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

In-class Laboratory Exercise 8 (L08)

Part I – Objectives and Lab Materials

Objective

The objectives of this laboratory are to:

- Familiarize students with the operation of the Optimized Link State Routing (OLSR) protocol for mobile ad hoc networks (MANETs).
- Investigate delay, throughput, connectivity and overhead in MANETs.

After completing the assignment, the student should be able to:

- Understand the operation of the OLSR routing protocol.
- Evaluate multi-hop ad hoc routing protocols in wireless environments.

Hardware to be used in this lab assignment

Each student group needs the following hardware:

- One (1) Dell Latitude C640 notebook computer **(*It is especially important that you come to lab with a fully charged battery since some nodes will be mobile.*)**
- One (1) Xircom IEEE 802.11b wireless Ethernet adapter

Software to be used in this lab assignment

- OS: Red Hat Linux 9
- OLSR INRIA implementation with NRL modifications (see http://pf.itd.nrl.navy.mil/olsr/)

Part II – Pre-laboratory Assignment

This portion of the assignment ***must*** be completed ***prior*** to the in-class lab session.

Reading Assignment

- Read the documents for the in-class and take-home assignment. Each student must be familiar with the procedures to successfully coordinate with other students in this lab experiment.
- Read T. Clausen, P. Jacquet, A. Laouiti, P. Muhlethaler, A. Qayyum, and L. Viennot, "Optimized Link State Routing Protocol," *Proc. IEEE INMIC*, 2001, pp. 62-68. (Available at the class web site.)
- For more information about OLSR, including a Flash animation of MPR flooding, browse the OLSR INRIA homepage (http://menetou.inria.fr/olsr/).

Part III – In-Class Laboratory Assignment

Overview

In this lab experiment, we will observe the operation and evaluate the performance of the OLSR protocol in a real-world environment. The mobile ad hoc environment introduces many challenges in routing, such as rapid topology changes, unidirectional links, and high error rates. The following experimental data will be collected for analysis.

1) Topology, routing table, and routing daemon logs will be automatically saved when running the OLSR routing daemon.

2) Delay, connectivity, and throughput are to be measured between mobile nodes. A specific test configuration has been developed for coordinating the experiment.

Each student group will need to analyze the results in the take-home assignment. **The results may depend on how the experiments are carried out, thus coordination and cooperation among all groups are strictly required**. Specifically, we will conduct the tests using two specific topologies.

1) In the first topology, all participating mobile nodes are located in close proximity in the classroom and, thus, can directly communicate with each other.

2) In the second topology, some of the mobiles nodes will move outside of the classroom to assigned locations, thus forming some multi-hop connections.

The lab instructor will form a maximum of seven teams in a MANET group and assign team identifiers for this in-class experiment. The lab instructor will setup the controlling node as team 8. Each team needs one notebook computer and one 802.11b card. To avoid interference, other notebook computers and PDAs not used for the experiment should be turned off.

All participating teams are expected to conduct the following tasks.

Task A - Setup the Ad-hoc Network

1. **Remove any IEEE 802.11b cards from the PC card slots before starting the notebook computer**. Boot into Linux and log into the system as user **root**. Open a command console and setup the wireless network interface as follows.

```
# cd ~/WNMS/lab_9
# ./setup_manetA  <TeamNumber>  <RFChannel>          // for MANET-group A
# ./setup_manetB  <TeamNumber>  <RFChannel>          // for MANET-group B
```

The team number is assigned by the laboratory instructor and will range from A1 to A7 and B1 to B7. The laboratory instructor will assign RF channel for MANET-groups A and B. All participating teams in a MANET-group will use the same channel number. The ***setup_manet*** script will modify the default configuration for wireless interface **eth1** (/etc/sysconfig/network-scripts/ifcfg-eth1). The following options are used:

For MANET-group A

MODE	Ad-hoc	ESSID	MANET_A
RATE	Auto	CHANNEL	: <RFChannel>
IP address	10.0.1.<TeamNumber>	NETMASK	255.255.255.0
Broadcast	10.0.1.255		

For MANET-group B

MODE	Ad-hoc	ESSID	MANET_B
RATE	Auto	CHANNEL	: <RFChannel>
IP address	10.0.2.<TeamNumber>	NETMASK	255.255.255.0
Broadcast	10.0.2.255		

Now insert your IEEE 802.11b network interface card into one of the PC Card slots. The network interface will be setup automatically using the above configuration. As shown below, use ***iwconfig*** to change the transmission power to **1 mW** and check that the ad hoc network is properly setup. We will bring down the interface **eth0**, which is not used. Ping the controlling node **10.0.1.8 or 10.0.2.8** to ensure the network is correctly configured. The lab instructor will check all participating nodes before continuing with the experiment.

```
# iwconfig eth1 txpower 1mW                    // set 1mW to reduce range
# iwconfig eth1                                // check eth1 interface status
# ifconfig eth1                                // check eth1 info.
# ifdown  eth0                                 // bring down eth0 interface
```

2. To analyze the time-stamped logs on all mobile nodes, we need to synchronize the system time with the controlling node, **10.0.1.8 for MANET-group A and 10.0.2.8 for MANET-group B**, which is running the time-udp service. Use the following command.

```
# rdate  -u  -s  10.0.1.8 (for MANET-group A)
# rdate  -u  -s  10.0.2.8 (for MANET-group B)
```

Note: All participating nodes and the controlling node must use the same time zone (use command "cat /etc/timezone" to check the current time zone).

