Simulating LTE Mobility Management in presence of coverage holes with ns-3

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Outline

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• Deterministic Handover Algorithm in ns-3
• Simulation Scenario
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Motivation

• Bringing the network closer to the user is the key to achieve 1000x.
• Ultra-dense deployment of Small Cells everywhere.
• Indoors and outdoors, on lampposts and at all possible venues, residences and enterprises.
• User deployed and Operator deployed.
• Mobility management will become more challenging.
• Simulating challenging propagation scenarios could help us to study and design better mobility management solutions.

Source: METIS/D6.2, Initial report on horizontal topics, first results and 5G system concepts
Obstacle model in ns-3

- Building model can’t be used to simulate obstacles.

- Obstacle model enhancement to ns-3
  - Method to check the intersection between a line segment and a 3D Box (ns3::Box::IsIntersect)
  - Implementation of ObstaclesPropagationLoss model (inherited from ns3::PropagationLossModel)
  - Obstacle shadowing loss is modeled as an additive loss using the ns-3 chaining of propagation loss models.
    - e.g., OkumuraHata + Obstacle path loss

- Implementation of chaining for path loss models in LTE module of ns-3.
Obstacle Path Loss Model

New features

PropagationLossModel

ObstaclePropagationLossModel

Buildings

Box

DoCalcRxPower(txPower, MobilityModel a, MobilityModel b);

Building::IsIntersect(Pos_a, Pos_b)

Box::IsIntersect(Pos_a, Pos_b)

if(intersect)
    loss = loss + m_ObsLoss
Deterministic Handover Algorithm

Handover Algorithms in LENA-LTE module of ns-3

- X2-based handover procedure
- Event-based handover triggering
  - E.g., A1, A2, A3, A4, A5
- Three built-in state-of-the-art handover algorithms
  - Handover is always triggered to the same target base station when facing the same handover conditions.
- Implementation of deterministic A2-RSRP handover algorithm
  - i.e., Trigger handover to the user defined target cell id to evaluate the performance of different handover algorithms for each possible target eNB.
Deterministic Handover Algorithm

Event A2 Triggered?

Yes

EvaluateHandover

No

Neighbour available?

Yes

Choose neighbour with max-RSRP

No

Is TargetCellid assigned?

Yes

Choose user defined neighbour

New feature

No

Trigger handover

End
# Simulation Scenario

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>System bandwidth</td>
<td>5 MHz</td>
</tr>
<tr>
<td>Inter-site distance</td>
<td>500 m</td>
</tr>
<tr>
<td>Simulation area</td>
<td>2000x2000 m²</td>
</tr>
<tr>
<td>Number of eNBs</td>
<td>3</td>
</tr>
<tr>
<td>eNB Tx Power</td>
<td>46 dBm</td>
</tr>
<tr>
<td>Number of UEs in system</td>
<td>3</td>
</tr>
<tr>
<td>Velocity of UE1</td>
<td>16.667 m/s</td>
</tr>
<tr>
<td>Path Loss Model</td>
<td>Cost231 + ObstaclePathLossModel</td>
</tr>
<tr>
<td>eNB height</td>
<td>30 m</td>
</tr>
<tr>
<td>Obstacle height</td>
<td>35 m</td>
</tr>
<tr>
<td>File size</td>
<td>15 MB</td>
</tr>
<tr>
<td>Number of runs for each target</td>
<td>200</td>
</tr>
</tbody>
</table>

![Simulation Diagram](image)
Results

- SoTA handover algorithms neglects the actual perceived QoE of the user after the handover.
- Strongest neighbor is not always the best choice.
- Handover to eNB3 in the range of \([0^\circ,-30^\circ]\) has decreased
  - Average download time by 19.5 %
  - Number of incomplete downloads from 46.15% to 15.3%
Summary

Outcome:

• An obstacle and a path loss model has been implemented using ns-3 Buildings and PropagationLoss models.
  • The model is not only specific to LTE module.
• A deterministic handover algorithm for the evaluation of different handover algorithms.
• An interesting LTE mobility management scenario in presence of an obstacle.
• Code is submitted to ns-3 review process and available at https://bitbucket.org/zoraze_cttc/ns-3-dev-obstacle

Future work:

• Design of a smart handover algorithm based on machine learning techniques to guarantee the best user’s QoE.
• More heterogeneous scenarios, i.e., more UEs and more eNBs.
Thanks for your kind attention!

- Questions?

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Neural Network based handover Algorithm
Preliminary Work

Machine Learning based Handover Scheme for improved QoE.

Platform Used:
• LENA LTE-EPC Network Simulator
• R

Neural Network Input
• UE measurements (RSRP, RSRQ)

Neural Network Output
• Probability of successfully down-loading a file (NN1)
• File download time in seconds (NN2)

The proposed two level Neural Network Scheme
## Results

Comparison of handover schemes for $[-30^\circ, 0^\circ]$  

<table>
<thead>
<tr>
<th>Handover Schemes</th>
<th>Completed Downloads (%)</th>
<th>Avg. Download Time (Sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOTA</td>
<td>54.48</td>
<td>50.51</td>
</tr>
<tr>
<td>Proposed</td>
<td>95.37</td>
<td>42.51</td>
</tr>
<tr>
<td>Optimal</td>
<td>100%</td>
<td>42.39</td>
</tr>
</tbody>
</table>
Results