Advanced Technology Laboratories: A Crucible for Technology Enhanced Learning

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Abstract

A partnership among industry, academia and government has led to the construction and development of a facility which provides a capstone experience for engineering students. The purpose of the ATL is to provide a vehicle that enables partnerships between industry, faculty, and students. This partnership is designed to produce research for industry and provide real-life projects for students in the form of thesis and graduation exit required senior projects. Thus, the implications of the ATL are a win-win environment for all involved. The Advanced Technology Laboratories (ATL) provides a crucible where students can undertake defining educational capstone experiences that fully reflect new ABET criteria and the new millennium. This paper describes the computing resources and systems that have been put in place to support this goal. The ATL is a place where government, industry and academia have come together, where education and research have come together, where computing and engineering have come together to create a knowledge-age, and where students grow into enabled engineers for the 21st Century.

I. Introduction

The ATL is an extraordinary facility that enables students and faculty to undertake the kinds of hands-on projects and applied research that have long distinguished the College of Engineering. But the ATL not only ensures the continuation of our acclaimed "learn by doing" pedagogy; it symbolizes the very future of undergraduate engineering education. To prepare students for the 21st century, we must expand our time-proven, hands-on, project-centered teaching model. Students must have an opportunity to undertake "real world" applied research – interdisciplinary projects that provide a seamless connection between the discipline dominated academic sphere and the function dominated professional world. And they must have the tools of modern research; access to state of the art technology and equipment, access to the growing database of engineering and computer science scholarship, and the ability to work collaboratively across disciplines and around the globe. With its six interdisciplinary, industry sponsored labs and its classroom of the future providing database and worldwide communications linkage, the ATL will offer all of the above. Because it is the first building on campus built entirely with non-state funds, the ATL is a

stunning testament to the importance of industry partnership in sustaining our laboratory-based curriculum.

Recently, advances in computing technology have created the opportunity to bring massive computing resources to bear on engineering problems. Algorithms have been developed to bring computing into engineering synthesis, not simply data acquisition and analysis. Computing systems hold the promise of renewing education itself, not simply by changing delivery modes, but by allowing us to more clearly understand and couple to human learning mechanisms. In the 1990's, computing brought us the information age – and computing revolutionized the communications industry. In the next decade computing and engineering will combine to create a knowledge age – where computing will be fully integrated into engineering infrastructure. In this paper, we discuss the computing technology which have helped to create this timely learning environment. The ATL has placed the future of engineering education in view and within reach.

Historical Perspective

The educational process for engineers in the United States post 1950 was dramatically affected by the experiences of World War II. The technical demands of the war for new developments made clear the shortcomings of engineering education at that time. The Hammond Reports (1940, 1944) and Grinter Report (1955) stressed that "engineers required a deeper understanding of fundamentals that could be applied broadly, and less emphasis on current technical practice". These reports, when coupled with a growing awareness of the rapid growth of knowledge, the ever accelerating pace of technological advances and the complex and intertwined social, economic and technical relationships evolving in society, led to drastic alterations in engineering curricula. Engineering education attempted to integrate physical science, mathematics, engineering science, social science, economics, humanities and analysis in an unprecedented attempt to accomplish both breadth and specialization in a four-year degree. Because of this effort, several key exposures were eliminated. At many institutions, the unintended victims of this effort were integration and synthesis, engineering design, engineering process, laboratories and device centered approaches to education.

This flaw in engineering education manifested itself in economic trial. Throughout the 1970's and early 1980's, U.S. industry, in almost every sector, was being battered by international competition. Foreign companies capitalized with more innovative design, more agile manufacturing, greater productivity, higher quality and lower prices. Part of the problem was an engineering education system that graduated students with an inadequate understanding of the engineering process. They lacked an ability to convert engineering knowledge into real gains for society. In the ensuing twenty years, what has evolved is a partnership between government, industry and academia to the benefit of each and to the benefit of society.

The new era presents many opportunities for the engineer. The rapid pace of technological innovation impacts engineers directly, bringing new power and responsibility. Post cold war international politics brings different conflicts and new partnerships. The blurring of the distinctions between defense and commercial industries creates vast new possibilities. Markedly

improved global communication and low-cost computing power diminish the importance of national boundaries.

