Objectives:

1. Get familiar with Riverbed (previously OPNET) Modeler
2. Learn to use Modeler to perform simple network simulations
3. Collect simulation results and analyze them.

Due: 5:30pm, 10-18-2018

Project Specification:

This is an individual project.

References:

There are various resources online for opnet tutorial. Some are:

http://www.opnet.com/university_program/itguru_academic_edition/

http://www.sce.carleton.ca/faculty/lambadaris/courses/5001/opnet_tutorial.pdf

https://www.youtube.com/watch?v=XAzXKnAwKxo

Write-up:

You do not need to write anything in this lab. But be sure you look at the results of different scenarios and know how they compare to each other. Just submit your results and screen shots.

Submission Guidelines:

Save your results in PDF/DOC format for submission to blackboard, with a file named *yourstudentID*.doc or yourstudentid.pdf (replace your student ID with your 1000… student id number).

Make sure your name and your student ID are listed in your write up. Late submissions will be accepted at a penalty as announced in the class website.

Grading: Total 100 Points

Each simulation run result is 15 points. Correct parameter setup are totally 10 points.

Deductions for failing to follow directions:

-10 No parameter screen shot.

-5 No student ID and name.

-5 Submitting write up in other than pdf/doc format.

-5 Submitted file has a name other than yourstudnetid.pdf/doc

Important Note:

You may discuss the problem definition and tools with other students. You may discuss the lab requirements. You may discuss or share project designs. All coding work must be your own. You may use any book, WWW reference or other people's programs (but not those of other students in the class or other sections) as a reference as long as you cite that reference in the comments. If you use parts of other programs or code from web sites or books YOU MUST CITE THOSE REFERENCES

If we detect that portions of your program match portions of any other student's program it will be presumed that you have collaborated unless you both cite some other source for the code. You must not violate UTA, state of Texas or US laws or professional ethics. Any violations, however small, will not be tolerated. Students who do not submit anything get a grade of 0. Therefore students who break the rules may receive a negative grade – most likely a -50 on this lab assignment.

1. Objective

The objective of this lab is to addresses the Medium Access Control (MAC) sublayer of the IEEE 802.11 standard for the wireless local area network (WLAN). Various different options of this standard are studied. The performance of these options is analyzed under multiple scenarios.

2. Overview

The IEEE 802.11 standard provides wireless connectivity to computerized stations that require rapid deployment, such as portable computers. The Medium Access Control (MAC) sublayer in the standard includes two fundamental access methods: distributed coordination function (DCF) and point coordination function (PCF). DCF utilizes the carrier sense multiple access with collision avoidance (CSMA/CA) approach. DCF is implemented in all stations in the wireless local area network (WLAN). PCF is based on polling to determine the station that can transmit next. Stations in an infrastructure network optionally implement the PCF access method.

In addition to the physical CSMA/CA, DCF and PCF utilize a virtual carrier sense mechanism to determine the state of the medium. This virtual mechanism is implemented by means of the network allocation vector (NAV), which provides each station with a prediction of future traffic on the medium. Each station uses NAV as an indicator of time periods during which transmission will not be initiated even if the station senses that the wireless medium is not busy. NAV gets the information about future traffic from management frames and the header of regular frames being exchanged in the network.

With DCF, every station senses the medium before transmitting. The transmitting station defers as long as the medium is busy. After deferral and while the medium is idle, the transmitting station has to wait for a random back-off interval. After the back-off interval and if the medium is still idle, the station initiates data transmission or optionally exchanges request to send (RTS) and clear to send (CTS) frames with the receiving station. The effect of RTS and CTS frames will be studied in these labs.

With PCF, the access point (AP) in the network acts as a point coordinator (PC). The PC uses polling to determine which station can initiate data transmission. It is optional for the stations in the network to participate in PCF and hence respond to polls received from the PC. Such stations are called CF-Pollable (contention free pollable) stations. The PCF requires the PC to gain control of the medium. To gain such control, the PC utilizes the Beacon management frames to set the NAV in the network stations. Because the mechanism used to set NAV is based on the DCF, all stations comply with the PC request to set their NAV, whether or not they are CF-pollable. This way the PC can control frame transmissions in the network by generating contention-free periods (CFPs). The PC and the CF-Pollable stations do not use RTS/CTS in the CFP.

The standard allows for fragmentation of the MAC data units into smaller frames. Fragmentation is favorable in case the wireless channel is not reliable enough to transmit longer frames. Only frames with a length greater than a fragmentation threshold will be fragmented. Each fragment will be sent independently and will be separately acknowledged. During a contention period, all fragments of a single frame will be sent as bursts with a single invocation of the DCF medium access procedure. In case of PCF and during a contention-free period, fragments are sent individually following the rules of the point coordinator (PC).

3. DCF and PCF Labs

Creating a Project in OPNET

1) In the *Startup Wizard: Initial Topology* dialog box, select Create Empty Scenario
2) Choose Office from the *Network Scale* list and check Use Metric Units
3) Select Yes in front of wirless_lan for *Startup Wizard: Select Technologies*
4) Click Finish to complete the Wizard selections. These steps are shown in the following figures

