Implementing a Wireless Network Infrastructure to Enhance ET Curriculum

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Abstract

During the summer of 2001, a team of students was brought together to design, install, and test an 802.11b wireless local area network (WLAN). The team was tasked with installing a WLAN in and between two buildings on the Texas A&M main campus that house the Engineering Technology and Industrial Distribution Department (ETID). The primary goal of the WLAN installation was to provide an infrastructure that would be used by Engineering Technology students and faculty for educational and research purposes. The Wireless Infrastructure Project (WIP) became a real world classroom/laboratory environment for the team members to learn about wireless communications, networking, and authorization and authentication security and to gain practical experience in project management, technical communications and presentation skills.

Additionally, the Electronics and Telecommunications Engineering Technology Program is developing innovative ways to leverage the new infrastructure that depart from traditional administrative uses. Professors and students are developing coursework that utilize the infrastructure for the monitoring and control of mobile platforms while WIP students are adding new labs that expand the scope of teaching wireless network design and security. Through the WIP initiative, an innovative resource has been created that will add significantly to engineering technology education both in the classroom and the laboratory.

I. Introduction

Computer users have had access to powerful computers with fast Internet connections for sometime now. With the recent increase in speed and power of mobile computers, many users are doing work they normally did in an office, on the go. The only thing lacking in these fast mobile computers is a fast mobile connection. Mobile users now demand connectivity anywhere they go, and they want it to be fast.

At Texas A&M University, the Engineering Technology honor society, Tau Alpha Pi, recognized this need and decided to find a solution. Tau Alpha Pi submitted a proposal to Cisco Systems, Inc. requesting a donation of wireless equipment, including wireless NICs and enough access points (AP) to cover the two main Engineering Technology buildings, Thompson and Fermier Halls. This type of

wireless environment would give the students and faculty 11 megabit per second (Mbps) connectivity in the labs and classrooms to further research and education. There was also a request for equipment to support a small network of four APs for experimentation and project development.

After Cisco approved the donation of equipment, a group of four ETID students were brought together to form the Wireless Infrastructure Project (WIP) Action Team. The Action Team was given the task of designing, implementing and testing the wireless network infrastructure. Action Team members included Clay Barbee, Brian Lenahan, and Zack Russell (undergraduate students) and Mike Warren (graduate student). An ETID faculty member, Dr. Joseph Morgan, also assisted the Action Team by providing an interface to a group of faculty advisors.

The wireless network allows students and faculty the ability to obtain a level of communication not previously possible with wired Ethernet. The ETID faculty now has the ability to access information in a classroom setting using the wireless network to assist them in teaching. Instructional information can now be summoned by the lecturer at the click of button without leaving the classroom. Students can use the wireless network to follow instructor's presentations in soft form and gain access to information such as data bases in real-time. Projects have been created and continue to be developed that introduce students to the wireless infrastructure. This exposure teaches students about wireless networking and fosters creative brainstorming for new projects that utilize the wireless network. Numerous senior design projects focus directly on the wireless infrastructure while others are indirectly dependent on it. The students involved with installation of the wireless network found this project to be an extremely valuable experience in a number of areas: technical communications, project management and technical information.

II. Installing the Wireless Infrastructure

Implementation of the wireless infrastructure began in Fermier Hall. The Action Team discussed how many APs would be needed to give the building full coverage and possible locations for installment that would yield the most signal coverage. Once a few preliminary installation locations were chosen, the Action Team performed a site survey in which each AP was temporarily installed and powered up. An 802.11b handheld tester was used to measure signal strength in and around the entire building. When necessary, the power level of the AP can be adjusted to give more or less coverage. Fermier required three APs for complete coverage, each at the maximum power level of 100mW. In the 802.11b standard, there are 3 non-overlapping frequency channels (1, 6 and 11), so each AP was set to a different frequency. Because there were only three APs in Fermier, frequency interference was not an issue.

After placement and configuration settings were decided, the Action Team ran CAT5 network cable from each installation location to the Fermier wiring closet and terminated the ends with RJ-45

connectors. Since the APs would be mounted in open, easily accessible areas, it was decided that security enclosures were needed. Figure 1 shows the security enclosures that were made by modifying clear lock boxes, normally used to secure air conditioner thermostats and controls. The security enclosures were mounted in the locations previously decided and the APs were installed in them.

