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Enclosure 1

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Final Progress Report  
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Title: Wireless Grid Education Project

Submitted By  
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## Institution

Navajo Technical College was the recipient of a grant from the Department of Defense through the office of research and development, which was to develop a wireless grid for education on the Navajo Indian Reservation more specifically the Eastern Agency. The concept of the project was to enable Navajo Technical College; then Crownpoint Institute of Technology; to develop a state of the art wireless network and provide a model for educational delivery and economic development based upon the idea that only people who can move toward the engine of the world's technology train can hope to move from the economic basement to the economic mainstream. The project is occurring in one of the poorest places in the United States where mountain ranges, high deserts, and canyon lands make even road access difficult to small communities. The Navajo Nation is the heart of the digital divide in the United States, a place where people from many remote communities have to drive seven or eight miles down dirt roads that are impassible during rain or snow storms to get to the nearest pay phone.

## Project Goals

There are five major reasons for building the wireless grid.

The first is to establish an E-learning system that can deliver Navajo Technical College STEM (Science, Technology, Engineering, and Mathematics) programs to remote chapterhouses in the Eastern agency region of the Navajo Nation. Two degree programs will initiate the E-learning system: Applied Computer Technology and Veterinary Technician, which will include a number of science and math courses such as Biology, Chemistry, Ecology, College Algebra, Geology and Soil Science, Ethno-Botany, etc.

The second is to build a wireless research capability to teach STEM student's methodologies and approaches possible in the contemporary world with remote technology enabled research tools.

The third is to model the solution to the digital divide on the Navajo Reservation by actually building and implementing a world-class wireless grid designed and implemented by Navajo IT professionals.

The fourth is to provide an element of the cyberinfrastructure capability that NTC is working to put into place. This cyberinfrastructure, which will put into place a number of advanced technologies, such as visualization, metadatabases, the access node, etc., designed to meet educational, research, and community needs on the Navajo Nation, will increase both research and experiential opportunities for NTC faculty and students.

The fifth is to provide real world experience in the construction and implementation of wireless technology to NTC's technology students, giving them as powerful an experience with working with advanced technologies as possible. Students from NTC's alternative energy and construction programs will also be able to gain practical world experience in their respective disciplines as part of the project's design.

## Wireless Network Design

The wireless design team working with Hans Werner Braun, of the San Diego Supercomputing Center, High Performance Wireless Research and Education Network (HPWREN) at University of California at San Diego reviewed wireless technologies. Points that had to be addressed consisted of ease of deployment, high costs for right of ways, and limited funds. The team found that Turtle Mountain Community College located on the Turtle Mountain Band of Chippewa Indian reservation in Belcourt, North Dakota had previously designed a beta wireless network to provide connectivity to the community under the guidance of Leslie Romero, Chief Information Officer. After discussions with Mr. Romero the design team selected the Motorola Canopy technology that was used for the infrastructure of the project in Turtle Mountain. While the project at Turtle Mountain was a beta design project in conjunction with Motorola the benefits of the canopy system were relevant as the terrain on the Navajo reservation has sparse vegetation and line of site to communities was apparent. The Motorola Canopy system was developed to deliver high bandwidth broadband communications to rural communities that lack the infrastructure or capitol.

Design of the wireless network consists of point to point and point to multipoint connectivity depending on locations. A point-to-point connection to the Veterinary Clinic located approximately 2 miles from the colleges main campus has been connected to the colleges' fiber network via a wireless jump of 150Mbps usable throughput. The use of orthagon frequency technology multiplexing (OFTM) a proprietary technology of Motorola is used in the connection between the veterinary clinic and the college to provide 98% throughput and 99% uptime. OFTM transmits data on multiple frequencies, resulting in higher channel bandwidth and greater resistance to interference and signal fading thus ensuring a high availability signal even in extreme conditions. Advanced Spectrum Management with Dynamic Frequency Selection (DFS) allows self-selection of frequencies over which it can sustain the highest data rate at the highest availability ensuring high throughput at all times.

Figure 1: Demonstrates backhaul technology used between main hub areas operating at 150Mbps. The term backhaul describes the main communications channel used to link local switching networks together. A clear line of path between the switching networks is preferred, but with orthagon frequency transmittal, non line of site installations are acceptable. At a central location such as a chapter or tower the canopy system is deployed. The Canopy system allows for a 360<sup>0</sup> degree distribution of wireless signal. Range of the wireless signal is up to 30 miles circumference or 15 miles from center point in any direction. Within the first 3 miles a subscriber module is the only device needed. From 3 to 15 miles a subscriber module and small dish may be required, in most instances where the distance is greater then 4 miles dish and subscriber module are required. Just as with satellite signals the dish concentrates spread communication signals to allow for the best signal.

