



Research Centre in
Real-Time Computing Systems

RoutesMobilityModel: Easy Realistic Mobility Simulation using External Information Services

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Outline

- Mobility models for ns-3
 - ns3::RandomWaypointMobilityModel
 - SUMO
- Using external information services
 - Google Maps API
- ns3::RoutesMobilityModel
 - Features
 - Results
 - Internals
 - Limitations
- Future (current) work

Mobility Models for ns-3

- Simulation of mobile communication makes use of mobility models
- ns-3 possesses several synthetic mobility models implemented, such as:
 - Random Waypoint Mobility Model
 - Random Walk 2D
 - Gauss-Markov Mobility Model
- Another approach is coupling ns-3 with a traffic simulator, such as
 - Simulation of Urban MObility (SUMO)
 - Multi-agent Microscopic Traffic Simulator (MMTS)

ns3::RandomWaypointMobilityModel

- This module picks for each node a destination and velocity at random. When the node reaches the destination, it pauses for a specified amount of time and restarts the process.
- Easy to configure:
 - Only parameters: area where to place the nodes, speed range, pause time
- Disadvantages
 - Not much realism (constant speed, random positions, random destinations, does not consider the underlying road network)

SUMO

- SUMO is a microscopic vehicular traffic simulator
- Provides lots of interesting features
 - Can model vehicles, pedestrians and public transport
 - Can import maps, or generate custom road networks
 - Can model car following models and inner junction traffic
 - Gas emissions, traffic light frequency, etc
- Disadvantages
 - Steep learning curve
 - Can potentially take long time to configure since many details can/have to be specified
 - The user documentation consists mainly on its wiki
 - The SUMO architecture consists on a number of small programs that comprise the SUMO suite
 - Need to know, and possibly configure and run each tool to maximize realism

Using an external Information Service

- Synthetic mobility models in ns-3 are relatively simple and straightforward to use
 - However, they suffer from a low degree of realism.
- Full-fledged traffic simulators such as SUMO are more realistic
 - Time-consuming configuration
 - Easy to misconfigure / need expertise in vehicular traffic simulation
- We propose to distill data from travel planning services into mobility directives
 - We built a prototype that makes use of Google Maps API

Why Google Maps API?

- The Google Maps Web Services are one of the main core products of Google and provide geographic data for applications
 - Good support to developers
 - Feature rich
- We propose to use two APIs in particular:
 - Directions API
 - This API retrieves direction information between two locations
 - Places API
 - This API retrieves real world places (restaurants, hospitals, etc) around a given real world location

ns3::RoutesMobilityModel

- What it is
 - An interface to request directions between two (or more) points from external services, and parse them into a ns-3 mobility
 - A trade off between complex traffic simulations and easy (unrealistic) synthetic mobility trace generators
- What it isn't
 - A full-fledged traffic simulator for ns-3
- Currently, implemented for Google Maps only
- Can function online (contacting external service) or offline (importing travel plans from filesystem)
- Allows to select transportation method (driving, walking, cycling and public transportation)
- Allows to specify a departure time
 - Especially important when modeling public transportation

