LAB 9

Mobile Wireless Network

A Wireless Local Area Network with Mobile Stations

OBJECTIVES

This lab simulates mobility in wireless local area networks. We'll study the effect of mobility on the TCP performance. In addition, the lab examines how the request to send (RTS) and clear to send (CTS) frames are utilized in avoiding the hidden node problem usually induced by mobility in WLANs.

OVERVIEW

One of the requirements of the IEEE 802.11 standard is to handle mobile stations in wireless local area networks (WLANs). Mobile stations are defined as the stations that access the LAN while in motion. IEEE 802.11 handles station mobility within the MAC sublayer, and hence such mobility is hidden from the higher layers in the network. However, the disconnection and reconnection events induced by mobility in a WLAN significantly affect the performance of higher-layer protocols such as TCP. For example, TCP interprets disconnection due to mobility as congestion, and hence, it multiplicatively decreases its congestion window size. After reconnection, TCP takes an unnecessarily longer time to recover the congestion window to a size that matches the available bandwidth.

IEEE 802.11 utilizes the request to send (RTS) and clear to send (CTS) frames in various circumstances to further minimize collisions. RTS and CTS are especially useful in solving the hidden node problem in WLANs that have mobile stations. Exchanging the RTS and CTS between the sender and the receiver informs nearby stations that a transmission is about to begin. Duration information in RTS/CTS frames are used to set the network allocation vector (NAV) in all stations that are within the reception range of the RTS/CTS frames. This way, the problem of a hidden sender can be solved because any station that sees the CTS frame knows that it is close to the receiver and, therefore, cannot transmit for the period of time indicated in the NAV. If transmitted data frames are short, sending RTS/CTS frames is not recommended, since it adds overhead inefficiency. Therefore, a threshold is defined to use RTS/CTS only on frames longer than a specified length.

In this lab, we will simulate a wireless LAN with mobile workstations and server. The workstations will run an FTP application to upload files to the server. We will study the effect of node mobility on the performance of the TCP connection for the FTP session. We will also study the role of the RTS and CTS frames in avoiding the hidden node problem usually induced by mobility in wireless LANs.

PRE-LAB ACTIVITIES

Read Section 4.4 from *Computer Networks: A Systems Approach, 5th Edition*.

Go to www.net-seal.net and play the following animation:
- Wireless Network and Multiple Access with Collision Avoidance

PROCEDURE

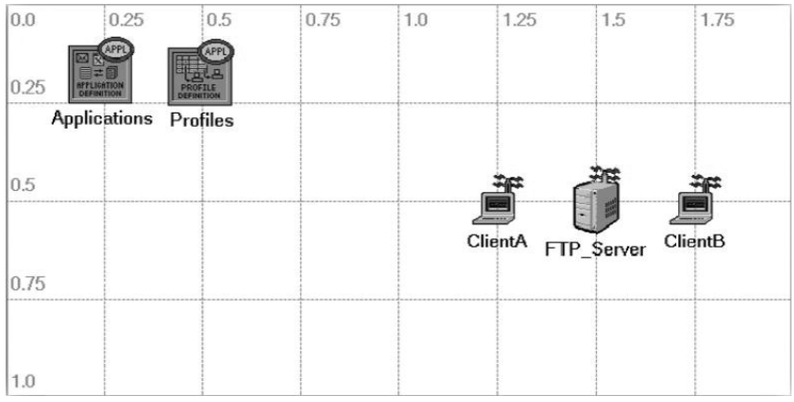
Create a New Project

1. Start **OPNET IT Guru Academic Edition** → Choose **New** from the **File** menu.
2. Select **Project** and click **OK** → Name the project **<your initials>_MobileWLAN**, and the scenario **Mobile_noRTSCTS** →Click **OK**.
3. In the *Startup Wizard: Initial Topology* dialog box, make sure that **Create Empty Scenario** is selected → Click **Next** → Select **Campus** from the *Network Scale* list → Click **Next** → Make sure that Kilometer is the unit chosen for the **Size** and then assign **2** and **1** to the **X Span** and **Y Span**, respectively → Click **Next** twice → Click **OK**.

