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Analysis of Wireless Networking on the University of Arkansas Campus

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ANALYSIS OF WIRELESS NETWORKING ON THE UNIVERSITY OF ARKANSAS CAMPUS

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Abstract.

Wireless communication has already begun to change the way business and research is done today. Development of the wireless network for digital cellular phone has already improved the area of voice communications. The area of portable and mobile connectivity for computers and other devices is beginning to emerge. The research analyzes and compares a few of these wireless networks. Physical aspects such as range, interference factors, and frequency capabilities and restrictions are assessed. Capacity analysis including round trip times, latency, and throughput are done as well. Issues of authentication and addressing protocols are researched to determine optimal performance and convenience depending on the desired functions of a given wireless network. The research is done on three existing wireless networks on campus, each having unique configurations and physical attributes.

Julia Lincoln and Amy Apon

Introduction.

Wireless communication has already begun to change the way business and research is done today. Development of the wireless network for digital cellular phone has already improved the area of voice communications. The area of portable and mobile connectivity for computers and other devices is beginning to emerge. As the popularity of this technology increases, institutions are going to have to make decisions on many factors when determining if and which of these technologies are right for them.

The research analyzes and compares a few of these wireless networks. Physical aspects such as range and interference factors are assessed. Capacity analysis including round trip times and throughput are done as well. Issues of physical implementations are researched to determine optimal performance and convenience depending on the desired functions of a given wireless network. The research will be done on three existing wireless networks on the University of Arkansas campus, each having unique configurations and physical attributes.

Wireless technology works much like it sounds. Instead of physically connecting machines by various combinations of cables, connectors, and bridges, the machines contact each other or the bridges through the air. Much like radio transmission, wireless networks operate using some form of an antenna and receivers. The data is sent via electromagnetic waves to a receiver that then translates the waves back into data.

In the current standard, there are three physical characteristics that categorize wireless networks: diffused infrared, direct sequence spread spectrum (DSSS), and frequency hopping spread spectrum (FHSS). The infrared operates at different bands and has its own set of limitations that are much different from the spread spectrum types. Spread spectrum is used to avoid noise interference that can occur if data was only sent on one frequency. It utilizes different frequencies within the band to avoid the interference. Direct sequence spread spectrum (DSSS) takes the base signal and replaces it with calculated blocks of fixed length codes. DSSS uses multiple frequencies in the band to transmit data, but it only uses one pre-selected frequency for each transfer. Frequency hopping spread spectrum (FHSS) uses up to 80 frequencies to transmit. The signal will start on one channel and then after a designated amount of time, it will "hop" to another channel. The spread spectrum types of wireless implementation are the focus in this paper.

There are two main terms that describe how much and how fast data can be transferred on a network, bandwidth and latency. Bandwidth is the capacity or volume of data that can be sent. Throughput is measured bandwidth and is often referred to in Kbps (kilobits per second), Mbps (megabits per second), or Gbps (gigabits per second). The frequencies used for wireless networks at this time support 1 Mbps and 2 Mbps capacities. Latency can be thought of as the speed of a network. Latency describes how fast the data can be transferred over the network. Latency is referred to in sec (seconds), msec (millisecond; 10^3 *sec), usec (microsecond;* 10^6 *sec), or nsec (nanosecond;* 10^9*sec).*

The first network analyzed is on Ozark Hall. This configuration consists of a bridge that is physically plugged into the Ethernet in Ozark Hall. On top of the roof there is an 8dBi omni-directional antenna that is wired to the bridge. The receivers are wireless modems that fit into a laptop computer. The laptop can connect through the antenna and bridge to the campus network when it is within a 700' radius of the antenna. This radius is affected by physical interference such as trees, buildings, etc. The connection is limited by line-of-sight. If the receiver is not able to "see" the antenna, then it does not transmit. It uses direct sequence spread spectrum. This wireless network has a 2Mbps capacity and operates in the 2.4GHz frequency range.