Visual comparison

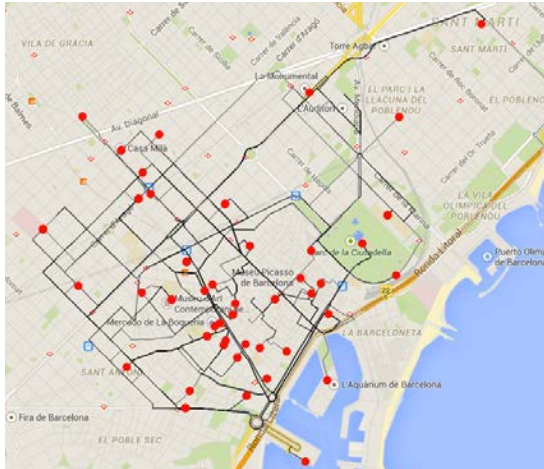


Figure 1 – RoutesMobilityModel

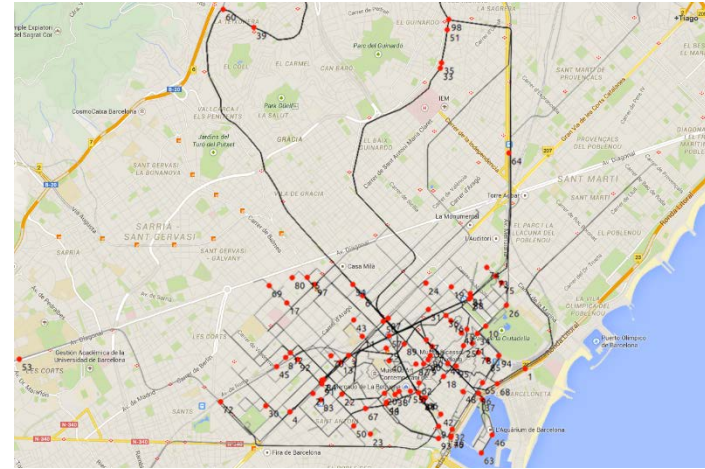


Figure 2 – SUMO

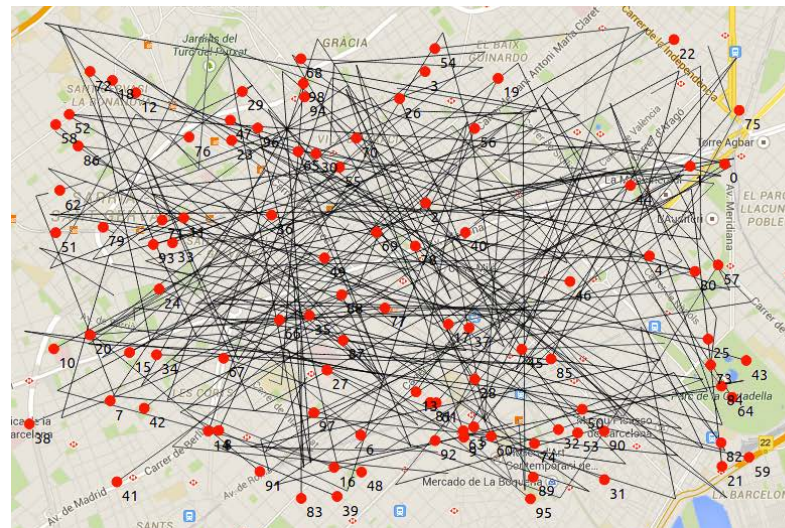


Figure 3 – RandomWaypointMobilityModel

Configuration complexity comparison

```
MobilityHelper mobility;  
//Assign initial random positions  
ObjectFactory pos;  
int64_t streamIndex = 0;  
pos.SetTypeId ("ns3::RandomBoxPositionAllocator");  
pos.Set ("X", StringValue ("ns3::UniformRandomVariable[Min=0.0|Max=4600.0]"));  
pos.Set ("Y", StringValue ("ns3::UniformRandomVariable[Min=0.0|Max=3000.0]"));  
pos.Set ("Z", StringValue ("ns3::UniformRandomVariable[Min=1.0|Max=2.0]"));  
  
Ptr<PositionAllocator> pAlloc = pos.Create ()->GetObject<PositionAllocator> ();  
streamIndex += pAlloc->AssignStreams (streamIndex);  
//Configure the speed and the pause time  
std::stringstream ssSpeed;  
ssSpeed << "ns3::UniformRandomVariable[Min=0.0|Max=" << 11.2 << " ]";  
std::stringstream ssPause;  
ssPause << "ns3::ConstantRandomVariable[Constant=" << 5 << " ]";  
mobility.SetMobilityModel ("ns3::RandomWaypointMobilityModel",  
                           "Speed", StringValue (ssSpeed.str ()),  
                           "Pause", StringValue (ssPause.str ()),  
                           "PositionAllocator", PointerValue (pAlloc));  
  
mobility.SetPositionAllocator (pAlloc);  
//Install the mobility to the nodes  
mobility.Install (nodes);  
streamIndex += mobility.AssignStreams (nodes, streamIndex);
```