Create and Configure the Network

Initialize the network:

1. The *Object Palette* dialog box should now be on the top of your project space. If it is not there, open it by clicking → Select **wireless_lan** from the pull-down menu on the object palette.
2. Add the following objects from the palette to the project workspace: **Application Config**, **Profile Config**, two **wlan_wkstn (mob)**, and one **wlan_server (mob)**.
   a. To add an object from a palette, click its icon in the object palette → Move your mouse to the workspace → Click to drop the object in the desired location → Right-click to finish creating objects of that type.
3. **Close** the palette.
4. Arrange and rename the objects you added as shown:



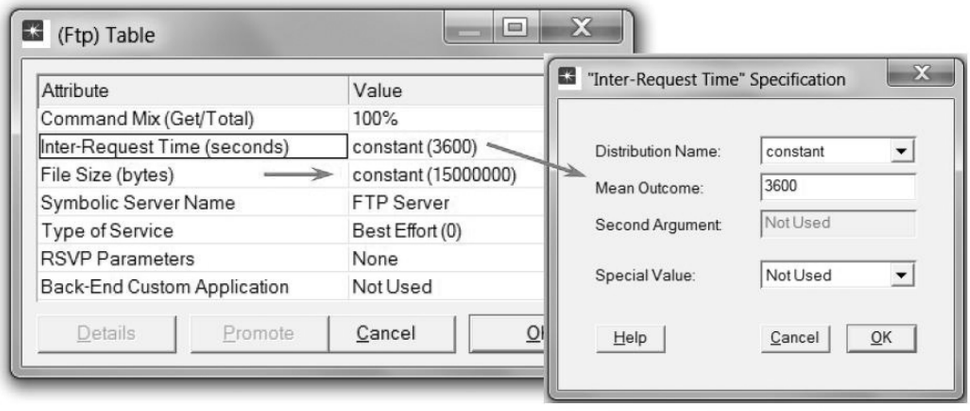
5. Position the workstations and the server according to the x and y positions shown in the following table:
   a. To position an object: Right-click on the object → **Advanced Edit Attributes** → Edit the **x position** and **y position** attributes.

Node	x position	y position
Client A	1.25	0.5
FTP_Server	1.5	0.5
Client B	1.75	0.5

Configure the applications:

1. Right-click on the **Applications** node → **Edit Attributes** → Expand the **Application Definitions** attribute and set **rows** to 1 → Expand the new row → Name the row **FTP_Application**.
   a. Expand the **Description** hierarchy → Edit the **FTP** row as shown (you will need to set the **Special Value** to **Not Used** while editing the shown attributes).

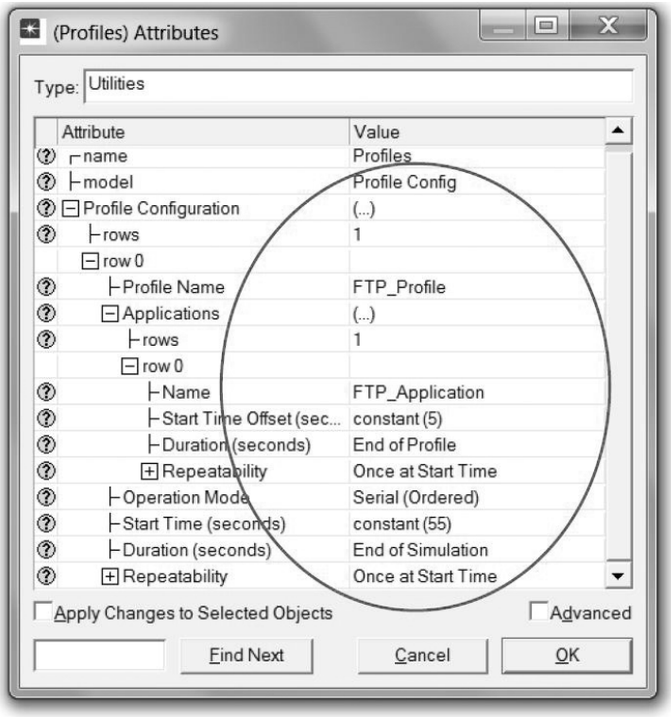
0% for the Command Mix (Get/Total) attribute means all the FTP sessions will be only "Send" from the clients to the server.



