PARALLEL AND DISTRIBUTED COMPUTING RELATED ISSUES IN EDUCATION

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Abstract

The advancements in computer technology -- rapid processors, rapid graphic, and cheaper memory, promote the evolution towards parallel and distributed computing environments. In recent years, parallel processing and distributed computing is attracting a lot of attention in education field. In this paper, the author will describe several issues or research activities that have been carried out in education field, which relates to distributed and parallel computing. This paper will highlight the effort taken by several educational institutions to move towards parallel or distributed computing environment and pointing out the need for this evolution. In addition to that, research work from several researchers on effective way of teaching distributed & parallel computing related courses will be presented. The paper will also discuss tools/courseware used in distance education and describe the use of an evolutionary learning method (SQ3R) in distance education. Finally, research work on designing, development and implementation of web-based education, real-time education, and multimedia-based education will be discussed. It is obvious that by utilizing the parallel & distributed computing technology, we can enhance our education system in various aspects (speed, quality of contents, presentation styles etc). It benefits both the educators and the learners by supporting a wide range of educational modes of learning (including virtual learning environment and web-based courseware), and by allowing the sharing of knowledge and learning resources.

1. Introduction

Distributed computing system is defined as [1]: -

"*Application using servers to deliver services over a communications network through user interfaces to end users, managed as a single set of operating entities*."

Distributed computing system reflects a complex client/server model in which the system is built up from many nodes, and each with specified function, which are connected to each others through networks (internet) [2]. The client/server model is a separation of resources into two halves so that some computer resources like processing power can be saved.

The rapid advancement in the network technology and computer technology parallel processing and distributed computing are attracting a lot of attention in education field in recent years. Experiment in conceptualising, designing, and delivering web-based courses to geographically distributed

students stimulate the development towards a new educational approach: network-mediated collaborative learning.

The main purpose of this paper is to describe several issues and research activities that have been carried out in education field, which relates to distributed and parallel computing. This paper highlights the following issues and activities that relate to distributed and parallel computing: -

- Effort and Need to Move Towards Parallel and Distributed Computing Environment (Section 2)
- Effective Ways of Teaching Parallel or Distributed Computing Courses (Section 3)
- Tools and Courseware (Section 4)
- Improving Effectiveness and Acquiring Success of Web-Based Learning or Distance Learning (Section 5)
- Designs, Development and Implementation of Web-Based, Real-Time and Multimedia-Based Education (Section 6)

2. Effort and Need to Move Towards Parallel and Distributed Computing Environment

The importance of using network in education has gradually increased at Harvey Mudd College (HMC), a highly selective college of science and engineering, which belongs to The Claremont Colleges. HMC program is founded on the interrelationships of various disciplines with computing providing a primary means of fostering the development of this educational model. The client/server model of computation (Figure 1) reflects the HMC interdisciplinary educational environment [2]. The load in HMC network increased significantly due to the added of new equipment and the need for the equipment to send/receive data on the network. The increasing demand has urged HMC to create a new vision of computing in the campus. Erlinger [2] discusses specific actions taken in 2 main areas – network development and distributed computing, to allow HMC moves towards academic computing environment based on the client/server model. An advanced network management via SNMP (Simple Network Management Protocol) was applied to this network. The major advantages of this approach are: higher performance at lower cost compared to other backbone; ease of management (by using SNMP); and scalability [2].

Figure 1 Client/server model of computation

From the distributed computing aspect, three sets of computer systems are provided by HMC [2]: -

a) A set of backbone computing servers – available via the campus wide network.
b) A set of department servers – gives the departments control over their own destiny.

c) Computing resources for faculty members for research and education.

This approach, being taken by HMC towards an academic computing environment, allowed the implementation to occur in parallel or serial fashion. The computing model emphasised on using the network as the centerpiece.

Project Athena [3], one of the world's largest centrally administered distributed computer environment, is a partnership between MIT (Massachusetts Institute of Technology), Digital Equipment Corporation (DEC), and International Business Machine (IBM). In this project, more than 1,000 workstations scattered across MIT are linked together and used by students, faculty and some others staff. The main goal of this project is to improve the quality of education. Fermann [4] and his group have developed a number of tools for users, consultants and others who may log in anywhere in the campus. An example is the Athena Zephyr [5] messaging system, which is used to locate, communicate and coordinate with, the consultants and Network Services and Systems Support staff members in real-time. The OLC [6] on the other hand is an online consulting system software, which enables users and consultants to contact each other's from any part of the campus.

