Foster and Kesselman, 2004) has the potential to change the way of computing and data access. Computational Grids are widely regarded as the next logical step towards computing infrastructure, as they are:

- Tightly linked clusters
- Enterprise-wide clusters
- Geographically dispersed computing environments following a path from standalone systems

Generally speaking, the grid could be considered as the new technology for transparent access computing and for accessing storage resources anywhere, any time and with guaranteed Quality of Service. Grid is already being successfully used in many scientific applications

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to process and store the vast amount of data. E-Learning can adapt to:

- Use power of distributed computers in grid network to create virtual labs
- Use distributed contents to create a completely customized class for learners
- Make possible collaboration between education resources, contents and services within grid network

In our prior work *gBeL* (*Grid basede-Learning*) (Manjusha *et al*., 2011), proposed and developed a new framework for e-learning using grid computing technology and this opened a new horizon to e-learning (Pankratius and Vossen, 2003; Kashfi and Razzazi, 2006; Nassiry and Kardan, 2009).

Typical examples where current e-learning systems reach their limits are, consider a medical student who wants to examine the human body and prepare for practical exercise. Presently, it is impossible to compute, say, photo-realistic visualization of a complex body model in real-time and display the computation result on a remote screen. With the advanced functionality of e-learning grid, students could be provided with possibility to grab, deform and cut model elements with a click of mouse.

The above example for e-learning comprises of lots of multimedia file consuming a large amount of storage space and larger bandwidth while streaming. To cut the size of multimedia file and to avoid wastage of bandwidth, that file can be compressed (Lodge, 2002; Das *et al*., 2010). As the huge volume of raw multimedia data entails rigorous bandwidth requirements on the network, compression is widely employed to get transmission effectiveness. Since the video takes larger bandwidth (56 kbps-15Mbps) than audio (8-128 kbps), the former is used for amendment to meet QoS requirements. Hence, the focus on the characteristics of video compression becomes useful for amendment.

LITERATURE REVIEW

For an effective e-Learning, the basic internet infrastructure is not enough and is not capable of providing a seamless and intelligent framework. For the efficient deployment of e-Learning, some kind of support is needed and they are:

- Seamless resource sharing such as information storage and computational power
- Support for dynamic and continuously evolving participants
- Service oriented architecture
- Dynamic content and resource management
- Intelligent indexing and match making for resources
- Security and trust mechanisms
- Group management
- Knowledge management
- Quality of service

The e-Learning system is a rapidly developing field and is important to highlight the current research activities under this area. E-learning projects like SELF (Abbas *et al*., 2005), APPLE (Jin, 2004), CoAKTinG (Shum, 2002), Access Grid and Onto Edu (Guangzuo, 2004) motivated our work.

From web-based learning to innovations such as online conferences, e-Learning has progressed a long way. World-wide interest in e-Learning can be seen from the estimates of the e-Learning market growing to 50 billion USD from 3 billion USD (Levis, 2002). Historically the internet and the World Wide Web gave birth to the concepts of E-learning and collaborative knowledge sharing across the globe. SELF aims to identify the key-enablers in practical grid-based E-learning environment and to minimize technological reworking by proposing a well-defined interaction plan among currently available tools and technologies.

The APPLE project emphasizes the importance of grid and P2P infrastructures for e-Learning applications instead of a static web. Thisstudy proposes the use of the grid for group-centric and P2P for individual-centric information retrieval. The designers of APPLE used WSRF.NET to develop and deploy a virtual classroom service. They integrated a P2P platform with the grid to exploit extensive resource potential from the grid. Despite being an extensive framework, a major limitation of APPLE seems to be its dependency on a proprietary technology (WSRF.NET). Moreover intelligent semantic matching structures, personalization and collaboration technologies are not explicitly addressed in the original APPLE proposal. By using P2P (Chervenak and Cai, 2006; Randriamaro

Table 1: Recent work- e-learning: A summary

	E-learning projects				
Benchmark	SELF	APPLE	CoAKTing	AccessGrid	OntoEdu
Seamless resource sharing	Yes	Yes	Yes	Yes	Yes
Dynamic participants	No	Yes	No	No	No
SOA compatible	No	No	Yes	No	No
Dynamic content management	Yes	Yes	Yes [Admin]	Yes [Admin]	Yes [Admin]
Security	No	No	No	Yes	Yes
Group management	No	Yes	No	Yes	Yes
QoS	Yes	Yes	NA	NA	Yes

et al., 2006; Forestiero *et al*., 2008) or the grid (Pacitti *et al*., 2007), the objective is to pool and coordinate the available distributed resources.