2. Click **OK** twice, and then **Save** your project.

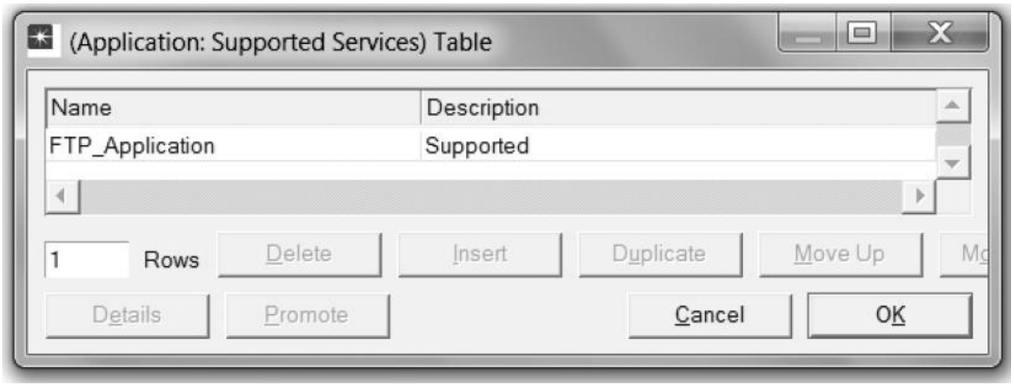
Configure the profiles:

1. Right-click on the **Profiles** node → **Edit Attributes** → Expand the **Profile Configuration** attribute and set **rows** to 1 → Name and set the attributes of **row 0** as shown → Click **OK**.



Configure the applications in the server and clients:

1. Right-click on the **FTP_Server** node → **Edit Attributes**.
   a. Edit the **Server Address** attribute → Assign the value **FTP_Server** to it.
   b. Edit **Application: Supported Services** → Set **rows** to **1** → Set **Name** to **FTP_Application** → Click **OK** twice.



2. Select both **ClientA** and **ClientB** in the network simultaneously → Right-click on one of them → **Edit Attributes** → Check the **Apply Changes to Selected Objects** check box:
   a. Expand the **Application: Supported Profiles** hierarchy → Set **rows** to 1 → Set **Profile Name** to **FTP_Profile**.
   b. Edit the **Application: Destination Preferences** attribute as follows: Set **rows** to 1 → Set **Symbolic Name** to **FTP Server** → Edit **Actual Name** → Set **rows** to 1 → In the new row, assign **FTP_Server** to the **Name** column as shown → Click **OK**.

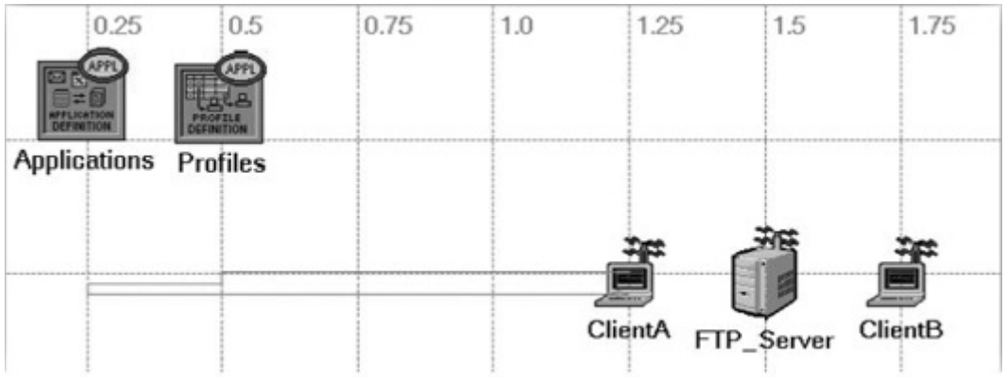
Configure the trajectory:

The **trajectory** attribute specifies the name of an ASCII trajectory file that specifies the times and locations that a mobile node will pass through as the simulation progresses.

1. Right-click on **ClientA** → **Edit Attributes** →Assign **trajectory_1** to the **trajectory** attribute → Click **OK**.
2. A green trajectory will appear on the project workspace. Right-click on that trajectory and select **Edit Trajectory** → In the *Edit Trajectory Information* dialog box, name the trajectory **<your initials>_left_trajectory** → Click **OK**.
3. From the **Edit** menu, choose **Preferences**. Check the value of the **mod_dirs** attribute. The first directory in the list is where a trajectory file with the name *<your initials>_left_trajectory.trj* is saved. Edit that file using any text editor (e.g., Notepad). Replace all the contents of the file with the info shown in the following figure and then save.

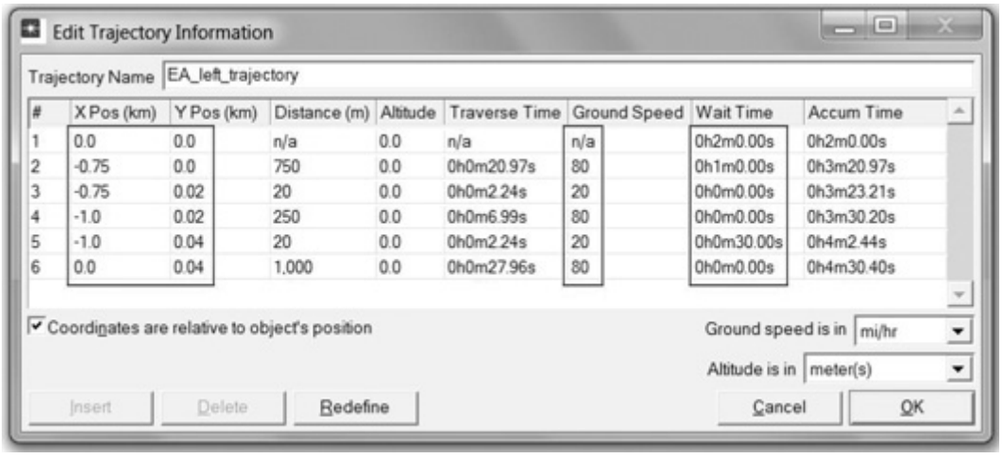
```
Version: 2
Position_Unit: Kilometers
Altitude_Unit: Meters
Coordinate_Method: relative
Altitude_Method: absolute
locale: English_United States.1252
Coordinate_Count: 6
# X Position        Y Position          Altitude            Traverse Time       Wait Time
0                   ,0                   ,0                   ,0h0m0.00s          ,0h2m0.00s
-0.75               ,0                   ,0                   ,0h0m20.97s         ,0h1m0.00s
-0.75               ,0.02                ,0                   ,0h0m2.24s          ,0h0m0.00s
-1                  ,0.02                ,0                   ,0h0m6.99s          ,0h0m0.00s
-1                  ,0.04                ,0                   ,0h0m2.24s          ,0h0m30.00s
0                   ,0.04                ,0                   ,0h0m27.96s         ,0h0m0.00s
```

4. Right-click on **ClientA → Edit Attributes →** Assign **<your initials>_left_trajectory** to the trajectory attribute → Click **OK**.
5. The new trajectory should look exactly like the following one. Right-click on the trajectory and select **Edit Trajectory**.