In the University of Saskatchewan, a centralized department, namely Computing Services, used to handle most of the computer support tasks. Due to the number and diversity of disciplines of the university, many departments started to have their own computer support personnel to solve their own problems. This results in distribution of services, indirectly. Saini [7] explains some of the difficulties encountered during the decentralized of support services and how these problems were resolved. In addition, the advantages and disadvantages of decentralized support for both client and computing centre are highlighted in [7] along with further explanation on the importance for distribution of services for an institution.

SI (System Integration) is defined as [8] "*the assembling of various hardware (such as computers and telecommunication systems), software (such as accounting, desktop publishing, and personnel management) and human interfaces to accomplish a specific goal*". Zaitun et al [8] describes an approach to achieve SI in University of Malaya (UM). UM as the oldest university in Malaysia has 8 main Information Systems (IS) being used in the campus, SI is essential to ensure smooth running of the university administration. Paper [8] discusses the advantages and disadvantages of existing mechanisms of SI and proposes an alternating mechanism called InFac. InFac is able to handle the following situations to complement the existing mechanism [8]: -

a) Relational Database to Object Oriented Database (OODB)
b) OODB to Relational database
c) OO to OO
d) Relational Database to Relational Database

There are others related effort taken by other educational institutions to move towards a distributed computing environment (DCE) motivated by the use of networks and the need for communications between workstations or networks in a rapid speed.

3. Effective Ways of Teaching Parallel or Distributed Computing Courses

Due to the price drop of the processing power, there are many large computer systems that contain hundreds or even thousands of processors nowadays. This scenario has led to parallel processing

and computing where some parts of the algorithm can often be done at the same time (concurrent) as other parts. One example for parallel algorithm is finding of all the prime numbers that are less than *n*. This example demonstrates a common technique used in parallel algorithms -- solving a smaller case of the same problem to speed the solution of the full problem.

"*Computational grids are an exciting new technology that blend high-performance computing, distributed systems and operating system. Grids provide a coherent software infrastructure that permits the seamless integration of wide-area resources such as computers, instruments, devices and data archives to solve large scale science and engineering problems*" [9]. Grid technology has received a great deal of demand from numerous research groups and industry worldwide so it is essential to introduce grid concepts in classroom. Weissman [9] introduces an effective way of teaching grid technology through his experience in teaching this course not only in undergraduate but also postgraduate level. The prerequisites for the course, the possible courses contents and some useful references are given. Four main sections are suggested for the grid class [9]: -

a) **Introduction**: provides the definition for grid computing and importance/reasons of learning grid technology is examined.
b) **Grid building blocks**: studies of grid's physical content, which includes machines, high-sped networks and programming methodologies.
c) **Grid infrastructure paradigm**: examines the suitable architecture for building a grid infrastructure by presenting the related architectures and giving the contrasts between one another.
d) **Research Challenges**: examines the interrelated challenges for grid system designers, which includes scheduling and resource management, security, applications, and fault tolerance.

However, there is still lack of high-quality grid courseware to teach the course. Thus, there is still a room for researchers and educators to improve the condition and enhance the teaching of grid class.

Mechanism for coordinating concurrent processes, synchronizing processes and avoiding deadlock and livelock are the more difficult concepts in the field of teaching distributed and parallel computing. The conventional way to coordinate concurrent processes by primitive constructs of Java is difficult and not scalable. Thus, Nevison [10] discusses the advantages of using the CSP (Communicating Sequential Processes) libraries as compared to the use of the primitive constructs of Java. The tools provided by the JCSP (Java Communicating Sequential Processes) library, which developed by University of Kent, are reviewed, and methods of using these tools to implement parallel algorithms on multiple processors with two different architectures, on multiprocessors and clustered computers are discussed in [10]. In short, the concept of parallel computing can be delivered to the students more effectively by utilizing the tools because Java is a commonly used language and JCSP is an easy and scalable library for coordinating concurrent processes [10].

