Evaluating Communication Models on Mobile Robots

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Introduction
Mobile robots can work cooperatively to explore areas, gather information, and complete tasks with minimal human control, e.g., search and rescue.

The robots need reliable, adaptive, and self-organizing communication networks to complete their tasks efficiently and timely.

This project aims at evaluating different propagation loss models, in different network environments i.e. inside building and outside the building (urban area).

Background
- Robot Operating System: It is an open source OS which provides libraries and tools to create robot applications.
- Gazebo-ROS Simulator: It is a simulator to effectively simulate robot in complex indoor and outdoor environments.
- Network Propagation Models: Different network models exist to predict path loss in different conditions.

Model

Log Distance Propagation Model:
Received signal strength is a logarithmic function of distance as shown in Fig. 1.

It is a model which predicts path loss the transmitting signal encounters inside the building and outside in open spaces in populated areas over distance.

\[ PL_d = PL_{d_0} + 10n \log \left( \frac{d}{d_0} \right) \]

\[ RxPower = TxPower - PL_d \]

where, \( n = \) Path Loss Exponent,
\( d_0 = \) Reference distance, and
\( PL_{d_0} = \) Reference Loss at \( d_0 \)

The value of \( n \) depends on the environment.

<table>
<thead>
<tr>
<th>Environment</th>
<th>Path Loss Exponent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Space</td>
<td>2</td>
</tr>
<tr>
<td>Urban area</td>
<td>2.7 to 3.5</td>
</tr>
<tr>
<td>Inside Building</td>
<td>4 to 6</td>
</tr>
</tbody>
</table>

Results

The figures below show results with 25 mobile robots with starting position in 5x5 grid with \( \Delta x \) and \( \Delta y \) of a unit distance. Robot transmitting data is at (0, 0) and robot receiving data is at (4, 4).

Conclusion
- Log Distance Propagation model is the most accurate among different propagation models since it considers environment when predicting path loss
- Path Loss and Packet Loss depended significantly whether environment was inside the building or urban area.

Future Work
The work done can further be extended if, both, gazebo simulator and network simulator are integrated together. Integrating both will give us results which will be observed in real time.

Caching and its replacement policies implemented by each robot to improve sharing of data between robots.