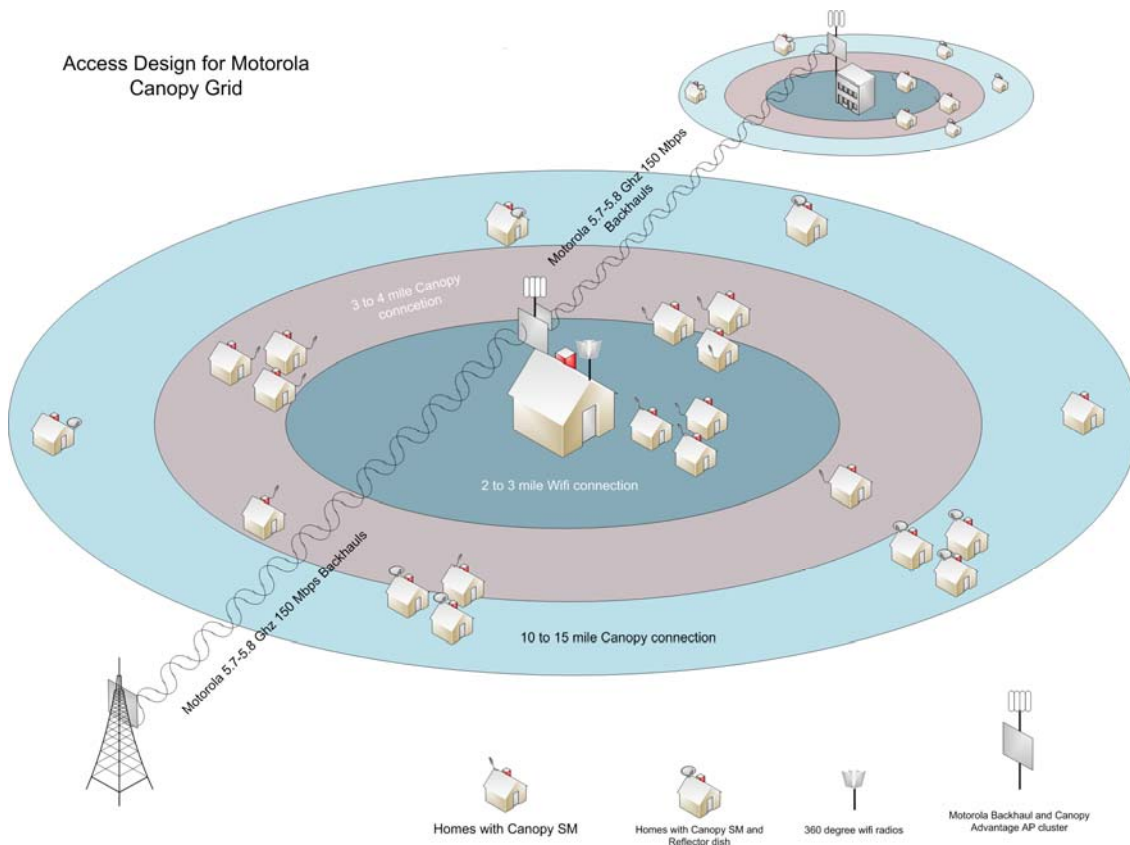


Figure 1

## Build Wireless Research Capacity

To build the research capacity through the wireless grid education project the model for a distributed computational grid was developed that is used as part of the effort to improve STEM education on the Navajo Nation and technology transfer that can be useful to Pueblo and other New Mexico communities. The key unit of this distributed grid is a unit of hardware called a Little Fe. A Little Fe is a complete 4 to 8 node Beowulf style computational cluster. It is designed to act as a platform for parallel and distributed computing education. By leveraging the bootable cluster cd project, and its associated curriculum modules, Little Fe makes it possible to create a powerful, computational science and High Performance Computing educational platform. It allows access to high bandwidth curriculum that cannot be accessed without such a platform. It also allows the creation of a grid that increases computational resources from various places that would not be able to experience advanced collaborative and lab-based science tools, learning, and knowledge. The Little Fe has provided the college with the ability to provide a cyberinfrastructure environment on a scale not seen before by taking entire communities and allowing for the resources of the community to be shared across the wireless network. Supercomputing capabilities have been further enhanced through the

supercomputing cluster at Navajo Technical College. This type of environment is referred to as a scalable distributed supercomputing environment. In collaboration with the National Science Foundation five Little Fe units have been built by Navajo Technical College personnel for this project and it has become known as the Dine' Grid Project, while grid computing is a new science with the wireless grid education project new opportunities for continued research and development are being evaluated.

## K-12 Engagement

### TeraGrid

A summer workshop sponsored by TeraGrid (<http://www.teragrid.org>) and National Computational Science Institute and use of Little Fe and the wireless grid education project. Date: July 15 to July 21, 2007. First computational science workshop to be held at a tribal college.