6. In the *Edit Trajectory Information* dialog box, verify that the trajectory info matches the values shown in the following figure:

Note: The trajectory makes ClientA start moving after 2 min from the beginning of the simulation. ClientA waits at X Pos 0.5 for 1 min and at X Pos 0.25 for 20 s.



7. Click **OK** twice, and then **Save** your project.

Configure the Simulation

Here, we will configure the simulation parameters:

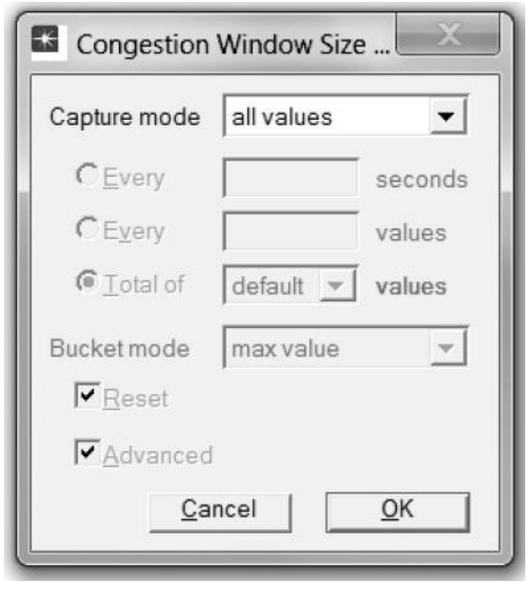
The **Seed** attribute is an integer that is used by the simulation's random number generator. Its default value is 128.

1. Click on and the *Configure Simulation* window should appear.
2. Assign **10.0 minutes** to the **Duration** attribute.
3. Assign **256** to the **Seed** attribute.
4. Click **OK**, and then **Save** your project.

Choose the Statistics

To test the performance of our mobile wireless network, we will collect some of the available statistics as follows:

1. Right-click anywhere in the project workspace, and select **Choose Individual Statistics** from the pop-up menu.
2. In the *Choose Results* dialog box, expand the **Node Statistics** hierarchy → Choose the following three statistics:
   i. **Congestion Window Size (bytes)** under **TCP Connection**.
   ii. **Traffic Received (bytes)** under **TCP Connection**.
   iii. **Load (bits/sec)** under **Wireless Lan**.
3. Right-click on the **Congestion Window Size (bytes)** statistic → Choose **Change Collection Mode** → In the dialog box, check **Advanced** → From the drop-down menu, assign **all values** to **Capture mode** as shown → Click **OK**.



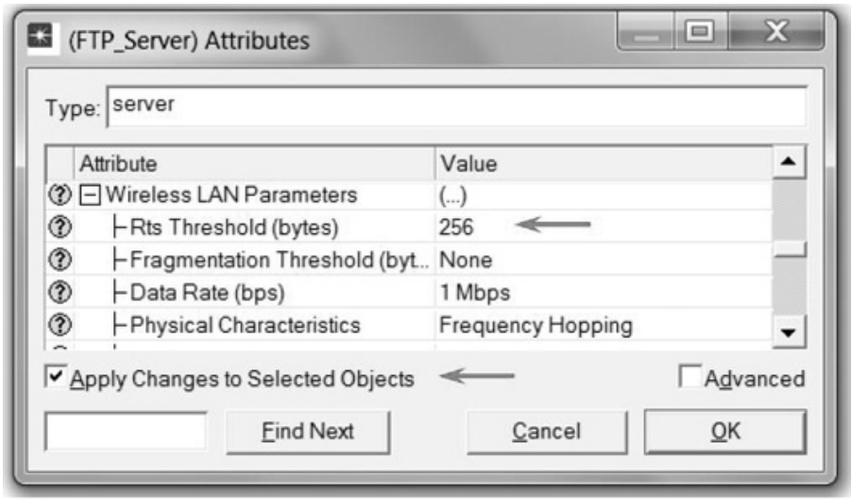
4. Right-click on the **Traffic Received (bytes)** statistic → Choose **Change Collection Mode** → In the dialog box, check **Advanced** → From the drop-down menu, assign **all values** to **Capture mode**.
5. Click **OK** twice, and then **Save** your project.

