Virginia Tech ■ ECE/CS 4570: Wireless Networks and Mobile Systems ■ Spring 2006

At-home Exercise 2 (E02)

Report Due: February 2, 2006 (at 4:00 PM)

Part I – Objectives and Laboratory Materials

Objective:

The objectives of this at-home exercise are to:

- Introduce the operation of a wireless LAN in infrastructure mode.
- Illustrate the effect of distance to the access point on throughput.
- Study the effect of co-channel interference on the performance of 802.11b.

After completing the assignment, you should be able to:

- Set up an infrastructure network consisting of multiple nodes and an access point.
- Measure the throughput and evaluate the range of the wireless devices.

Hardware to be used in this Laboratory Assignment:

- Dell notebook computer
- Compaq iPAQ
- Xircom 802.11b ethernet adapter
- Intel wireless gateway.

Software to be used in this Laboratory Assignment:

- Client-server throughput measurement tool developed by Agnes Tan.[1] The client runs on the iPAQ and the server runs on the notebook computer. Documentation is included in the folder C:\WNMS\Tools\Agnes on the Dell notebook.
- vxUtil, which runs on the Compaq iPAQ.

Part II – At-home Laboratory Assignment

You are expected to perform the following tasks.

- Read the document describing the throughput measurement tool before starting on the experiments. This document is available on the course website and in directory C:\WNMS\Tools\Agnes on the notebook computer.

In class, we set up an infrastructure network using IEEE 802.11a. Similarly, you will set up an infrastructure network using IEEE 802.11b. The first step is to configure the Intel wireless gateway.

- Configuration of the 802.11b wireless gateway.
    1. The process is similar to configuring the IEEE 802.11a access point as shown in class. Connect the Ethernet card to the Intel wireless gateway using the cross-over cable (the red cable provided with the access point). Enter 192.0.2.2 as the IP address for the 10/100 Ethernet controller card on the notebook. Open Internet Explorer and enter the IP address

[1] SiewYeen Agnes Tan, "A Network Measurement Tool for Handheld Devices," M.S. Thesis, Virginia Polytechnic Institute and State University, 2003 (available at http://scholar.lib.vt.edu/theses/available/etd-05192003-213320/).

192.0.2.1 in the address bar to configure the Intel wireless gateway. Click on "Setup Wizard" tab. A pop-up window will appear asking for username and password. The username is "Intel" with "I" in upper case and the default password is "Intel" (also with an upper case "I"). Click on the wireless settings tab and enter SSID as "wnms*groupnumber*" where *groupnumber* is the number assigned to you.

2. Under the "Wireless Setting" tab, set the encryption algorithm to 40-bit and set the WEP key to "ABCDEF4570". Save the current changes by clicking on the Save/Next button and proceed to Function Settings.
3. Under "Function Settings" select the "Use the access point as a wireless router and access point" option and enter the internal IP, as 198.69.*groupnumber*.1. This IP address is the internal LAN address of the access point. Only the internal nodes associated with the access point know it. Record the LAN MAC address of the access point. This can be obtained by viewing the "Device Information" tab.
4. The Dynamic Host Configuration Protocol (DHCP) allows the automatic assignment of IP addresses to the clients from a DHCP-enabled server. Enable the DHCP server setting under the "Advanced Settings" tab and enter the following valid range of IP addresses:

   198.69.*groupnumber*.2 – 198.69.*groupnumber*.50

   This range of addresses will be allocated to clients by the wireless gateway. Save the settings and restart the gateway by clicking on the Save and Restart button.
5. While the access point is restarting, change the IP address assigned to the 10/100 Ethernet controller card from 192.0.2.2 to 198.69.*groupnumber*.2 and the subnet mask to 255.255.0.0. The default gateway address can be set to 198.69.*groupnumber*.1.
6. After the access point has restarted the configuration window will reappear on the screen. Verify that the settings have changed. If the changes made are successful, remove the red cross-cable and insert the Xircom wireless Ethernet card in the notebook computer.

