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Integration of Educational Methodologies in the Computer Science Curriculum based on the Beowulf Curriculum Enrichment Integrated Lab (B-CEIL)

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Abstract

Over the past two years, the Computer Science faculty have been hard at work implementing BCEIL (the Beowulf based Curriculum Enrichment Laboratory) which was funded through a grant from the National Science Foundation (NSF). As the Lab neared completion, with involvement from the CS/CIS faculty and students, and was fully funded, we started looking into institutionalizing the outcomes of BCEIL through its many individualized lab modules. This paper looks closely at the dissemination as well as the implementation efforts that are being taken in order to achieve the department's instructional goals through BCEIL. These efforts have allowed the faculty to reevaluate and to rejuvenate the currently used projects and lab modules by dressing them up in a state of the art networking and simulation environment; additionally, many new lab modules were created and specifically used based on knowledge gained through the lab implementation.

Keywords:
Educational Methodologies, Implementation of an Integrated Lab, Networking, Distributed and Parallel Processing, Optimization Techniques, Image Processing, Operating Systems.

Introduction

The Computer Science/Computer Information Systems department (CS/CIS) at the University of Texas- Brownsville is a relatively new program that has been growing steadily. In addition to the bachelor of Computer Science and the associate in Applied Science that have been offered since the program inception, the department is now offering a bachelor of applied technology and has submitted a proposal for offering an

associate degree in web design and programming. Currently, the department has more than 300 students with about 90% of them being Hispanics who are gravely underrepresented in the Science and Technology areas. To remedy this problem, the faculty has been looking for different ways to enhance recruitment and retention of the department students as well as reinforce key concepts in many of the CS/CIS critical courses.

In 2001, the National Science Foundation (NSF) awarded the CS/CIS Department at the University of Texas at Brownsville a grant to develop a Beowulf-based Curriculum Enrichment Integrated Laboratory (BCEIL). The goal of the grant was to enhance important concepts and principles in key courses of the Bachelor of Science in Computer Science (BSCS) degree, the two-year associate degree in Applied Science in Computer Information Systems (AAS-CIS), and the four-year Bachelor of Applied Technology in Computer Information Systems Technology (BAT-CIST). Support for the project was given for two years and was geared towards developing the BCEIL lab to a point where its technology and concepts are applied in a set of targeted courses and exported to other institutions and regional entities through dissemination. Our main instrument in infusing concepts and principles in the key or targeted courses was to have a set of lab modules created and taught as an integral part of the courses.

The lab was initiated in fall 2001 and has been operational ever since. We continued to purchase equipment through the second year of the grant to establish the lab fully. With the help of many student lab assistants, we have developed many lab modules to be used in the targeted courses. The labs include:

BCEIL Lab Module	Description
LM1	Beowulf Cluster and its Architecture
LM2	Benchmarking Computational Machines
LM3	Operating Systems: Kernel, Scheduling and File Systems
LM4	Public Switched Networks
LM5	Videoconferencing over IP and Network Traffic
LM6	Pattern Recognition
LM7	Image Coding
LM8	Image Processing
LM9	Simulation
LM10	Matrix Operations
LM11	Parallel and Distributed Processing

LM12	Concurrent Processing
LM13	Digital Logic
LM14b	Distributed Databases
LM4b	PC Components and Assembly
LM16	Monitoring Network Traffic
LM17	Data Base Management Systems. Title: Using MPI to Implement a Simple Paging Manager
LM18	Data Structures. Title: Parallel Implementation of Bi-tonic Merge Sort

Details of these modules are given in a previous ADMI paper [1]. Additionally references [2-10] give details about the content of these modules. The creation of the lab has been a great success as it has included a great number of faculty and students as major participants. The participants include:

Faculty

Dr. Fitratullah Khan, Principal Investigator

Dr. Juan Iglesias, Senior Participant

Dr. Mahmoud Quweider, Co-Principal Investigator

Students

Francisco Arteaga, Work period: 6/16/2003- 6/28/2003, 7/16/2003-8/31/2003

Mario Guajardo, Work period: 9/24/2001-12/21/2001, 1/1/2002-5/31/2002, 1/1/2002-5/31/2002, 9/3/2002-12/15/2002, 12/16/2002-12/31/2002, 5/12/2003-8/3/2003