Duplicate the Scenario

We will create one more scenario to utilize the RTS and CTS frames to study their effect on minimizing collisions.

1. Select **Duplicate Scenario** from the **Scenarios** menu and give it the name **Mobile_RTSCTS** → Click **OK**.

2. Select **ClientA**, **FTP_server**, and **ClientB** simultaneously → Right-click on any one of them → **Edit Attributes** → Check the **Apply Changes to Selected Objects** check box.
3. Expand the hierarchy of the **Wireless LAN Parameters** attribute → Assign the value **256** to the **Rts Threshold (bytes)** attribute.
4. Click **OK**, and then **Save** your project.



Run the Simulation

To run the simulation for both scenarios simultaneously:

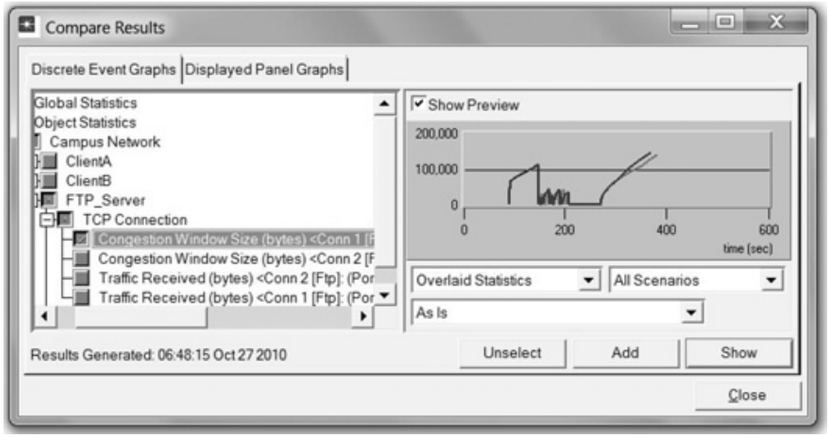
1. Go to the **Scenarios** menu → Select **Manage Scenarios**.
2. Click on the row of each scenario, and click the **Collect Results** button. This should change the values under the Results column to <collect> as shown.

3. Click **OK** to run both simulations. Depending on the speed of your processor, this task may take several seconds to complete.
4. After the simulation of both scenarios completes, click **Close** and **Save** your project.

View the Results

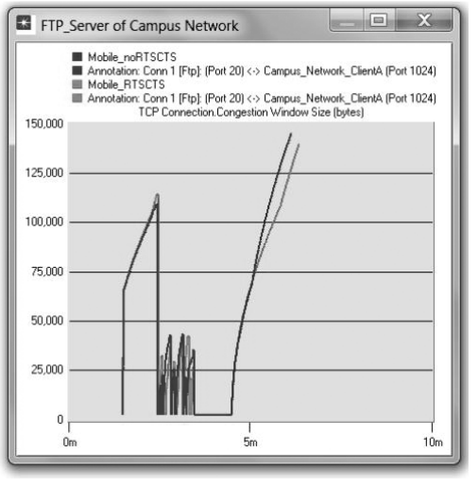
Do the following to view and analyze the results. (*Note:* Actual results will vary slightly based on the actual node positioning in the project.)