Introduction to Interdisciplinary Computational Science Education for Educators.

[http://205.242.219.103/events/2007\\_ncsi\\_workshop.html](http://205.242.219.103/events/2007_ncsi_workshop.html)

This workshop is designed to be truly introductory in nature; no prior exposure to computational science will be assumed as this is designed to address educational opportunities for K-12 students.

Topics include

Integrating computational methods into science and mathematics classes using simple modeling tools including AgentSheets, VenSim, and NetLogo, and web based tools such as Interactivate. Participants will work with techniques, software and curriculum modules which can be directly integrated into their classroom activities.

Little Fe + Bootable Cluster CD + Computational Science Education Reference Desk = Acme, an inexpensive, portable platform for teaching computational science and high performance computing. Participants will learn the basics of cluster computing, both hardware and software, and see how the Acme platform can be used to teach high performance computing and computational science in a variety of educational settings. Design of the Dine' educational grid.

First Look - Introduction to Computational Science

Bioinformatics Curriculum Modules, High Performance Computing Curriculum Modules, Taxonomy of High Performance Computing, aka Supercomputing in Plain English, Building Little Fe, Environmental Science Curriculum Modules, and much more.

Attendance at workshop was 20 during the sessions with six being in grades 10-12 and seven from the Navajo Nation Department of Education. The others attending came from colleges across the U.S. This was the first workshop held utilizing the wireless grid.

#### Attendance at summer workshop by ethnicity

|                  | Native American | Non-Native | Female | Male | Total |
|------------------|-----------------|------------|--------|------|-------|
| K-12 student     | 6               | 0          | 2      | 4    | 6     |
| k-12 educator    | 6               | 1          | 4      | 3    | 7     |
| College educator | 1               | 6          | 3      | 4    | 7     |

### NSF

The National Science Foundation sponsored a Summer Science Engagement Camp which utilized the wireless grid in the area of graphical information technology. Date: June 4<sup>th</sup> 2007 to June 22<sup>nd</sup> 2007. Students attended at 3 week session where teams were required to document vegetation, wild life, and soil types around Crownpoint via the use of remote sensing, wireless cameras, laptops, and GPS devices. Students then provided presentations on finding and conclusions on their outcomes. Presentations held by IT staff on wireless grid and supercomputing efforts.

#### Attendance summer camp

| School     | Native | Non-Native | Female | Male | Total |
|------------|--------|------------|--------|------|-------|
| Crownpoint | 12     | 0          | 7      | 5    | 12    |
| Thoreau    | 4      | 0          | 2      | 2    | 4     |
| Tohatchi   | 2      | 0          | 2      | 0    | 2     |
| Gallup     | 3      | 1          | 4      | 0    | 4     |
| Other      | 3      | 1          | 1      | 3    | 4     |

With the development of the wireless grid for education the college has achieved worldwide awareness by national entities that deal in the development of research opportunities through super computing and computational science.

### Accomplishments

Broadband 150Mbps links between switching points to remote locations. Maximum distance is 15 mile hop between Navajo Technical College and Whiterock chapter.

In March 2006 the first live real time test was broadcast from Navajo Technical College to Whiterock Chapter along with over 13 major entities of the Navajo Nation. Distance education was the topic for NTC with broadcast in Veterinary Science, Early Childhood, and student recruitment. Broadcast was to over 300 in attendance at the Whiterock Chapter ranging from district representatives to local

ranchers. The Whiterock Chapter is the last chapter on the Navajo Indian reservation to receive electrical power. Chapter residents still had to travel 8 miles down a dirt road to access a pay phone on the side of the state highway. Three IP telephones have been installed at the chapter thus allowing for calls to any Navajo Nation Government Department. Two workstations have been installed allowing for internet access at the chapter as most homes in Whiterock do not have a source of power.

