University of Trento

PAF-FPE: Privacy aware content filtering for future pervasive environments

Simluator documentation, vers. 0.1

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Contents

1 Introduction

This simulator is a derivation from Inet 1.99.1 version, it will be probably updated in the future when the version 2.0 comes out and is intended to perform mesh/ad-hoc networking simulations using as much as possible realistic conditions. The aim of this project is to study the privacy features of an ad-hoc network used as a communication base for a social network. This fork of inet provides the basic blocks to be able to simulate this kind of network with realistic applications, mobility and channel models.

Changelog

- Version 0.1 contains:
  - Musolesi mobility model ported to Omnet with various modifications
  - Raytracing from Omnet by Christian Sommers (obstacles definition) and Dual Slope pathloss model
  - Obstacle avoidance for LineSegmentsMobility (and consequently for any other module based on that)
  - AddressGenerator module to have a fresh pool of addresses for the applications
  - ChatApp application with literature-based statistics and behaviour
  - Initial implementation of firewalling strategies (this will be documented soon)
  - Tests scenarios for realistic networking

2 Constributed source code

2.1 Musolesi Mobility

This mobility model has been detailed by Musolesi et. al. in various papers, it is a realistic model derived from social theory of communities, that is, it generates random traces according to the actions a community of people performs based on social studies. The source is not really polished, but the original code itself was some kind of c-style c++ that should be rewritten from scratch. I obviously preserved the original LGPL license.

The main idea is the following (even though some details are more complex than this):

- divide the space in blocks, x rows and y columns
- divide the n nodes in g groups, fill a nxn matrix with 1 where nodes are in the same group and 0 otherwise.
- rewire the matrix, that is, with certain probability some links are broken and some new ones are created (so that groups are not disjoint)
- assign to each group a block, place the nodes inside that block
- now each node ranks the blocks with a weight that is the sum of the non-zero links it has in that block. The highest ranked one is the next target.

The ranking of the blocks (calculated by a single node) changes with time, so nodes in different moments will have different targets. As the paper shows this mobility model has a high statistical similarity with real traces measured in various experiments around the world, i.e. the distribution of the contact time (the time a couple of nodes spend in the same neighborhood (that in my implementation is approximated with the block they stay in)) and the inter-contact time (interval between two contacts) is a power-law and not an exponential as in random way point, that changes the behavior of the network. The ranking is a deterministic function, so there are various modifications in order to support periodic reshuffling of the groups or rewiring, without modifications the nodes all collapse in a single block that behaves like a magnet. Two modifications are: the assignment of a non-zero rank to all blocks independently by the nodes that reside in it and then random choice of the block with probability proportional to the rank, second is presented in a following paper where the model has been modified introducing a parameter that gives the probability of "going back home" independently from the other's position.

In my implementation there are two more differences: the first is that once the rank has been calculated (with initial non-zero weight) the target block is then chosen as a random number with exponential distribution (1/average is parametrized) this produces a strong bias on the most attractive ones, but adds some turbolence to the choice. This is much more controlled than

uniform choice, since even if the initial weight is little, the number of blocks may be high and spread the choice. The second one is that if you insert obstacles into the scenario the nodes will try to avoid them. This is very basic and it works like this:

- Nodes never enter obstacles, so their initial position is never inside an obstacle and they never chose a target point inside an obstacle
- If a node realizes that the next step to the chosen waypoint is inside an obstacle, it choses an intermediate waypoint that is a random point close to the corner of the obstacle that is on the shortest path to the original waypoint.
- When it arrives to the intermediate waypoint it switches the next waypoint to the original one. Since the intermediate is chosen at random, it may be that he is going to hit a wall again (and do the procedure again with another random point. Note that this means he is just wolking a few more meteres, he never goes around the obstacle over and over) but this saves me from calculating gradients and doing smarter things.

Obstacle avoidance works only if the obstacles are not concave (in this cas you should do something better than this) and there is enough room between obstacles so that a random point can be chosen close to a corner of an obstacle with reasonable probability of not falling into another obstacle. In practice I've tried with rectangular obstacles spaced at least 10m but you can play with source code.

Note that you could chose a pathological situation, for instance you put an obstacle that covers an entire block and a nde decides (due to Musolesi's logic) to go into that block. This obviously doesn't work so you should avoid this. In the simulator there are counters that check when the simulator is not able to choose a random point and will raise an error.

Note that if you run one of the examples with obstacles on Tkenv you will see a grid corresponding to musolesi blocks (if they are squared, omnet is not able to show a non-squared grid) and also the obstacles, this helps placing them sanely.