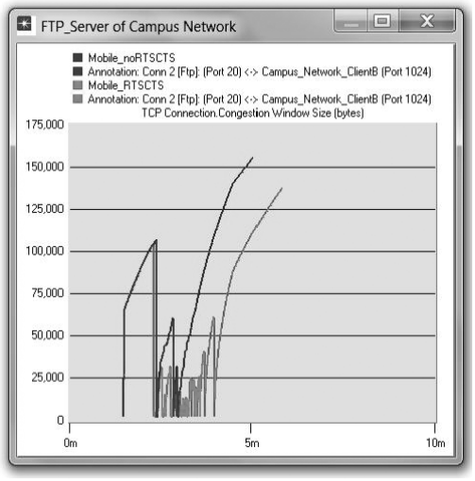
1. Select **Compare Results** from the **Result** menu.
2. Select the **Congestion Window Size (bytes) <Conn 1…** statistic for the **FTP_Server** from the **TCP Connection** hierarchy as shown.

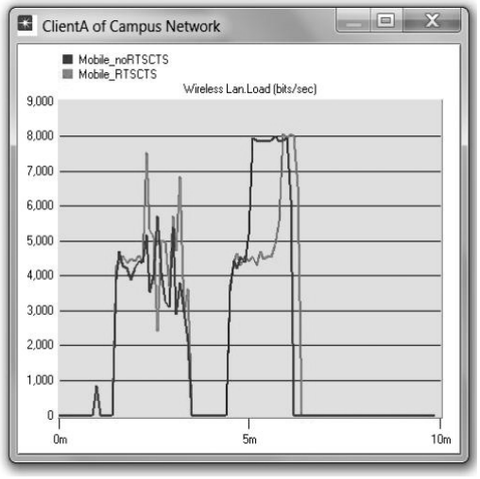


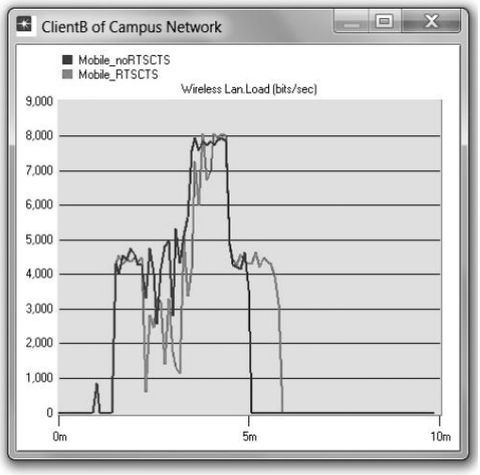
3. Click **Show** to show the result in a new panel.
4. Repeat the preceding steps for the following statistics:
   a. **FTP Server → TCP Connection → Congestion Window Size (bytes) <Conn 2…**;
   b. **ClientA → Wireless Lan → Load (bits/sec)**; and
   c. **ClientB → Wireless Lan → Load (bits/sec)**.

The resulting graphs should resemble the following graphs.