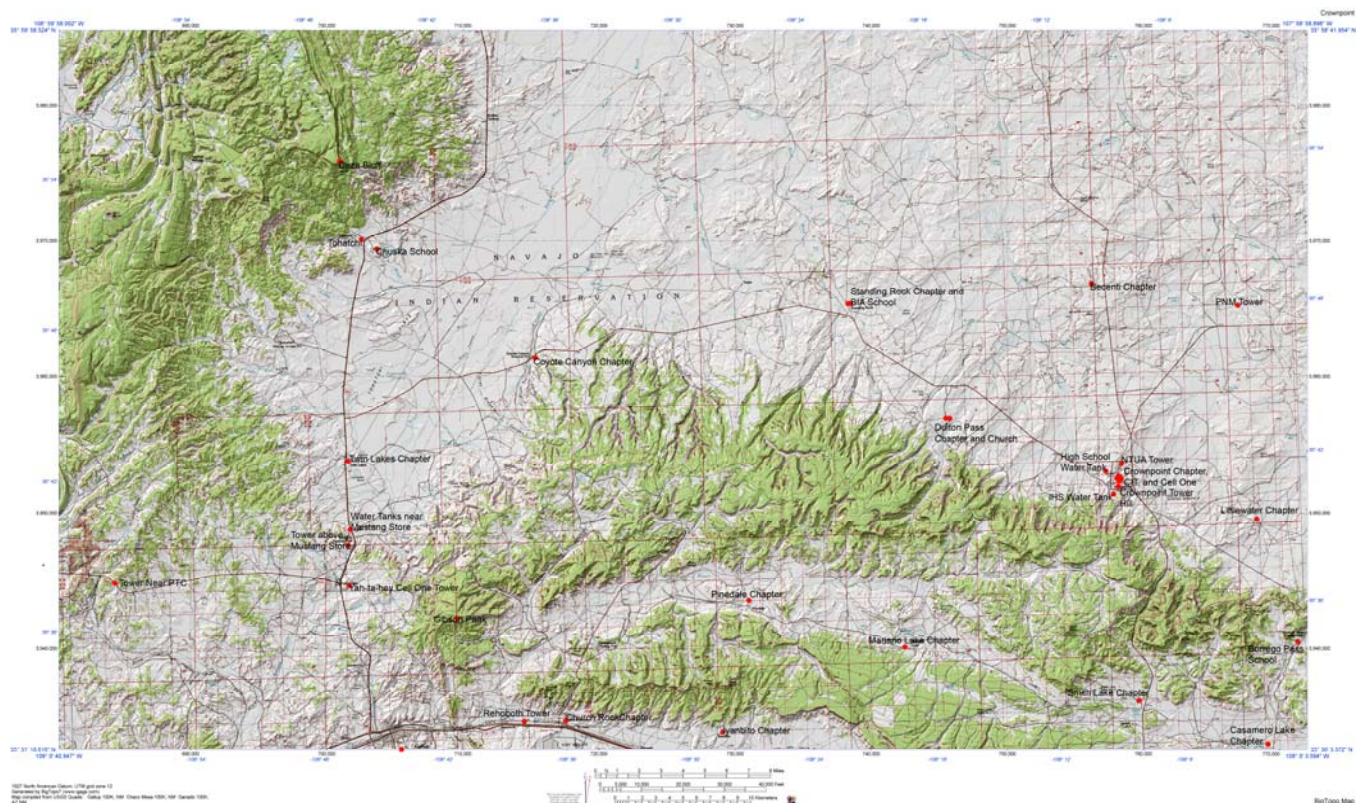
The Design of 155 Mbps backbone between Navajo Technical College and the Albuquerque Giga-Pop, which houses the New Mexico portion of the Lambda Rail, a national high speed research network capable of over 100Gbps (10 Lambda). With the design of the wireless grid it was apparent the local Telco did not have the infrastructure to support high bandwidth request that would arise from the build out of the wireless grid. The local Telco was capable of only 3 T1's max as the digital microwave equipment owned by the company was outdated. To address this problem the design team developed a backbone network capable of a minimum 155Mbps and Maximum of 300Mbps with today's existing technologies. The wireless grid educational project allowed the leverage needed to entice the State of New Mexico to support the project with 1.3 million dollars to design, build, and furnish a wireless communications backbone between Navajo Technical College and Albuquerque Giga-pop.

The Navajo Nation with the support of Navajo Technical College has established a telecommunications meta-database designed to provide real time information to the Nation on its communications assets on the reservation. Data is extracted from cellular providers, the Bureau of Indian Affairs, and others showing locations, power sources, and other needed information. Figure 2 is an example of data collected.