Many universities offer courses on parallel programming/algorithms and distributed operating systems, but most of the courses do not include much hardware in it. Narasimhan [11] presents a course structure with considerable emphasis on the hardware for parallel processing by covering various topics on hardware design in the course. The need for a new course on parallel architectures is explained in detail, the overall course structure and the course content for the new course are also provided in [11]. Through experiences in implementing the course, the author has gained a number of positive feedbacks from both academia and industry. Among them is the course has stimulated the interests of students in working in the areas of parallel and distributed processing, parallezation

of algorithms, scheduling theor, modeling and performance analysis [11]. Besides that, some students who joined the industry suggested that the course should concentrate more on practical systems than the theoretical systems and they also pointed out that the exposure to work with parallel machines would improve understanding of certain subject matters.

It is necessary to offer effective lessons on parallel or distributed computing courses as now the trend of computer technology is moving towards parallel/distributed systems. The students should master these related courses well in order to cope with the growth of this technology. Thus, effective lessons on these courses become very important to achieve this objective.

4. Tools and Courseware

Generic network tools (like email, computer conferencing and newsgroups) are found to have some key problems to support educational activities. They do not provide tools to support basic instructional activities, and also do not contain relevant models to support learning strategies for collaborative learning and knowledge building, etc. Thus, Harasim et al [12] has developed a system (named Virtual-U or abbreviated as VU) to support collaborative learning. Virtual-U is a framework that support advanced pedagogies based on active learning, collaboration, multiple perspectives, and knowledge building, which employs various instructional formats, including seminars, tutorials, group projects and labs. VU serves as an integrating course management system with conferencing, chat, and grade book tools, that provides a framework for designing, delivering, and managing individual courses or entire programs [12]. VU researcher and developers have developed three tools to advance understanding of teaching and learning online – VU Research Database and VU DataMiner are researcher tools while VUCAT is for users to track online course activities. The VU system provides several benefits for both students and also instructors [12], however, there are also some major problems faced by students, which are like technical difficulties and slow networks.

Imai et al [13] has built a visual simulator known as "VIsuSIM", a web-based education tool for beginner to understand internal structure and behaviour of computer visually. The features of this tool are: showing internal computer structures graphically, interpreting sample assembly programs, demonstrating data transfer between CPU registers and memory. Basic design concepts and system configuration for this simulator are described in [13]. Besides, its effectiveness for being an education tool to use in classroom lecture and self-learning software is also evaluated.

WWW (World Wide Web) based courseware tends to vary a lot, both in quality and educational effectiveness so some of the courses fail to enhance the learning skill of the learners and could not integrate with the curriculum effectively. Wade [14] proposes a set of general requirements for successful WWW based instructional design and the criteria for assessments and evaluation of WWW based educational courses. Based on the requirements and criteria specified, the effectiveness and impact of using the WWW based virtual learning environment and WWW based courseware for two groups of students are evaluated [14]. In short, the WWW based educational courses gained a satisfactory feedback from the learners because it is more learners centred (partial learner control) as compared to the traditional lecture. However, there are several problems that occurred like students felt uncomfortable to read directly from the computer screen and they found it difficult to study in a traditional computing laboratories as there may be noisy and cramped.

The move to the Windows NT operating system has given a chance for the Electronic Engineering Department in University of Kent to develop a new digital engineering curriculum. The department has closely integrated EDA (Electronic Design Automation) tools and multimedia courseware into their syllabus. Walczowski et al [15] describes in detail the development of the new curriculum and the integration of the Windows based EDA tools and the CBL (Computer Based Learning) courseware. The tools (for schematic capturing, logic simulation, VLSI (Very Large Scale Integration) design and high level simulation) have become popular among students, not only because of the availability and exposure to the software is excellent but also it is easily used.

Although many software packages have been developed in the area of power engineering education to cultivate the interest of students in this field, however most of them lack portability and accessibility in many ways. Ong et al [16] describes a prototype software package that includes a WPFS (web-based Power Flow Simulator) and a Java-based Graphical User Interface (GUI), which is a portable and flexible tool for teaching power system operation and control. The setup, that provides an interactive distance learning environment capability, enables classes of the Java implemented GUI to be downloaded or deployed onto any authorized student's and lecturer's Java-enabled machine from anywhere via the internet [16].