Figure 1. Secure mounting fixture for AP

The last step to completing the Fermier installation was to connect the APs to the existing, wired Fermier network. The Computer and Information Services (CIS) department at Texas A&M has mandated that all wireless users connect to the campus network using Virtual Private Networking (VPN). All wireless users and wireless APs in the Thompson/Fermier area were placed on a single private Local Area Network (LAN) that connected to the campus network through a firewall that was installed by CIS. The Action Team configured each AP with the private Internet Protocol (IP) addresses assigned by CIS. A virtual LAN was then created on the network equipment in Fermier to support the wireless LAN. Once this was complete, the APs were plugged into the Fermier network and were brought online. With their increased experience, the Action Team began work on the more complex Thompson Hall.

Thompson Hall is a much larger building, has much thicker internal walls, and has a higher density of potential wireless users than Fermier Hall. Given these factors, the Action Team had to expand on what they learned about site surveying in Fermier. As with the Fermier project, preliminary installation locations were decided on. However, in this installation, the APs were placed closer together than they were in Fermier Hall so that more users could be supported in key areas such as labs and classrooms. It was determined that fifteen APs would be required for full coverage in Thompson which posed a

frequency re-use problem. As was stated previously, there are only three non-interfering frequencies that can be used. Therefore, APs had to be placed with matching frequencies as far apart as possible. Controlling the power level was another way the Action Team was able to deal with interference, with most APs in Thompson set between 5mW and 20mW.

Once all installation locations and power/channel configurations were determined, each AP was installed in a secure mounting enclosure with CAT5 cable run to each AP from the Thompson wiring closet, Figure 2. The network equipment was configured for the wireless APs prior to being connected to the wired networks. Fermier and Thompson wireless VLANs were virtually connected between the buildings through the use of Q-tagging. This ensured any wireless user roaming between Thompson and Fermier Halls would remain on the appropriate network segment.

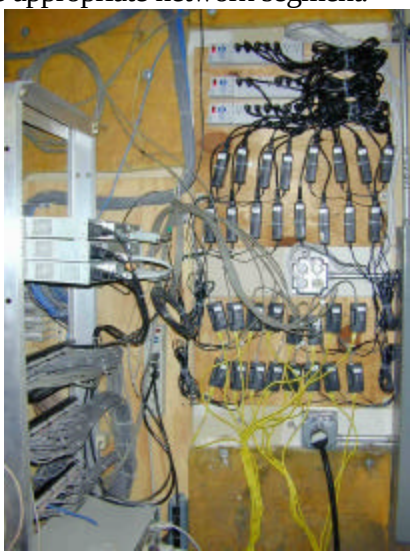

Figure 2. Thompson wiring closet

After both networks were operational, the Action Team moved into a testing phase. Several experiments were performed to measure maximum users per AP, download and upload rates, and how well a wireless user is handed off from one AP to the next while downloading. Tests were also conducted to measure coverage in and between buildings, and to assess the distance a user could be from the buildings without losing connectivity. Coverage analysis was performed for every AP installed. This information was then put into an interactive graphical tour on the project's web site to show users where they could receive coverage from, as well as where the APs were located. Figure 3 illustrates wireless coverage at 11Mbps on the entire first floor of Thompson Hall.

III. What the Action Team Learned

The Wireless Infrastructure Project became a real world classroom/laboratory environment for the

students to learn about 802.11b wireless technology, networking, wireless security, project management, technical communications, and presentation skills. One of the first tasks of the Action Team was to research 802.11b technology as well as Cisco's 350 series wireless APs and Network Interface Cards (NICs). Faculty advisors met with the Action Team to discuss problems and questions the Team had.