- For the Xircom card to continue being associated with the access point, it will need to have encryption enabled. The SSID also needs to be changed. Insert the Xircom card and open the Xircom Client utility on the notebook and go to Commands> Edit Properties. Change the SSID to "wnms*groupnumber*". WEP can be enabled on the card by clicking on the network security tab and checking the WEP key radio button.
- To set the WEP key, open the Xircom Client Encryption Manager. Enter password as "Xircom". Click on Commands>Enter WEP key and set the WEP key 1 to "ABCDEF4570". The WEP key is fixed for all sessions with the access point. Check the "persistent" button in the client manager.
- Check whether the card is associated with the access point by checking the IP address obtained. The IP address in Windows can be checked by using the *ipconfig* command. Type *ipconfig /?* in the command window to display the options associated with the command. Use *ipconfig* command and report the IP address obtained by the card.

You will evaluate network performance by measuring the link throughput using a client-server utility.

- You must first configure the iPAQ to enable it to communicate with the wireless access point. Read the document T02_iPAQ.pdf (available on the Blackboard course web site).
- With the iPAQ connected to the notebook and a connection established with Microsoft ActiveSync, copy the IEEE 802.11b driver file (CWESA11xxPPC30v150.cab) from directory C:\WNMS\iPAQ on the notebook to My Computer>Mobile Device>My Pocket PC folder on your notebook.

- To install the driver, go to Start>Programs>File Explorer>My Device on the iPAQ and tab on the CWESA11xxPPC30v150.cab file. This will install both the Xircom client utility and the driver.
- Insert the iPAQ into the dual CardBus sleeve and insert the Xircom WLAN card in one of the slots.
- To set up the card, go to Start>Programs>Xircom and click on the Xircom client utility. Enter the SSID as wnms*groupnumber* and set the Infrastructure mode field to "Yes." Set the WEP field to "Enabled." Set the transmission power to 1 mW.
- To set the WEP key, open the Xircom Client Encryption Manager on the iPAQ. Enter the password as "Xircom". Click on Commands>Enter WEP key and set the WEP key 1 to "ABCDEF4570". The WEP key is fixed for all sessions with the access point. Check the "persistent" button in the client manager.
- Remove your Xircom card from the card sleeve and re-insert it for the settings to take effect.
- Set up an infrastructure network consisting of the notebook, iPAQ and the Intel Wireless Gateway. Check whether the network has been setup by noting the IP addresses assigned to the nodes. On the iPAQ, the IP address obtained can be determined by using the vxUtil.
- To install vxUtil, click on the intallCE.exe in directory C:\WNMS\iPAQ\vxUtil Install on the notebook computer. Make sure that you have a connection between the notebook and the iPAQ using Microsoft ActiveSync. This will install the vxUtil utility to the iPAQ.
- To use vxUtil, go to Start>Programs>Communication on the iPAQ. Click on vxUtil to start the utility. The utility can be used to initiate a ping session, start a traceroute operation, or obtain the IP address of the iPAQ. Use the Info function located at the bottom of the iPAQ screen to obtain the IP address of the iPAQ.
- After the network has been setup, copy the throughput measurement client, in file C:\WNMS\iPAQ\Agnes\client.exe, to My computer>Mobile Device>My Pocket PC folder on the notebook computer. Be sure that ActiveSync is running to move the file to the iPAQ. Start the throughput measurement server application on the notebook computer and then start the client on the iPAQ. The server can be started by going to C:\WNMS\Tools\Agnes\server_pc2.exe on the notebook computer. Go to Start>Programs>File Explorer>client on the iPAQ to start the client. Ensure that the transmission power for the cards on both nodes is set at 1 mW.
- Configure the client to transmit 5,000,000 (5 million) bytes of UDP data to the server by clicking on the configure button of the client. Enter the IP address of the server in the host field. Select the UDP protocol and set the total number of bytes to send as 5,000,000 bytes. Run this test with the iPAQ and the notebook computer in the same room and the iPAQ within about 10 feet of the notebook computer. Record the received throughput at the iPAQ and the number of packets lost. Perform this procedure three times and report the average throughput obtained. Also, report the signal strength at the iPAQ for the duration of the connection. The signal strength at the iPAQ can be observed by viewing the Xircom Link Status meter in Start>Programs>Xircom. Capture a snapshot of the server window that lists the throughput values for each instance. Include this snapshot along with your results in the report for this assignment.
- Repeat the same test with 10,000,000 (10 million) bytes of UDP traffic and note the difference in throughput. Take a screenshot of the server window on your notebook and include it in your report for this assignment.
- Now change the location of the iPAQ by moving to another room or behind some walls and repeat the above two steps of transferring 5 million and 10 million bytes of data. Monitor the signal strength and report whether there is any change in the number of packets received. Capture

a screenshot of the throughput values as reported at the server (notebook) for the two different readings and include them in your report.