5. Improving The Effectiveness and Acquiring Success Of Web-Based Learning Or Distance Learning

The ever-changing economic conditions have urged the working people to acquire the latest knowledge and skills. Thus, it becomes essential to support a lifelong education. Obviously the classroom education is not the best way for lifelong education because it requires people to be in a specific place during a specific time, which would be difficult for working adults. Web-based learning and distance learning are more promising solutions for this problem. Many web-based systems have been developed and it is important to have a method to evaluate the effectiveness of web-based learning to enhance the systems. Murakoshi et al [17] has developed a web-based learning system and a method to evaluate the system using AHP (Analytic Hierarchy Process). The AHP enables the authors to evaluate the effectiveness of their system compared with the conventional classroom learning. Based on the evaluation results, the authors are able to improve their system [17]. Repeating the similar method of evaluation can further enhance the improved system. By doing this, the effectiveness of the web-based learning system developed can be examined and further improved.

Maki et al [18] has performed a case study by teaching a psychology course on the Web. The results from the case study showed that this type of online course is a viable alternative to the traditional lecture course. Maki has provided some tips for web-course instructors to deliver the course more effectively. The tips are summarized as below [18]: -

a) Available technology should be used to the fullest extent possible when designing courses in order for the web-course harness more power in pursuits of active learning.
b) The online course should be prepared far in advance because there are a number of unexpected problems, which may occur in the process.
c) There is a need to train the students on using the web facilities because not all the students would have Internet knowledge.

d) Frequent announcements and clarify grading practices have to be made, however, it is essential to be flexible on deadlines because problem like server outages may occur.
e) Supervised tests and web-based assignment should be given to certify that students are learning the material.

The tips are useful for those who are involved in teaching or developing web-based course for improving the effectiveness of web-based learning.

Smith [19] examines the contributing factor to acquire success in using computer conferencing for teaching (distance learning). Among the factors are: the selection of appropriate conferencing software, the identification of interested and enthusiastic faculty, and the support of user services staff through education, documentation, and consulting. The feedback from the faculty and students on this computer conferencing teaching are also provided in [19]. It seems that a conferencing system is of great benefit not only in a discussion-type course (such as English, history etc.) but also in other courses such as management, engineering and computer science, by customizing the computer conferencing to the needs of each individual field.

SQ3R is a study method developed based on educational psychology, which is proven to be efficient in traditional school education. SQ3R stands for Survey, Question, Read and Recite and Review. This method uses the mechanisms of memorising, fogotting and cognitive processes of human's brain. Zhang et al [20] provides an explanation for SQ3R and suggests a support method to transplant the SQ3R learning method into the web-based distance learning system. This support method is implemented into a web-based distance learning system designed by the authors. The implementation will be evaluated to examine the availability, performance of the system, and the efficiency of learners' learning activity [20].

6. Designs, Development and Implementation of Web-Based, Real-Time and Multimedia-Based Education

Despite the advancements in electronic learning, a convenient framework still does not support design and implementation of the distributed learning systems. Therefore, many functionality of similar, independent systems are being developed again and again. Santos et al [21] addresses the interoperability issues among large-scale distributed e-learning systems and proposes a standard-driven object-oriented framework to develop such system. OMG's (Object Management Group) CORBA (Common Object Request Broker Architecture) technology is capable in providing a suitable environment to build frameworks for domain specific applications. There is a proposal for a new CORBA facility for a domain where an important standardization is being carried out: e-learning [21]. The design process for CORBAlearn framework has been guided by Unified Software Development Process and modelled using the UML (Unified Modeling Language). From the analysis model, implementation environment-independent reference model and reference architecture is identified. The application of CORBA, and its object-oriented distributed computing capabilities, allowed us to add software interoperability and reduce time-to market factor for new developed educational systems [21].

A multimedia platform over an ATM (Asynchronous Transfer Mode) network used for teaching purposes, on campus or at a distance is introduced by Groza et al [22]. The presented environment covers lecturing, laboratory training, and students'evaluation recording in the Tele-educational

process. The multimedia and laboratory facilities have been developed on top of CORBA standard for distributed processing on heterogeneous platforms. Therefore, further development to extend the domain of Tele-laboratory application for this proposed platform is envisaged.

Anido-Rifon et al [23] presents a framework for developing and designing interactive and collaborative web-based educational applications (named SimuNet). The proposed model to support this application is organized into three layers (service level, component level and application level) on top of a foundation composed of commercial-off-the shelf services and standard Internet protocols. The developed framework is tested in a web-based distributed educational platform by following standards for learning technologies that allow the reuse of the learning contents form others that follow the same standards [23].

