Developing Cybertek E-learning Tool on Emerging Cyberinfrastructure

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Abstract—The paper describes a framework and the state of the art for integrating Cyberinfrastructure systems on the Internet and the new e-learning tool Cybertek for instrument control and course presentation. The proposed framework combines Web Services to integrate data and services on the Cyberinfrastructure. It utilizes the Remote Control technologies in LAN and the powerful communication capability of Web Services to accommodate different communication interfaces/protocols. References have been made to Cyberinfrastructure models and middleware and the impact on the network bandwidth of Cybertek tool.

Keywords- e-learning, Cyberinfrastructure, collaborations tools, research instrument

I. INTRODUCTION

Cyberinfrastructure is an infrastructure which relies on distributed computers, cloud computing, computer networks and distributed communities of researchers all working together as to provide new scientific breakthroughs. At the bases of the Cyberinfrastructure is the Internet, which provides the framework for communication, data transfer and collaboration [1].

Cyberinfrastructure is a computer enabled tool that can help researcher and educators to find new knowledge by collaboration.

There are several integrating parts of the Cyberinfrastructure, the most important being (see Figure 1):

- Cloud/Grid Computing
- Data Visualization
- Virtual Organization for Distributed Communities
- Learning & Workforce Developing

Through Cloud Computing we have access to many dynamic and scalable services over the Internet. Cloud Computing has the following key features: EaaS (Everything as a Service), scalability, transparency, accessibility, virtualization and utility. Some benefits when using Cloud Computing are: ready to use applications (no need for downloads, installations or updates) and reduce costs for capital, support and maintenance.

Grid Computing is essential to the research process, giving the researcher the opportunity to handle, analyze and process peta-bytes of data.

Data Visualization and Data Analysis are the most important processes in the research activity. Nowadays scientists and researchers are generating huge amounts of data through different experiments. All the data generated, must be stored in data repositories/ data warehouses that run powerful data mining algorithms.

Learning and Workforce Developing is another important part of the Cyberinfrastructure. The future of education is the digitalization of the learning resources and the online availability of them. Cyberinfrastructure will create new science and engineering learning hubs, where students can access their curricula and expand their scientific vision with the help from their professors and researchers. In the future through Cyberinfrastructure professionals in their fields can give presentations and conduct tutorials to the training workforce. This comes to the help of companies and their

Figure 2 Different Cloud Computing Resources

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managing staff by lowering costs with logistics and the training program.

By creating data repositories in Cyberinfrastructure that contain courses, education materials and other knowledge resources, the access to that knowledge will be more accessible to the students, researchers and learning workforce.

Cyberinfrastructure helps enhance the research and learning opportunities through its facilities and unbounded collaboration capabilities.

Virtual Organizations for Distributed Communities are the driving force of the Cyberinfrastructure, connecting scientists and researchers from all around the globe into organizations in which they can work together and collaborate to make outstanding breakthroughs in science and engineering. Cyberinfrastructure offers state-of-the-art services to researchers from different areas of science and technology empowering scientific discovery and innovation. With the help of high speed networking services of Cyberinfrastructure, researches in different parts of the country, the continent or the globe, can interact, work and exchange ideas like in a group. Cyberinfrastructure offers end-to-end services in order for the virtual organization to collaborate scientific workflows, share knowledge, conduct experiments using remote instrumentation, execute code on high performance remote clusters, access and analyze data, view and compare results, and even deliver new and immersive learning activities.

Cyberinfrastructure can be viewed as a structure with different levels, as seen in Figure 3:

The bottom layer provides a network infrastructure to enable access of resources in the Cyberinfrastructure and remote access ability to geographically distributed instruments. At this level the hardware has different elements that can be sectioned in three sections: first section with computers, networking hardware and other communications mediums and data archives; the second section with interface equipment and smart networking devices; and the third section with measurement equipment, observing and analyzing equipment, cloud and high performance computing equipment.

The second and third layers from bottom, which are resource and protocol layers respectively, provide some key technical supports for the construction and operation of instruments, including instrument model database, instrument resource database, basic protocols and related specifications.

II. CYBERINFRASTRUCTURE MODELS AND MIDDLEWARE

Middleware is an important part of the Cyberinfrastructure, it is the one which connects and/or mediates two separate applications or components of the same software. A middleware provides a standard set of interfaces for a collection of resources distributed, heterogeneous and proprietary. Such applications developers will interface with the middleware interfaces instead of proprietary low-level resources [2].

In the Cyberinfrastructure environment there are different types of middleware. Grid middleware is the glue between user’s applications and the grid services. Here we can specify a few of the most important ones: Globus Toolkit (GT2-pre-standards and GT4-Web serviced based), UNICORE, ARC and gLite. The grid middleware must be able to perform certain services: security services (securing communications, authorizing users and authentication), execution management services (provisioning, placing and lifetime management of jobs and workflows), and information services (provides information about resources, policy, services and applications to tools and users) and data management services (manages movement and replication of data as well as metadata about data).

A. Cyberaide

A first model of a Cyberinfrastructure model is Cyberaide, it provides virtual appliance and makes easy access to access Cyberinfrastructure, work management and user built organizations. Cyberaide is based on an open and free technology and software Cyberaide JavaScript, a service oriented architecture (SOA) and grid abstraction framework that allows users to access the grid infrastructures through JavaScript [3].

B. HUBzero

HUBzero is a powerful middleware that provides a solution to create dynamic scientific gateways for different communities of scholars and students. HUBzero is a middleware for accessing simulation tools and computing resources that can also provide a method for users to provide their own educational materials and courses directly on the website [4].