Since IEEE 802.11b operates in the 2.4 GHz unlicensed Industrial, Scientific, and Medical (ISM) frequency band, there are other potential sources of interference such as microwave ovens and some cordless telephones that also operate in the same band. These devices interfere with the IEEE 802.11b signals and act as noise sources, leading to a decrease in the signal-to-interference noise ratio (SINR). The decrease in SINR can potentially cause packet losses. You will determine quantitatively the effect of interference from a microwave oven with the operation of an IEEE 802.11b WLAN.

- Move to a location in your current (or some other) environment such that there is a microwave oven in the path between the client and the server. Turn the microwave oven on[2] and start transmitting 5,000,000 (5 million) bytes of UDP data from the client to the server and record the throughput and the number of packets lost. Repeat the transfer three more times and record the average throughput and number of packets lost. Capture a snapshot of the server window that lists the throughput values for each instance. Include these snapshots along with your results in the laboratory report.
- Perform this procedure for different channels of operation for 802.11b. To change the channel of operation select the appropriate channel from the access point configuration page.
- Change the access point configuration by entering 198.69.*groupnumber*.1 in the address bar of Internet Explorer. Select a different channel of operation and repeat the procedure of data transfer of 5 million bytes of data as in the above step. Note the average throughput and the number of packets lost, if any. Perform this for channels 6 through 11, inclusive, and note the channel (frequency) at which you observe the most packet losses.
- Change the transmission power of the adapter from 1 mW to 30 mW on both the iPAQ and the notebook computer. Use the same configuration as above when testing with the microwave oven. Turn the microwave oven on and repeat the transfers with the different transmission power (30 mW instead of 1 mW). Perform this for channels 6 through 11, inclusive, and report the throughput and the number of packets lost with each transmission power.

Part III – Report

Your report will discuss both in-class and take-home components of this week's work. The report will be graded for both form and content. The report must be submitted in electronic form to the Digital Dropbox on the Blackboard site for this course. Each group must submit <u>one</u> report for the entire group. Follow the report guidelines.

Provide a report that addresses each of the following items <u>in the order specified</u>.

Part I – Pre-lab Assignment

How can the Iperf throughput measurement tool be used to configure the server and the client to tune a TCP connection?

Part II – In-class Experiments

1. Throughput

   Report the throughput obtained with the traffic exchange done using Iperf. Show any calculations you performed to obtain this throughput. Include the screen snapshot captured during the in-class laboratory session.

[2] Since you should not operate a microwave oven that is empty, it is recommended that you put a cup of water in the oven before starting it to avoid damage to the oven.

2. Packet loss

   Report the number of packets lost during the data transfer. Include the screen snapshot captured during the in-class laboratory session.

Part III – Take-home Experiments

1. Experiments setting up the 802.11b access point

   (a) What is the MAC address of your access point? Is it possible to change the MAC address by reconfiguring the access point?

   (b) Provide the output of the ipconfig command, including the IP address obtained by the notebook computer.

2. Experiments with UDP data transfer

   (a) Report the average throughput and average packet loss in the data transfer(s), with line of sight with the access point. Also, report the signal strength for the duration of the connection. Include all relevant screen snapshots.

   (b) Repeat part (a) with walls or partitions between the client and the access point. Include relevant screen snapshots.

   (c) Repeat part (a) with interference caused by a microwave oven. Report your results for multiple choices of frequency. Include relevant screen snapshots.

3. Experiments with varying transmit power

   Report your results on the effect of transmit power on throughput and lost packets.

Part IV – General Conclusions

This is the free-form portion of your report. Provide a summary of lessons learned in this assignment, general observations on how each of the tools used in the experiments can be employed to configure and assess performance of a wireless network, any unexpected results obtained, etc. Feel free to suggest improvements to the experiments performed in this assignment.