The CoAKTinG project aims to advance the state of the art in collaborative mediated spaces for the Semantic Grid (Page *et al*., 2005). This study presents an overview of the hypertext and knowledge based tools which have been deployed to augment existing collaborative environments. The ontology used exchanges structure and promotes enhanced process tracking and aid navigation of resources before, after and while a collaboration occurs. While the primary focus of the project has been supporting e-Science, this project also explores the similarities and application of CoAKTinG technologies as part of a human-centered design approach to e-Learning.

An exciting work in collaborative learning is the Access Grid project of Argonne National Labs. Currently deployed at 150 institutions around the world, the Access Grid is a multicast video-conference technology that enables its users to conduct real-time virtual conferences and maintain a wholesome online group-aware.

OntoEdu is a flexible education architecture based on three technologies i.e., ontology, grid and semantic web. This architecture adopts:

- Ontology for reusability
- Adaptability for device and user using ubiquitous computing

The core is educational ontology and is divided into four parts:

- User adaptation
- Education
- Service and content model
- Automatic composition

Grid based design is adopted for function and performance scalability. Table 1 summaries the findings and important aspects in e-Learning field.

MATERIALS AND METHODS

Existing vs. proposed framework:

Grid based e-learning framework (gBeL): Figure 1 explains the procedure of the gird based e-learning process *gBeL* (Manjusha *et al*., 2011), adopted in an engineering college and explains the use cases involved in it. It shows the various actors and the relationship between various use cases available in the e-learning. There are 3 actors i.e.:

- **Professor:** Who plans the lecture, creates the lecture and presents it in multimedia format and stores it.
- **Student:** Can login and download can the lecture file.
- **Admin:** The main actor who maintains the details about professor and student, manages data, security and the system containing the *gBeL* framework. The main use case in *gBeL* framework is embedded in grid system containing Globus middleware and maintained by the admin.

Optimized grid based e-learning framework (OgBeL): Figure 2 explains the proposed framework an extended work of *gBeL*. Figure 2 shows various actors and their relationship between various use cases. In addition to *gBeL* framework, *certificate* use-case takes