The most relevant parameter are:

- minHostSpeed/maxHostSpeed: speed is chosen randomly in this interval

- connectionThreshold: when randomizing the groups give random value to the matrix between 0,1. If the value is higher than this threshold then there is a link (discretized to 1) numberOfRows/numberOfColumns
- rewiringProb: when rewiring the matrix, each link value is changed with this probability
- rewiringPeriod: rewiring interval
- reshufflePeriod: reshuffling interval
- numberOfGroups
- girvanNewmanOn: this is an alternative way of building the groups, I've not been able to make it work from original code...
- targetChoice: deterministic/pseudodeterministic/proportional, see the paragraph on ranking
- recordStatistics: output some statstics to test the model
- drift: the inital weight of a block
- expmean: exponential distrbution parameter for pseudodeterminstic
- reshufflePositionsOnly: do not reshuffle the groups composition, just change their base block
- RWP: disable group movements, just a random way point. This has been added just to perform statistical comparisons numHosts
- hcmm: Boldrini modifcation, this is the probability of going back home

To better understand how the mobility model works go to this link where you have some videos I've realized to show the mobility and the dependency of the statistical properties by the parameters.

2.2 Address Generator

This module is an address generator that the applications can use to choose the destination of the sessions they open. The need for this is that each application takes care of choosing where to send the next packet, but it does this quite simply, whether you specify it on configuration or, some, take a random() keyword meaning anyone. In wireless ad-hoc simulations this does not work since the network is often disconnected and you may not want your application to send packets to somebody that is not reachable now (this obviously applies to proactive routing). So the module uses the current routing table to give a list of address that are effectively reachable and returns the list to the application that is requesting them. You can do also more simple things like fixed list or random addresses. The main configuration items are:

- string generatorMode = default("RoutingTable"): The way addressess are gathered, this can be (you can mix 1 and 3):
  1. RoutingTable: get them from your routing table (useful in ad-hoc networks)
  2. FixedList: get them from the configuration
  3. NodeType: specify a node type and get any of them
- int listSize = default(-1): size of the list to be returned.
- string addressList = default(""): needed for FixedList mode, may be "random(host)" where host is the nodetype
- string nodeType = default(""); needed for NodeType mode
- string routingTablePath = default(""); it it is unset, the default is host[].routingTable
- int waitTime @unit(s) = default(1s): when using routingTable mode do not start at time==0 but wait an amount of time, this is useful when routing tables take some time to be filled and keepSetConsistent is used
- bool keepSetConsistent = default(false): try to keep time consistency of the list among updates (not just random IP taken by routes, safeguard the ones already present in the list at previous iteration)

- bool keepSetBalanced = default(false); try to keep topology consistency of the list among updates. In group mobility models the keepSetConsistent will probably produce sets with a lot of one-hop nodes since they are always reachable. This tries to proportionally spread the target set over the possible hopcount in the network.

- int updateTime @unit(s) = default(1s): The time interval to refresh the address pool. Keep this high if possible, since refreshing the pool can be expensive with large routing tables.

The last two options prove to be useful when you want to limit the set of possible target nodes. For instance, you want your application to talk to only a subset of n nodes over the N present in the network. Since the routing table changes with time (if you have mobility) every time you ask for a set of target address you will receive n random addresses over N. You may instead want to keep it as consistent as you can (that is after a certain subset has been chosen, the next time keep the in the set the nodes that were in the previous choice and are still reachable).

With certain mobility models, keeping the target set consistent is not a good idea, for instance with cluster-based models such as Musolesi's model your 1-hop neighbor set does not changes often. If you keep it consistent you will basically talk only with one-hop neighbors. The keepSetBalanced instead gets the n addresses taking into account the distance in hop (well, in the metric value) and tries to give you a set that is uniformly distributed over the possible metric value.

2.3 Dual Slope

Dual Slope introduces one breakpoint distance at which the decay coefficient changes, the rationale is to simulates situations in which the two communicating nodes are in LOS up to a certain distance and NLOS after that distance (or other effects that influence the pathloss). You can choose the two coefficients and the distance using the configuration parameters. There is one more parameter that is used to avoid producing a hard step at the breakpoint distance, if you enable it a smoothing factor is used. Configurations are quite straightfoward. See this link for graphics.