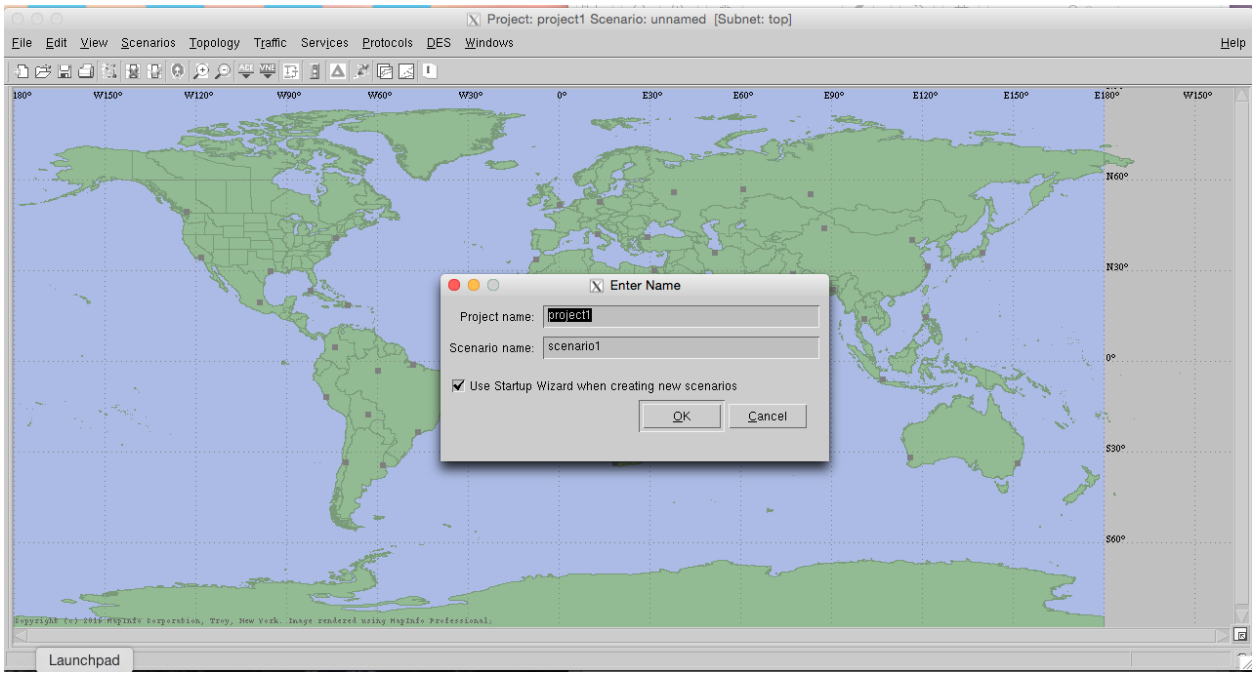


Figure 1

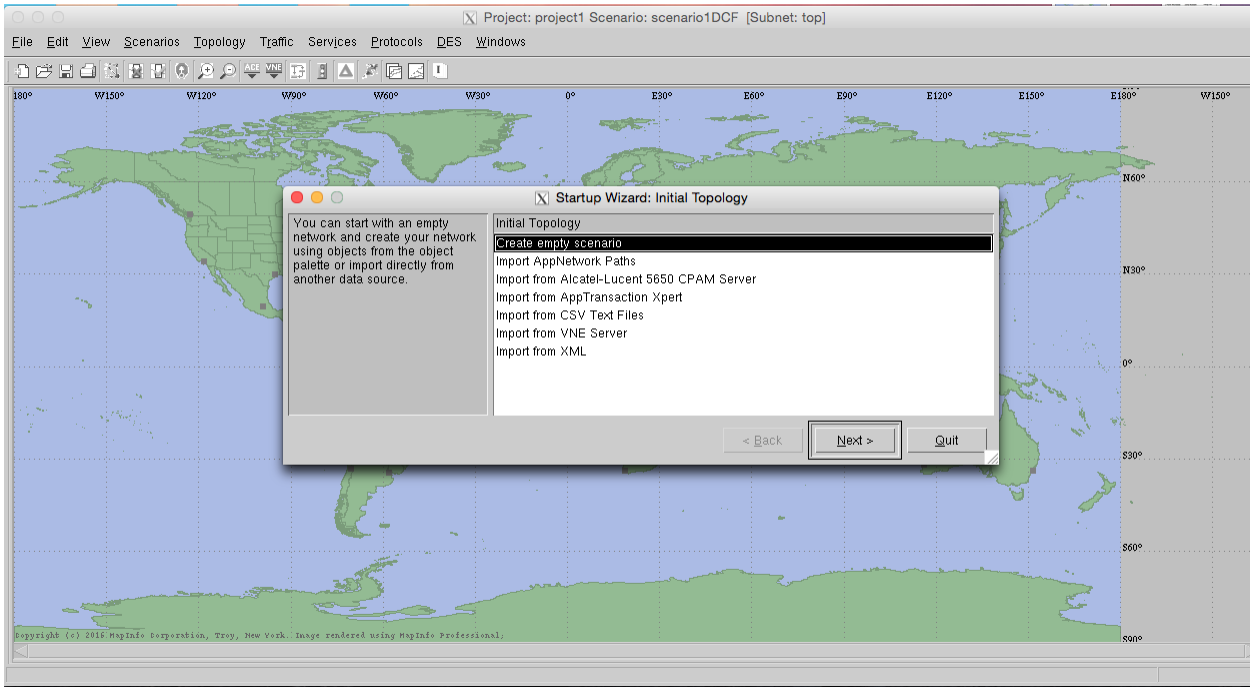


Figure 2

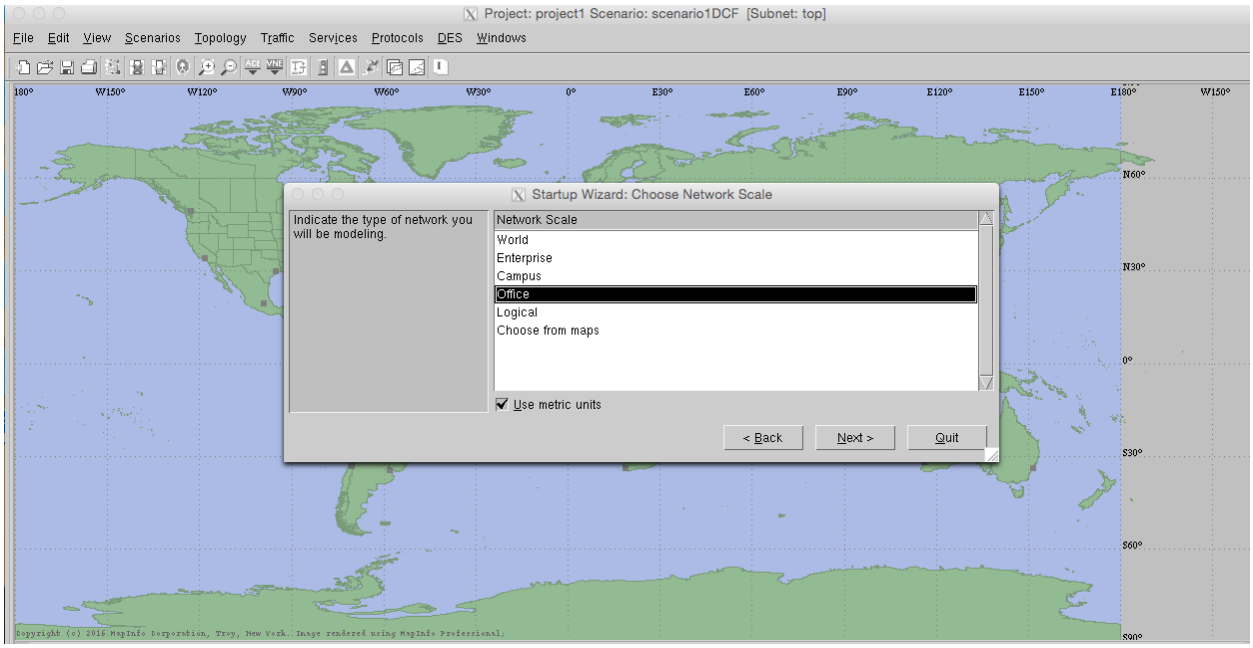


Figure 3

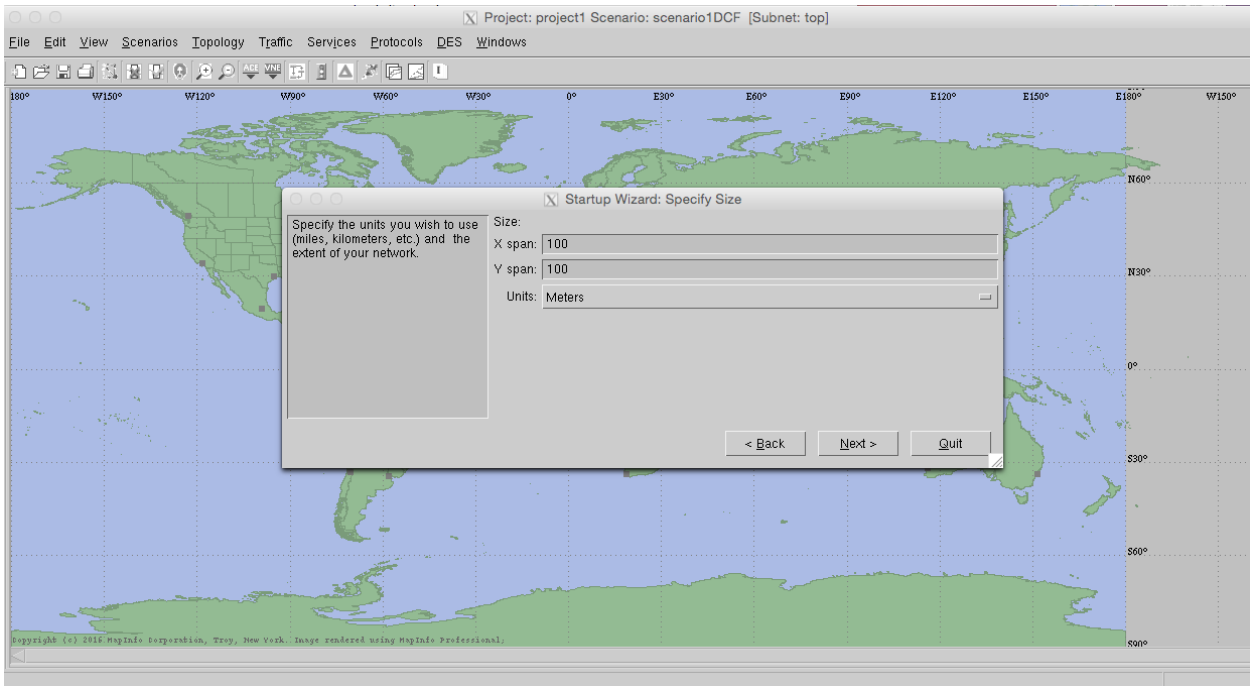


Figure 4

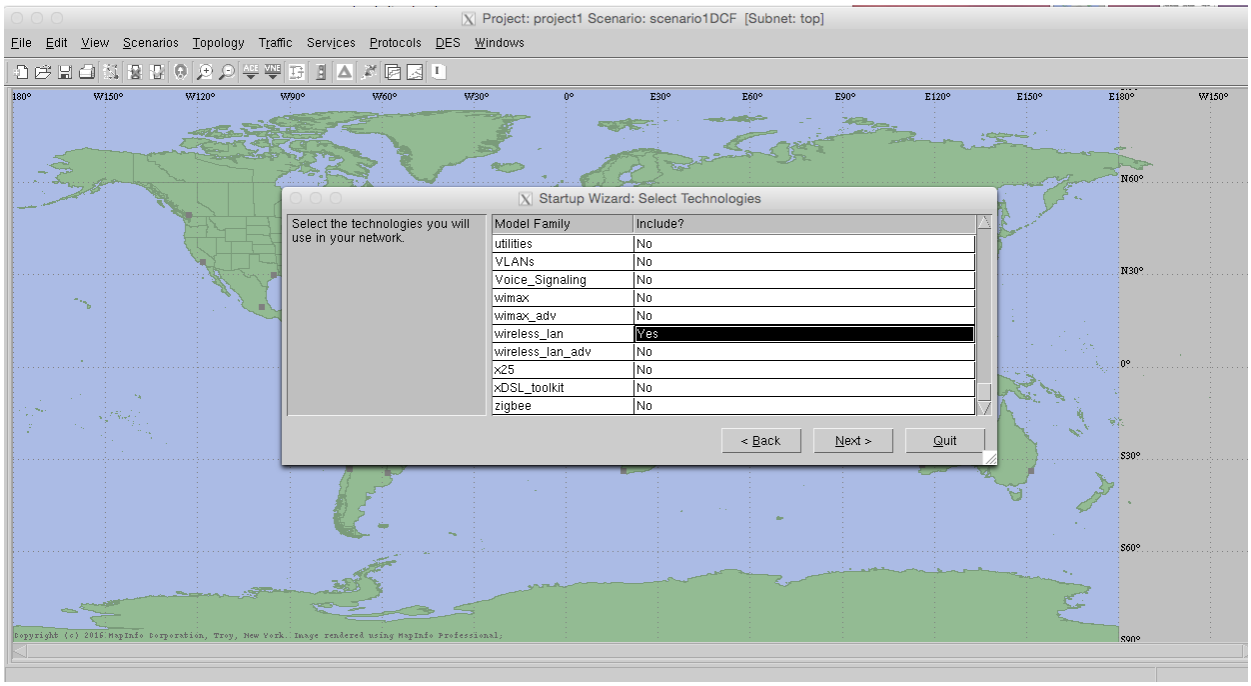


Figure 5

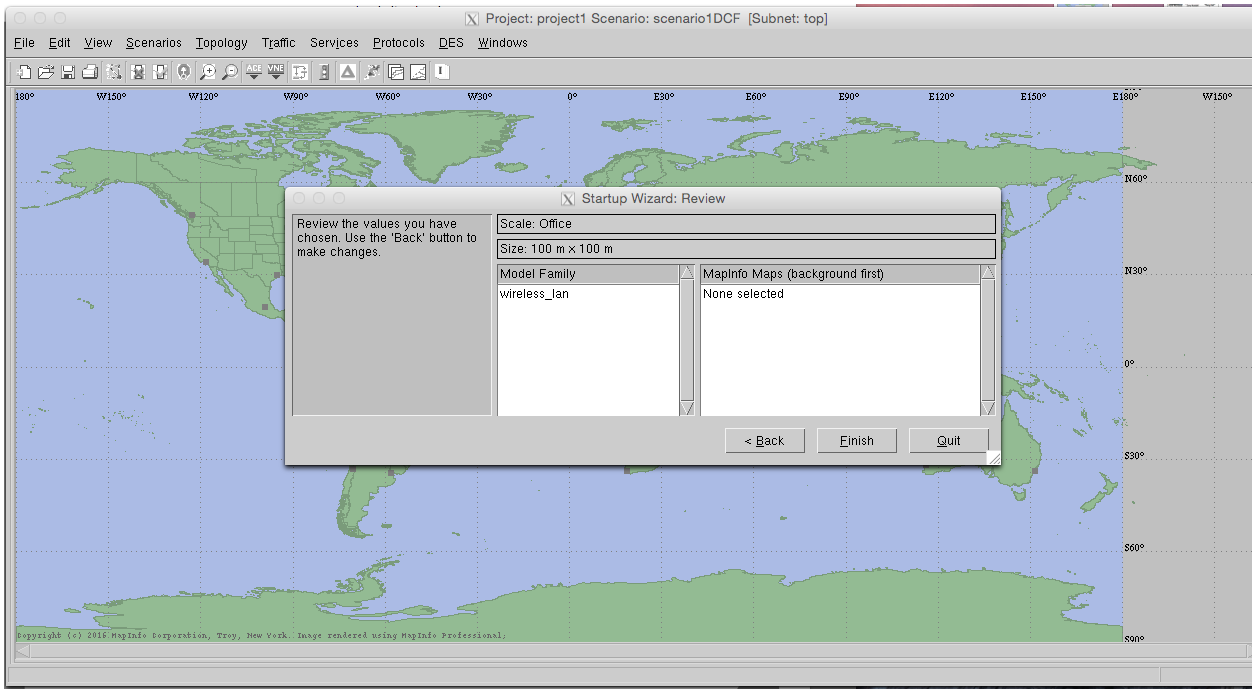


Figure 6

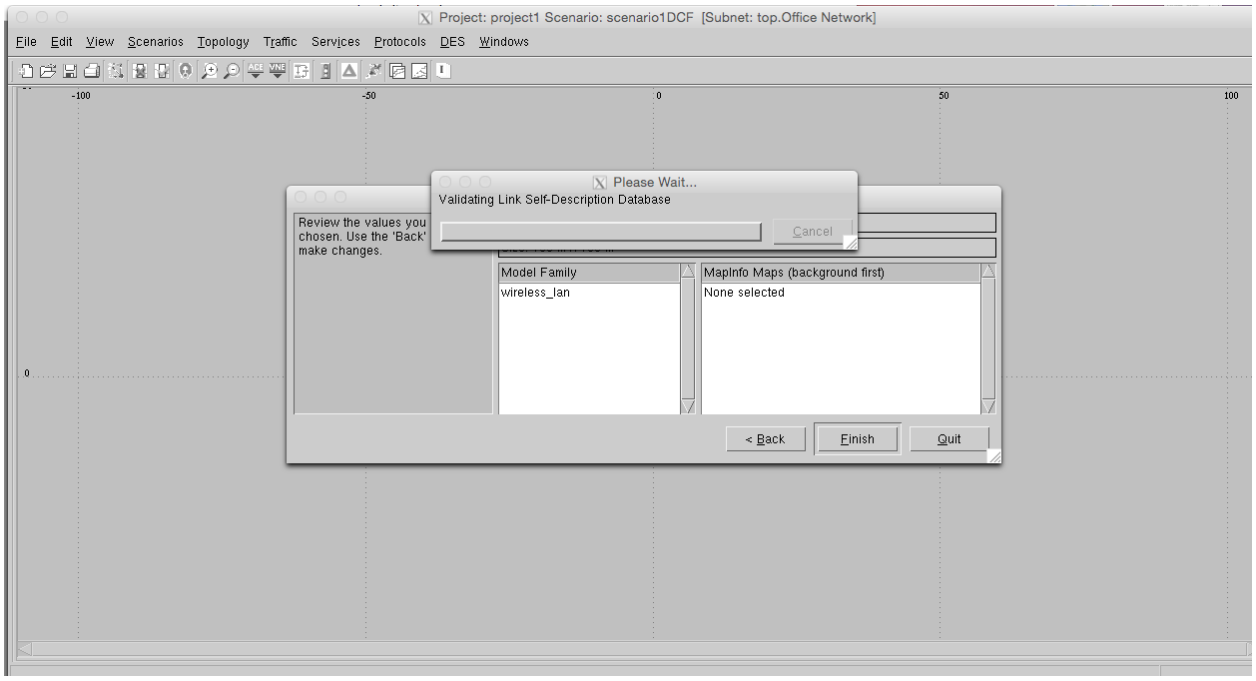


Figure 7

Creating and Configuring the Network

1) From the *Object Palette* dialog box add to the project workspace nine wlan_station_adv (Fixed Nodes) from the palette as shown in the following figures

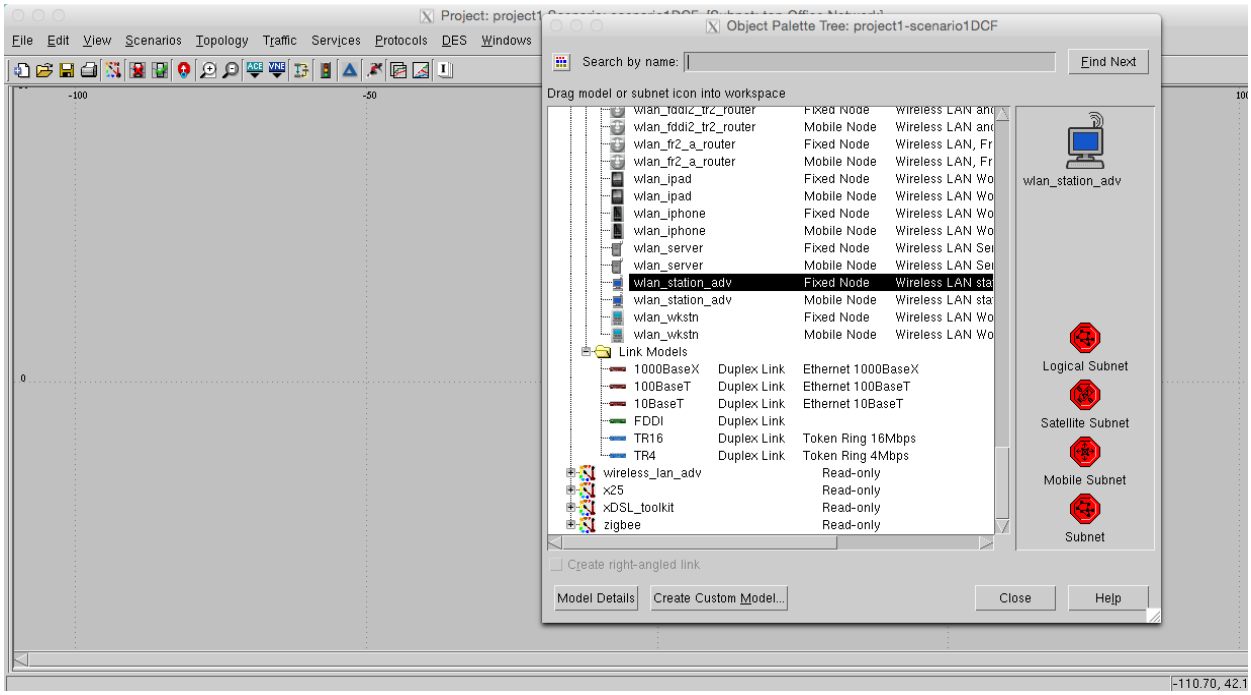


Figure 8 (a): Selecting wlan_station_adv (Fixed Node)

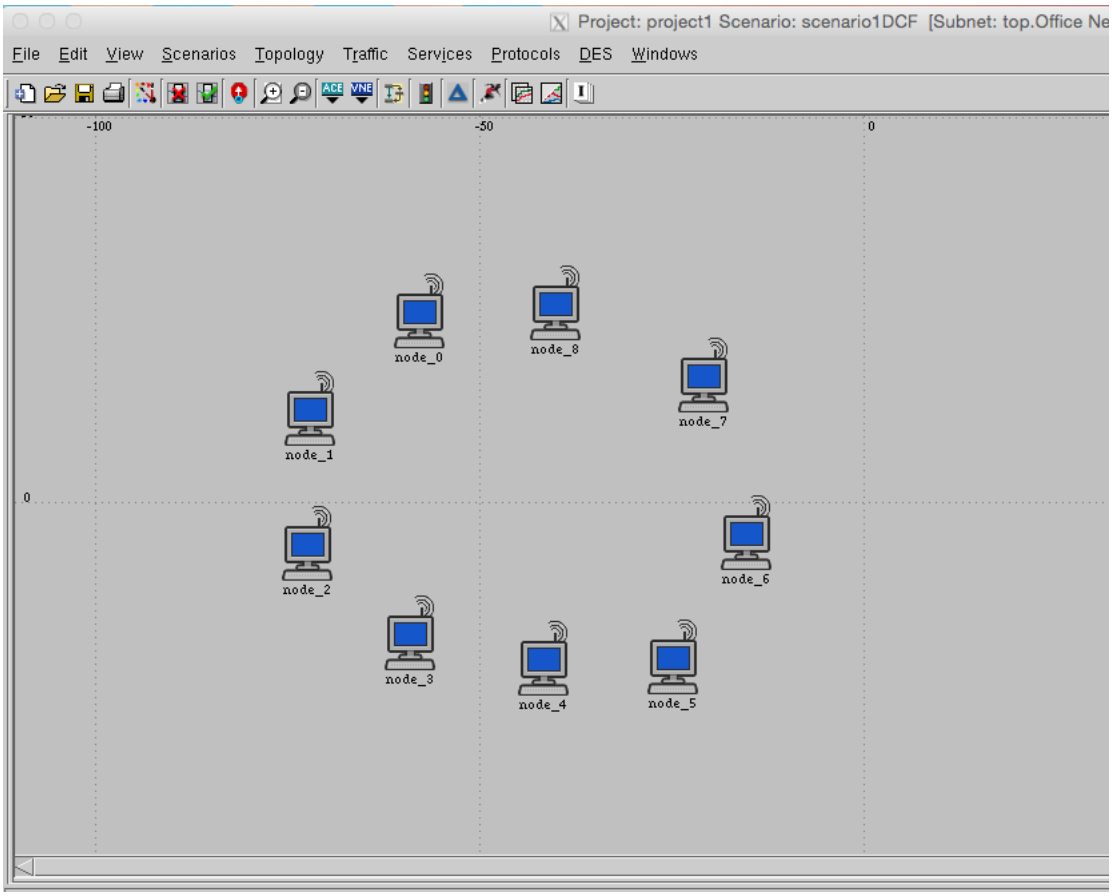


Figure 8 (b): Adding nine wlan_station_adv (Fixed Node) to the project