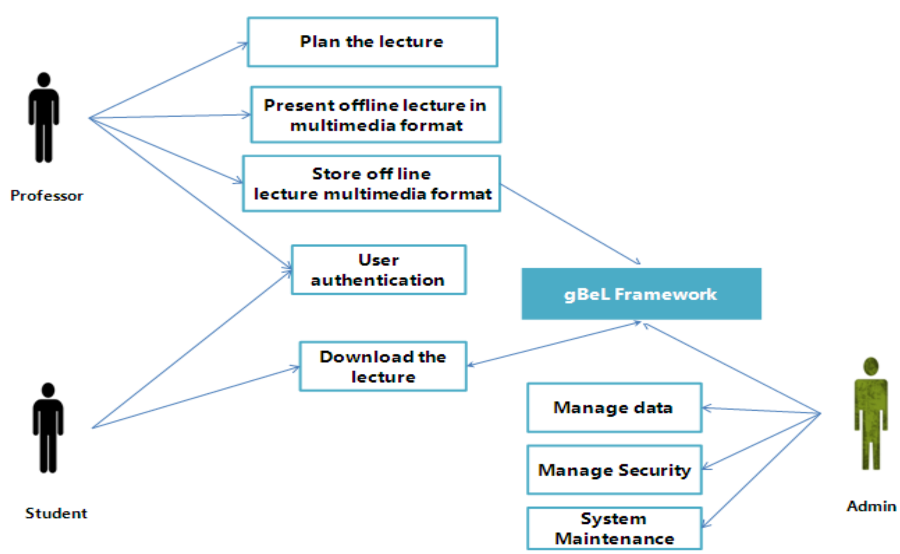

Fig. 1: Use-case diagram for *gBeL*

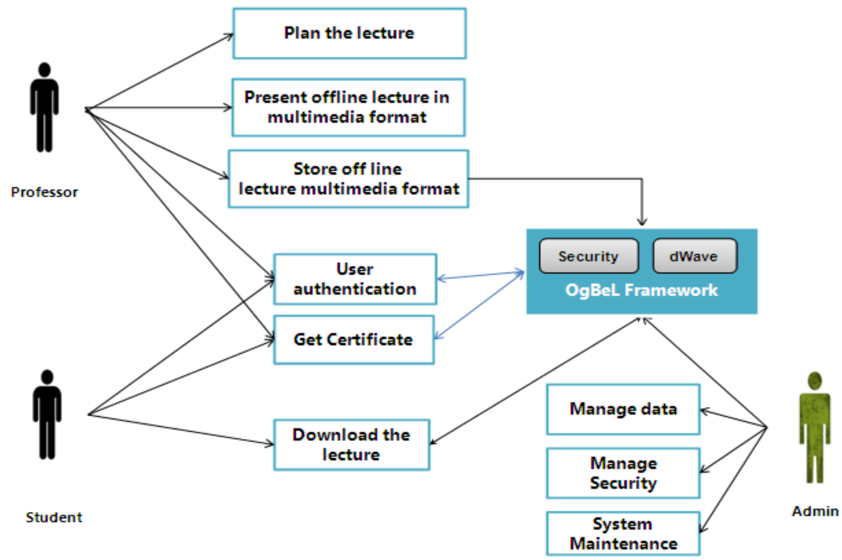

Fig. 2: Use-case diagram for OgBeL

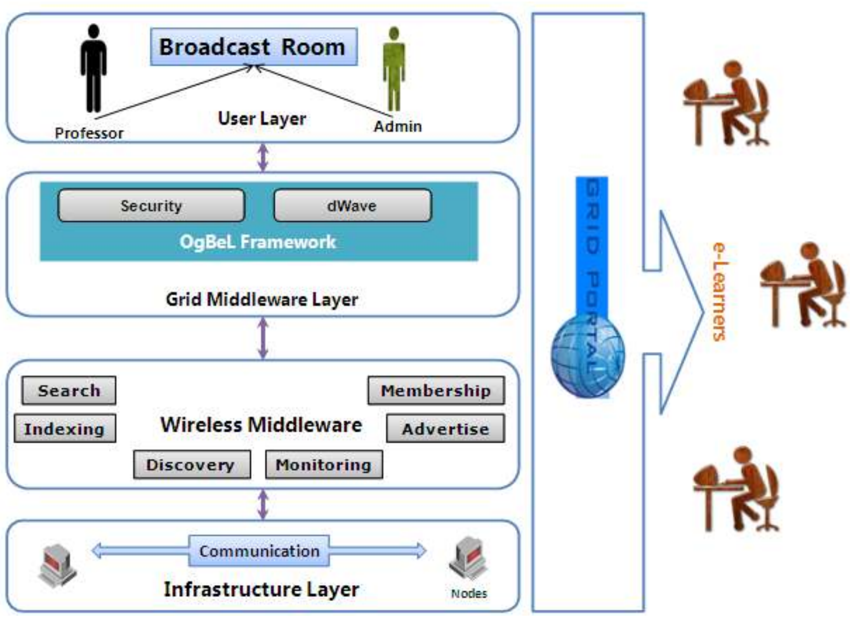

Fig. 3: OgBeL component model

care for registering and getting certificates from the grid server for uploading and downloading video lecture file securely from the grid server or from the user. For speedy transfer of video lecture file, the proposed framework adopts a light weight video compression algorithm called *dWave* (Arulanandam *et al*., 2012a).