The second network is a point-to-point network based from the Graduate Education building to the Speech and Hearing Clinic across Arkansas Ave. There is one parabolic, 23dBi antenna on each building that is connected to a bridge inside, much like the first network. The machines in the Clinic are physically wired to the bridge. The bridge in the Graduate Education building is physically connected to the campus ethernet. This network operates only on a point-to-point basis. It sends from one antenna to the other, using direct-sequence spread spectrum. The network has a 2Mbps capacity and operates in the 2.4GHz frequency range.

The third network is a lab in the first floor of the Science and Engineering building. The network consists of two antennas and three stations. The stations in this case are three AI (artificial intelligence) robots. The antennas are connected to the campus ethernet. A server machine is used to guide the robots at this time, transmitting the data via the wireless connections. This network uses frequency hopping spread spectrum and operates in the 2.4GHz range.

The tool used to test each network's latency was ping. This program is part of the Windows 98 and Linux operating systems, which were the operating systems on the machines tested. The ping program sends a message of specified size from one host to another host machine and times how long it takes from the time it leaves the first host to when the message returns to the first host. This time is called the round trip time (RTT).

For all of the networks, the ping is repeated ten times at each message size interval and the average of those ten pings is taken as the RTT for that message size. As the message size is increased, the RTTs are expected to increase as well. In an isolated environment, the RTTs can be expected to form a relatively smooth curve when graphed. Outside factors such as other network traffic and interference can have an effect on the RTT, however, causing inconsistencies in the RTTs.

The antenna on Ozark Hall was tested first. Pings were conducted between the wireless laptop and a machine, Comet, on the campus network. The only traffic that would alter the RTTs during the primary testing was from any regular traffic on the campus network that might slow the switches' response times. The results were very close to the numbers expected. (Figure 1). The testing was repeated on the same configuration but with traffic purposely introduced between the laptop and comet. Music files were played on the laptop that were physically located on comet. This ensured a continuous stream of data being transferred between the two hosts during the duration of the test. The inconsistency of the numbers reflects the interference caused by the streaming traffic. The longer RTTs as compared to the first test also reflect the added traffic. (Figure 2). The next test was performed on the network between the Graduate Education Building and the Speech and Hearing Clinic. The RTTs were expected to be higher because the messages would have to travel a farther distance to reach their destination with more traffic using the same wire. (Figure 3). The relative closeness of the results between the first two networks is expected. They both use DSSS and have 2Mbps capacities. The point-to-point antennas must transmit over a farther distance. The final test was done on two of the AI robots. When compared to the first two networks, this network had higher RTTs on the smaller messages, but the RTTs did not increase as much as the message size increased. (Figure 4). This can be accounted for due to the difference in spread spectrum methods of the wireless networks. The last network uses FHSS as opposed to the DSSS used on the other two networks.

In conclusion, the wireless networks on the University of Arkansas campus are similar in their speeds and capacities. The physical configuration of each network provides advantages for differing situations. The range of needs met by the networks provides good groundwork for determination of the expansion of use of wireless networking on campus. As the technology advances with wireless networking, I feel that the advantages of wireless networks will very soon outweigh the disadvantages.