Developed at Purdue University, HUBzero is the Google of simulation tools sort, a place where programs deploy and access computational research codes, and visualizing and analyzing results, using the common web interface of a web browser. It has WEB 2.0 features built-in, like Facebook which helps create communities of researchers and educators in science and engineering and facilitate online collaboration, distribution of research results, training and education [3].

HUBzero is the backbone for nanoHUB.org Cyberinfrastructure. nanoHUB.org can help users run simulations tools and analyze the results online without having to install any additional software on their computers; it is one
of the biggest Cyberinfrastructure for scientific collaboration. This great achievement is possible with the help of TeraGrid (see Figure 4); offering powerful high-end infrastructure that unites eleven sites through high speed networks with computational resources and experimental facilities around the globe [5].

III. THE PREMISES FOR CYBERTEK DEVELOPMENT IN CYBERINFRASTRUCTURE ENVIRONMENT

The desire for collaboration and advancements in research lead to the development of novel Cyberinfrastructure. In the Eastern European region Cyberinfrastructure and e-science is a growing domain, integrating more and more universities and research centers and helping scientists and researchers rich their goals. Cyberinfrastructure also provides a great teaching and e-learning environment in which tutors and academia can offer a new kind of learning experience provided by Cyberinfrastructure services. “Ștefan cel Mare” University of Suceava wants to join the Cyberinfrastructure either as a central node in the northern region of the country or as a node on an existing one.

We have developed a new software tool called “Cybertek” in order to come the aid of the emerging Cyberinfrastructure at “Ștefan cel Mare” University of Suceava. The tool can be used to interact, control and study different instruments and equipment over the Cyberinfrastructure. It gives the user the possibility to interact with other researchers and students to share data, ideas and opinions other on courses, presentation and other available materials on the Cyberinfrastructure, or on running live experiments on the tools provided. Cybertek also provides the user with live feed from the laboratory in which the experiment is running, so they can see the equipment they are interacting with. The live feed is made easy with the use of a dedicated video server offering a 4 camera view of the experiment and its surroundings. With this function the student may record a laboratory session, and then replay it to better understand the facts presented in the lesson. Also live audio feed can be provided if the circumstances demand it. It provides access for now, to three equipments a Network Analyzer from Fluke, a LAN simulator from Spirent both top of the line offering student a great opportunity to create, view and analyze different networking aspects and Rensselaer IOBoard RED 2 used for electronic measurements. This is a great opportunity for those users that can’t afford such expensive instruments, this being the benefit of Cyberinfrastructure for e-learning and research.

Cybertek was designed to help students learn and better understand the lesson presented by the professors or other teaching personnel, as well to help masters and PhD students do their research. The Cybertek control interface (see Figure 5) was designed to ease access to its functions and services.

In order to assess the requirements for a novel Cyberinfrastructure we made a study with respect to data/video communications and network performance of the application Cybertek.

In data networks we face the problem of identifying the optimal conditions for the transport of data streams. Cybertek uses all of the three types of data; user generated, sound and video. Because the data stream is so large, compression with different codecs of the video and audio data stream is a must.

Our first analysis has been focused on the main transmission parameters of the dedicated video server: the video codec (H.264 video codec), video resolution (800 x 600px, 1280 x 720px and 1920 x 1080px), image quality (Lowest, Low, Medium, High and Highest), and image frequency.

The most relevant sample data results taken with dedicated software for network performance analysis are presented in the following figures:

Figure 6 Bandwidth usage for transmission of video stream with all of the parameters to the maximum.
During our testing of the network performance of Cybertek, we have found that for video and audio transmission we need 11,287 Mbps for a fluent connection and 46,173 Mbps of bandwidth for video and data packets transmission.

IV. EFFECT OF CYBERINFRASTRUCTURE ON THE EDUCATIONAL SYSTEM

In the traditional paradigm of undergraduate teaching the theoretical knowledge is transferred during the lectures while the experimental knowledge is transferred during the laboratory sessions. Thus, the students need to assimilate the information in an abstract form and they can observe the practical effects of the accumulated knowledge only in laboratories. This paradigm of teaching does not allow the students to perform hand-on experiments in the process of teaching the lecture, and consequently, the students have difficulties in assimilating the great amount of abstract information presented in a two or three–hour lecture. Moreover, the balance between information transfer and the development of abilities is inclined toward information transfer since the abilities are usually developed only in the laboratory sessions. After-class homework might help in equilibrating this balance but it is mainly focused on developing theoretical abilities due to the unavailability of experimental infrastructure.

A new paradigm of teaching technical lectures has been developed by a group of researchers from the Rensselaer Polytechnic Institute (USA) led by Prof. dr. Don Lewis Millard with the aim of combining theory and practice during the lectures and making them more interactive. They observed that "by simultaneously stimulating a student's multiple senses, the student's understanding of the educational concepts can be improved with the effects of greater retention and application of the acquired knowledge" [6]. This is where the Cyberinfrastructure, with its hub based services contributes to the development of better learning and teaching methods [7].

V. CONCLUSIONS

This paper provides a view on the state of art of Cyberinfrastructure for research and education. Cyberinfrastructure the future of e-learning, a computer enabled tool that we can use today for the discoveries of tomorrow. The time when the Internet was a commodity is long gone; nowadays the Internet has become a necessity and a tool through which we can aspire to great scientific breakthroughs. We have presented the software application Cybertek, its characteristics, and the way in which it can improve collaboration and e-learning study. Also a network analysis of Cybertek network resources requirements was provided.

VI. FUTURE WORK

Future papers will contain an improved version of Cybertek with cluster data analyze capabilities for e-learning and scientific collaboration. Future versions of Cybertek will access different Cyberinfrastructure tools and instruments.

In the future papers will study different emerging wireless technologies on the Cyberinfrastructure and the impact they have on improving Cyberinfrastructure services.

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Figure 7 Bandwidth usage for video and large data package transmission