Contributions: The proposed framework fulfils the needs of e-learning and upcoming sections reveal the needs and explain the contributions done by us.

OgBeL component model: Figure 3 illustrates the general schema adopted in this framework. The physical interconnection architecture is a class room, this is the physical environment where the lecture is broadcast and students might join for learning. In addition to the physical facilities for housing everyone i.e., those who are attending the lecture, has all the necessary equipment to integrate into a "virtual lecture room". Equipment includes a computer along with a projector to which a video-camera connected and managed by a specialized operator. The proposed framework uses an application level transfer protocol available in grid called *GridFTP* for communicating video lecture file. Component Model consists of four layers:

- **Infrastructure layer:** Has the basic elements of communication needs for the network.
- **Wireless middleware layer or P2P layer:** Establishes a communication between peers using a virtual protocol and with grid layer (Arulanandam *et al*., 2012a). It describes and uses the P2P middleware JXTA (Riasol and Xhafa, 2006), which forms the basic communication between peer.
- **Grid layer:** Grid has architecture, this layer has sub-layers consisting of:
  - **dWave:** a new video compression algorithm for compressing multimedia e-learning materials and
  - **Security:** which helps to transfer securely, authentically
- User layer, recording of video lectures and broadcasting is done.

Wireless Middleware Layer adoptsa mesh programming and computing platform called JXTA (Riasol and Xhafa, 2006) to resolve some troubles in recent disseminated computing, particularly in peer-to-peer computing. It is initially considered and conceived with the participation of an increasing number of professionals from learned organizations and industry. It delineates a universal set of protocols for construction wireless peer to peer submissions to address the recurrent difficulty in wireless networking schemes of conceiving incompatible protocols. It is an open mesh computing platform, having construction blocks and services needed to endow anything any location programming connectivity. It has a widespread set of open protocols endorsed with open source implementations for evolving peer-to-peer submissions and are normalized, in which peers can:

- Find out each other
- Self-organize into peer assemblies
- Advocate and find out mesh assets
- Broadcast with each other
- Supervise each other

The protocols can be applied in programming dialects for example:

- Java
- C/C++
- NET
- Ruby

Furthermore, they can be applied on peak of TCP/IP, HTTP, Bluetooth and other mesh conveys all the while sustaining international interoperability.

Primary concern of this middleware is to supply a platform that embodies the rudimentary wireless mesh functions in peer networks. The functionality sustained by this middle ware is:

- Interoperability-endow peers to find services and broadcast with one another, unaligned of mesh protocols.
- Platform independence- unaligned of programming dialects, mesh transport protocols and deployment stages.
- Ubiquity-accessible by any node with a digital heartbeat. And it empowers end points (peers/nodes) on for demonstration of the mesh by supplying an exclusive ID. The nodes with exclusive IDs can migrate over personal systems, altering conveys and mesh address, even being for the time being disconnected and still be addressable by other end points (Antoniu *et al*., 2005).

Individual site: This denotes the places where the students may join the conference using personal computing resources. This might be widely scattered and will be having all the facilities for participating in the lecture.

Broadcasting room: The place from where the professor broadcasts the lecture to all the students in the classroom. The technical resources are the same as those found in the classrooms. An operator assists the professor to manage such equipment.

Grid portal: The is portal by which users do activities such as submitting lectures, subscribing to lectures and uploading and downloading the content and takes care of authentication.

Our OgBeL framework is the heart and describes the technique, used to give high quality of service for transmission of e-Learning materials from professors to the students.

OgBeL framework: Figure 4 presented above illustrate the OgBeL framework. The proposed framework consists of 3 layers:

Layer 1: Grid middleware layer where globus is used and takes care of storage, transport, security and authentication.

Layer 2: Security layer, where actors (student and professor) register their details and obtain certificates and secure access of e-learning materials. For security, the proposed framework insists the users to register and issues certificate for uploading and downloading video lecture file.