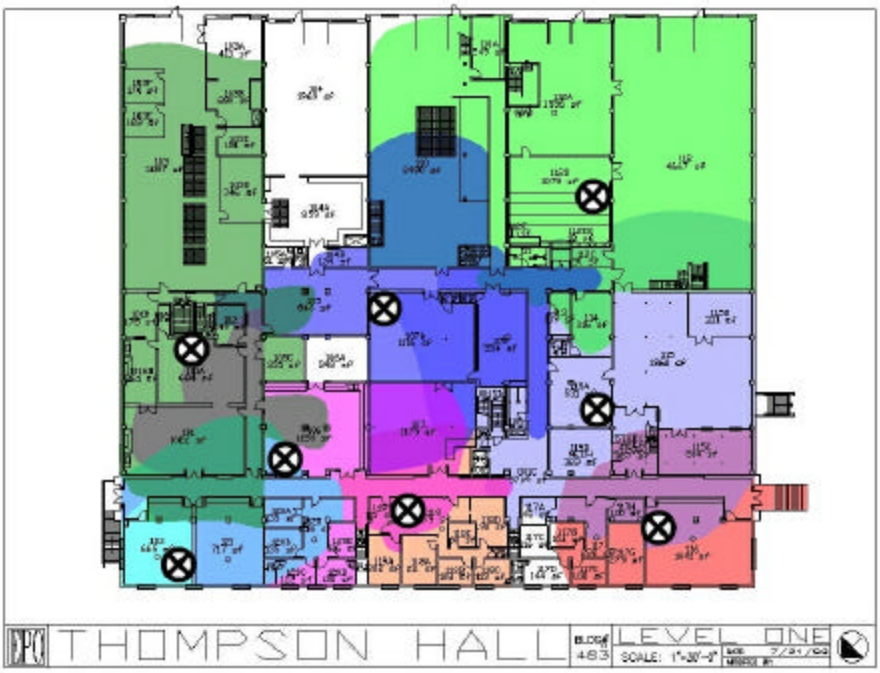

Figure 3. Thompson wireless coverage map

Once equipment was received, empirical data was taken from simple experiments to test signal strength and what type of materials attenuate signal. Figure 4 shows members of the action team consulting on placement and power settings of access points. Throughout the design process, the Action Team learned how to place APs for best coverage and minimal interference with each other. After completing the design and installation of all APs in Fermier and Thompson, the Action Team felt confident about their understanding of the 802.11b technology and equipment.

The Action Team also learned a great deal about networking. Part of the installation task was to integrate this system into the existing wired networks of the ETID buildings and the campus networks. After AP placement was decided for the two buildings, the Action Team pulled CAT5 cable from each AP to the wiring closet and terminated them. The Ethernet switches were configured for the wireless network and provided a seamless wireless LAN between the two buildings.

The added flexibility that comes with wireless access brings with it the need for increased network

security. In addition to the Virtual Private Network required by Computer and Information Services, Action Team members also provided another level of security by adding MAC address filtering which allows only those NIC MAC addresses that have been registered with the ETID department to associate with the wireless APs. A RADIUS server was implemented to centralize the authentication for all APs.

Figure 4. Action team meeting

Project management was a big part of the wireless infrastructure project. Weekly meetings and short daily meetings were held to set goals, work out problems, and ensure that the team was staying on task. Mike Warren, the graduate student, organized the undergraduate student workers and assigned them tasks. Work began in Fermier due to its smaller size and physical structure. After gaining experience with the Cisco 350 equipment and the design process, implementation was begun in the more complicated Thompson Hall with problems such as frequency reuse and a more complex physical structure.

As the Action Team progressed through the project, they documented what they learned Some of these documents detailed the processes for doing wireless site surveys, creating secure mounting fixtures, and building site survey tools. A web site [1] was also developed for the project that outlines the project, gives an interactive tour of areas that have wireless coverage, hosts the wireless knowledge

base, and also contains many photographs of the Action Team at work.

The Action Team also learned a great deal about presentation skills. As the project progressed, several presentations were prepared and presented to Cisco personnel outlining the status of the project. Figure 5 shows Cisco employees and ETID faculty in attendance at one of the WIP Action Team's presentations. Presentations were also prepared and presented to faculty to show the capabilities of the network, how it can be used, and the potential benefits to ETID courses.

Figure 5. Cisco and faculty attendants of WIP presentation

IV. Enhancing the ET Curriculum

Wireless networks allow users access to a number of resources previously available only to computers physically connected to a network. Students and faculty of the Texas A&M ETID department now have greater access to information via the Internet, improved communication via email, and exposure to new and exciting projects involved with wireless communication. Much of the information used in the engineering technology curriculum is based on information from datasheets and other technical reports too large to print. A student can now access the data sheet or report electronically to obtain the necessary information for a class or laboratory. In addition to Internet access, email is a popular method of contact to convey information between student project groups, faculty, and staff. With the wireless network available in Thompson and Fermier Halls, each student, faculty member, and staff member has the ability to maintain communication through email regardless of their location.

Unconventional uses of the wireless network have been expanded to include laboratory and project exercises in the Engineering Technology department. The wireless infrastructure now gives students the ability to undertake projects that involve remotely accessing and controlling equipment, studying wireless network radio properties, and utilizing the wireless network to carry voice and video traffic. ENTC 359 Electronics Systems Interfacing, a required course in the Engineering Technology curriculum, gives students the opportunity to participate in a laboratory project where groups compete against one another to design and develop a mobile platform, as shown in Figure 6. Most notably, this exercise requires students to remotely control a motorized platform, which then relays real time video back to the user. The wireless infrastructure allows students to test their mobile platform design as it is manipulated throughout the Thompson and Fermier hallways while being controlled from a central location via the wireless network.

