Blockage-aware Deployment of 60 GHz Millimeter-wave WLANs

Zhicheng Yang†, Parth H Pathak†, Jianli Pan†, Mo Sha†, Huanle Zhang†, and Prasant Mohapatra†
†Dept. of Computer Science, University of California, Davis
‡Dept. of Math and Computer Science, University of Missouri, St. Louis
§Dept. of Computer Science, George Mason University

Introduction

60 GHz millimeter-wave networks have emerged as a potential candidate for designing the next generation of multi-gigabit WLANs. Since the 60 GHz links suffer from frequent outages due to blockages caused by human mobility, deploying 60 GHz WLANs that can provide robust coverage in presence of blockages is a challenging problem [1].

Constraining indoor propagation profile

We propose to use a small set of pilot measurements to sense and construct the indoor layout which includes the relative positions of blocking and reflective objects. Instead of identifying the exact material of the objects, we rely on classifying them into either moderate or strong reflectors based on the measurements. The error in room contour construction compared to the ground truth room layout is captured through Hu Moment Invariants (HMI) [2].

Coverage metric for spatial diversity

![Figure 3: Profiling a concave layout using multiple AP-client location pairs](Image)

![Figure 4: Reflection coefficients of various indoor materials (one line represents one material)](Image)

![Figure 5: Using k-means clustering to categorize the reflection points into strong or moderate reflectors](Image)

We define a new coverage metric, ASC (Angular Spread Coverage), based on the multi-path angular spread property of a millimeter-wave channel. For a given deployment of AP, ASC can quantify (1) the number of major paths available at a client location, (2) the spatial diversity of these paths and (3) the received power of the paths. Using the ASC metric, different AP deployments can be compared before choosing a suitable one.

Complexity of 60 GHz AP/relay placement

The use of relays complicates the deployment where the AP and relay placement should be jointly studied. Hence, we study the MACAR (Maximum Coverage using Single AP And Minimum Relays) problem which provides a joint solution for AP and relay placement in 60 GHz WLANs. We prove that the MACAR problem is NP-hard and provide a greedy strategy for the AP/relay placement. The strategy aims at maximizing the summation of the ASC metric for all client locations using one AP and the minimum number of relays.

Evaluations (cont.)

Traditionally, a coverage metric refers to a binary value representing whether a client location is covered by the AP or not. We refer to this metric as “Binary Coverage” (BC). Two relays are used on an average. MACAR can cover 88% of all possible client locations with at least two spatially diverse paths.

We find that MACAR deployment can guarantee average connectivity of 91.7%, 83.9%, and 74.1% of clients in the presence of 1, 3 and 5 concurrent (human) blockages, respectively. Compared to a deployment that is agnostic of spatial diversity (captured through the ASC metric), MACAR deployment results in an average 25%, 21.6% and 22.6% more connected clients for 1, 3 and 5 concurrent human blockages, respectively.

References