Clearly, as reflected in ABET 2000 Criteria, nascent engineers must be exposed to systems integration and synthesis as well as engineering science and analysis. They must practice problem forming as well as solving. They must be able to design and to realize products. To be successful, engineers will need to have facility with intelligent technology to enhance creative opportunity. They will also need the ability to manage complexity and uncertainty, to function as productive members of teams, and to be sensitive in and to interpersonal relationships. The emphasis in engineering education programs must shift from a dedication to course content to a more comprehensive view. It must focus on the development of human resources and the broader educational experience in which the individual curricular parts are connected and integrated. We must place emphasis on the development of students as emerging professionals with the knowledge base and capability for life-long-learning. We must engage students in engineering from the day they matriculate and make the study of engineering more attractive, exciting and fulfilling. Engineering students must be given the opportunity to experience the defining activity of engineering, to design - create something that has never been. They must learn to design to meet the full range of objectives encountered in actual practice. They must understand manufacturing and construction and have the ability to realize products. They must be able to create and operate complex systems. They must understand physical constructs and the economic, social, political and international context in which engineering is practiced. Finally, they must be committed to “life-long-learning”. The ATL, and the partnerships it provides, creates a vehicle to accomplish many of these objectives

"Education is important not from a business standpoint but because it’s the right thing to do. We need to make sure students have the tools to prepare for the information age." Kim Jones, Vice President, Sun Microsystems

II. ATL Concepts

The ATL is an independent facility designed to provide for students a hands-on “learn by doing” environment. The purpose of the ATL is to provide a vehicle that enables partnerships between industry, faculty, and students. This partnership is designed to produce research for industry and provide real-life projects for students in the form of thesis and graduation exit required senior projects. Thus, the implications of the ATL are a win-win environment for all involved. Industry, faculty and students work in tandem to create a greater educational experience. Industry gets inexpensive educated talent that is equipped to hit-the-ground-running on their current projects and issues. Students and faculty get current and future state-of-the-art projects that give an immediacy and relevance to augment their traditional studies.

III. Industry and Faculty

The ideal environment for a student to understand theoretical engineering concepts are through industry example. The concept that industry and CENG faculty partner to create an environment that promotes real-life student engineering project involvement and education. The partnering

between industry and faculty is an ongoing function of a restructured educational model. The partnering relationship focuses the restructured educational model into a relevant laboratory in which both sides of the partnering relationship acquire cooperative knowledge transfers.

IV. Vehicle Requirements

The ATL is the vehicle to produce the next level engineering graduate. It provides a unique environment that is specific to engineering research only. There are no faculty offices or traditional classrooms in the facility. The ATL is made up of various laboratories that create an educational research model that enable the student and faculty to focus on the projects specified by their industry sponsors. Within the ATL are a number of components that allow the research process to flourish.

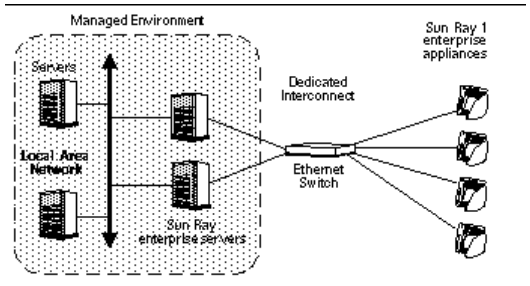
- Space – The ATL consists of more than 17,000 square feet of state-of-the-art applied research space divided into six main interdisciplinary laboratories. These research laboratories enable the students and faculty to plumb real-life-engineering projects.

- Technology – Sun Microsystems has generously donated computing technology within the ATL. These computing resources consist of seven servers, a tape library for data archiving, and approximately 100 workstations scattered throughout the building.

- Communication infrastructure – The Sun Microsystems computers are networked together using switched 10/100BaseT Ethernet hubs and category 5 cable. This infrastructure is connected to the campus backbone via a 100 MB fiber FDDI connection.

V. Use of Communications / Computing Technology in the ATL

The network design of the ATL was to insure fast computer networking capability. A minimum specification of switched 100BaseT hubs and category 5 cabling was designed to each network faceplate in the facility. Each room has at least one pair of network access ports installed. Most of the building network infrastructure was designed using external cable conduits thus allowing for easily accessible communication upgrades -- as technology evolves with a modicum installation expense and educational downtime. With the fast networking available, students and faculty have access to applications and data stored on the multiple Sun Microsystems Servers within the ATL. The necessity of fast networking infrastructure allows users instantaneous access to data and applications from servers as if it was accessing this information on the local computer. In addition, the network design fit the network requirements of Sun Microsystems's Sun Ray appliance computers. These appliance terminals require an independent switched 100baseT network. The Sun Ray's were segmented off from the building network through the Sun Ray server. In the Sun Ray server, multiple network cards allow communication between the Sun Ray appliance and the server and the server acts as a network router allowing access to the rest of the campus computing infrastructure and the Internet.