Layer 3: Where the e-learning material is compressed using *dWave* algorithm.

Grid middleware layer: Grid computing has been an active research area for several years and several

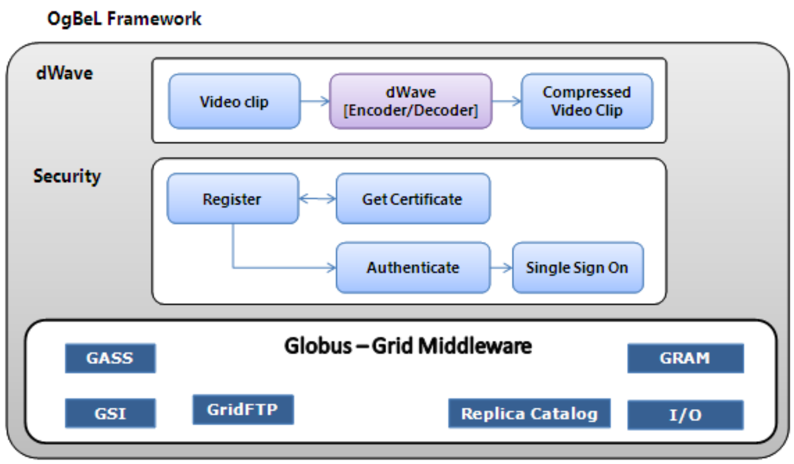

Fig. 4: OgBeL framework

systems exist that utilize functional computational grids. The introduction of computational grids has given developers a considerable number of extra problems to overcome in order to make them work correctly, reliably and also to build new middleware's apart from Globus, which is widely used. The Globus Wankar (2008) toolkit is designed to enable people to create computational grids. Globus is an open source initiative aimed at creating new grids capable of the scale of computing. As an open source project any person can download the software, examine it, install it and hopefully improve it. By this constant stream of comments and improvements, new versions of the software are developed with increased functionality and reliability.

The Globus toolkit itself is made from a number of components such as:

- Resource management (GRAM)
- Information services (MDS)
- Data management GridFTP/UDT)

Grid Security Infrastructure acts as a base for the three components. The data management provides support to transfer files among machines in the grid and for the management of these transfers. The design of the toolkit itself is very modular and has been developed in a way to make alterations and improvements easier, with less impact on connected components. It is designed to work on a number of platforms, predominantly that of Linux but with limited support for Microsoft. So far Globus has been a lead contender in the development of grid computing and is currently the only major effort with open source availability. The toolkit itself is designed to work in research environments, predominantly as an impetus to be redesigned and improved.

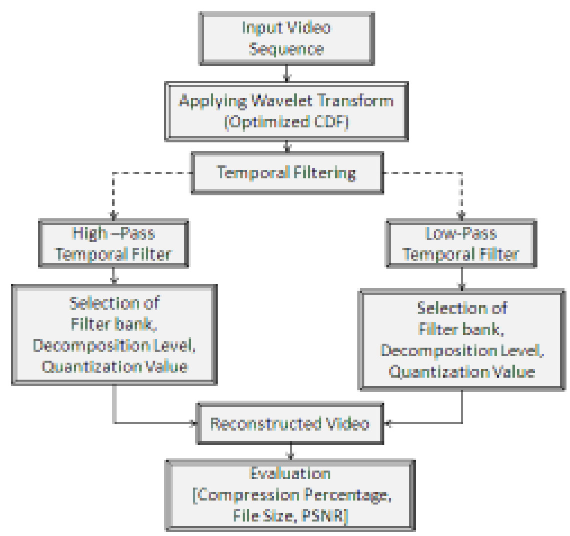

Fig. 5: Architecture for video compression (*dWave*)

Video compression/decompression module (*dWave*): Internet has made multimedia access pervasive, new and more efficient techniques are being developed constantly to ensure maximum compression and as a consequence, minimum network bandwidth usage. Though many techniques have been proposed in the past regarding video compression techniques, many of them suffer from shortcomings. We utilize a light weight video compression algorithm *dWave* that offers better compression and PSNR values as compared to existing techniques. By utilizing the power of discrete wavelet transforms, we have implemented and evaluated the algorithm that attempts to minimize the redundancies present in a video.