Ariel Martinez, Work period: 9/24/2001-12/21/2001

Brian W. Matthews, Work period: 12/10/2002-12/21/2002

David Ortiz, Work period: 9/24/2001-12/21/2001, 1/1/2002-5/31/2002, 6/1/2002-8/31/2002

Julie Pedraza, Work period: 12/26/2002-5/31/2002, 6/1/2002-8/31/2002

Jose D. Zamora, Work period: 9/24/2001-12/21/2001, 1/1/2002-5/31/2002, 6/1/2002-8/31/2002

CS/CIS Instructional Goals

In order to take full advantage of the BCEIL lab in a systematic and institutionalized way, we have looked closely at the instructional goals which are set forth by the department in order to make sure that graduates have mastered specific skills that are critical to their future jobs or graduate work. These goals are summarized in the following table:

Computer Science Department Instructional Goals				
Goal-1	**Goal-2**	**Goal-3**	**Goal-4**	**Goal-5**
Students should be able to demonstrate knowledge of information structures.	Students should be able to understand data representation and the transformation of data.	Students should be able to understand the role of computer hardware in the processing of information.	Students should be able to understand the relationship between hardware and software.	Students should be able to apply their understanding of software and hardware structures in scientific or industrial applications.

As the table shows, the goals try to make sure that our CS/CIS students will receive high quality education that will enable them to become productive members of the society upon their graduation. The task of the BCEIL then becomes that of an enforcer to these goals. Successful integration of the BCEIL labs will in effect insure that our students are at the forefront of the highest quality of education.

It is important to note that BCEIL can easily be used to enforce a specific instructional goal from either CS or CIS because of the many modules it incorporates. For CIS students the emphasis is on technology use and therefore modules stressing the use and configuration of devices can be stressed. CS goals on the other hand are design oriented and modules stressing design aspects can be chosen for a specific goal. It is interesting that these modules can bring CS and CIS students together thus fostering team work and multi-disciplinary integration, a requirement by many accreditation boards.

BCEIL Enforcement of Instructional Goals

After looking at the above table of instructional goals, we looked closely at the BCEIL lab modules and created a table that relates the lab modules to the instructional goals as listed above. The preliminary table is given in appendix A. As we can see from the table above, we have tied the labs to specific instructional goals. This allows the lab modules the flexibility to be course independent and for them to be use in more than one course. These lab modules have been mad available through a dedicated web site for easy access by student and interested parties. The web site address is http://blue.utb.edu/bceil. It is also important to notice that another methodology in integrating BCEIL into the CS/CIS curriculum has been through senior projects. Senior projects have been introduced into the degree plan three years ago and have been a great factor in integrating knowledge from many different courses into a capstone project. BCEIL has given students a great deal of freedom in choosing realistic projects that accentuate their

creativity while experimenting with state of the art equipment. As of today, senior projects in the areas of network security, web server design, image processing, operating systems, data mining and database management systems have been implemented.

Case Study

As an example for the role of BCEIL in enforcing departmental instructional goal, we present on example, out of many others, to show how a given lab module can be used for a specific instructional goal. The fourth instructional goal calls for the student to be able to understand the relationship between hardware and software. In looking at LM7, LM8, we can see that they can be easily used to insure that goal. Labs in those modules allow the student to set up cameras and capture images in real time. The captured images are then used for writing many software programs that stress image processing and coding. These modules clearly calls on the student to critically understand the operation of the cameras hardware and how the captured images are acquired and extracted from memory where they are passed to a software program for image manipulation and processing. A sample lab session from LM-7 is given in appendix B.

There are many ways to use the lab modules, especially with many of them overlapping in terms of their instructional goals, to enforce an instructional goal. This freedom of selection is left for the instructor who can choose one or more modules for his purpose.