|                          |                    |               |                |      |     |     |     |      |  |  |
|--------------------------|--------------------|---------------|----------------|------|-----|-----|-----|------|--|--|
| Chapter Houses           | Dalton Pass        | 35° 43.632,5' | 108° 16.954,4' | 6734 | na  | na  | na  | Grid |  |  |
|                          | Standing Rock      | 35° 48.272,3' | 108° 21.632,0' | 6332 | na  | na  | na  | Grid |  |  |
|                          | Becenti            | 35° 48.887,0' | 108° 9.906,6'  | 6593 | na  | na  | na  | Grid |  |  |
|                          | Thoreau            | 35° 24.333,9' | 108° 13.131,6' | 7154 | na  | na  | na  | Grid |  |  |
|                          | Baca               | 35° 21.680,3' | 108° 3.326,6'  | 6886 | na  | na  | na  | Grid |  |  |
|                          | Iyanbito           | 35° 31.346,3' | 108° 28.590,2' | 6972 | na  | na  | na  | Grid |  |  |
|                          | Church Rock        | 35° 32.027,2' | 108° 36.009,1' | 6680 | na  | na  | na  | Grid |  |  |
|                          | Crownpoint         | 35° 41.042,4' | 108° 8.810,2'  | 6942 | na  | na  | na  | Grid |  |  |
|                          | Pueblo Pintado     | 35° 57' 50.3" | 107° 38' 49.5" |      |     |     |     |      |  |  |
|                          | White Horse        | 35° 48' 44.5" | 107° 45' 44.5" | 6740 | na  | na  | na  | Grid |  |  |
| Community Infrastructure | Ojo Encino         | 35° 57' 13.2" | 107° 20' 54.8" | 6768 | na  | na  | na  | Grid |  |  |
|                          | Pueblo Pintado     | 35° 58' 40.7" | 107° 38' 17.2" |      |     |     |     |      |  |  |
|                          | PP Boarding School | 35° 57' 45.7" | 107° 39' 20.2" | 6518 | na  | yes | na  | Grid |  |  |
|                          | Becenti Water      | 35° 47' 45.3" | 107° 09' 40.8" |      | na  | na  | yes |      |  |  |
|                          | Tanner Ranch       | 35° 55' 0.1"  | 107° 34' 19.9" | 6742 | na  | yes | na  | Grid |  |  |
|                          | Horse Canyon       | 35° 49' 21.0" | 107° 21' 20.8" | 6826 | na  | na  | yes | no   |  |  |
|                          | Ojo Encino Bl      | 35° 57' 21.4" | 107° 20' 54.8" | 6739 | na  | yes | na  | Grid |  |  |
|                          | Gibson Peak        | 35° 36.250,0' | 108° 41.167,0' | 7822 | na  | na  | na  | Grid |  |  |
|                          | Tohatchi APS       | 35° 54.500,0' | 108° 46.383,0' | 8973 | na  | na  | na  | Grid |  |  |
|                          | Ojo Encino s/      | 35° 57' 08.8" | 107° 21' 08.2" | 6798 | yes | na  | na  | no   |  |  |
| Cell One                 | Torreón Spet       | 35° 48' 19.3" | 107° 11' 51.1" | 6731 | yes | na  | na  | Grid |  |  |
|                          | Ciniza             | 35° 27.933,3' | 108° 24.643,3' | 7208 | yes | na  | na  | Grid |  |  |
|                          | Crownpoint         | 35° 41.123,3' | 108° 8.750,0'  | 6971 | yes | na  | na  | Grid |  |  |
|                          | Gallup Central     | 35° 31.023,3' | 108° 44.020,0' | 6728 | yes | na  | na  | Grid |  |  |
|                          | GDT                | 35° 23.176,7' | 108° 44.540,0' | 7218 | yes | na  | na  | Grid |  |  |
|                          | Mt Powell          | 35° 28.110,0' | 108° 14.480,0' | 8620 | yes | na  | na  | Grid |  |  |
|                          | Twin Lakes         | 35° 39.233,3' | 108° 46.441,7' | 6757 | yes | na  | na  | Grid |  |  |
| Frontier                 | Ojo Encino Fr      | 35° 56' 22.7" | 107° 20' 51.1" | 6852 | yes | na  | na  | Grid |  |  |
|                          | PNM Pump st        | 35° 55' 25.2" | 107° 27' 57.5" | 6655 | yes | na  | na  | Grid |  |  |
|                          | Torreón Fron       | 35° 48' 32.5" | 107° 18' 05.5" | 6801 | yes | na  | na  | Grid |  |  |
|                          | Pueblo Pintado     | 35° 54' 55.7" | 107° 43' 16.6" | 7194 | yes | na  | na  | Grid |  |  |

Figure 2

Data has been collected for over 400 pre-existing locations that did not exist before the Wireless Grid Education Project. Figure 3 shows a topical map of some locations that