2) Repeat the following steps for each of the nine nodes: Right-click on the node select Edit Attributes and assign to the Wireless LAN MAC Address attribute a value equal to the node number. Also, assign to the Destination Address attribute the corresponding value shown in the following table. See also the figure below

Node Name	Destination Address
node_0	Random
node_1	5
node_2	8
node_3	6
node_4	7
node_5	1
node_6	3
node_7	4
node_8	2

Table 1: Destination Address assignments

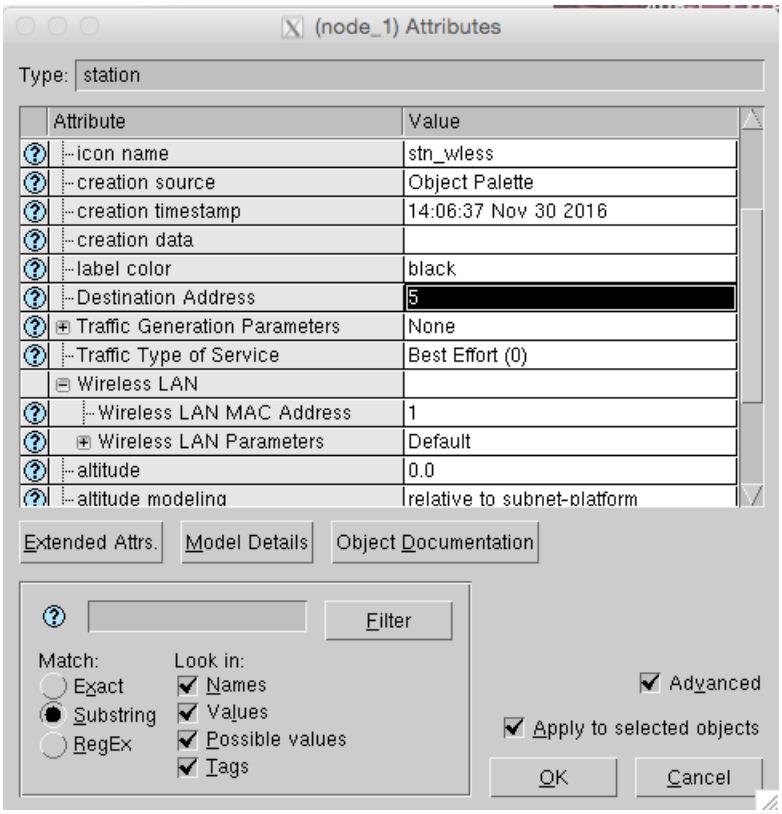


Figure 9: Assigning Wireless LAN MAC Address and Destination Address to node_1

Configuring Traffic Generation Parameters

1) Using the shift key, select all nodes in the network, except node_0 (as can be seen in the following figure), then right-click > Edit Attributes and check the Apply Changes to Selected Objects check box.