The continuous technological advancements in networking and multimedia systems have brought improvements to the telelearning environment by integration of real-time interactive telelectures as a service in the environment [24]. Real-time interactivity determines the success of a telecourse because there is a need for communication between one another during discussion to exchange ideas and for one to respond to question spontaneously. Without this feature, telecourse is limited to the broadcast of lectures. Arapis et al [24] describes the design issues and alternatives for setting up a multimedia and networking environment for operating telecourses. He also highlights several technical problems they had to deal with during the running of the real-time interactive telelecture.

The use of Java as an application language has becoming more and more popular. This is due to its security manager, the implementation with web-browsers and the wide network class library. Foster et al [25] presents a Java based implementation of the SLP (service location protocol) and its use in Tele-teaching environment. In addition to that, the problems experience (includes the authentication and security) have been specified and the solutions for the problems are provided. In short, SLP v2 is capable of meeting the need for a Tele-teaching system and allow it to widely expand [25].

Parrish et al [26] describes the evolution of the distributed computing environment at the Vanderbilt University School of Engineering. The work in [26] is concerned with the various phases, which occurred during the design and development of the network. The constraints that imposed during the initial design and implementation, and the latest network conditions are specified in [26]. A future plan is also mentioned in this work.

In order to evaluate the support method of SQ3R in web-based education, a web-based distance learning system is designed [20]. The system consists of TA (teaching agent), LA (learner agent), CMap (content map), LCCB (learning course case base) and CPM (Course Presentation) based on study method of SQ3R. TA and LA are constructed based on LDB (learner database). The functions for the entire system and also for each of the parts mentioned above are provided in [20]. Besides that, the application of SQ3R into this system along with the method system implementation is presented.

7. Conclusion

This paper described several issues and research activities that have been carried out in the education field, which relates to parallel and distributed computing. From this paper, it shows that

the criticality of the network and the rapid growth in the computer technology has resulted in rapid development of web-based course and learning in the education field. This development can benefit more people by encouraging and enabling them to learn through WWW or through a network based environment anywhere and anytime. This resolves the problems caused by conventional classroom education where people have to attend classes at a particular place and time.

By utilizing some techniques or approaches of parallel and distributed computing technology mentioned in this paper, we are able to improve our education system in various aspects (speed, quality of contents, presentation styles and etc). The parallel and distributed technology will continue to benefit both the educators and the learners by supporting a wide range of educational modes of learning (including virtual learning environment and web-based courseware), and by allowing the sharing of knowledge and learning resources.

The author feels that some incorporation of the traditional classroom based education systems into the www based learning/education system would be beneficial because the traditional classroom based education has it own strength (such as SQ3R learning method as mentioned earlier). It would be useful if more research on this matter can be carried out when deal with work on enhancement of parallel and distributed computing technology in education field. At short, this paper serves as an introduction for people to understand the importance and influence of parallel and distributed computing technology to the development of the education field. It is hoped that the current education system can be enhanced through further utilization of this technology.

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References

[1] John A. Hamilton Jr., David A. Nash, Udo W. Pooch, “Distributed Simulation”, *CRC Press Boca Raton, New York*, 1997, pp. 153.
[2] Michael A. Erlinger, "Networking – Centerpiece of Academic Computing", *IEEE Trans. on Education*, vol. 36, no. 1, Feb 1991, pp. 90-94.
[3] E. Balkovich, S.R. Lerman, R.P. Parmelee, “Computing in Higher Education: The Athena Experience”, *Communications of the ACM*, vol. 28, no. 11, Nov 1985, pp. 1214-1224.
[4] Carla J. Fermann, “Distributed Consulting in a Distributed Environment”, *Proceedings of the XVIII ACM Conference on User Services*, Cincinnati, 1990, pp. 117-120.
[5] C. Anthony DellaFera, “The Zephyr Notification Service”, *Proceedings of USENIX Association Winter Conference*, Feb 1998, pp.213-220.
[6] B. Anderson, T. Coppeto, D. Geer Jr, G.W. Treese, “OLC: An On-Line Consulting System for UNIX”, *Proceedings of USENIX Association Summer Conference*, June 1989, pp. 83-94.
[7] Surinder Saini, “Distributed Support: A Case Study”, *Proc. of the XVIII ACM Conf. on User Services*, Cincinnati, 1990, pp. 335-340.
[8] Zaitun A.B., Mashkuri Y., Mohammad Z.R., Helena B., “InFac: A Mechanism To Achieve System Integration”, *Proc. of Technology of Object-Oriented Languages*, 1997, pp. 214-220.

