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PR Mobile and Wireless Systems
Problems part 4

1. Answer the following questions:

(a) In the 'Configure/Run DES' dialog many parameters for the simulation run can be set. What is the purpose of all the parameters in the 'common', the 'input' and the 'runtime displays' tabs?

(b) If you select 'file/new' in the menu and choose simulation sequence, you get the simulation sequence editor. What can this editor be used for? Try to use it to run a simulation of a network of your choice (e.g. a solution of one of the previous problems)!

(c) What is a 'analysis configuration' good for? Try to create a simple analysis configuration of the simulation done for question (b)!

2. Create some different antenna patterns.

Now you should create some different antenna patterns. Antenna patterns describe, how an antenna radiates the signals for each direction. You can use the antenna pattern editor (file/new, choose antenna pattern) to create some different antenna patterns.

The first antenna pattern we want to create is a very directed antenna. Most of the transmission power is radiated in one specific direction whereas in all other directions there should be nearly no transmission at all. To create the pattern, start the antenna pattern editor. In the lower area you can edit the pattern. If you right click in that area, you can choose the ϕ-plane you want to edit. Select the ϕ-plane 0.0 and set all values to about 50 dB. For that purpose you can set the upper and lower bound of the graph accordingly. Set the same values for the plane 5.0. After that you should click on the 'Normalize the function' button.

You should now be able to create some more antenna patterns:

(a) An antenna with a litttle bit wider cone.

(b) An antenna with a very wide cone.

(c) An antenna with only a preferred sending/receiving direction (antenna receiving in all directions, but in one direction a little bit better).

You should also watch some of the antenna patterns provided by OPNET (especially the isotropic antenna).

3. Simulate a wireless network using different antenna patterns.

Now we have created some antenna patterns, we can use them in a simulation and compare the results. For that purpose you first have to create a small network consisting of one transmitter, one receiver and a jamming node (or reuse the network of the second part of problems set 3).

The difference in the node model to the network of the last time is that each node model has to contain an antenna. The antenna model for the two sending nodes should be isotropic to ensure that they send with the same power in all directions. The antenna pattern of the receiving node should be promoted to be able to automatically run the simulation for each antenna pattern (don't forget to enter it in the node interface of the node model).

There is one additional problem using directed antenna patterns. To be able to receive packets from a given transmitter, the antenna cone has to aim exactly to that transmitter. For that purpose we have to create an additional processor and a process model containing only one state. The enter routing for that state should be the following (with your additions):

```
Objid subnet_id,         /* subnetwork object identifier */
tx_node_id,      /* transmitter node object identifier */
rx_node_id,      /* receiver node object identifier */
rx_ant_id;       /* receiver antenna object identifier */
double altitude,         /* the altitude of the transmitter node */
latitude,        /* the latitude of the transmitter node */
longitude,       /* the longitude of the transmitter node */
x_pos,           /* the subnetwork x position of the transmitter node */
y_pos,           /* the subnetwork y position of the transmitter node */
z_pos;           /* the subnetwork z position of the transmitter node */
Compcode comp_code;      /* the completion code for Ima procedures */

rx_node_id = op_topo_parent (op_id_self ());
subnet_id = op_topo_parent (rx_node_id);
tx_node_id = op_id_from_name (subnet_id, OPC_OBJTYPE_NDFIX, "tx");
comp_code = op_ima_obj_pos_get (tx_node_id, &latitude, &longitude,
        &altitude, &x_pos, &y_pos, &z_pos);
if (comp_code == OPC_COMPCODE_FAILURE)
   op_sim_end ("get attributes failed", "", "", "");
rx_ant_id = op_id_from_name (rx_node_id, OPC_OBJTYPE_ANT, "ant_rx");

comp_code = op_ima_obj_attr_set (rx_ant_id, "target altitude", altitude);
if (comp_code == OPC_COMPCODE_FAILURE)
   op_sim_end ("set target altitude failed", "", "", "");

// insert the routines for latitude and longitude
```

The trajectory for the jamming node should be a little bit more complex in this simulation. Try to let the jammer move between sender and receiver, the backside of the receiver, etc.

Now we want to simulate the network 5 times with different antenna models for the receiver. For that purpose you can enter the antenna models as multiple values for the promoted antenna pattern attribute of the receiver in the object attributes section of the 'Configure/Run DES' dialog. If you start the simulation, it takes five runs to complete. In the results window there will be five different graphs, one for each antenna pattern. You should now compare the results (compare BER, SNR, throughput, etc.)! What is the interpretation?

4. Using more channels for wireless transmissions.

It is possible to use one wireless transmitter (or receiver) with more channels transmitting at the same time. Your task is to create a node that is able to receive from four point-to-point links (cable) and send the data over four different wireless channels (use two different spreading codes and two different frequencies) and in the other direction. Explain the term 'spreading code' and CDMA!

To be able to send in both directions, you have to use a multiplexing method. Describe TDM and FDM and use one of them in the simulation! Try to simulate a network containing the new node(s) and measure some important values like BER and delay. Repeat the simulation with different bandwith values. Does the BER depent on the used bandwith? Why? Try to find different bandwiths that result in good, medium and poor transmission of the data!

Hint: Don't forget to set the altitude of the nodes containing the wireless transmitters and receivers to a value > 0 (in advanced attributes). Otherwise no transmission will be possible.

5. Creating a web report of the results above.

Now you should create a web report containing the results of the simulation of problem 4. For more information on how to create a web report, refer to the turorial about web reports. The report should provide an overview of the bit error rates of the transmission for different bandwidths (e.g. you can use several different frequency bands with different bandwidths).