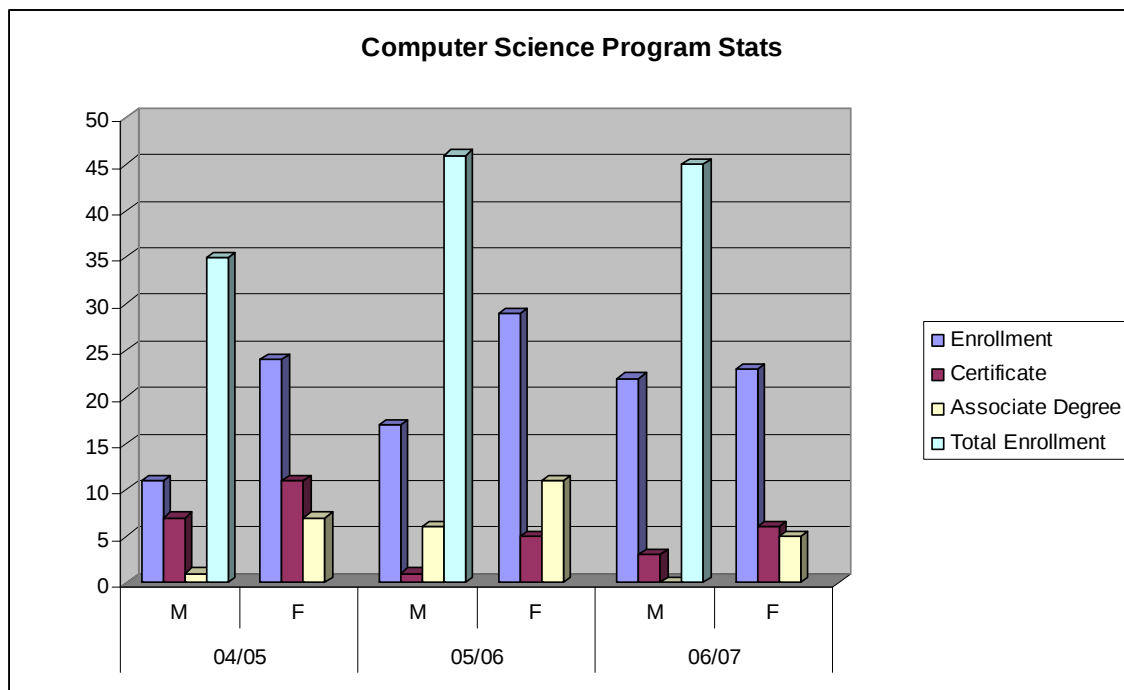


have been identified. The Navajo Nation land is larger than the state of West Virginia.

Figure 3

### Increase Enrollment/Graduation

Applied computers has changed curriculum in order to engage students in the build of the Wireless Grid Education Project. Navajo Technical College has passed new curriculum which provides a hands on experience for students. Graph 1 shows an increase in enrolment for the computer science program.



Graph 1

| Computer science program |       |    |       |    |       |    |
|--------------------------|-------|----|-------|----|-------|----|
|                          | 04/05 |    | 05/06 |    | 06/07 |    |
|                          | M     | F  | M     | F  | M     | F  |
| Enrollment               | 11    | 24 | 17    | 29 | 22    | 23 |
| Certificate              | 7     | 11 | 1     | 5  | 3     | 6  |
| Associate Degree         | 1     | 7  | 6     | 11 | 0     | 5  |
| Total Enrollment         | 35    |    | 46    |    | 45    |    |

Figure 4 shows Navajo Technical college students building little fe computational science cluster computer and working on Motorola canopy system both backhaul and subscriber module.