Figure 5 shows the architectural diagram of *dWave.* The algorithm initially obtains a video and splits this data into the audio and video streams. The video track is initially split into its constituent frames using a third

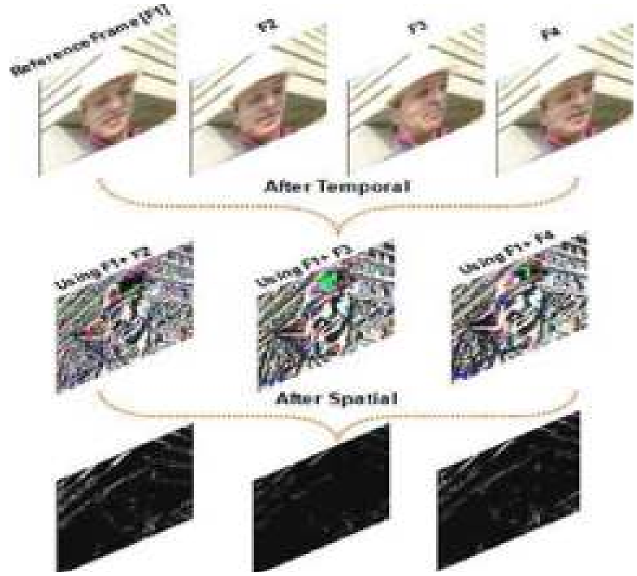

Fig. 6: Temporal-spatial decomposed images

party Java library that aids video manipulation. Once the constituent frames are obtained and they are passed to a temporal decomposition module which aims at reducing the redundancies in between frames. This algorithm exploits redundancies that occur due to recurrent patterns in data and offers good compression for data comprising large numbers of frequently occurring patterns.

Figure 6 shows the images after applying temporal and spatial decomposition.

Preliminary tests are conducted using *dWave* algorithm and shows that the compression percentage and the PSNR values obtained are significantly better when compared to existing wavelet based compression techniques (Arulanandam *et al*., 2012b). We compared the results with some of the results from existing techniques in order to get a quantitative standing of proposed *dWave* algorithm. The preliminary results are very promising and provide further support to our claim.

EXPERIMENTAL RESULTS

The proposed framework is tested and the results are tabulated by comparing various transfer protocols used in grid environment for transferring video lecture file. The results compared with in-use protocol such as GridFTP and UDT protocol.

GridFTP (Allcock *et al*., 2003; Ohsaki and Imase, 2009) is a high performance, secure, reliable data transfer protocol optimized by high bandwidth wide area networks. It is built on RFC 959 (File Transfer Protocol), RFC 2228 (FTP Security Extensions), RFC 2389 (Feature negotiation mechanism for FTP) and IETF draft on FTP extensions. The Grid FTP protocol is used in Globus, which allocates multiple TCP streams per file transfer and per host. Multiple TCP streams per dataflow provide significant performance benefit (Cannataro *et al*., 2003; Ohsaki and Imase, 2009) for two reasons: first, it creates an aggregate TCP buffer size that is closer to the real size of the bandwidth and the network secondly it essentially circumvents the congestion control mechanism implemented in the TCP protocol.

UDT is a high performance data transfer (Gu and Grossman, 2007; Suresh *et al*., 2010). The goal of UDT is to overcome TCPs inefficiency in the high bandwidth delay networks. UDT is a connection orientedunicast, duplex and it supports both reliable data streaming and partial reliable messaging. The congestion control module is an open framework which can be used to implement and/or deploy different control algorithms. UDT also has a default control algorithm based on AIMD rate control. Rate control tunes the inter-packet arrival time at every constant interval called *SYN*. When there is a packet loss rate during the last *SYN* time, the number of packets to be sent in the next *SYN* time is increased and calculated by using below equation:

$$inc = \max\left(\frac{10log_{10}(b-c)*8x}{MTU}, \frac{1}{MTU}\right)$$

where *B* is the estimated bandwidth and *C* is the current sending rate, both in number of packets per second, is a constant value of 0.0000015. *MTU* is the maximum transmission unit in bytes, which is the same as the UDT packet size. The inter packet time is then recalculated by using the total estimated number of sent packets during the next *SYN* time. The UDT receiver calculates the packet arrival rate (AS) at the time of sending ACK back to sender. On the senders side, if an *ACK* is received and the *AS* is greater than 0, the size of the flow window *W* is updated using below equation:

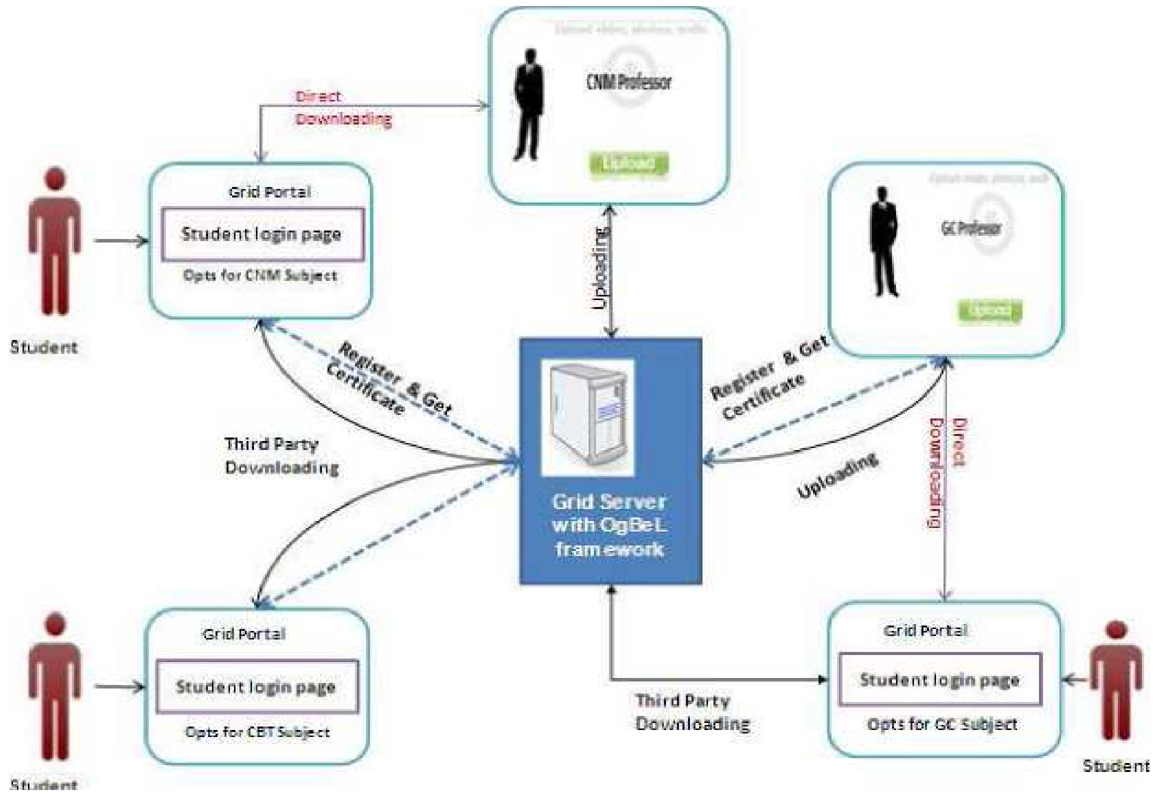

Fig. 7: Implementation scenario

Table 2: Time taken to transfer video lecture file using various techniques

Video size	Globus-url-copy	Globus-url-copy+compress	Globus-url-copy+UDT	Globus-url-copy+UDT+compress
(MB)	(seconds)			
35	33.400	6.1600	25.490	6.1000
40	40.870	9.7800	32.300	8.2200
80	82.240	24.120	73.920	22.560
215	222.50	75.030	180.28	71.970
400	459.17	176.59	392.69	169.53