3 Scenario Documentation

The scenarios are included in order to give a starting point for anyone that wants to simulate an ad-hoc or mesh network without wasting too much time to set-up a realistic environment. The scenarios are divided according to various criterias:

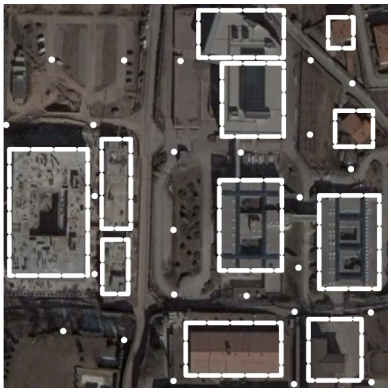
- Ad-hoc/Mesh: the first case is a completely ad-hoc network, in the other case there is a mesh network with fixed nodes (and more powerful radio) distributed with a grid topology plus some ad-hoc nodes roaming
- Little/Middle/Big/Fat: the size of the area and number of nodes. Fat stands for Middle area with more nodes into it.
- SlowMobility/FastMobility: there is a difference in the average speed of nodes, in the mobility update time, in the frequency of the generation of packets from the applications and in the duration of the simulation. Basically fast simulations are used to test the changes you implement and slow ones are imagined to get real results
- Obstacles: in presence of obstacles the grid may be substituted with a wiser placement of the mesh nodes, as in the figure below, which resambles a simplified topology of the area around the DISI department.

The scenarios are defined in various .ini files, one for topology and mobility, one for traffic and another one to sum up everything.

For each scenario in the anf/ folder you can find some evaluation parameters, they include the average arrival rate of the echo applications (there are 25 available ports on each mobile node pinged randomly by udpApp[26]), average routing table size, average hopcount, average chat session run. See appendix for example images.

4 OLSR and firewalling

Most of the modifications deal with OLSR and firewall implementation, which I will document in the future. I didn't try the scenarios with other routing algorithms.



A Scenario results

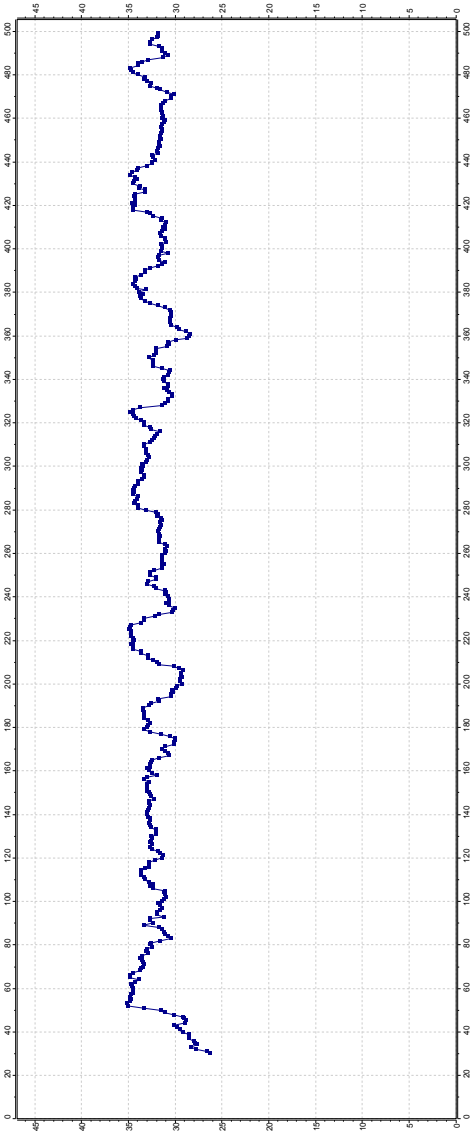


Figure 1: Routing table size averaged for all the nodes, reported as a vector. To have an always connected ad-hoc network (without power control) the hopcount would be too low and the capacity would fall down. I chose to have an almost always-connected network and use addressGenerator to talk only to nodes that are effectively reachable. Nevertheless we have some loss

