SYSC 5104

Discrete Event Modelling and Simulation

Assignment2: Modelling Ad-Hoc Network using Cell-DEVS

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Introduction

This assignment aims at modelling an Ad-Hoc network using Cell-DEVS formalism. This follows the work by Orenstein et al[1] which shows that a cellular automaton can be used to model mobility and communications of wireless network systems. The idea is to model and define an Ad-Hoc network using the Cell-DEVS formalism. An ad-hoc network is a mobile network in which nodes can enter and leave the network randomly and move about randomly within a specified area.

Conceptual Model Description

In this assignment a simple ad-hoc network is modelled by defining a network area as a two dimensional grid. Each grid represents a position in the area, which could either be occupied or not occupied by a network node. The network is modelled herein as a homogeneous network with all nodes being the same. This sets up the possiblity to model the nodes using a simple cellular model governed by the same rule. Each cell has a state which corresponds to the status of the node that occupies it. The neighborhood of each cell is the range of communication of each node defined as a Von-Neumann neighborhood governed by a circle of radius R around the cell (the same neighborhood will be used for mobility to keep things simple). A network node has connectivity if there exists atleast one working network node in the communication neighborhood. Netwok nodes can move randomly to any of the neighboring cells provided they are unoccupied.

The local states of each cell are described as :

0 = empty, no network node
1 = occupied by a working node, isolated(no communication)
2 = occupied by a failed node
3 = occupied, node has connection to other nodes

The local transition rules for each cell based on the neighborhood:

- if unoccupied, generate a node based on a probability that a node will enter the network, Penter (this generates nodes that enter the network)
- if occupied, move with probability Pm to any unoccupied cell in neighborhood(this moves the nodes around the network)
- if occupied, check if there are any occupied cells in the neighborhood and change state acoordingly
- if occupied, with probability Pfail, set the status to fail
- if occupied , set cell to empty with probability, Pexit

Implementation

During the implementation of the model, the preliminary model was changed due to the requirement of many state variables for each cell, hence two planes were used to accomodate the two different variables. The model is herein described as built, with one plane reperesenting the movements of the nodes and the other plane marking the area of radio coverage for each node.

The ad-hoc model was implemented as a 20 by 20 by 2 matrix. One plane reperesentes the nodes as how they are moving and the coverage of each node is represented on the other plane. The null boundaries were used in the implementation, i.e. un-wrapped boundaries. Nodes bouce back into the area of interest if they get to the borders. The network was formally defined using the Cell-DEVS formalism as :

CD = <X, Y , I ,S, θ, N, D , δint , δext , τ, λ, D >
where;
X = {Ø}
Y = {Ø}
I = <η, μ, Px, Py>
η = 26
μ = 0
Px = {all in neighborhood}
Py = {all in neighborhood}
θ = {// defines the states of each cell
0 : Empty slot, no network node present/ no radio coverage;
1 : Occupied by a node moving in the East directions;
2 : Occupied by a node moving in the North-East direction;
3 : Occupied by a node moving in the North direction;
4 : Occupied by a node moving in the North-West direction;
5 : Occupied by a node moving in the West direction;
6 : Occupied by a node moving in the South-West direction;
7 : Occupied by a node moving in the South direction;
8 : Occupied by a node moving in the South-East direction;
10: Node that has failed;
11: Area of coverage for a nodes radio transmission;
}

N = {Ø}
D = transport delay 100ms
δint :described as the “move” rule pseudocode of the rule given below

- If a cell is unoccupied and there is a node in the neighborhood that wants to move into the cell, accomodate the cell after 100ms and give it a random direction between 1 and 8
- If a cell is a boundary cell and occupied by a node that wants to go outside the boundary, change the nodes direction towards non-boundary cells
- If a cell is unoccupied give, occupy it with a probability Penter(0.1) to simulate new nodes entering the network
- If a cell is occupied, make it unoccupied with probability Pexit(0.1) to simulate node exiting the network
- If a cell is occupied by a working node, make the node fail with probability Pfail(0.01)
- If a cell is occupied by a failed node , make the node work with probability Pwork(0.99)

δext = {Ø}

Results

The model was run and it was found to work satisfactorily showing the expected evolution of an adhoc network. The nodes moved around in random fashion and occasionally one would get a few failed nodes and then have them working again. The model provides a good visual aid in observing adhoc networks as shown in the figure below. The picture below shows the initial state of the network.