Task B – Test 1

The following steps conduct measurement for the first topology – where all mobile nodes are stationed within the classroom and can directly communicate with each other.

1. Team **1** and **2** from each group A and B should run the *iperf* server on TCP port 5000 before others start the test. Run the *iperf_server* script and report throughput to log file ~/WNMS/lab_9/test1/iperf_serverA.log and ~/WNMS/lab_9/test1/iperf_serverB.log.

```
# cd ~/WNMS/lab_9
#  ./iperf_server  test1/iperf_serverA.log     (for MANET-group A)
#  ./iperf_server  test1/iperf_serverB.log     (for MANET-group B)
```

2. All teams (including teams 1 and 2) should run the *start_test1A of start_test1B* shell script and wait for the laboratory instructor's signal to start. A greeting screen for the MANET routing test will appear. *Since some of the teams will run the performance measurement differently, it is very important that you specify the correct team number.*

```
# cd ~/WNMS/lab_9
# ./start_test1A <TeamNumber>    (for MANET-group A)
# ./start_test1B <TeamNumber>    (for MANET-group B)
```

When you press the <Enter> key to start the test, the script will automatically start the OLSR routing daemon. The test will run for **5** minutes and the routing daemon will be automatically shutdown. The total remaining time is printed on the console. Follow the instructions printed on the console. Each team needs to conduct the following steps during the test.

1) Use the *ping* command to test the connection to other participating mobile nodes.
2) Use the *olsrquery* command to query the routing table as follows. **Make a screen capture of the results and include it in your report.**

```
# olsrquery  -r  <YourIPAddress>
```

The above command will send a query to the OLSR routing daemon to retrieve the current routing table.

3) Use the *olsrquery* command to query the neighbor list as follows. **Make a screen capture of the results and include it in your report.**

```
# olsrquery  -n  <YourIPAddress>
```

The above command will send a query to the OLSR routing daemon to retrieve the current list of neighbors. Links in OLSR are listed as being one of three types: (i) symmetric ("SYM"), where bidirectional connectivity has been confirmed; (ii) asymmetric ("ASYM"), where only unidirectional connectivity has been observed; and (iii) MPR selector links.

The following measurements will be performed automatically by the *start_test1* shell script.

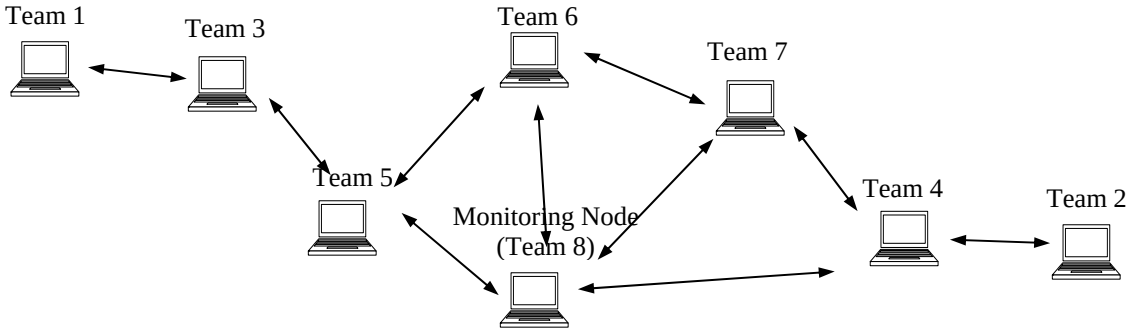
1) The *ping_test* shell script on Teams 1 and 2 will run to measure the delay and connectivity to the controlling node 10.0.1.8 or 10.0.2.8. It will repeatedly run the *ping* command every **15** seconds and report the statistics to the log file (~/WNMS/lab_9/test1/pingtest.log). We will use the log file to evaluate the connectivity and delay for the OLSR routing protocol.

2) Teams **3** and **4** each will run two *iperf* clients and connect to the *iperf* servers of teams **1** and **2**. The throughput will be reported every **15** seconds and saved to the log files (~/WNMS/lab_9/test1/iperf_1.log and ~/WNMS/lab_9/test1/iperf_2.log).

3) The routing table on each mobile node will be saved to log file /var/log/olsrd_rt.log every **2** seconds. General log messages will be saved to /var/log/olsrd.log. Changes in the kernel routing table will be saved to /var/log/olsrd_rtupd.log. These log files will be copied automatically to directory ~/ WNMS/lab_9/test1 when the test stops.

Task C – Test 2

The following steps conduct measurements for the second topology. The laboratory instructor will conduct a site survey before the class to plan the network topology. The laboratory instructor will explain the procedures and assign locations to participating teams. All teams will be initially stationed in the classroom. Some teams will then move slowly to outside of the classroom to form a multi-hop configuration. The actual topology layout may be affected by some environmental factors. A sample topology is illustrated below.