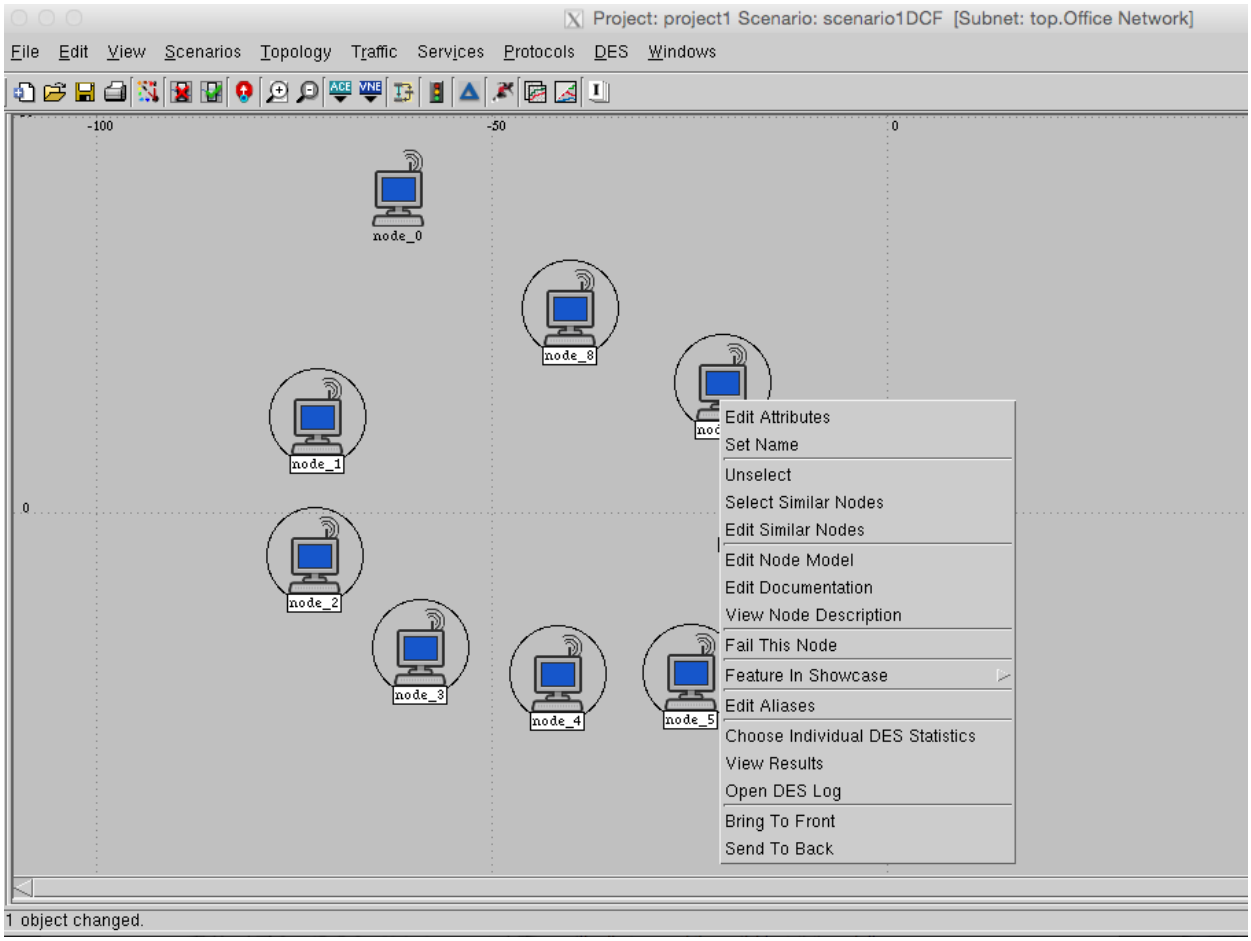


Figure 10: Select all nodes, except node_0, and right-click >Edit Attributes

2) Expand the Traffic Generation Parameters and the Packet Generation Arguments hierarchies; Edit the attributes to match the following figure

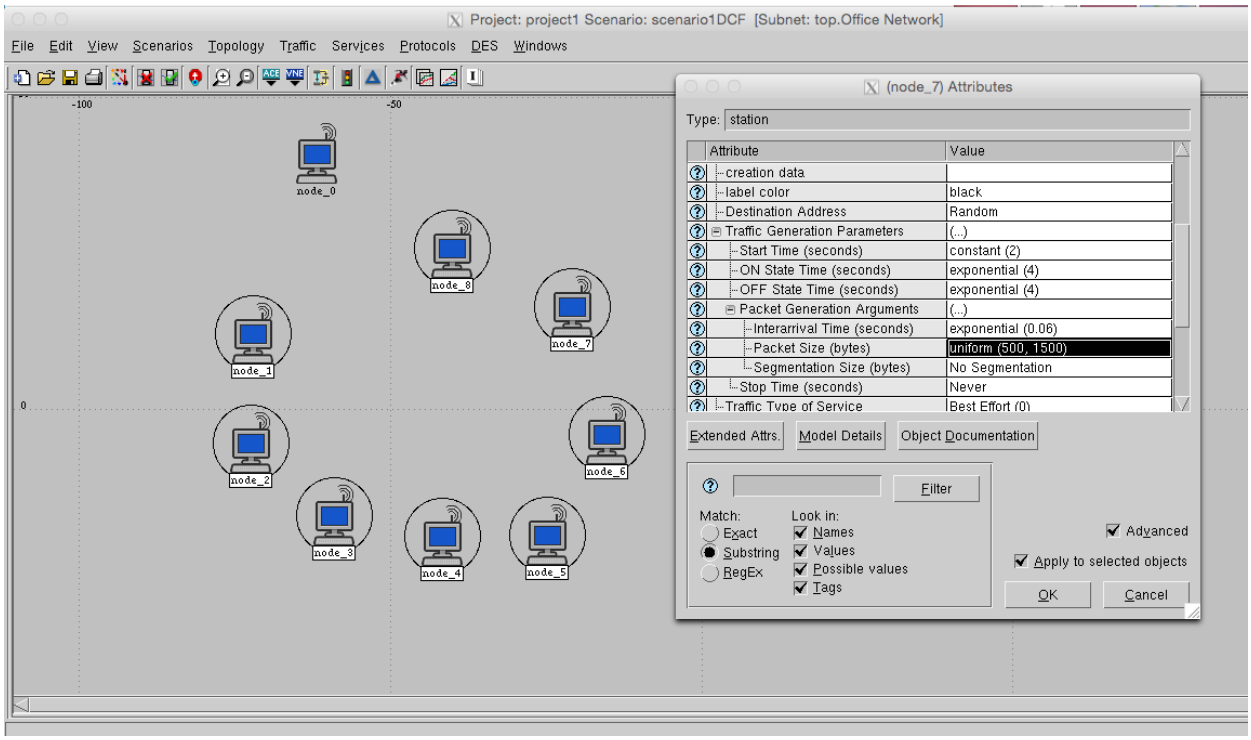


Figure 11: Traffic Generation Parameters' changes. Don't forget to select the Apply to Selected Objects option

3) Select all nodes in the network, including node_0·(as can be seen in the following figure)

Right-click on any of the nodes, select Edit Attributes, expand the hierarchy of the Wireless LAN Parameters attribute, and assign the value 4608000 to the Buffer Size (bits) attribute.

Check the Apply to selected objects option Click OK

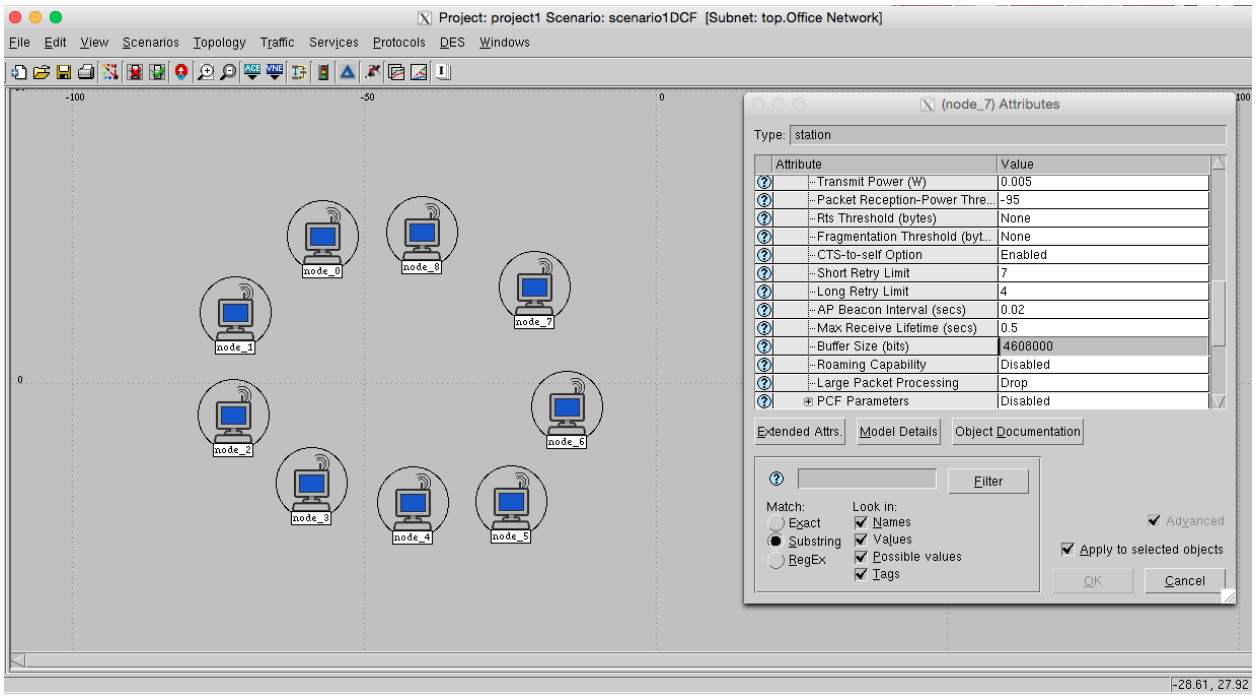


Figure 12: Changing Buffer Size in Wireless LAN Parameters attribute. Select Apply to selected objects before OK

4) Right-click on node_0,·Edit Attributes, Expand the Wireless LAN Parameters hierarchy and set the Access Point Functionality to Enabled, Click OK