Conclusion

We have shown that integrated of labs, such as BCEIL, can be an invaluable tool in implementing the educational goals set by the department to insure the delivery of top quality education to students in the CS/CIS area. As the students graduate, they are bound to make important contribution as work force professionals. While BCEIL started as a small grant from NSF it is gradually finding its way in many key courses in CS/CIS through a thought-out institutionalization and departmentalization process that the authors have undertaken.

As a dynamic educational tool, new concepts and instruments, incorporating state of the art technologies, many new modules in areas such as encryption, autonomous intelligent systems, and web design and programming can be created and await the creative faculty and the curious student.

BCEIL future includes possible use in gaining accreditation such as those required by the ABET accreditation board where abilities to function in a multi-disciplinary team, engaging in life-long learning and knowledge of contemporary issues are required by all students. Moreover, BCEIL can be used as a tool to expedite technical certification in areas such as network administration, routing and language programming.

Appendix A

BCEIL Integration into the Computer Science Department Instructional Goals					
Lab Module	Goal-1	Goal-2	Goal-3	Goal-4	Goal-5
LM1: Beowulf Cluster and its Architecture		X	X	X	
LM2: Benchmarking Computational Machines	X		X		
LM3: Operating Systems: Kernel, Scheduling and File Systems		X	X	X	
LM4: Public Switched Network				X	X
LM5: Videoconferencing over IP and Network Traffic				X	X
LM6: Pattern Recognition				X	X
LM7: Image Coding	X		X		
LM8: Image Processing		X	X	X	X
LM9: Simulation		X	X	X	X
LM10: Matrix Operations		X	X	X	X
LM11: Parallel and Distributed Processing		X	X	X	X
LM12: Concurrent Processing		X	X	X	X
LM13: Digital Logic		X	X	X	X
LM14b: Distributed Databases		X	X	X	X
LM4b: PC Components and Assembly		X	X	X	X
LM16: Monitoring Network Traffic		X	X	X	X
LM17: Data Base Management Systems. Title: Using MPI to Implement a Simple Paging Manager		X	X	X	X
LM18: Data Structures. Title: Parallel Implementation of Bi-tonic Merge Sort		X	X	X	X

Appendix B

Sample Lab Session

(B-CEIL) LM – 06/07/08
Image Processing/Coding Operations
Lab # 1

Image Capture and Storage

Lab Objectives/Goals:

The purpose of this lab is to acquaint you with the basic equipment available for image capturing (acquisition/formation), processing, and storage/display

Approach:

Using the ***digital camera and the image capture card from B-CEIL***, capture an image with 8-bits/pixel resolution (256 gray levels) and write a program to read the image, process it by creating its negative and then storing the result as portable gray map (PGM) file.

- **Dynamically** create **one**-dimensional array for the original. The negative image can be created and stored in the same array (in place processing).
- The captured image data are in raw format (binary data with each **byte** representing a pixel) with no header information. The data are stacked row by row.

  row1→---row2→---row3→

- To preserve space, it's customary to store the image as **unsigned char** data type, if the number of bits/pixel is 8 bits or less
- The negative image has to have the same size and dimensions as the original image
  - **The negative of a pixel p(**x,y**) is given by the equation:**

$$p(x,y) = 255 - p(x,y);$$

- Append the PGM header to the image so it can be viewed using the external software such as IMAY or Photoshop.

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Biographical Information

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Juan Iglesias is an assistant professor at the Computer Science Department at the University of Texas, Brownsville (UTB). He has a PH.D in Computer Science from the New Mexico State University, New Mexico. His areas of research include Data Mining, Databases and Artificial Intelligence.

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Mahmoud Quweider is an associate professor and the chair of the Computer Science Department at the University of Texas, Brownsville (UTB). He has a PH.D in Engineering Science from the University of Toledo, Ohio. Prior to joining UTB, he has worked as a Software Design Engineer for companies such as Pixera, 3 Com and Mercantec. His areas of research include Image Processing, Computer Vision, and Computer Graphics.

Fitratullah Khan

Fitra khan is full professor and the Director of Infrastructure, Telecommunications and Networks (ITNet) Operation at The University of Texas at Brownsville. He has a PH.D in Electrical Engineering from the University of Texas, Arlington. His areas of research include Networking, Parallel Processing, and Computer Architecture.