BIOGRAPHICAL INFORMATION

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Specific Responsibilities

Joined Telcordia at its founding (as Bellcore) in 1984. Corey Clinger has over 20 years experience in the telecommunication industry specializing in Operation Support Systems (OSS). He has worked extensively on automated support systems supporting the complex challenges facing the optimization, performance, and network engineers. These solutions frequently require the use of GIS technology. He is currently Director of Product Management, RF Optimization Products and has previously held positions in Professional Services (Consulting), Customer Support, and Product R&D.

Educational Information

B.S. – Computer Science and Economics (Double Major) – University of Pittsburgh
M.S. – Applied Mathematics – Stevens Institute of Technology

Professional Memberships

GITA
Institute of Electrical and Electronics Engineers (IEEE)
Association of Computing Machinery (ACM)

Utilizing Mobile Handset GPS and Data Collection in Wireless Network Optimization

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Introduction

The combination of wireless data network capabilities, GPS equipped mobile handsets, and handset based data collection opens the door to a wealth of new information on how a mobile network is actually performing. This information can be used to significantly improve current network planning, monitoring, and optimization tasks. This paper explores what data is currently available and what will be available as next generation wireless network evolve. More importantly, it will discuss why GPS coding of the data collected is key to using existing GIS tools and processes to their full potential.

Within this paper, we will focus on code division multiple access radio networks. This network technology is found worldwide in both W-CDMA (or UMTS) and CDMA networks. A number of the concepts and conclusions in this paper are similar for time division multiple access radio networks such as GSM and TDMA but some of technical reasons are different than the CDMA-based descriptions provided in this paper.

Challenges of Planning and Optimization

The job of a radio planner or performance engineer is a classic case of engineering tradeoffs. While the objective is to maximize the network coverage, capacity, performance, and capital efficiency, these are actually partially competing objectives. For example, the best way to increase capacity is to deploy small cell sizes with little to no interference from surrounding cells. This leads to a network where there are lots of holes in the coverage between cells. To maximize coverage, every cell is set to transmit at full power. This creates lots of interference and results in poor network performance (quality). So, in reality, the job a radio planner or performance engineer is to use good engineering judgment to make the correct tradeoffs to achieve a good balance of all goals. And even this exercise is limited by the reality that the exact position of a user when they make a call impacts every other user within several thousand feet!

How big this challenge is and how much work remains can be clearly seen both from the J. D. Powers and Associates 2004 U.S. Wireless Regional Customer Satisfaction Index (CSI) Study and FCC action. In the J. D. Powers Southwestern survey, only two of the six operator's call quality was rated better than "does not stand out". In setting their 2004 objectives, the FCC added monitoring wireless call quality due to the number of consumer concerns.

Contributing to the quality problem are the tools available to wireless operator's planning and engineering teams. The key software tools available are planning tools, static optimization tools, and network analyzers. The planning tools provide decision support and can be used for "what if" analysis. Static optimization tools automate part of the "what if" analysis. Network Analyzers provide a view in the actual operating data about a network. These are mostly used to fix design problems in the network.

There are two key challenges in network design; the first challenge is that while the science behind planning tools is quite advanced[i], the actual propagation will always be somewhat different from the forecast. The second challenge is the location of a customer when they make a call impacts the network capacity, coverage, and performance experience of every other nearby user. Since during the design of a network this information can not be known the design will always include a number of errors.

One view of an optimization or performance engineer's real job is to continually correct for errors in original design. These errors exist because the customer density and location forecast is never 100% accurate, and errors in the forecast network capacity and coverage are caused by inaccuracies in the radio propagation.

Benefits of actual data – an example

As part of Telcordia's ongoing research and product development efforts, the concept of utilizing actual network data was studied. At the time of the study, actual propagation data was not available, actual traffic information was available. The study presented at ICC 2004 - IEEE International Conference on Communications[ii] showed by optimizing the network with real traffic measurements, capacity gains up to 30% could be achieved. In addition to showing traffic capacity gains, an equally important conclusion is that the continuing change in the customer base and calling patterns requires ongoing optimization.