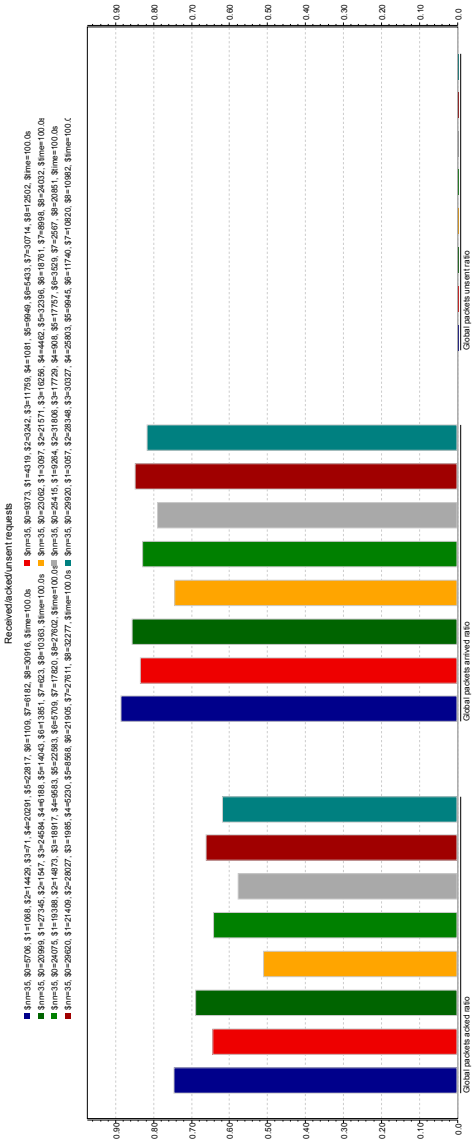


Figure 2: The ratio of received packets, of acket packets and unsent packets. Unsent are counted when there are no available addresses to be used (the node is isolated, may happen rarely)

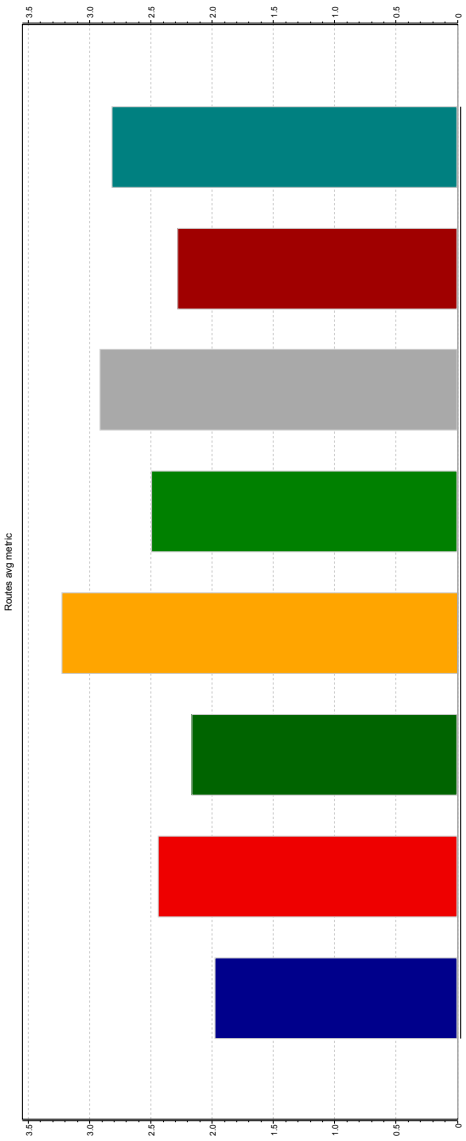


Figure 3: This is the average hopcount measured from the metric field in the routing table

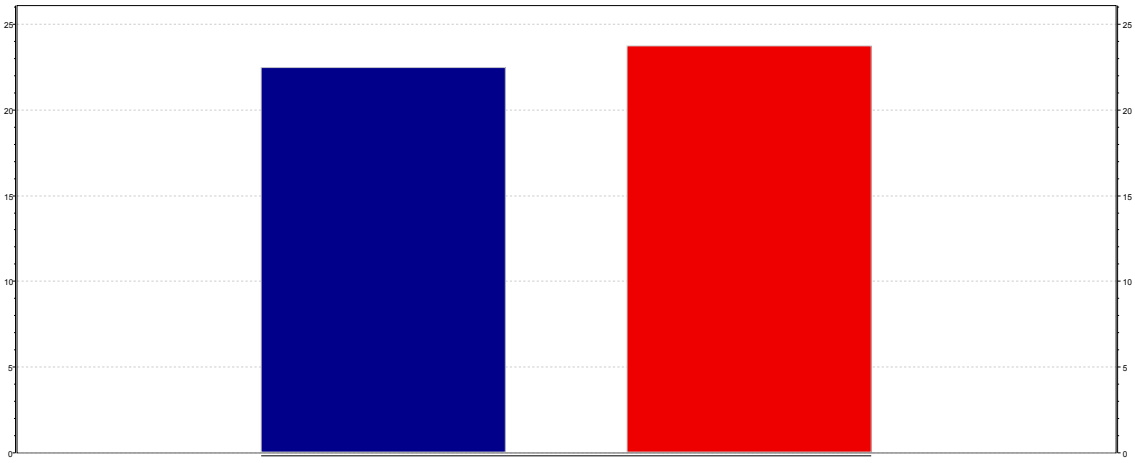


Figure 4: Chat sessions started and received from node 0

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References