RaLaNS

A Ray Launching Based Propagation Loss Model for ns-3

Thomas Hänel, Alexander Bothe, Nils Aschenbruck
1. Introduction
2. RaLaNS
   Related Work
   System
   Contribution of Effects
3. Node Placement
   Related Work
   Metric: SPNE
   Case Study
4. Conclusion & Future Work
• Wireless communication mainly in urban areas
• Many algorithms & evaluations assume circular ranges → significant differences in reality
• Multi-hop node placement strategies in the face of realistic radio wave propagation
1. RaLaNS – a ray launcher that integrates with ns-3
2. SPNE - a new metric for the evaluation of node placement strategies
3. A case study showing the impact of ray launching on node placement strategies
Related Work – Ray Launcher

• Several for visible light
• RaPSor from University of Poitiers
• Photon from RWTH Aachen [Schmitz & Wenig, 2006]:
  • Integration with ns-2
RaLaNS - System

- Rays only once per transmitter position
- Antenna simulation requires small changes
- Calculation energy-based
RaLaNS - Effects

- Ray update in Monte-Carlo scheme
- Values for a brick wall at 2.4 GHz from [Landron et al., 1993]
- Number of rays remains constant
- Assuming one material for all walls, as data is usually not available

\[ p_{\text{scatter}} = \frac{s}{s + r} \]
\[ p_{\text{reflect}} = \frac{r}{s + r} \]
\[ e_{\text{out}} = (s + r) \cdot e_{\text{in}} \]
• Diffraction calculation based on [Stephenson & Svensson, 2007]
• Idea: distribution behind edge similar to slit
• Only calculate if $a < 7 \cdot \lambda$
RaLaNS – Contribution of effects

- Setting all other probabilities to 0 for single effects
- Reflection & diffraction stronger but less homogeneously
- Effects strengthen each other
• Signal strengths for all possible transmitter-receiver-combinations in an area
• Small scale fading from interference or separate empirical model
Node Placement:
- Optimize wireless network
- Coverage
- Connectivity

Related Work:
- Grid-Pattern [Kar & Banerjee, 2003]
  - Low Overlap & Interconnected
- Hierarchical structures
- High-level metrics such as energy efficiency
→ All based on circular communication range
Node Placement – SPNE (Scanning Probe Network Efficiency)

- Scan area with probe
- At each position send packets to probe

\[ SPNE = \frac{1}{s} \sum_{cells} r_{cell} \]

\( r_{cell} = \text{number of packets received in a cell} \)

\( s = \text{number of sent packets} \)
Node Placement – Case Study

- Iteratively place nodes on crossroads based on distance, signal strength, and random
Node Placement – Case Study

- Grid placement superior with Friis
- Crossroads placement superior with RaLaNS
Conclusion & Future Work

Conclusion:
• New ray launcher for ns-3
• Decomposed influence of effects
• Introduced new metric
• Node placement evaluation significantly depends on propagation

Future Work:
• Evaluate required level of details in maps
• Advanced node placement strategies
• Further scenarios

Source available at:
http://sys.cs.uos.de/RaLaNS
Appendix - Calculation Time

\[ O(n) \text{ for polygons} \]
\[ O(n) \text{ for rays} \]
\[ O(n) \text{ for transmitters} \]
\[ O(n) \text{ for receivers} \]

BUT: larger maps \( \rightarrow \) more polygons/transmitters/receivers
Appendix – Multi Path

Free area

Street with buildings