[9] J.B. Weissman, "Grids in the classroom", *IEEE Concurrency*, vol. 8, no. 3, 2000, pp:6-9.
[10] C. Nevison, "Teaching Distributed and Parallel Computing with Java and CSP", *Proc. of first IEEE/ACM InterSymposium on Cluster Computing and the Grid*, 2001, pp. 484-491.
[11] V. Lakshmi Narasimhan, "A New Course on Supercomputers and Parallel Architectures", *IEEE Trans. on Education*, vol. 38, no. 4, Nov 1995, pp. 340-345.
[12] Linda Harasim, "A framework for online learning: the Virtual-U"**,** *IEEE Trans. on Computer*, vol. 32, no. 9, Sept. 1999, pp. 44-49.
[13] Y. Imai, S. Tomita, H. Inomo, Z. Furukawa, W. Shiraki, H. Ishikawa, A. Miyatake, "Design and implementation of Web-based education tool**"**, *Proceedings of Symposium on Applications and the Internet (SAINT) Workshops*, 2002, pp. 204-211.
[14] Vincent P. Wade, Conor Power, "Evaluating the design and delivery of WWW based educational environments and courseware", *ACM SIGCSE Bulletin, Proceedings of the 6th annual conference on the teaching of computing/3rd annual conference on integrating technology into computer science education on Changing the delivery of computer science education***,** vol. 30, no. 3, August 1998, pp.243-248.
[15] L.T. Walczowski, K.R. Dimond, W.A.J. Waller, "A Digital Engineering Curriculum with integrated Windows-Based EDA Tools", *IEEE International Conference on Electronic Circuits and Systems*, vol. 3, 1998, pp. 425-428.
[16] Y.S. Ong, H.B. Gooi, "A Web-based Power Flow Simulator for Power Engineering Education", *IEEE Power Engineering Society Summer Meeting*, vol. 2, pp. 1002-1007.
[17] H. Murakoshi, T. Kawarasaki, K. Ochimizu, "Comparison using AHP Web-based Learning with classroom learning", *Proc. of Applications and Internet Workshops*, 2001, pp. 67-73.
[18] William S. Maki, Ruth H. Maki, "Learning Without Lectures: A Case Study", *IEEE Trans. on Computer*, vol. 30, no. 5, May 1997, pp. 107-111.
[19] Andrew M. Smith, "Computer Conferencing in the Liberal Arts Classroom", *Proceedings of the XVIII ACM Conference on User Services*, August 1990, pp. 345-349.
[20] Guozhen Zhang, Saitou K., Zixue Cheng, Koyama A., He A., Tongjun H., "Design of SQ3R-based Support Method for Course Contents Provision in Distance Learning Systems", *International Conference on Distributed Computing Systems Workshop*, 2001, pp. 326-331.
[21] L. Anido, M. Llamas, M.J. Fernandez, J. Rodriguez, J. Santos, M. Caeiro, "Distributed Objects and Applications", *Proc. of 3rd International Symposium on DOA '01*, 2001, pp.260 -269
[22] V. Groza, D. Ionescu, N. Georganas, "An Interactive Multimedia Platform For Telelearning **",** *Proceedings of 27th Annual Conference on Teaching and Learning in an Era of Change*, vol. 2, 1997, pp. 802.
[23] L. Anido-Rifon, M.J. Fernandez-Igelesias, M. Llamas-Nistal, M. Caeiro-Rodriguez, J. Santos-Gago, J.S. Rodriguez-Estevez, "A Component Model for Standardized Web-based Education", *ACM Journal of Educational Resources in Computing*, vol. 1, no. 2, 2001, pp.1-21.
[24] Constantin Arapis, Dimitri Konstantas, Thomi Pilioura, "Design issues and alternatives for setting up real-time interactive Telelectures", *Proceedings of the 1998 ACM Symposium on Applied Computing***,** February 1998, pp.104-111.
[25] A. Foster, K.J. Macgregor, "The Use Of Java Implementation Of SLP In A Tele-Teaching Application", *Proc. of 7th IEEE Workshop on Distributed Computing Systems*, 1999, pp. 273-278.
[26] E.A. Parrish, D.R. Linn, W.A. Richter, L.F. Saettel, "Design and Implementation of a Distributed Computing System", *Proceedings of IEEE Energy and Information Technologies in the Southeast*, 1989, pp. 1392-1395.