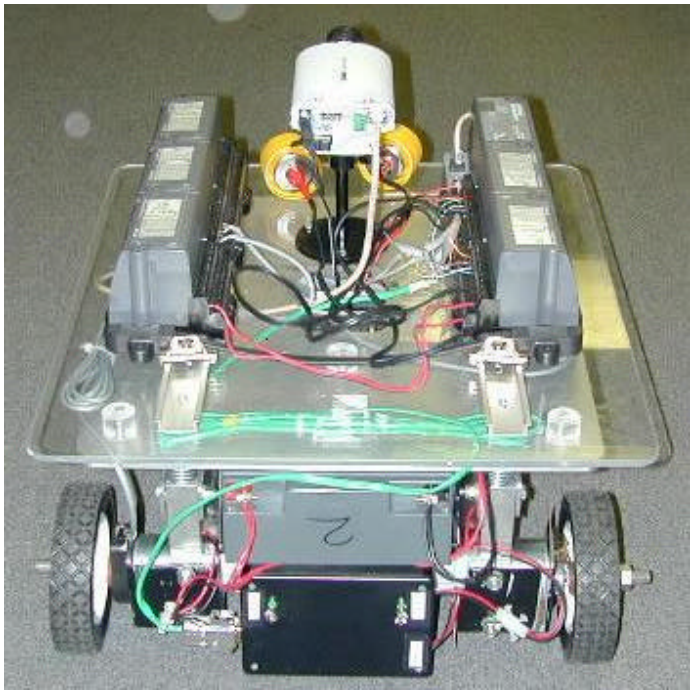

Figure 6. Mobile platform

Engineering Technology senior design projects for the Spring 2002 semester will be utilizing the wireless infrastructure in a number of projects. The first project involves the testing and monitoring of interference and the radio properties of multiple access points. These multiple access points will be competing in a single classroom for coverage. It will be up to the project team to take measurements and study the interference caused by one access point on another under various conditions. Along with the interference testing, the same project team will be observing the wireless signal behavior and properties. A second senior project involves video over the wireless network. This project team is

tasked with designing an interface that will allow video conferencing over wireless networks. Finally, a senior design project that will send video over satellite will use the wireless infrastructure to gain access to the Internet while in the satellite earth station. The wireless network will also be the means by which the earth station gains the video feed to be sent via satellite to a remote destination. A separate project utilizing the wireless network involves voice over IP and the feasibility of sending VoIP traffic over a wireless network connection.

V. Conclusion

While involved with this project, each member of the WIP action team was exposed to a system of learning that was only possible through close involvement with industry sponsors, engineers, and technical advisors. Throughout the wireless infrastructure project, numerous presentations to industry sponsors and departmental faculty provided a means by which each team member could improve their technical communication skills. Also, the close involvement between the WIP team and industry allowed the student team to obtain a high level of technical expertise through sharing of knowledge. The wireless project has been and continues to be used for both traditional and nontraditional purposes. Students, faculty, and staff will utilize the wireless infrastructure to gain access to the Internet and email. Nontraditional uses such as the mobile platform project continue to be developed and will utilize the wireless infrastructure in Thompson and Fermier Halls.

Bibliography

1. http://wip.tamu.edu/, WIP Team website with information on installing a wireless web.

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Clay Barbee is a student in the Electronics Engineering Technology program at Texas A&M University and will graduate in December of 2002. He is currently employed as a student worker in a project to build and implement a low cost tester. His interests are in test, LabVIEW and wireless technology.

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Michael Warren graduated in December 2000 with the BS in Engineering Technology. He is currently working on his MS in the Information and Operations Management Department at Texas A&M University. He also works as a graduate research assistant in the Virtual Instrumentation Laboratory in the Department of Engineering Technology and Industrial Distribution.

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Brian Lenahan is currently working towards a BS in Telecommunications Technology in the Engineering Technology program at Texas A&M University. For the past two years, he has worked for the Telecommunications department maintaining and installing various telecommunications and networking. Recently, he has accepted a position to manage Texas A&M's VoIP system during initial testing.

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Jay R. Porter joined the Department of Engineering Technology and Industrial Distribution at Texas A&M University in 1998 as an Assistant Professor and currently works in the areas of mixed-signal circuit testing and virtual instrumentation development. He received the BS degree in electrical engineering (1987), the MS degree in physics (1989), and the Ph.D. in electrical engineering (1993) from Texas A&M University.

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Joseph A. Morgan joined the Engineering Technology program at Texas A&M University in 1989 as the Program Coordinator for Electronics and Telecommunications Engineering Technology. His areas of interest included radar systems, data acquisition, and control systems. He received the BS degree in electrical engineering (1975), the MS degree in industrial engineering (1989), and the D.E. in industrial engineering (1993) from Texas A&M University.