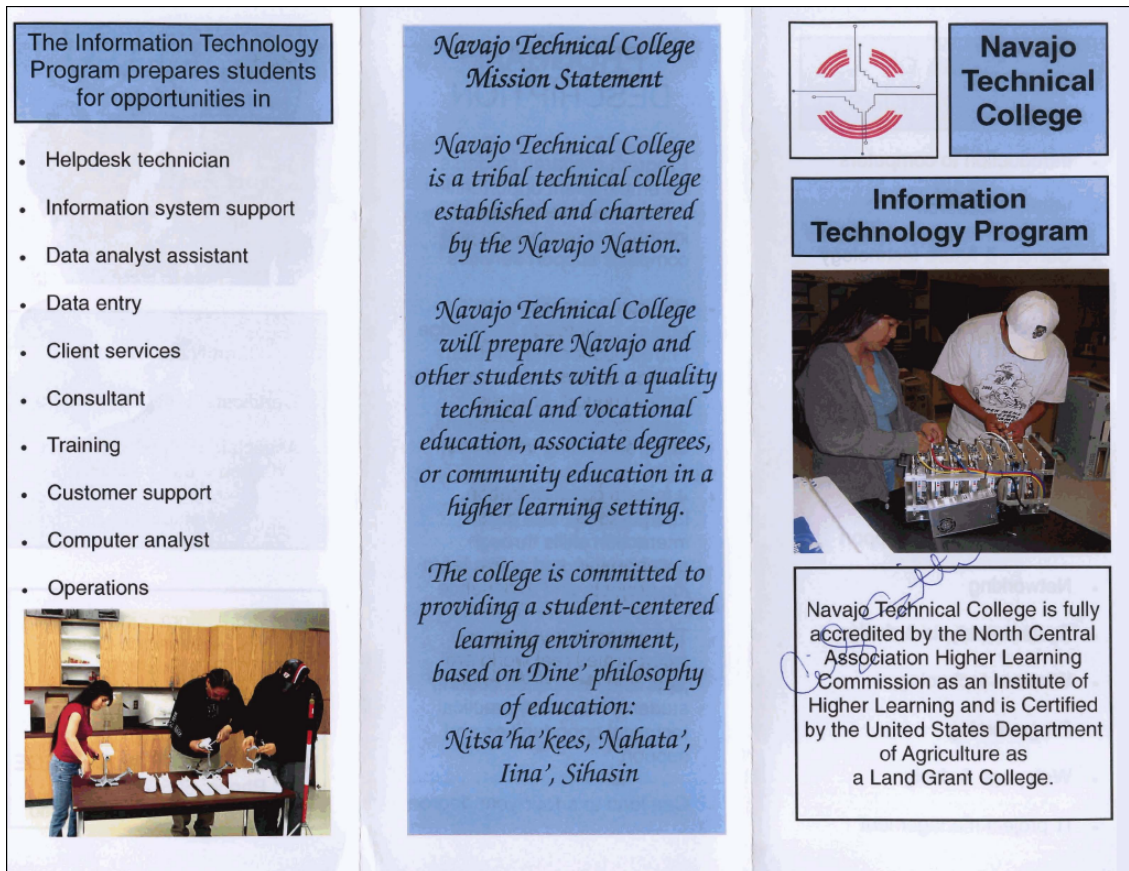


Figure 4

### Continued Support

Due to the Wireless Grid Education Project and the publicity it has received the State of New Mexico in its 06 legislation provided 1.3 million dollars in support of the wireless backbone designed by the team.

In the New Mexico 07 legislation 1.1 million dollars have been set aside to build a technology center to house equipment for the Internet to the Hogan Project at Navajo Technical College.

In the New Mexico 08 legislature a submittal for 3.2 million dollars is in review to build out a wireless grid to the northern New Mexico region.

The National science Foundation is supporting the building of Little fe units to be built at the Navajo Technical College for deployment throughout the reservation in schools and chapterhouses.

### News Release

<http://www.navajotech.edu/docs/releases/release.html>

For release January 10, 2007

## Navajo Technical College Begins Bridging Digital Divide

### The Beginning of the End of the Digital Divide

Navajo Technical College invites the public to "An Internet to the Hogan and Dine Grid Event" featuring the groundbreaking for the first Internet to the Hogan tower on January 29, 2007, beginning at 10:00 a.m. The event will take place in the multipurpose building on the Navajo Technical college campus located in Crownpoint, N.M.

This celebratory event will feature several significant highlights: Demonstration of advanced radio technology designed to end the digital divide in the eastern agency of the Navajo Nation; nationally renowned experts in advanced technology will be on hand; official acceptance of the Little Fe mini-supercomputer from TeraGrid, the world's largest supercomputing network; and a tour of the various technology developments on campus.

The Internet to Hogan project is designed to end the digital divide in the Navajo Nation. The first phase of the project will build a major wireless pipe using OC3 (155 megabit) speeds using the Lambda Rail and Internet 2 from urban Albuquerque, NM to rural Navajo Technical College (NTC), a small tribal college located in northwest New Mexico. From NTC, using backhaul and canopy technology from Motorola and Harris, broadband connectivity will be built to 31 chapter houses, community centers for social, cultural and political organization, on the NM side of the Navajo Nation. Connectivity will be further radiated out to schools, medical clinics, hospitals, police departments, fire houses, and homes within a 15 to 30 mile radius of each chapter house using the Canopy technology.

This means that people who have never had access to a personal phone, let alone the internet in these remote areas, will be able to connect to a computing environment that provides high bandwidth speeds to the World Wide Web and telephone system. This will allow increased communication, education, and business possibilities not thought possible for years into the future.

The Internet to Hogan project will solve what is called the "last mile problem" and provide an unprecedented model for educational delivery and economic development. This model is based on the idea that only people who can use the engine of the world's technology can hope to move from the basement to the top floor in the economic high rise. This development is uniquely occurring in one of the poorest places in the United States where terrain of high desert, including mountains and canyons, make even road access difficult for small communities. The Navajo Nation is in the heart of the United States' digital divide, a place where rain or snow storms often render roads impassable and can cut off access to the nearest phone.

Navajo Technical College has moved to the forefront of research institutions of higher learning in New Mexico with supercomputing capabilities. This was achieved by building an IBM blade cluster on the Navajo Technical College campus which was just one element of the Hogan to Internet project. Tied into both the wireless connectivity and cluster effort is the construction of a supercomputing grid using a technology called Little

Fe. The Little Fe allows the inexpensive building of a cluster that can be located at a chapter house or a school. These Little Fes effectively make possible a distributed supercomputing grid that can allow research and education activities to take advantage of the enormous powers and speeds of supercomputers tied into a single grid architecture. Thus, major research projects can be conducted locally.