$$w = s * 0.875 + (RTT + SYN) * AS * 0.125$$

Implementation scenario: Figure 7 shows the implementation scenario of the proposed framework in which the network uses 100Mb/s LAN. The actors are the Professors and the Students. As the first step, students and professors, register and get certificates from the grid server. Professors upload the lessons of different subjects in the grid server using the certificate obtained at the time of registration. A student has to login (using grid portal) into the student login page to download the lessons of different subjects, for e.g. Component Based Technology (CBT), Computer Network Management (CNM) and Grid Computing (GC).

The student has two options for downloading the lessons, the first one is, direct downloading i.e., directly from the professors system and the second is using third-party downloading i.e., using grid server. When the student opts for the third party downloading, i.e., from the grid server, the student has to send the certificate details to grid server and after verification the video lecture file is downloaded. The first option adopts the ordinary *globus-url-copy* command. When the student opts for the second option, the video is compressed using the proposed framework and uploaded. From the received results, our *OgBeL* framework solves the lower bandwidth problems because of using more efficient compression algorithm and embedding into grid technology and this leads to increase of the throughput up to 95% and fairness up to 92.3%.

Table 2 displays the experimental results obtained for the proposed protocol compared with the other in-use protocols for transferring multimedia related materials. It can be seen from the table and its corresponding graph (Fig. 8), that for the transfer of 400MB size file, *globus-url-copy* took 459.17 seconds, where *globus-url-copy* with *compress* took 172.59 seconds. *globus-url-copy* with *UDT* took 352.69

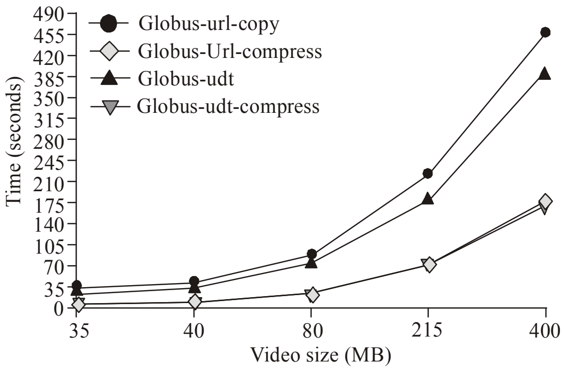

Fig. 8: Transfer time comparison for various transfer protocols

seconds which is lesser than *globus-url-copy*. The reason for the decrease in time in later case is due to the base protocol i.e., UDT (UDP+TCP), where in *globus-url-copy* the base protocol is TCP. When the option compress is used, the file size is reduced and results in decreased transmission time which comes to 169.53 sec for *globus-url-copy* with *UDT + compress* and 176.59 seconds for *globus-url-copy* with *compress* option.

CONCLUSION

In this study, an optimized framework is proposed for efficient e-learning system using grid and P2P technology, which satisfies the important needs of e-learning such as storage and saving bandwidth while streaming e-learning materials. The proposed framework uses P2P and grid computing for storage, high throughput and for high QoS. Experimental results obtained from various checkpoints show that the proposed framework reveals good results in speedy transfer, due to the efficient compression and maintains high quality of reconstructed videos. *dWave* has high compression ratio and compression percentage which gives reliable quality of video results and reduced processing time. This results in saving bandwidth and solves the low-bandwidth problems. Another interesting feature of this framework is, it saves storage space as it reduces the size of e-learning materials drastically. Presently, this framework adopts and embedded in a widely used grid computing toolkit *Globus*, our next step is to build as a separate component which can be used in any grid middleware's apart from *Globus* toolkit.

ACKNOWLEDGMENT

This study is an extended version of "gBeL: An Efficient framework for e-learning in grid technology", communications in Computer and Information Science, Volume 142, Part 1, 63-68, doi:10.1007/978-3-642-19542-6-11.

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