It is forecast that the benefits of using actual instead of predicted propagation data are at least as great as utilizing actual traffic data. And, because coverage is heavily dependent on radio propagation, optimizing performance and coverage can be done with significantly increased accuracy and greater capital efficiency.

Gathering actual RSSI information

A mobile phone continuously monitors pilot signal strengths from many different sectors to find a strong pilot signal. The proposed approach is to capitalize on the handset capability of continuously measuring received pilot powers form many different sectors. The actual format of the propagation data is received signal strength indication (RSSI). A handset keeps monitoring pilot signals from many different sectors to find a strong pilot signal. A handset actually monitors pilot signals from more than 20 sectors at the same time. The handset frequently monitors pilot signals from the sectors in its active set and neighbor set (minimum supported neighbor set size is 20 for IS-95A and 40 for IS-95B and 3G CDMA systems). The final piece of the puzzle, location, has been solved by the inclusion of GPS capabilities within the phone. Therefore, all required information on RSSI that is needed to improve optimization is readily available inside the mobile handset.

There are two final keys to obtaining the RSSI information from the handset:

- Capturing the information from the working memory of the handset.
- Transmitting the information to a processing system.

Capturing the information has recently become possible due to the opening of the handset platform to applications. The most common such development and execution platform is BREW. In addition to an add-on application, several vendors have announced plans to support gathering of this information as part of their handset management and performance data gathering solutions.

The ability to transfer the collected data to central processing system is now possible given the data network available. These included 1X RTT, EV-DO, and W-CDMA (or UMTS). The final remaining challenge of transmitting just enough data is discussed in the following section.

Challenges and Possible Solutions

The biggest challenge to the successful gathering and usage of phone based RSSI information is the sheer volume of information. Imagine each and every wireless phone collecting all the signal strength information every few seconds. The volume of this data is greater than the transmission capacity of the entire mobile network. Worse, the majority of this data is redundant. To see just how much redundancy there is, just look around any meeting room and realize that every mobile phone would be tracking and sending virtually the same signal information. So, the clear solution is to limit the data collected to “just enough.”

When an RSSI matrix is built for a certain geographical area, the area under study is usually divided into many small areas, called bins. For every bin, we need received pilot powers from many different sectors. To determine the RSSI value for a sector at a bin many RSSI measurement data are collected and its sample mean is used for the estimated RSSI value for the corresponding sector. The number of samples collected should be large enough to claim that the sample mean is the meaningful average of received signal powers from a sector for a bin area.

As the size of a bin is made smaller, the number of total bins for a given geographical area increases, and RSSI data for a bin will be more accurate since the RSSI measurements per sector for the bin will have a smaller variance. However, large number of bins for a given geographical area will require more processing. In general, the size of a bin for an urban area should be smaller than the size of a bin for a suburban area since the variance in RSSI measurement values will be larger in an urban area than in a suburban area. GIS technology can be used to reduce the number of data samples. Utilizing the wealth of land use information, terrain and other factors, a mechanized process can be created to easily determine the optimal bin size for a specific area. The GIS is used to categorize each bin and reduce the number of data points required.

An additional benefit of GIS analysis is to identify areas where the RF planning tool generated RSSI information is likely to be preferred to phone based data. Examples of where the RF planning tool data might be preferred include flat farmland and landfills.

Once the size of the bin is known, the number of samples required to develop a statistically significant set of measurements must be determined. Telcordia has conducted the required research to develop the analytical techniques. This research is beyond the scope of this paper.

Conclusion

This paper has provided an introduction to utilizing mobile phones to collect information on the mobile network operating design. It showed how the collection of actual signal strength information will benefit the process of network optimization. The role of GIS technologies to improve the feasibility of achieving this future vision was also discussed.

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[i] Lee, William C.Y. Leem PhD, "Lee's Essentials of Wireless Communications", McGraw Hill, 1985

[ii] White, R. G., "CDMA Network Capacity Improvements through Operating Parameter Optimization – Analysis and Trial Results", IEEE 2004 International Conference on Communications, June 2004