5) Save the project

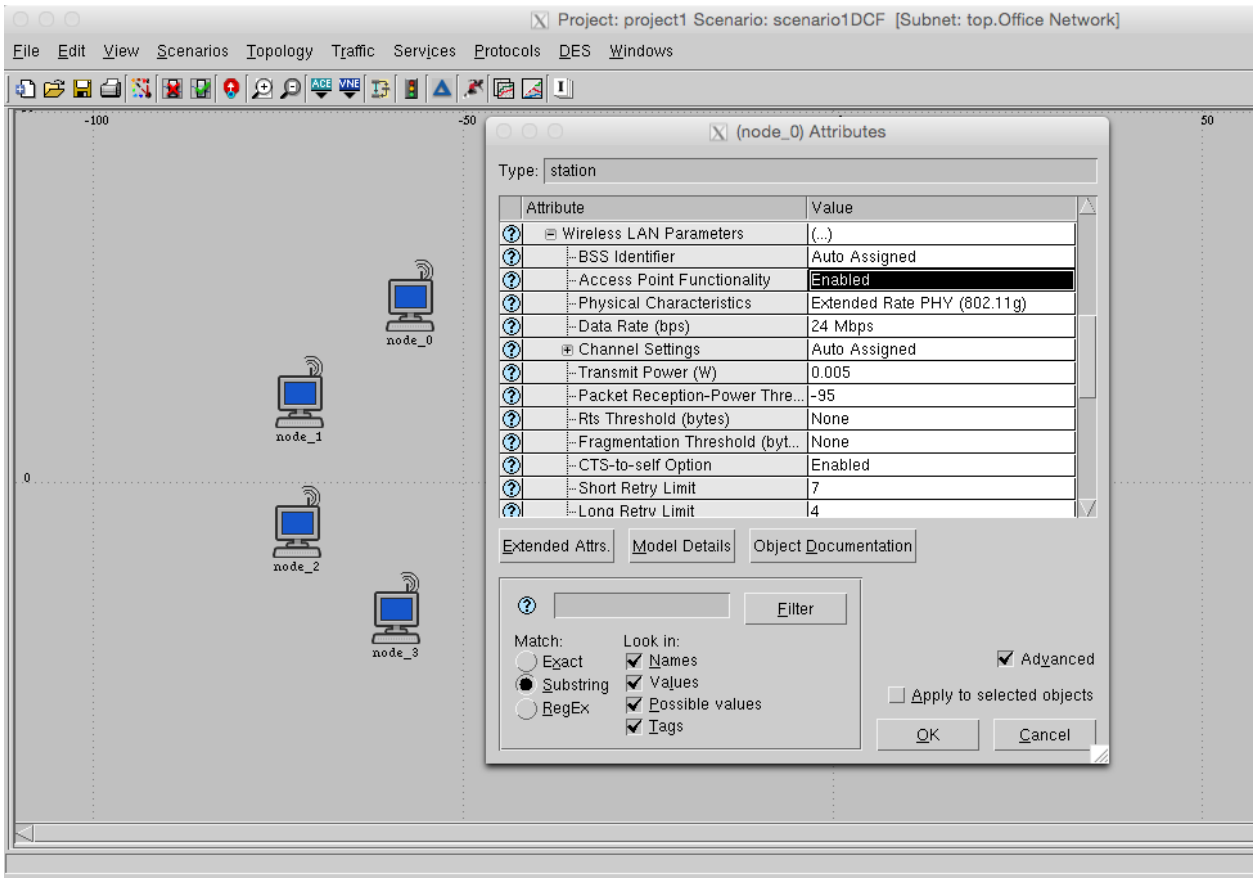


Figure 13: Enabling Access Point Functionality at node_0

Selecting Statistics

To test the performance of the network in our DCF scenario, we will collect some of the available statistics as follows:

1) As shown in the following figure, right click anywhere in the project workspace and select "Choose Individual DES Statistics" from the short cut menu

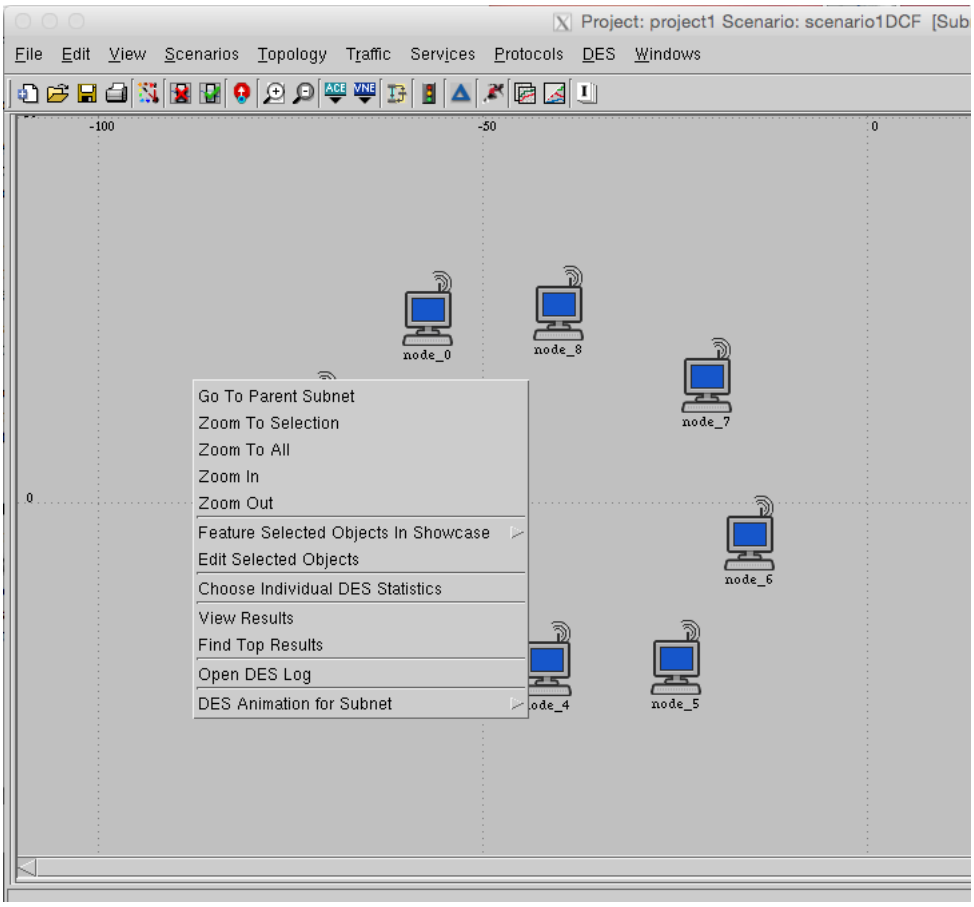


Figure 14: Enabling Access Point Functionality at node_0

2) In the Choose Results dialog box, expand the Global Statistics and Node Statistics hierarchies, and choose the five statistics shown below.

