Modeling of Fixed Wireless Access Mesh Networks

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Network modeling and design framework

Objective

Creation of a **network planning algorithm** to define communication links in a **fixed wireless access** mesh network given predefined node locations and bandwidth constraints.

Introduction

The high bandwidths that are available at mmWave frequencies enable fixed wireless access (FWA) applications, in which fixed point-to-point wireless links provide internet connectivity. In FWA networks, one or more fiber point of presence (PoP) nodes connect a wireless mesh network to the wired infrastructure. Two types of nodes are present in the mesh network. **Customer premises equipment** (CPE) nodes are client nodes that connect a household or enterprise to the FWA network, i.e., are the gateway towards the (wireless) local area network. **EDGE** nodes are part of the FWA network, but do not directly connect a client to the network. Instead, they acts as routers. FWA is a cheaper alternative than deploying a fiber optic network, as no digging is required and the infrastructure work is limited.

Figure: Fixed Wireless Access (source: Terragraph)

Goal

The goals of the framework are as follows

1. Characterize FWA networks via a network analysis
2. Create a network planning algorithm

We envision an FWA network operational at the mmWave frequencies, e.g., at 28 GHz using mmWave 5G communication, and at 60 GHz, using the IEEE 802.11ad wireless standard. For the **characterization** of the network, we use the tools from graph theory. Given a dataset, we will investigate distance statistics, clustering and centrality. Furthermore, we will compare an FWA network for an urban environment to a network for a rural environment.
The goal of the **network planning** algorithm is to define where EDGE nodes need to be installed, and which route the traffic needs to take from each CPE device towards a PoP.

Graph data

We use FWA network data generated by the GRAND tool The following input data is used to construct the graph

- Floor plan with house locations and streets
- Physical layer channel model, i.e., to calculate path loss between two nodes
- Antenna location characteristics, e.g., antenna height

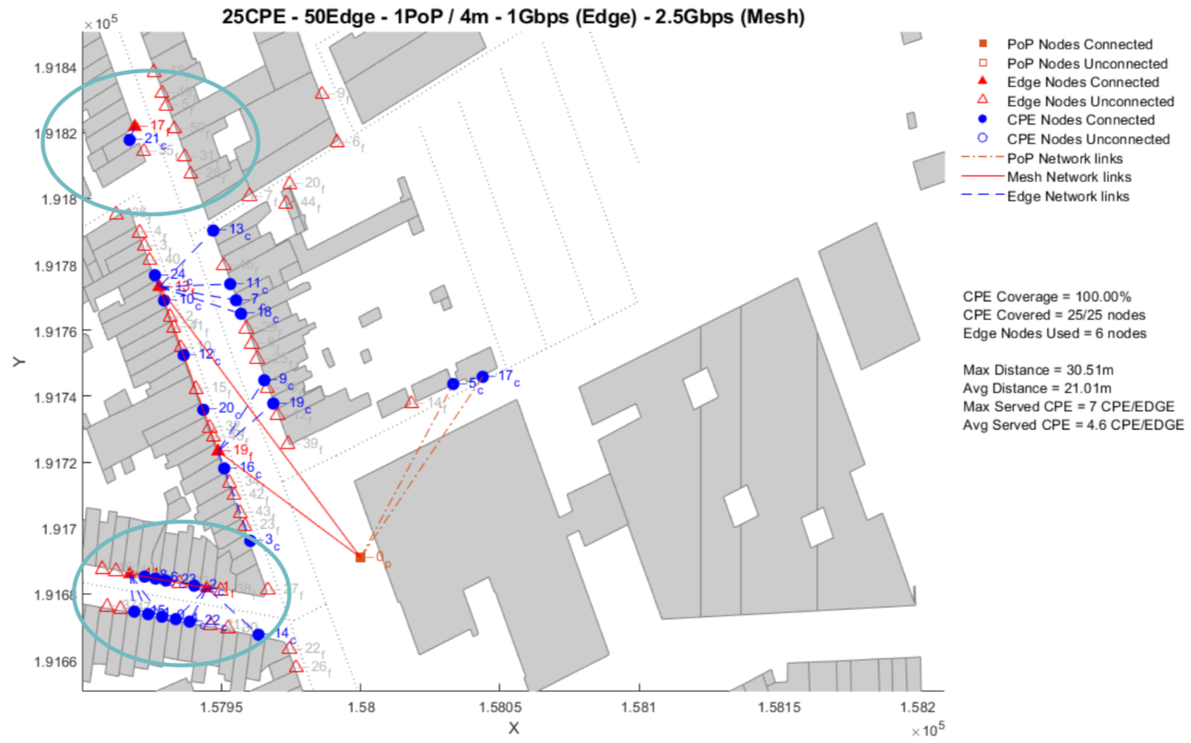

Figure: Example of output graph for single street

Methodology

The output is a graph with EDGE and CPE node locations as vertices. Edges indicate whether there is a reliable communication link between two nodes.
For each EDGE node, a communication path is defined towards a PoP node, based on existing graph theory algorithms. Network robustness is analyzed. The investigated research questions include

- How does the network characteristics change when the underlying physical network chances. For instance, instead of using a 60 GHz physical layer channel model, future FWA networks may use carrier frequencies around 140 GHz.
- Coverage aspect: investigation of tradeoff between number of EDGE nodes and number of PoP nodes to provide a certain coverage
- Comparison of different environments (urban city environment versus rural environment)
- Comparison of the number of network subscribers

Implementation

The implementation of the framework is done in Python, using the following packages:

- iGraph
- Numpy and matplotlib
- pycairo for plotting

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