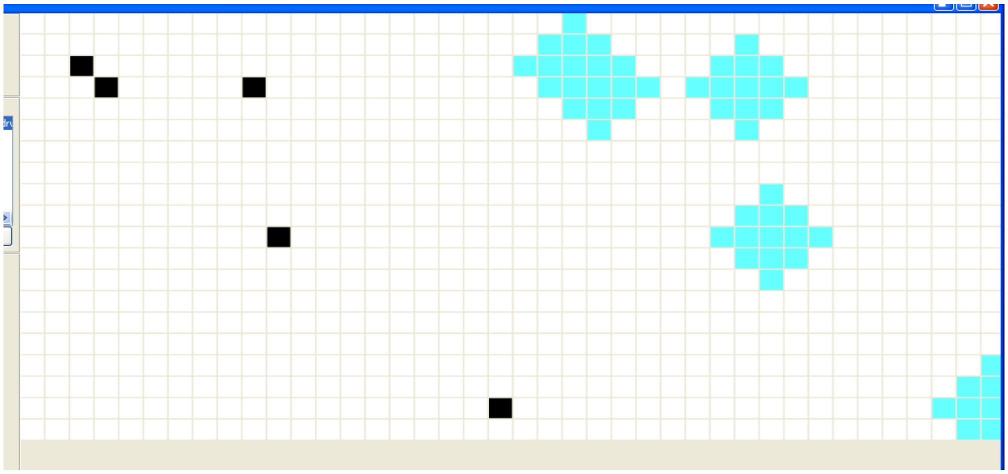

Figure 1: Showing the nodes in the network

The left half of the picture with black dots shows the plane representing the nodes and the right plane shows the radio coverage of the nodes in a different plane. The network evolves and the nodes move about in a random fashion as shown by the following picture:

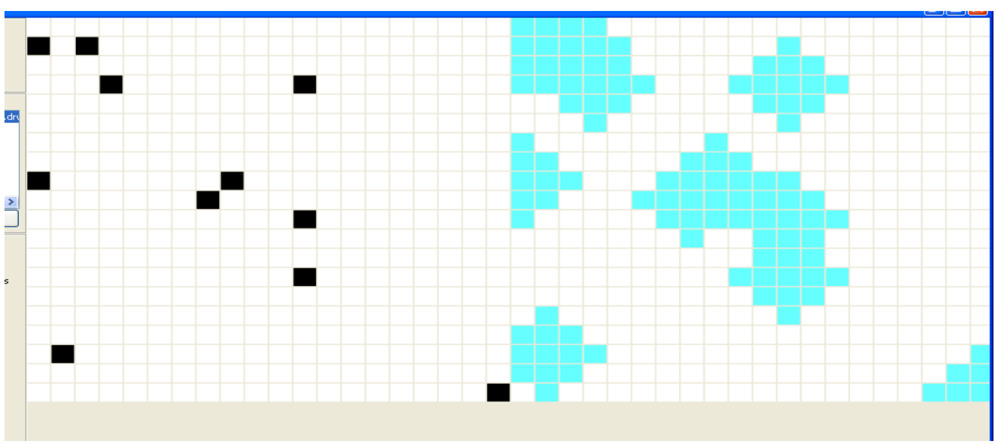

Figure 2: Showing the evolution of the network

Notice that the number netwok nodes have changed (increased) this was due to the random entry and exit of network nodes.

Conclusion

The ad-hoc model is a good good model to simulate networks with ad-hoc behaviour. Known properties like node clusterring are observed in this model and this model could be used to study such network properties in detail. The tests with different initial number of nodes results with different coverage patterns more importantly consistent with the reasoning that the more nodes there are the less likely that nodes will be isolated and vice versa. The model could still be improved to model behaviours like varing node movement speed. Instead of having the same delay for each node movement, have the nodes move more harpazardly with different speeds.

Reference

[1] P. Orrenstein, Z. Marantz, D. Goodman, "*Application of Cellular Automata to Modelling Mobility and Radio Communications in Wireless Networks*", IEEE *Advances in Wired and Wireless Communications*, 18-19 April 2005.