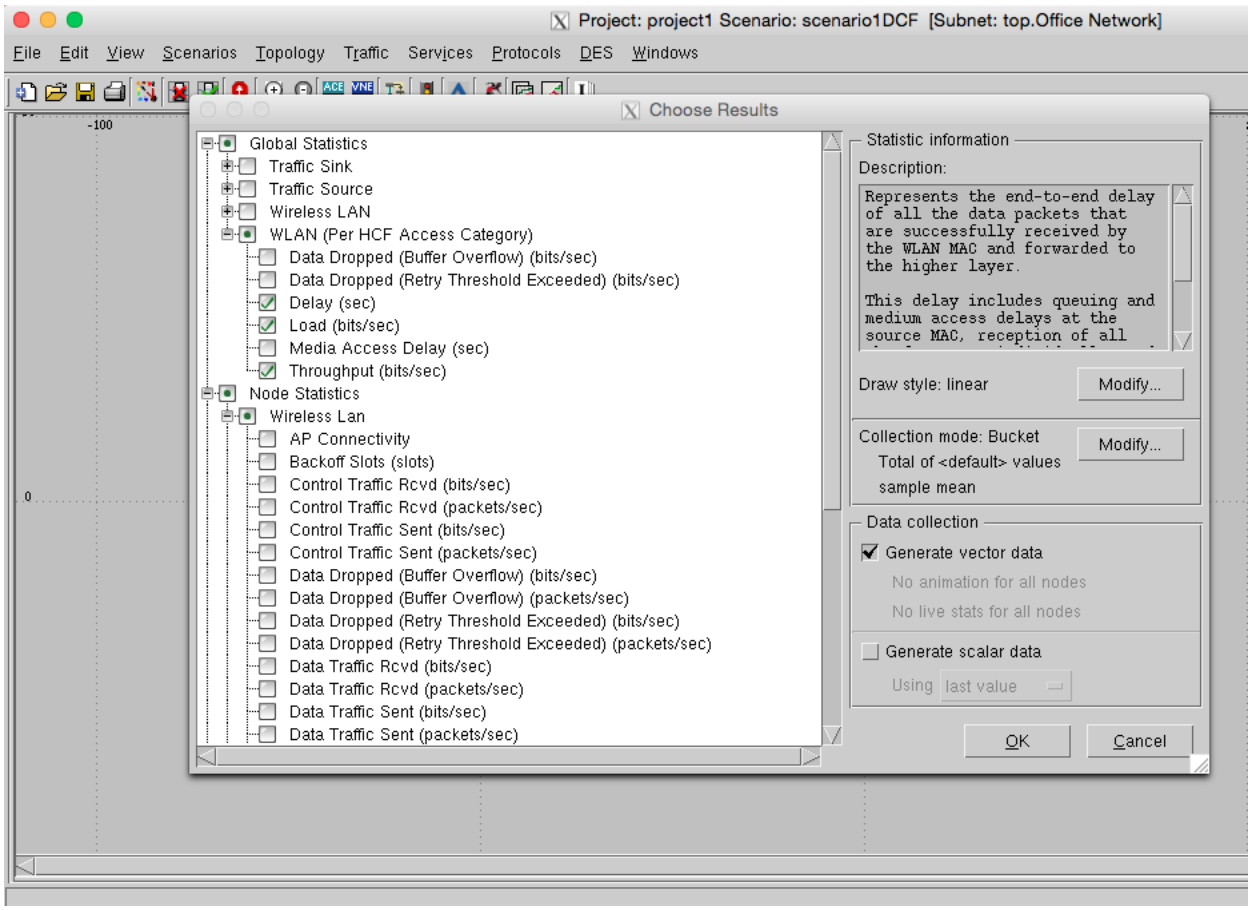


Figure 15: Selecting Global Statistics

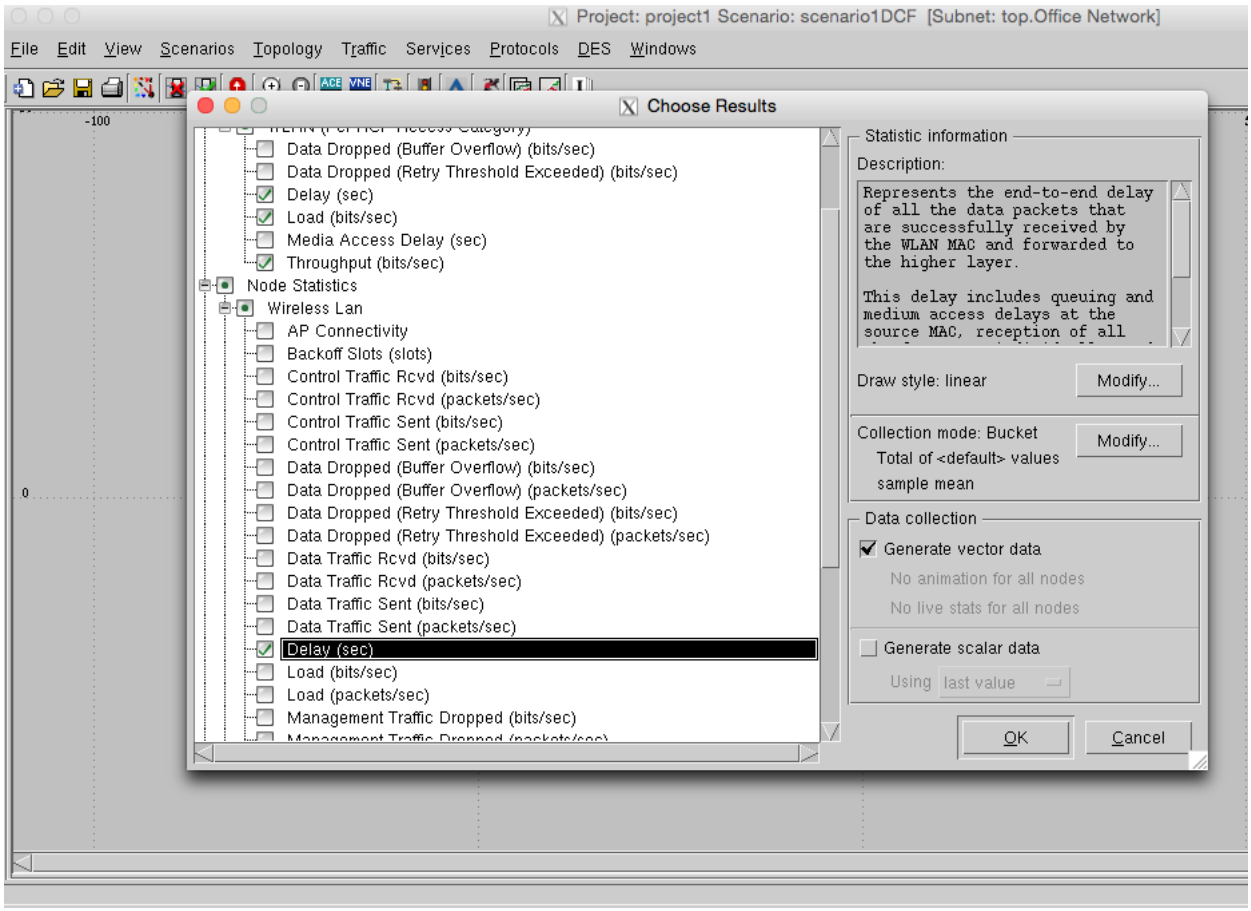


Figure 16: Selecting Nodal Statistics

Configuring the Simulation

1) Click on DES from title bar and select Configure and a Simulation window should appear.

2) Set the duration to be 10.0 minutes.

3) Click Apply and then save the project.

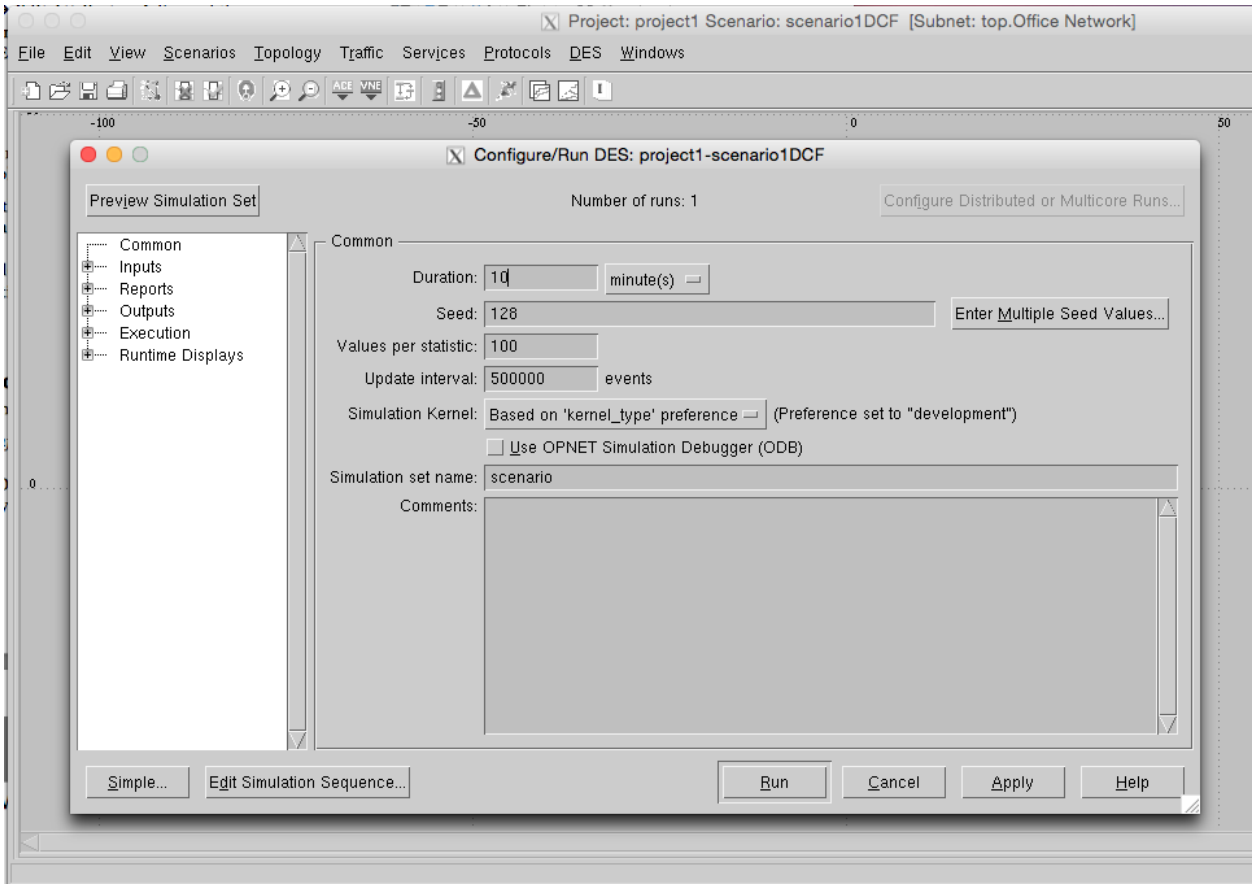


Figure 17: Selecting the duration of simulation

Adding Scenarios

We just created a network; however, we did not utilize many of the features explained above. We will now create three more scenarios to utilize the features available from the IEEE 802.11 standard. Fragmentation of the MAC data units into smaller frames will be carried out in the DCF_Frag scenario, which would allow us in testing its effect on the network performance. Utilization of the point coordination function (PCF) will be carried out in DCF_PCF scenario method for the MAC sublayer along with the DCF method. In the third scenario for DCF_PCF_Frag we shall allow fragmentation of the MAC data and check its effect along with PCF.

DCF_Frag Scenario

1 .Select Duplicate Scenario from the Scenarios menu and give it the name DCF_Frag , Click OK.

2 .Select all the nodes in the DCF_ Frag scenario, Right-click on any one of them, Edit Attributes, (as shown in the following figure) 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 Fragmentation Threshold (bytes) attribute, Click OK.

4 Right-click on node_0,·edit Attributes, expand the Wireless LAN Parameters hierarchy and set the Access Point functionality to Enabled. Click OK

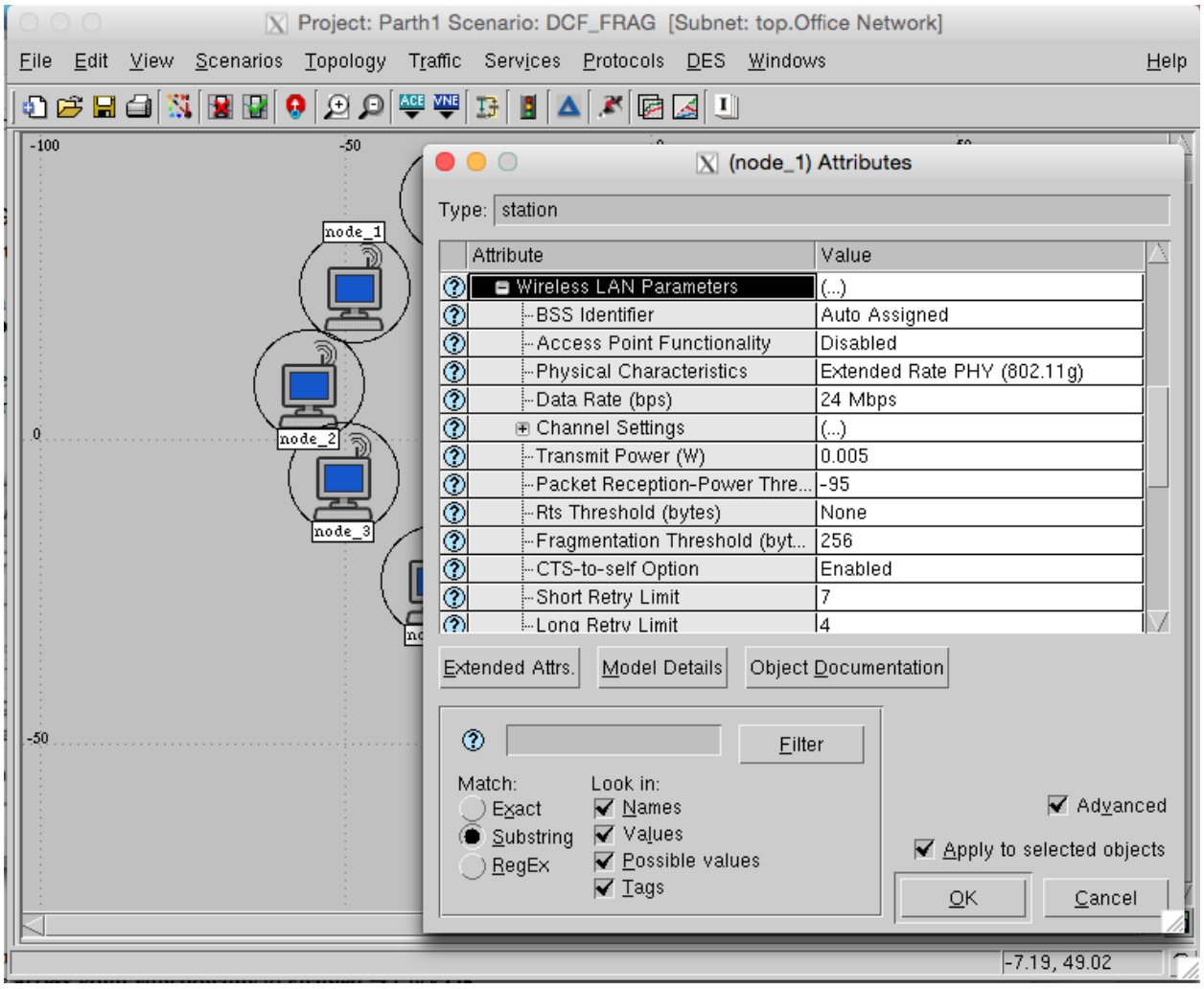


Figure 18: Changing Fragmentation Threshold*

The DCF_PCF Scenario

1 .Switch to the DCF scenario, select Duplicate Scenario from the Scenarios menu and give it the name DCF_PCF, Click OK and save the project.

2 .Select node_0, node_1, node_3, node_5, and node_7 in the DCF_PCF scenario simultaneously, Right-click on any one of the selected nodes, Edit Attributes.

3 .Check Apply Changes to Selected Objects, expand the hierarchy of the Wireless LAN Parameters attribute, expand the hierarchy of the PCF Parameters attribute, and enable the PCF Functionality attribute, Click OK.