Figure 4 – ns3::RandomWaypointMobilityModel configuration

```
MobilityHelper mobility;  
  
mobility.SetMobilityModel ("ns3::WaypointMobilityModel");  
  
mobility.Install(nodes);  
  
RoutesMobilityHelper routes (41.306717, 2.119782,0);  
  
routes.ChooseRoute(nodes,41.385329, 2.179434,2000);
```

Figure 5 – ns3::RoutesMobilityModel configuration

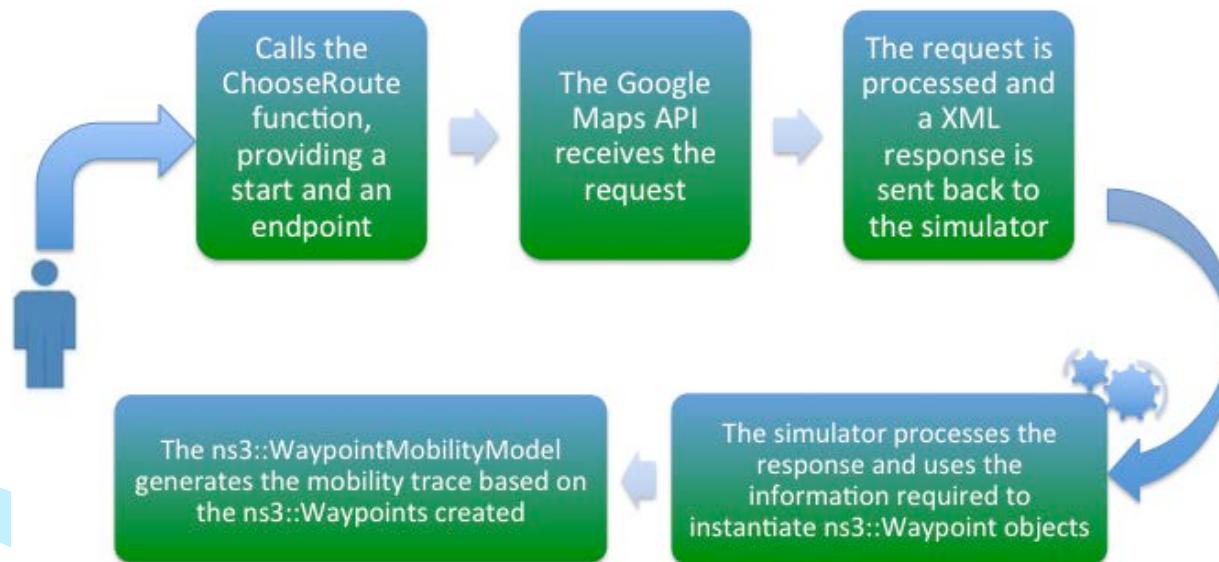
```
Export OSM map  
netconvert --osm-files Downtown\ Barcelona.osm -o dwntwnBarcelona-net.xml  
polyconvert --net-file dwntwnBarcelona-net.xml --osm-files Downtown\ Barcelona.osm --type-file typemap.xml -o DowntownBarcelona-poly.xml  
python /usr/share/sumo/tools/trip/randomTrips.py -n dwntwnBarcelona-net.xml -r barcelona-rand.xml -e 50 -l  
sumo -c config.sumo.cfg --fcd-output sumoTraceBarcelona.xml  
python ../tools/traceExporter.py --orig-ids --fcd-input sumoTraceBarcelona.xml --ns2mobility-output mobility.tcl
```

Each line corresponds to an action, which has got its own configuration file
Some of the files (e.g. typemaps.xml, a basic one is 36 lines) MUST be filled up for each scenario

