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Measurement-calibrated Conflict Graphs for Dynamic Spectrum Distribution

(Poster Abstract)

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Abstract—**Building accurate interference maps is critical for performing reliable and efficient spectrum allocation. In this work, we use empirical data to explore the feasibility of using measurement-calibrated propagation models to build accurate interference models. Our work shows that calibrated propagation models generate location-dependent signal prediction errors. Such error pattern leads to conservative conflict graphs that actually improve the reliability of spectrum allocations by reducing the impact of unpredicted accumulative interference.**

I. SUMMARY

The key to a successful spectrum allocation is gaining an accurate understanding of interference patterns among spectrum users. Generating accurate interference models for specific environments, however, is a challenging task. Due to the complex nature of RF propagation, modeling interference in a physical area accurately requires detailed measurements covering all combinations of sender/receiver locations [1], which is impractical for outdoor large-scale networks. Thus many works on spectrum allocation build interference map using simplified propagation models (*e.g.* [2]). While these simplifications ease the process of designing and evaluating allocation algorithms, empirical studies have shown that they produce incorrect interference predictions, leading to large performance degradation [3].

To address these challenges, an attractive alternative is to build interference maps using measurement-calibrated propagation models. Instead of performing exhaustive measurements, we can use measurements at a subset of locations to calibrate a propagation model, and then use the model to predict signal strengths in the area to build the interference model.

In this poster, we report our initial results on the feasibility of using measurement-calibrated models to build interference models such as conflict graphs. Our goal is to understand the accuracy of measurement-calibrated propagation models, and more importantly, how it will ultimately impact the reliability and efficiency of spectrum allocations. Our study uses three datasets from outdoor municipal WiFi networks at three US cities: GoogleWiFi (Mountain View, CA), MetroFi (Portland, OR), and TFA (Houston, TX), among which GoogleWiFi was collected by our own group. These datasets consist of beacon RSS values of WiFi access points (AP) measured in large outdoor areas of size 3-7 km^2, covering up to 78 APs and 27,885 distinct measurement locations.

Methodology. We treat each AP in the datasets as the transmitter of a spectrum user, and any measured location in its coverage area as the potential receiver position. We randomly select a subset of measurements from each dataset, and use them to calibrate four representative propagation models, ranging from the simplest uniform path loss model to sophisticated models that incorporate terrain features like buildings and streets.

Using the predicted signal strength maps from these models, we generate (estimated) conflict graphs for each network, and allocate spectrum for each AP using two representative allocation algorithms. We quantify the performance of the measurement-calibrated method by comparing its results with those generated by the entire measurement dataset (which we refer to as the measured conflict graphs). Our evaluation includes *graph level analysis*, in which we analyze the similarity between the estimated and measured conflict graphs, and *end-user performance*, in which we evaluate the reliability and efficiency of the spectrum allocation results using both the estimated and measured conflict graphs.

Findings. Our evaluation leads to the following findings. *First*, calibrated propagation models generate location-dependent signal prediction errors. They are more likely to underpredict the signal strengths received at short distances, and overpredict them for long-distance links. These prediction errors lead to conservative conflict graphs that rarely miss actual conflict edges, but commonly introduce extraneous conflict edges. *Second*, the estimated conflict graphs produce conservative spectrum allocations with up to 25% loss in utilization compared to the measured conflict graphs. However, surprisingly, we find that their extra edges actually serve to reduce the artifact of accumulative interference, whose impact is underestimated in previous studies. As a result, the location-dependent prediction pattern ultimately leads to more reliable links than that using measured conflict graphs. *Finally*, we propose a graph augmentation technique that addresses the accumulative interference.

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