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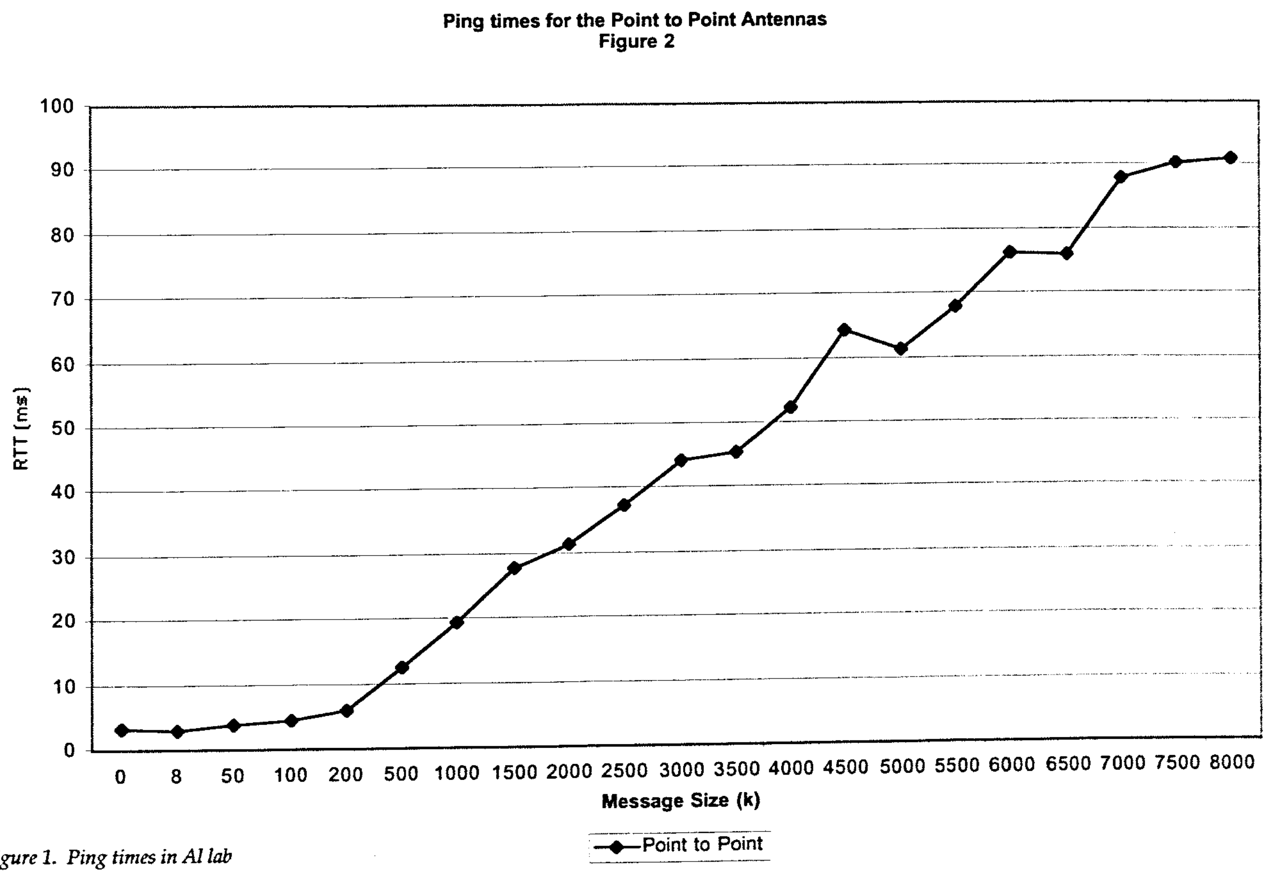

Figure 1. Ping times in AI lab

Faculty Comment:

Dr. **Amy W. Apon,** Assistant Professor of Computer Science & Computer Engineering, and Ms. Lincoln's mentor remarks:

> Julia's project has been to systematically evaluate and compare three different wireless local area networks that are currently installed at the University of Arkansas. Julia has used standard tools to measure the latency and bandwidth of the networks. Latency is the time that it takes for a message to be sent from end to end, and bandwidth is a measure of the amount of data that can be sent at one time. Network engineers at the University of Arkansas can use this information in planning the use of future wireless networks on campus.
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> The perceived performance of any network can vary tremendously depending on the type of applications and number of computers that use the network. With a wireless shared Ethernet network, as the number of computers attached to the network increases, the contention on the network increases. In this environment many messages must be sent repeatedly so that the performance of the network decreases. Even if only two computers send, but each sends data frequently, the performance of the network can decrease. Julia has experimentally investigated the performance of the three wireless networks under various operating conditions that are expected to affect the network performance.
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> Wireless networking technology is moving rapidly into network installations, but wireless technology presents new challenges for network engineers and administrators. Many performance and architecture issues of wireless networks in a real operating environment are incompletely understood. The availability of hardware to test and Julia's energy in approaching this project have provided a nice opportunity for an undergraduate to contribute to the understanding of wireless technology for local area networks.