Figure 6 – SUMO configuration

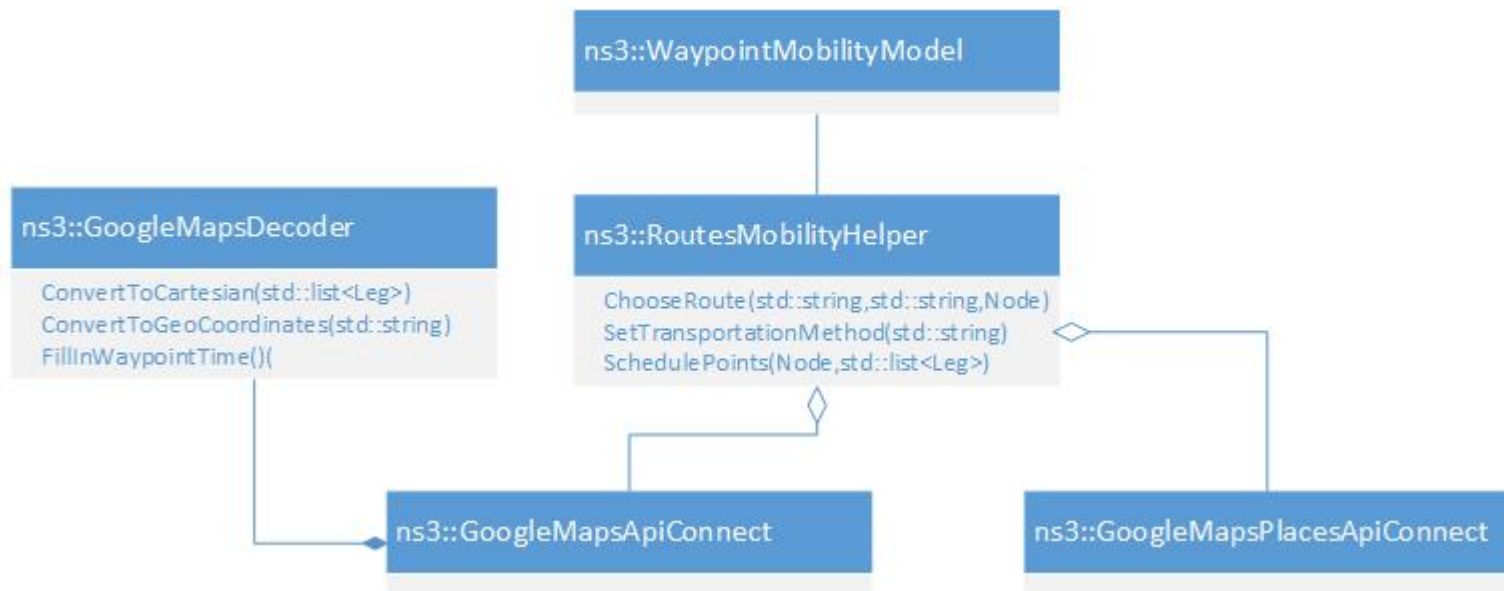
Internals 1/2

- The module was designed to import the routes via `ns3::WaypointMobilityModel`
 - Our module retrieves Geodetic points provided by Google Maps and converts them to Cartesian points, which can then be added to the `WaypointMobilityModel`



Internals 2/2

- The design of the module allows to download travel plans from different services, e.g. OSM
 - Module implemented using the Strategy Design Pattern, to adapt to additional external directions services
 - New strategy to access the service and parse the retrieved travel plan
 - Currently only the Google Maps services are being used



Limitations

- Current release of the module can/will be improved:
 - Only possible to generate mobility for node containers up to 30 nodes
 - Due to a limitation of the Places API
 - The module takes a long time to parse XML responses into mobility for large node containers
 - Still much faster than the execution of any non-trivial ns-3 simulation
 - No serialization is implemented
 - No bidirectional coupling with ns-3 is implemented
 - Currently, mobility impacts on what happens ICT-side
 - We want to allow ICT (car's computations) to lead to decision in changing car's routes
 - Traffic information is not available in the free version of the API