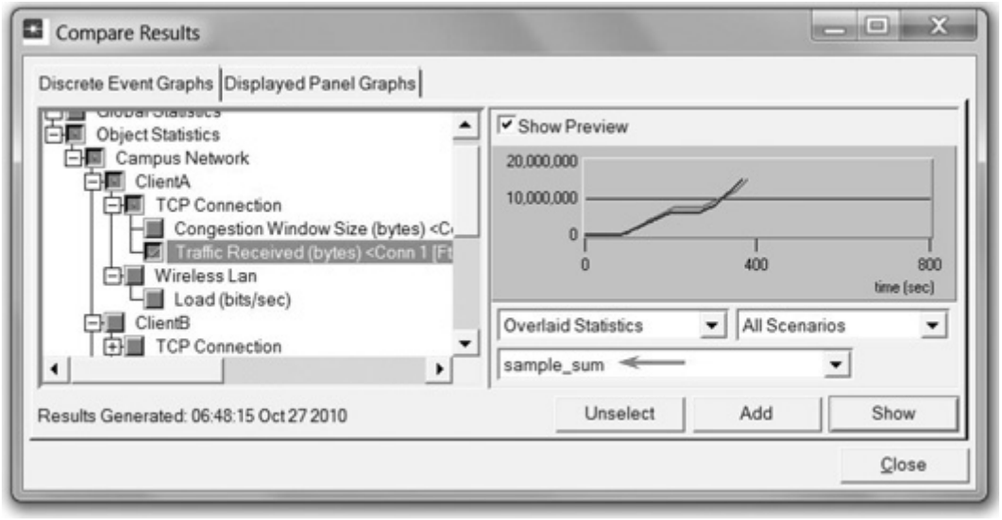


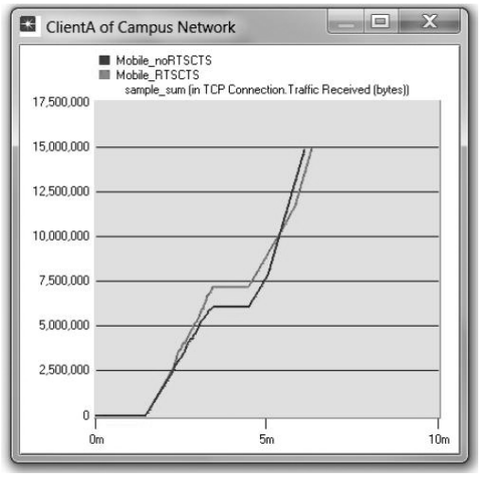


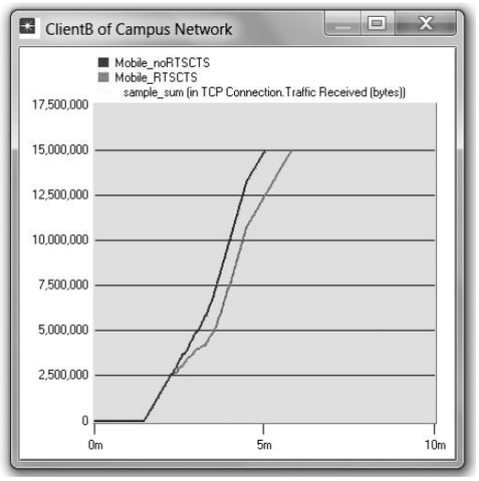




5. Go back to the *Compare Results* dialog box → Expand the **TCP Connection** hierarchy for the **ClientA** → Select the **Traffic Received (bytes)** statistic → Select **sample_sum** to replace **As Is** as shown in the following figure → Click **Show**.
6. Repeat the above step for the **Traffic Received (bytes)** by **ClientB**.
7. The resulting graphs should resemble the following graphs.







FURTHER READINGS

ANSI/IEEE Standard 802.11, 1999 Edition: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

Transmission Control Protocol: IETF RFC number 793 (www.ietf.org/rfc.html).

EXERCISES

1. Explain how **Load** and **Congestion Window Size** are affected by the mobility of **ClientA**.
2. Explain how enabling RTS/CTS helps in avoiding the hidden node problem and hence explain the effect of RTS/CTS frames on the network performance.

3. The graphs show that the server terminates the FTP session with ClientA earlier if RTS/CTS is enabled. However, the server terminates the FTP session with ClientB later if RTS/CTS is enabled. Explain why.
4. Create a new scenario as a duplicate of the **Mobile_noRTSCTS** scenario. Name the new scenario **twoMobiles_noRTSCTS**. Create a second new scenario as a duplicate of the **Mobile_RTSCTS** scenario. Name the second new scenario **twoMobiles_RTSCTS**. In both new scenarios, edit the attribute of the **FTP_Server**, and assign **<your initials>_left_trajectory** to its **trajectory** attribute. Run the simulation for all scenarios and create the graphs for the **Load (bits/sec)**, **Congestion Window Size (bytes)**, and **Traffic Received (bytes)** statistic results, as we did in this lab. Analyze the graphs explaining the effect of the server mobility on the network performance.

LAB REPORT

Prepare a report that follows the guidelines explained in the Introduction Lab. The report should include the answers to the preceding exercises as well as the graphs you generated from the simulation scenarios. Discuss the results you obtained and compare these results with your expectations. Mention any anomalies or unexplained behaviors.