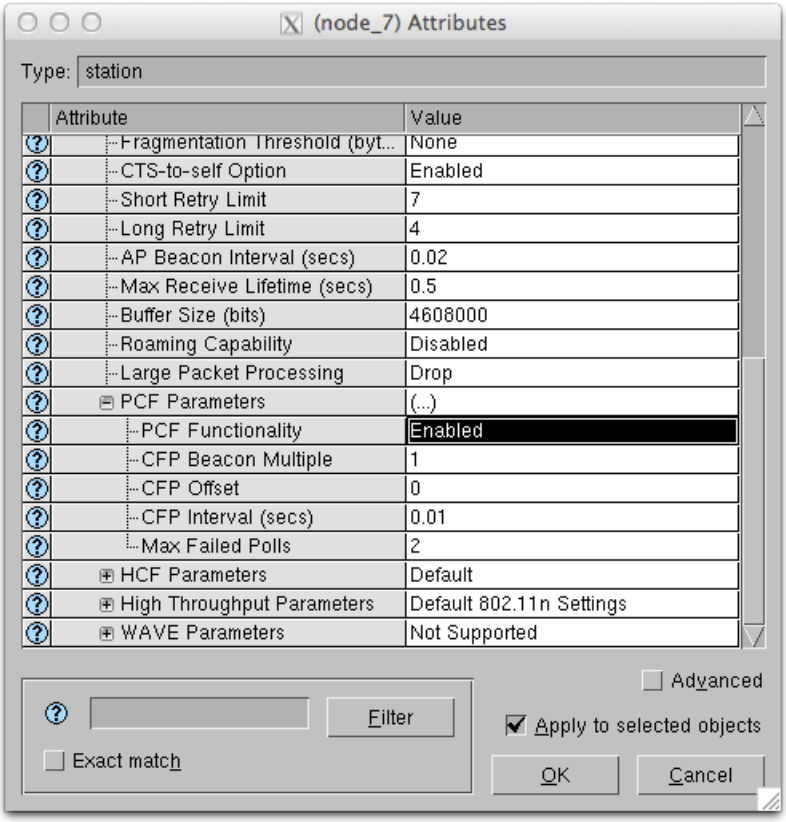


Figure 19: Enabling PCF Functionality

4 .Right-click on node_0, Edit Attributes, Expand the Wireless LAN Parameters hierarchy and set the Access Point Functionality to Enabled, Click OK.

The DCF_PCF_FRAG Scenario

1 .Switch to the DCF_Frag scenario, select Duplicate Scenario from the Scenarios menu and give it the name DCF_PCF_Frag, Click OK and save your project.

2 .Select node_0, node_1, node_3, node_5, and node_7 in the DCF_PCF_Frag scenario simultaneously, Right-click on any one of the selected nodes, Edit Attributes.

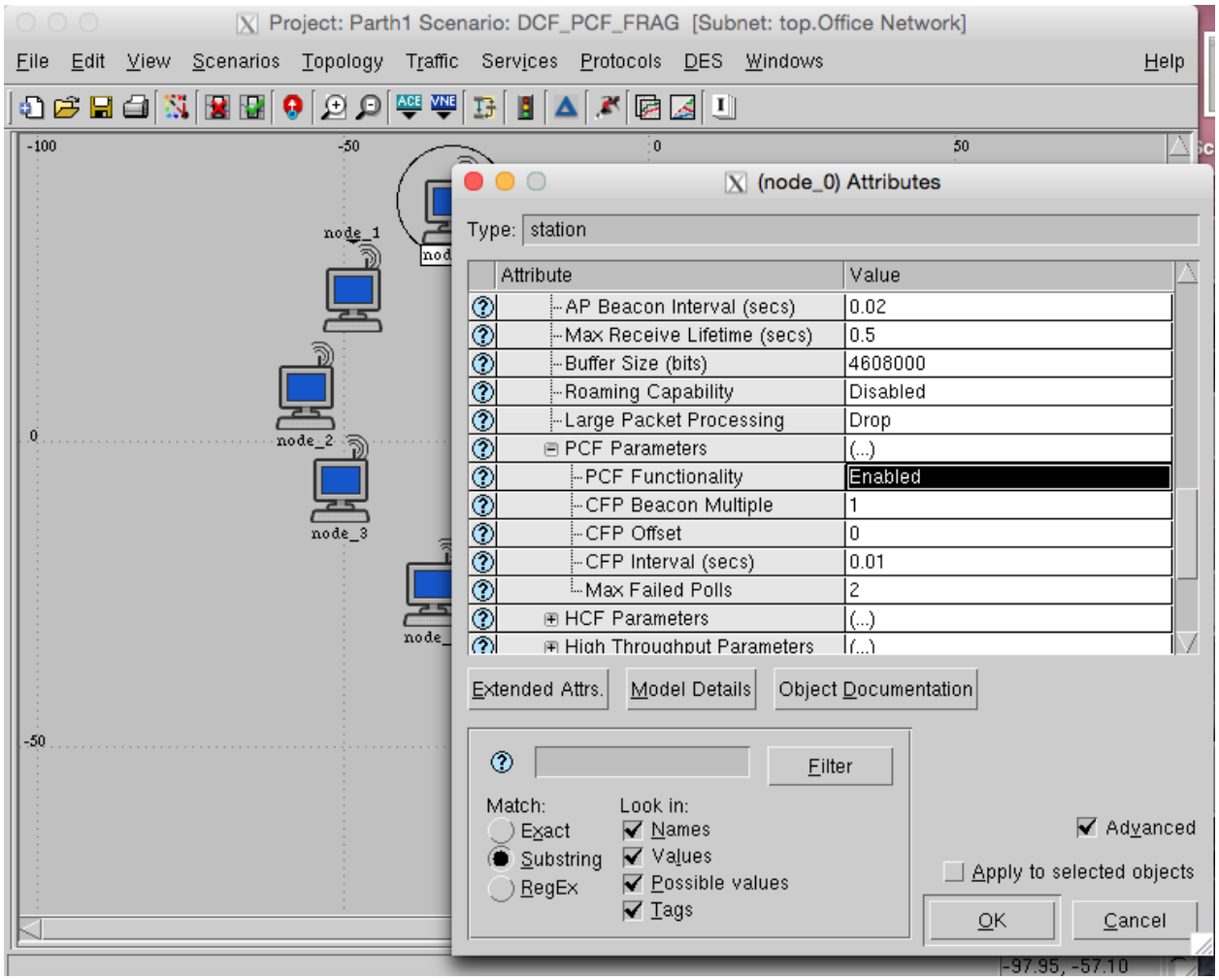


Figure 20: Enabling PCF Functionality for DCF_PCF_Frag scenario

3 .Check Apply Changes to Selected Objects, expand the Wireless LAN Parameters attribute, expand the hierarchy of the PCF Parameters attribute, and enable the PCF Functionality attribute, Click OK.

4 .Right-click on node_0·Edit Attributes, Expand the Wireless LAN Parameters hierarchy and set the Access Point Functionality to Enabled, Click OK.

* To switch to a scenario, choose Switch to Scenario from the Scenarios menu or just press Ctrl+<scenario number>

Simulation Execution

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 in the following figure.