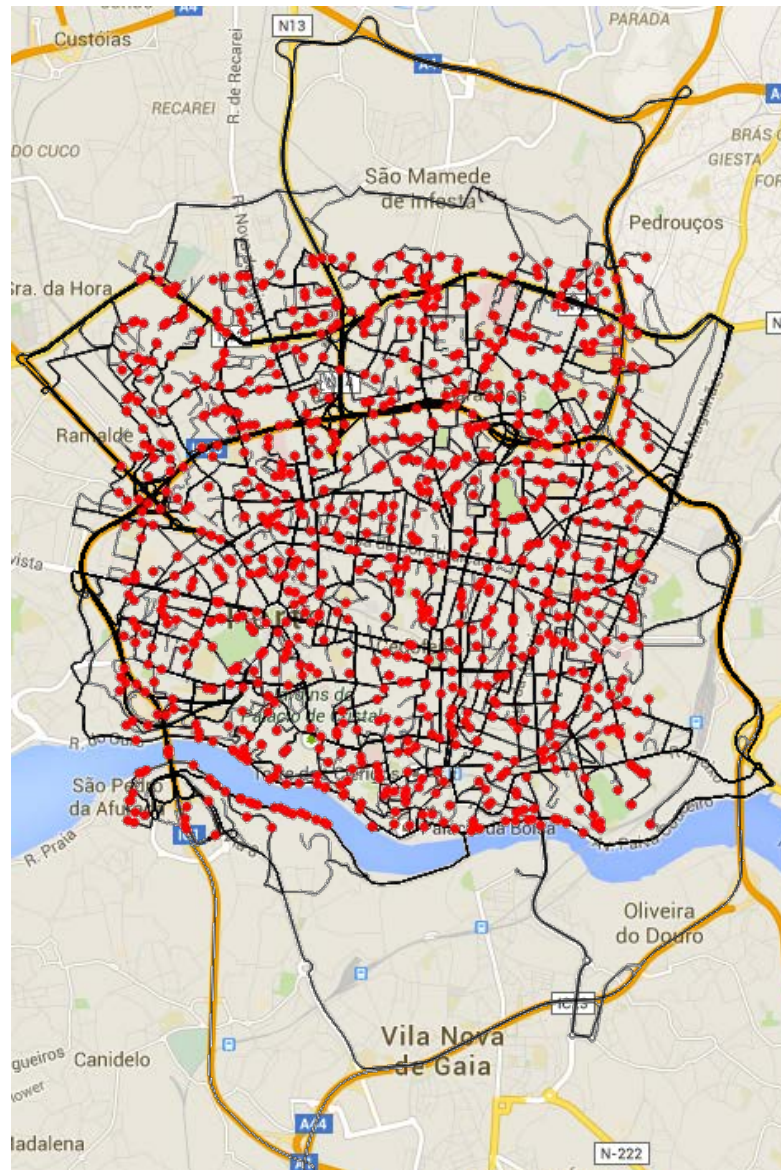
Future/current work

- Removing the 30 node limitation
- Switch from XML to JSON
 - Potential of speeding up the parsing of mobility data
- Implement serialization
 - To allow the user to repeat the simulation using the exact same mobility
- Bidirectional coupling with the simulator
- Thorough evaluation of the module
 - Other metrics
 - Other mobility models

Sneak preview of the next release

- Already available in the repository
 - NOT under review for ns-3 inclusion
 - Will not be included in ns-3's next version
 - Hopefully will be included later on
- The 30 node limitation was removed
 - By combining the 60 places returned by the Places API at random
 - By combining user specified locations at random
 - By randomly choose coordinates in a user specified location
- Serialization
 - In the current release if a user manually downloads a travel plan, the module can already parse it as mobility

