Popping no-coverage bubbles in citywide WiFi networks

By Glenn Fleishman | Published: October 01, 2008 - 10:25PM CT

A Rice University graduate student working with advisors at his institution and Hewlett Packard developed and tested a technique that could dramatically improve how outdoor, metropolitan-scale WiFi networks are planned and deployed, while also reducing the cost and time involved in getting a network's footprint right.

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PhD candidate Joshua Robinson developed predictive techniques for where dead zones would occur in WiFi networks. His work allows the use of simple two-dimensional terrain, or zoning maps, with relatively little detail as a starting point, and, for a deployed network, can increase accuracy with only a few measurements per square kilometer to produce surprisingly spot-on data about where holes exist.

Robinson also found that he could predict with definable accuracy how well varying densities of WiFi nodes—the number of radios hung in a given area, on average, from utility poles or other locations—would result in dead zones.

The work described in "Assessment of Urban-Scale Wireless Networks with a Small Number of Measurements" presented at the MobiCom '08 conference, run by the Association for Computing Machinery (ACM), relies on analyzing the terrain of an area and then dividing coverage up into radiating sectors that have relatively similar characteristics. In practice, the number of these sectors can be reduced or increased to improve accuracy.

Dead bubbles in a sea of WiFi froth

Dead zones are the curse of city-wide Wi-Fi, as evidenced in the complaints by users of many of the earliest and largest of those networks. Robinson and his advisor's paper, released earlier this week, documents that some dead zones were as small as 10 meters in diameter with access available just beyond the perimeter—almost like bubbles of no access within a froth of WiFi.

His results defy some conventional wisdom, which says that more nodes mean better coverage. In 2005, metro-scale WiFi network equipment makers often said 20 to 25 nodes per square mile were needed; by 2007, that number had risen in practice to 40, to even 70, to ensure both seamless outdoor coverage and indoor coverage using a wireless bridge with a signal booster.

Rather, Robinson found in examining Google's free Mountain View WiFi network, above a certain low node density point, adding nodes has only a tiny, and thus expensive, additive effect in filling in holes. He estimates that quadrupling the current density of roughly 17 nodes per square kilometer would only reduce coverage from 25 percent of the network's area to 10 percent.

These results might explain the failure of many municipally sponsored, privately built networks to please residents. It wasn't that the networks were underbuilt, but that it may simply be impossible to provide the coverage necessary with Wi-Fi in the environments in which they're deployed without spending far too much.

It's not all about the nodes

Robinson told Ars that node density turns out to not be the defining characteristic of whether and how frequently dead zones occur. It's not "just because they didn't put enough nodes out, or they didn't pick the right places," he said. Some dead areas exist "not because there aren't enough nodes around, but because they're just in a bad location for getting a good signal."

Most large-scale WiFi networks are planned using a combination of wardriving-like measurement, terrain and building data, and simulation. Rough ideas are tested with small deployments, and the model corrected. Some planning software allows building material types and vegetation to be noted.

But Robinson thinks quite a lot of this could be done away with, especially for groups like the Technology For All (TFA) network developed by Rice that he's worked on, which brings Internet service to an underserved Houston area. The nonprofit doesn't have the resources to spend tens of thousands of dollars for measurement software or consultant contracts. "I wanted to show that you don't actually need all the complication, you don't need to know what a building is made of, you don't need to know what types of trees there are," he said.

He drove the streets of Mountain View and gathered 35,000 GPS-tied samples, while also collecting 29,000 samples from the TFA network. The two networks have somewhat different characteristics: Rice's Wi-Fi nodes are placed high to avoid obstructions by buildings, but signals pass through substantially more tall trees than in Mountain View. (Robinson and TFA have made these measurements available for download.)

Robinson said he took all these measurements to be able to see how well his model performed, and whether taking many measurements would provide dramatically better results than plugging a 2D map into his model.

In his paper, he notes that more than 10,000 measurements per square kilometer appear to be required to exceed the roughly 80 percent accuracy that can be achieved with his model. Going into the field and taking a few dozen samples per square kilometer and using them to correct his model's data can push accuracy closer to 90 percent.

For now, his approach and tools are more evaluative: estimating and correcting his model to figure out where dead zones are. Robinson said his next paper, already submitted, applies his model to pure planning.

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