1. Teams **1** and **2** need to run the *iperf* server on TCP port 5000 before others start the test. Run the *iperf_server* script and report throughput to log file ~/ WNMS/lab_9/test2/iperf_server.log.

```
# cd ~/WNMS/lab_9
#  ./iperf_server  test2/iperf_serverA.log   (for MANET-group A)
#  ./iperf_server  test2/iperf_serverB.log   (for MANET-group B)
```

2. All teams (including Teams 1 and 2) should run the *start_test2* shell script and wait for the laboratory instructor's signal to start. A greeting screen for the MANET routing test will appear.

```
# cd ~/WNMS/lab_9
# ./start_test2A <TeamNumber>     (for MANET-group A)
# ./start_test2A <TeamNumber>     (for MANET-group B)
```

   When you press the <Enter> key to start the test, the script will automatically start the OLSR routing daemon. The test will run for **10** minutes and the routing daemon will be automatically shutdown. The total remaining time is printed on the console. Follow the instructions printed on the console. Each team needs to conduct the following steps during the test.

   1) Use the *ping* command to test the connection to other participating mobile nodes. Some teams will move slowly outside the classroom and check their connection to other nodes from time to time. The laboratory instructor will provide more instructions for these teams on how to form the planned topology.

   2) Use the *olsrquery* command to query the routing table as follows. **Make a screen capture of the results and include it in your report.**

```
# olsrquery  -r  <YourIPAddress>
```

      The above command will send a query to the OLSR routing daemon to retrieve the current routing table.

   3) Use the *olsrquery* command to query the neighbor list as follows. **Make a screen capture of the results and include it in your report.**

```
# olsrquery  -n  <YourIPAddress>
```

      The above command will send a query to the OLSR routing daemon to retrieve the current list of neighbors.

   4) You can also use the *olsrquery* command to query the routing table and neighbors of other mobile nodes. Try to determine the topology and verify the routing table by querying your neighboring nodes.

   The following measurements will be performed automatically by the *start_test2* shell script.

   1) The *ping_test* shell script on teams 1 and 2 will run to measure the delay and connectivity to the controlling node 10.0.1.8 or 10.0.2.8. It will repeatedly run the *ping* command every **15** seconds and report the statistics to the log file (~/WNMS/lab_9/test2/pingtest.log). We will use the log file to evaluate the connectivity and delay for the OLSR routing protocol.

   2) Teams **3** and **4** each will run two *iperf* clients and connect to the *iperf* server of teams **1** and **2**. The throughput will be reported every **15** seconds and saved to the log files (~/WNMS/lab_9/test2/iperf_1.log and ~/WNMS/lab_9/test2/iperf_2.log).

3) The routing table on each mobile node will be saved to log file /var/log/olsrd_rt.log every **2** seconds. General log messages will be saved to /var/log/olsrd.log. Changes in the kernel routing table will be saved to /var/log/olsrd_rtupd.log. These log files will be copied automatically to directory ~/WNMS/lab_9/test2 when the test stops.

Task D - Upload Results

For analyzing the operations of the OLSR routing protocol, we need all logs from all participating nodes. After completing the two tests, copy and upload these log files to the controlling node 10.0.2.8 as follows.

For MANET-group A

```
# cd ~/WNMS/lab_9
# tar -c  test1 | gzip -9 > teamA<TeamNumber>_test1.tgz
# tar -c  test2 | gzip -9 > teamA<TeamNumber>_test2.tgz
# scp  team*.tgz  student@10.0.1.8:/home/pub/
```

For MANET-group B

```
# cd ~/WNMS/lab_9
# tar -c  test1 | gzip -9 > teamB<TeamNumber>_test1.tgz
# tar -c  test2 | gzip -9 > teamB<TeamNumber>_test2.tgz
# scp  team*.tgz  student@10.0.2.8:/home/pub/
```

Remember to replace <TeamNumber> in the commands with your assigned team number. When prompted for the password of user "**student,**" use "**wireless**" as the password.

After all teams finish uploading the results, student groups can download the results for analysis as follows.

```
# scp student@10.0.1.8:/home/pub/team*.tgz   ~/WNMS/lab_9/results/    (for MANET-group A)
# scp student@10.0.2.8:/home/pub/team*.tgz   ~/WNMS/lab_9/results/    (for MANET-group B)
```

The laboratory instructor will also collect the results of all participating nodes (including the controlling node), and make them available on the course web site. All student groups need this data for analysis.

Summary of Items Needed for the At-home Exercise

- Screen captures of: (a) output of olsrquery to show the routing table for in-class lab Test 1; (b) output of olsrquery to show the neighbor list for in-class lab Test 1; (c) output of olsrquery to show the routing table for in-class lab Test 2; and (d) output of olsrquery to show the neighbor list for in-class lab Test 2.
- Routing daemon log files (olsrd.log, olsrd_rt.log, and olsrd_rtupd.log) for Test 1 and Test 2. Note that these files are generated by the scripts, as described above. Verify that the files are generated and saved after each test.