VI. Use of Sun Rays

The Sun Ray appliance is a compact, plug-and-work device, which features Sun's Hot Desk technology. Hot Desking provides session mobility, which means users are no longer tied to a particular desktop; a plus for these terminals is that they are quiet, unlike the typical personal computer. By using the Sun Microsystems Smartcard, a new concept that lets you jump from machine to machine within a workgroup and pick up where you left off. Simply insert your personal Smartcard into any Sun Ray on the network and you're back exactly where you were before, with the same screen, files and applications open. It doesn't matter where you are in the lab; the terminal you put your Smartcard into is yours. Thus, it works well for students with complex schedules. If a student starts working on a project and has to leave for class, the student can continue where he left off regardless of the terminal he was working on last.

The ATL's centralized Sun Ray lab allows the faculty and students to utilize any of the available machines to conduct their research and documentation. In addition, because the applications are centrally administered, maintenance on the Sun Ray systems is minimal which makes them economically effective.

Here are some of the benefits the Sun Ray's plays into as a student resource within the ATL:

- Flexible user environment. Smart cards let users access their sessions securely from any desktop unit within the Sun Ray workgroup. This enables the student to move from computer to computer without reconfiguring and rearranging the computing environment.
- Leverages shared resources. By sharing the processing capabilities of the Sun Ray server and centrally loaded applications users can access a vast array of engineering applications.
- No administration or maintenance needed on desktop. The operating system is centrally maintained.

VII. Sun Multiprocessor Workstations

The ATL also consists of Sun Microsystems Ultra workstations. Single (Sun Microsystems Ultra 10), dual (Sun Microsystems Ultra 60), and quad (Sun Microsystems Ultra 80) processor workstations are available for students and faculty to use.

The SunUltra workstation is perfectly designed for the student or faculty member who requires high performance and multiprocessing (MP) capability. Ultra 60 and 80 workstation also

addresses users needs with graphics-intensive applications. Some of these Sun Ultra workstation include SunPCi cards. The SunPCi card allowed dual technologies in one computer box. We can supply one box, one keyboard and one monitor running two different operating systems natively. In our case Solaris 8 and Windows 2000 Pro were installed. These workstations also have access with the ATL's server farm.

VIII. Server Farm

The ATL consists of seven Sun Microsystems servers. Three of those servers are dedicated to main computing functions; file server, Sun Ray server, Web server. The remaining four servers are clustered as a server farm. A server farm allows multiple servers to be available for high capacity number crunching. Sun Microsystems solution to this multiple server clustering uses Sun Gridware Engine software. Sun Gridware Engine software allows students and faculty to augment their desktop with additional cycles to get complicated computing processing done more quickly.

IX. Switched Fast Ethernet Networking Infrastructure

Switched 100 Mbps Ethernet from the server to the switch is the preferred interconnect configuration because it provides the highest collision-free performance. A 100 Mbps switched Ethernet configuration provides sufficient bandwidth for the most demanding bandwidth-intensive applications and helps ensures the highest quality expectations are met for each desktop.

X. W.M. Keck Engineering Education Research & Development Center

The W.M. Keck Lab is a key component of the ATL. It is an open access non-disciplinary engineering laboratory. Engineering students who use this lab work with faculty and an industry sponsor to utilize computing resources and this learning space to develop their research /thesis /senior project. These resources consist of Sun Microsystems Sun Ray appliances, Sun Microsystems Ultra 10 computing resources - student are also be given access to the Sun Microsystems server farm for data storage and high capacity numerical and graphic analysis. The Keck Lab also has video teleconferencing and presentation technology available. Students and faculty who wish to communicate with their industry sponsors can use this resource.

XI. Use of Technology to Further Goals

The ATL is not a traditional open access facility and access to the ATL's facility and resource are typically secure. Thus, the College has procured and installed an access control system. This system plays several functions within the ATL. One is to provide access to all entry points such as the lobby and each of the laboratories. In addition, since the facility deals with private industry and technology, security features are utilized with in the system. If an unauthorized person accesses an area, Campus Police are dispatched and the violators are either expelled or arrested. Also, this system includes an access tracking system. The College can identify usage of a laboratory for

statistical and billing purposes. Finally, users access the ATL using either an access card or a pass code. Most users will access the ATL using a card. However, if a visiting professor or an off-site person needs temporary access to the ATL, a temporary access code will be generated and distributed. The access code will expires on at a designated time period.

XII. Conclusion

The ATL is a unique collaboration of government, industry and academia, and provides benefits to each. The generous donation by Sun Microsystems in the ATL allows engineering students and faculty to experiment and produce solutions to relevant engineering projects. Sun Microsystems commitment to educational excellence assists the College in producing a valuable resource, a fully enabled graduate ready for the industry workplace. The ATL provides a crucible where students can undertake defining educational capstone experiences that fully reflect new ABET criteria and the new millennium. It is a place where government, industry and academia have come together, where education and research have come together, and where students grow into enabled engineers for the 21st Century.

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