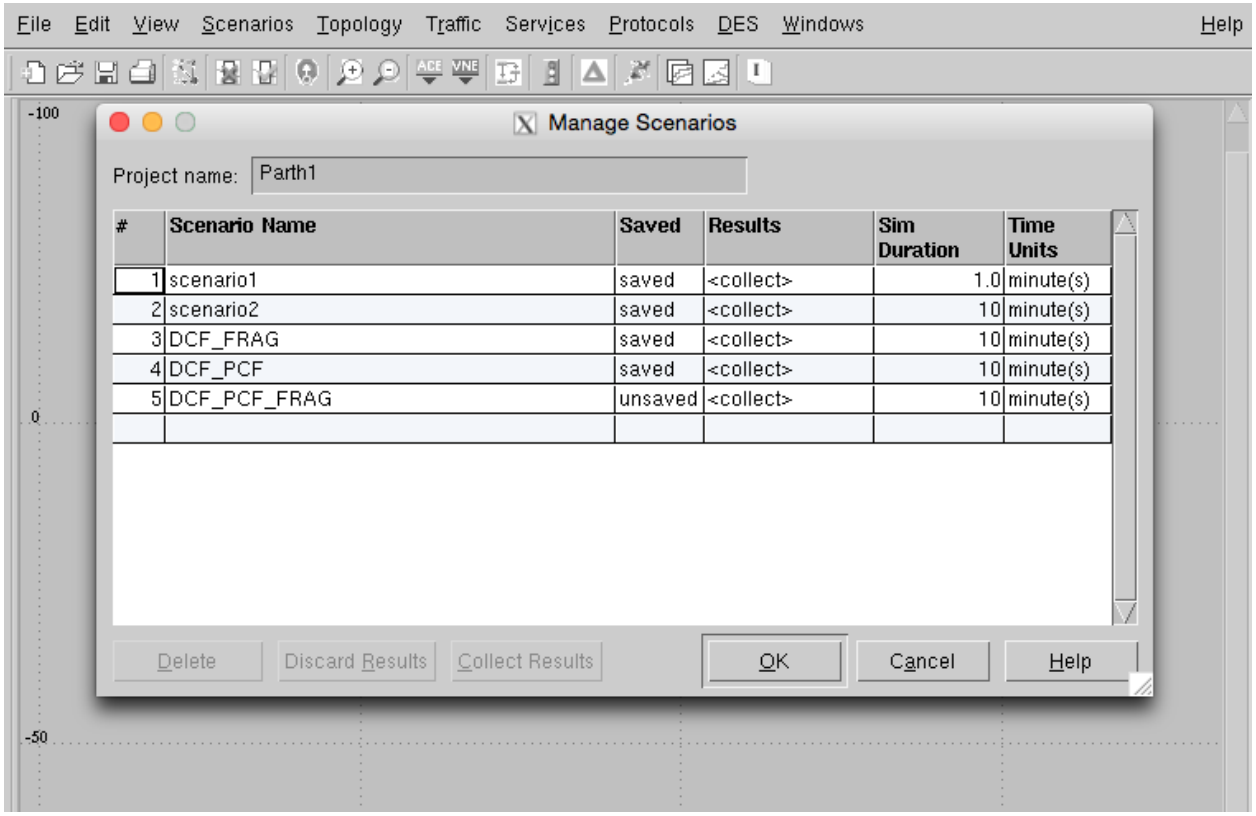


Figure 21: Managing scenarios before running simulations

3 .Click OK to run the four simulations

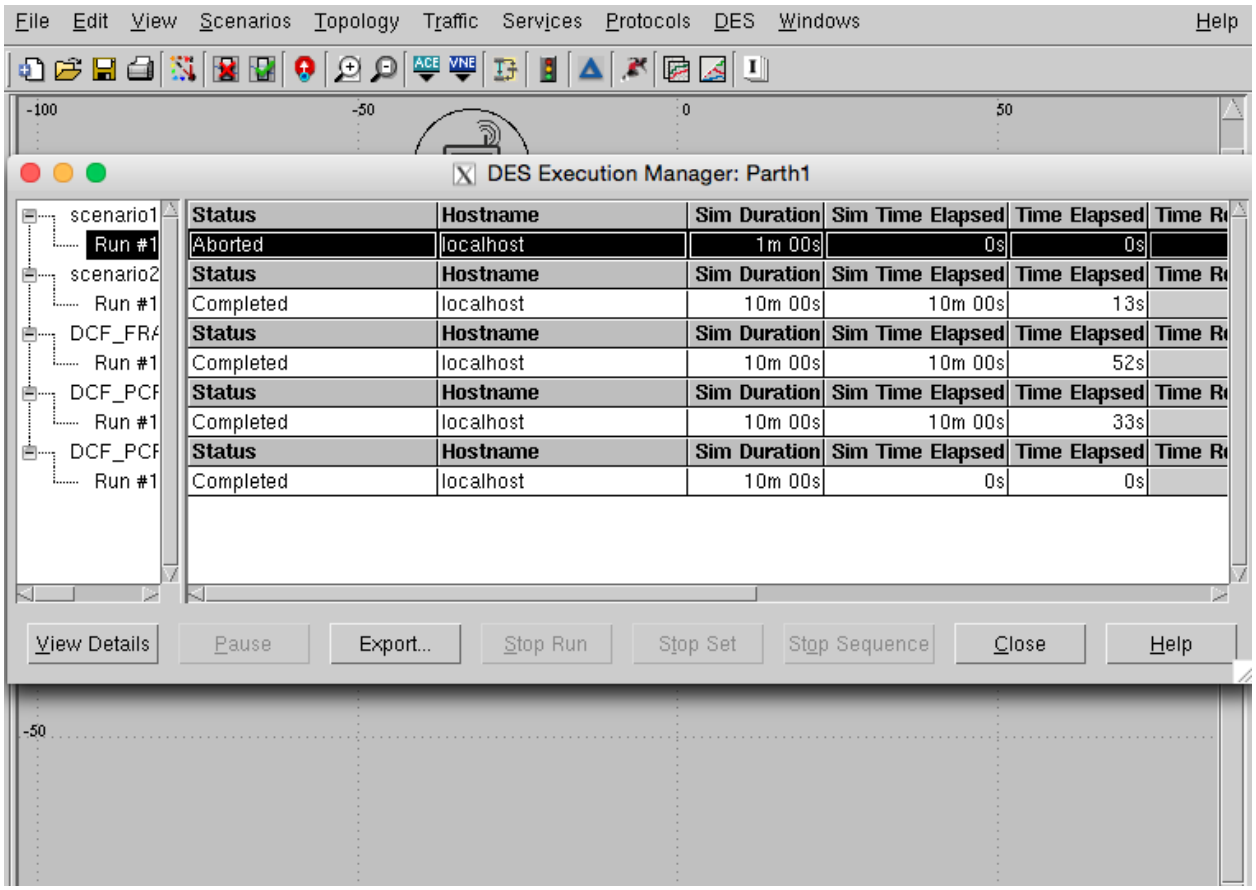


Figure 22: Scenarios post simulation runs

Viewing the Results

Follow the steps below to view the results (*Note:* Actual results might vary slightly based on your actual node positioning in the project created):

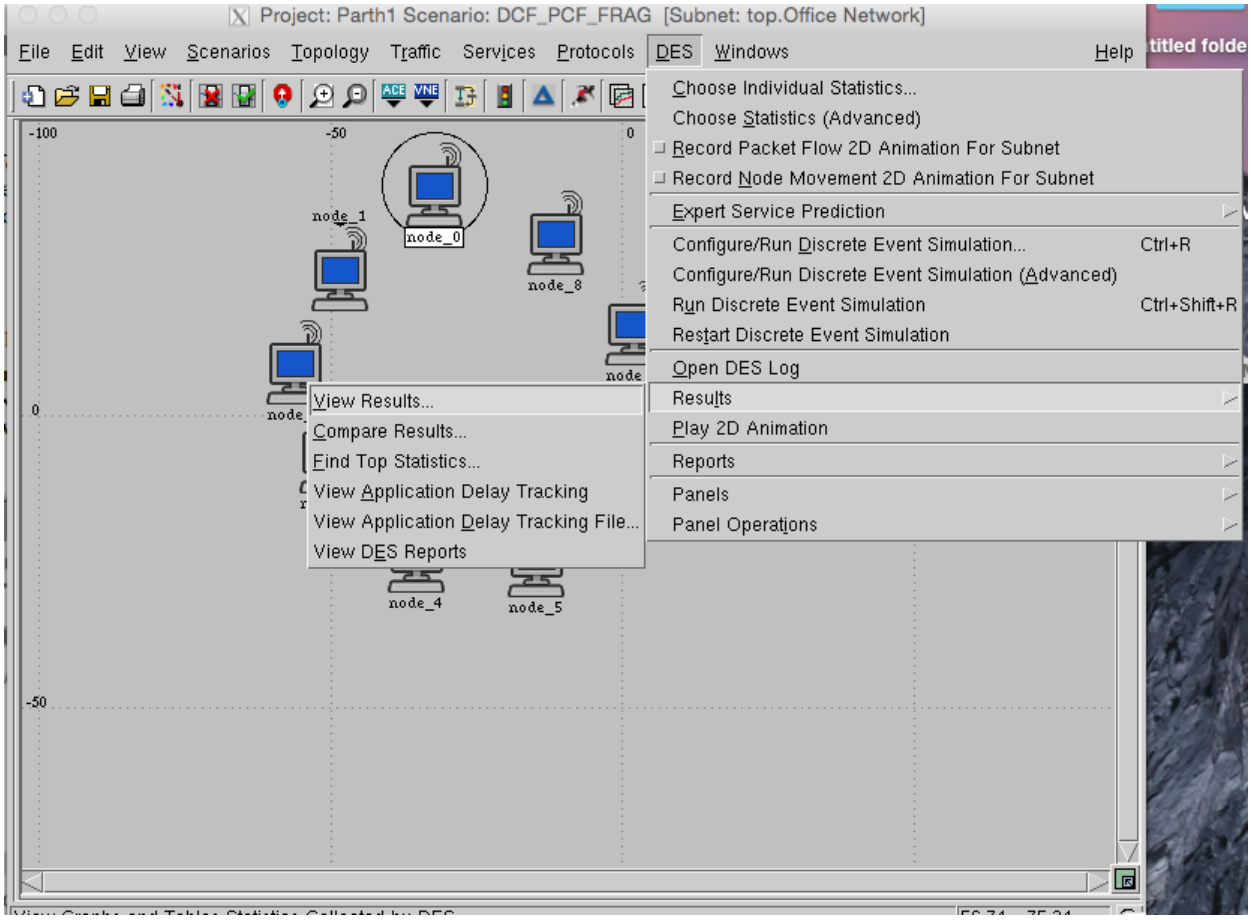
1 .Select Compare Results from the Result menu

2 .Change the drop-down menu in the lower-right part of the Compare Results dialog box from As Is to time average, Select the Delay (sec) statistic from the Wireless LAN hierarchy as shown in the figure below

3 .Go to Compare Results dialog box. Follow the same procedure to show the graphs of the following statistics from the Wireless LAN hierarchy: Load (bits/sec) and Throughput (bits/sec)

4 .Go to the Compare Results dialog box, and then expand the Object Statistics hierarchy, expand the Office Network hierarchy, expand the hierarchy of two nodes. One node should have PCF enabled in the DCF_PCF scenario (e.g., node_3) and the other node should have PCF disabled (e.g., node_2). ·Show the result of the Delay (sec) statistic for the chosen nodes. Repeat for different node combinations and also compare the results for throughput or load

5 .Repeat Step 4 above but for the Retransmission Attempts (packets) statistic. Show the resulting graphs



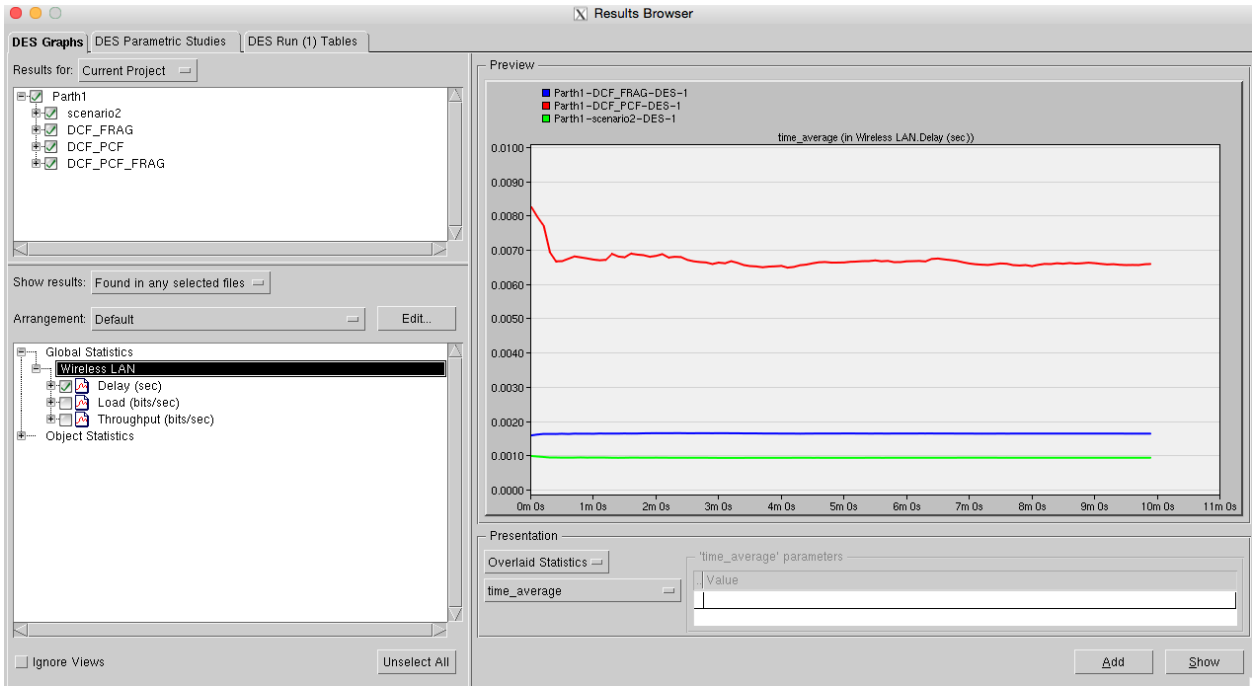


Figure 23: Comparing results

Lab Exercises

1 .Analyze the graphs that compare the Delay and Throughput of the four scenarios. What are the effects of utilizing PCF and fragmentation on these two statistics?

2 .From the last four graphs, explain how the performance of a node without PCF is affected by having PCF enabled in other nodes in the network.

3 .Create two new scenarios as duplicates of the DCF_PCF scenario. Name the first new scenario DCF_allPCF and the second new scenario DCF_twoPCF. In DCF_allPCF, enable the PCF attribute in all eight nodes: node_1 through node_8. (Note: Do not include node_0 in any of your attribute editing.) In DCF_twoPCF, disable the PCF attribute in node_3 and node_5 (this will leave only node_1 and node_7 with PCF enabled). Generate the graphs for the Delay, Load, and Throughput statistics, and explain how the number of PCF nodes might affect the performance of the wireless network.

4 .For all scenarios, select the Media Access Delay statistic from the Global Statistics· Wireless LAN hierarchy. Rerun the simulation for all scenarios. Generate the graph that compares the Media Access Delay statistic of all scenarios. Analyze the graph, explaining the effect of PCF, fragmentation, and number of PCF nodes on media access delay.