These major efforts are supplemented with partnerships built with TeraGrid: A high performance network using connections that integrate computers, data resources, tools, and high end experimental facilities around the country. Other partnerships include the University of New Mexico's Center for High Performance Computing national laboratories, scientists and universities from around the world. These resources will allow for the creation of innovative E-learning programs designed to use the most advanced communication, scientific and computing tools available. The excitement of advanced collaborative educational models will now be available in some of the most remote communities in the United States. The E-learning system, using open source software such as Moodle, is especially useful for science, technology, engineering and math education. This system allows students to collaborate over distance to achieve breakthroughs in both individual and scientific knowledge and understanding.

One of the most exciting expectations of the effort is the creation of technology knowledge that can be used to spin enterprises that will compete in niche and national markets. This will allow the Navajo people living in remote communities to expand their leadership capabilities in diverse fields ranging from arts and crafts to technological and scientific innovation.

The idea is to build intellectual human resources in the Navajo Nation who can build a new economic structure for new century. This economic structure will be the result of both entrepreneurship and trained individuals able to create and capitalize on high value, high intellect jobs and tasks of the twenty-first century.

Navajo Technical College is a tribal technical college established and chartered by the Navajo Nation. The Navajo Technical College prepares Navajo and other students with a quality technical and vocational education, associate degrees, or community education in a higher learning setting. The college is in a unique position to transition employees directly into the work force, or to transition students to 4-year schools and thus, it addresses the needs of the Navajo Nation in an immediate and comprehensive manner.

The internet to the Hogan is a joint effort partially supported by the Department of Defense, National Science Foundation, and the State of New Mexico.

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End of Press Release

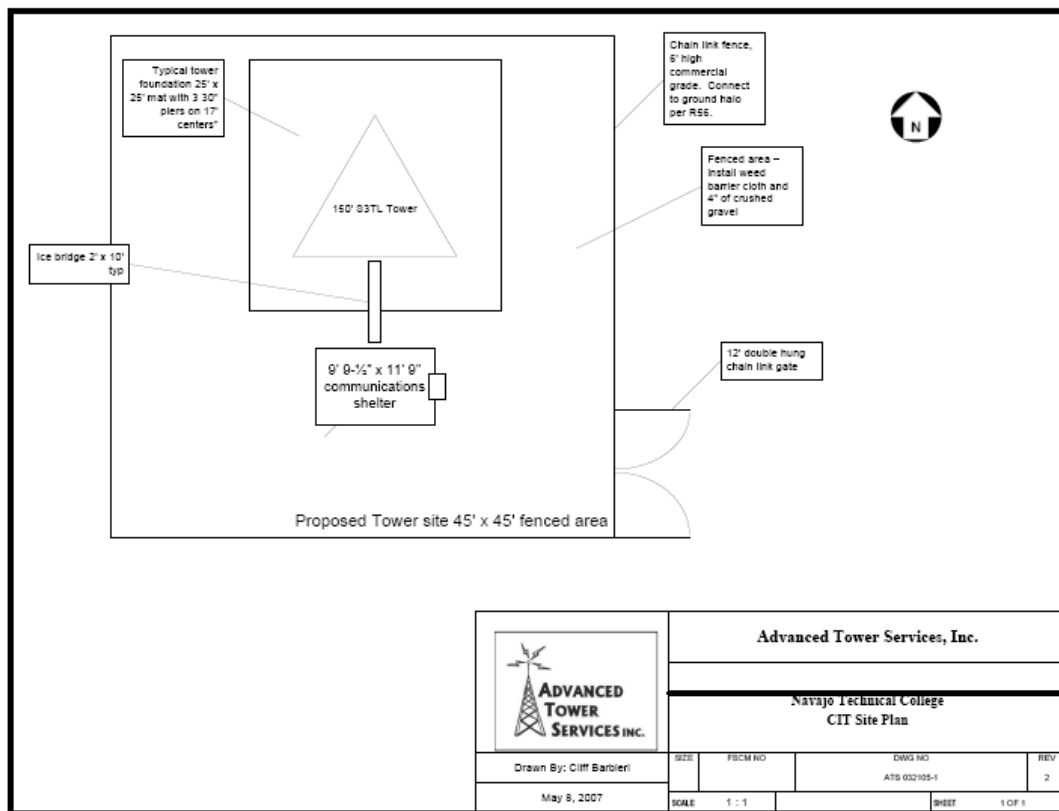
University of California press release

<http://ucsdnews.ucsd.edu/newsrel/science/hogan07.asp>

Denver Post press release

[http://www.denverpost.com/news/ci\\_5326782](http://www.denverpost.com/news/ci_5326782)

## Illustration



Foot print for Crownpoint tower