Sneak preview of the next release



Thank you for your attention

- Current testing repository

- <https://bitbucket.org/TiagoCerqueira/routesmobilitymodel>

- Wiki

- <https://www.nsnam.org/wiki/RoutesMobilityModel>

- Code review issue

- <https://codereview.appspot.com/176430044/>

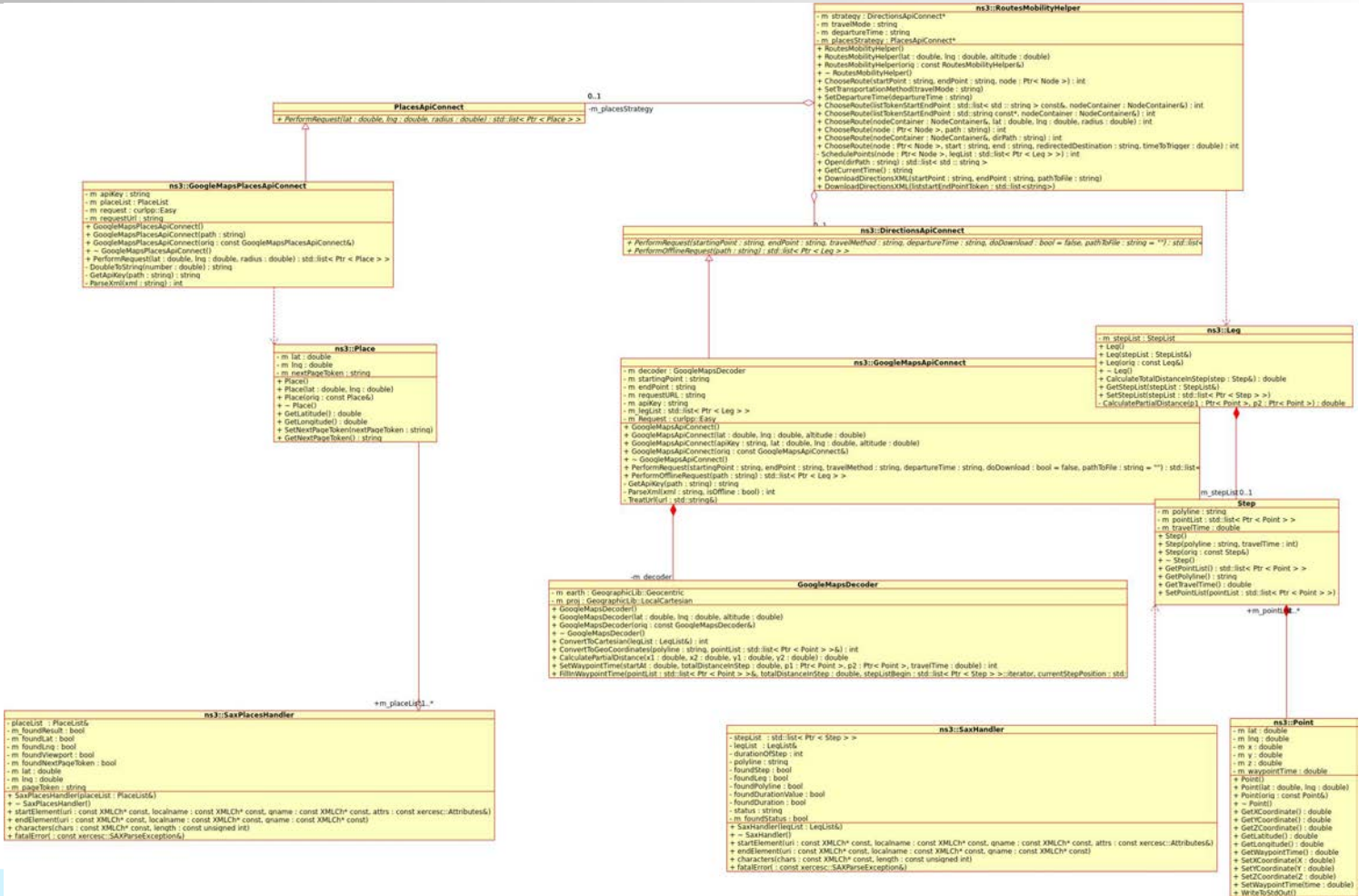
More material

- Both these APIs are free and have usage quotas
 - Directions API
 - 2.500 Directions requests per 24 hour period
 - 2 requests per second
 - No traffic information is available on the free version
 - Places API
 - 1000 requests per 24 hour period, which can be increased to 150 000 requests by verifying the user's identity with a credit card.
 - Unfortunately it's only able to return up to 60 places in any query (despite the fact that there are more locations in that area)

More material

- Caching the API's responses for more than 30 days is a direct violation of the ToS. Because of this, no caching feature was implemented. However, it is possible to load XML responses from the filesystem

More material



MacPhy overhead comparison

- An analysis of the performance of the routing protocol AODV was performed using vanet-routing-compare script, in order to further validate the results
 - Three scenarios where tested:
 - A scenario using the ns3::RoutesMobilityModel on Downtown Barcelona
 - A scenario using SUMO on Downtown Barcelona
 - A scenario using the ns3::RandomWaypointMobilityModel using the same area as the area in the scenarios using SUMO and the RoutesMobilityModel.
- The simulations where ran using 99 nodes, for 300 simulated seconds. The vehicles randomly chose the route to take.

