Optimize wireless networks for end-users

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The introduction of complex data services coupled with the immense growth in voice services have placed critical performance demands on wireless access networks. This situation is complicated by the need for 'all-you-can-eat' pricing to attract existing customers to perform trial on new offerings and to draw customers away from the competition.

Wireless access networks continue to hinder the delivery of these capabilities to the market. To address this challenge, radio technology standards are evolving rapidly. Service providers offering cdma2000 have introduced EV-DO technology and are looking beyond, to the next technology over the horizon.

The rapid evolution of network technology greatly benefits end-users, but at the expense of service providers who must make significant and frequent capital investments to adopt these solutions. In an environment with such frequent churn of infrastructure hardware and software, focusing on the optimal use of existing network infrastructure and minimizing the purchase of additional components are crucial.

Service providers who fail to track the service levels of their competitors may rapidly lose customers to their competition. Those who meet customer needs by over-engineering suffer significant penalties due to excessive capital expenditure and are not able to keep the per-user costs down. Frequent RF optimization is required to best utilize embedded networks, enabling them to provide high QoS with minimum capital investment. RF optimization solutions, such as those of Telcordia Technologies Inc., can provide several benefits (**Figure 1**). After the deployment of new RF power settings, voice quality is improved and call drop rates are lowered. Meanwhile, the load on the network achieves better balance after RF optimization, delaying the need for carrier upgrades.

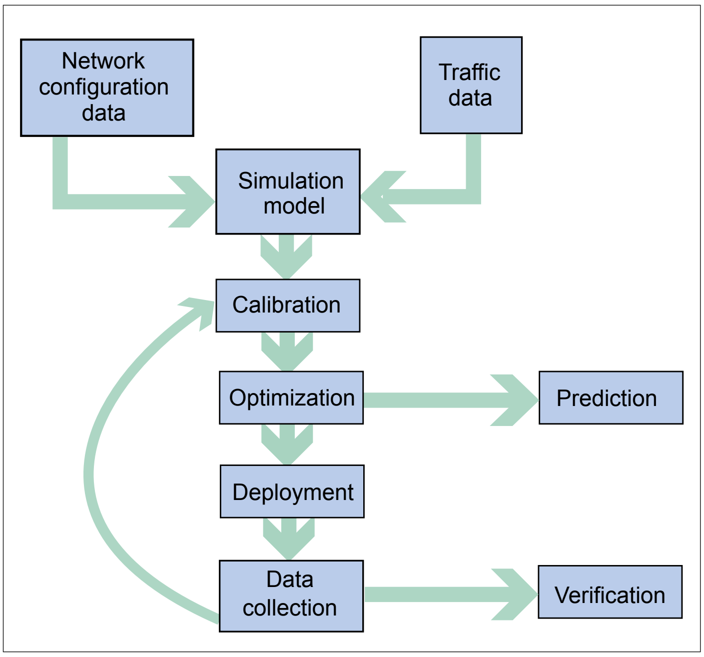

Figure 2: Coupling internal software tools and customer-specific interfaces offers a comprehensive solution for radio network optimization without requiring drive tests or cell site visits.

Network optimization

A proposed solution for RF network performance optimization is shown in **Figure 2**. A combination of internal software tools and customer-specific interfaces offers a comprehensive solution for the optimization of a radio network without requiring drive tests or cell site visits. This solution includes the following components:

Network configuration data—Several inputs to the simulation model are required to accurately represent a live network. Network configuration data is used to track the current equipment deployed in the field. By setting interfaces that directly read the outputs from network management systems, up-to-date network configuration data can be maintained. Likewise, the data can be crossed check to identify areas where it may not be consistent. Network configuration data includes network settings that are not specific to a particular cell site. These include maximum mobile transmit power, antenna-related information, specific information on cell sites (such as the number of sectors channel elements installed), specific information on sectors (such as the number of carriers and their location) and specific information on carriers (such as overhead power settings).

Traffic data—While some solutions can operate from long-term averages that can range to a month, changing geospatial demands placed by highly mobile users require improved granularity of analysis. The proposed solution retrieves traffic data on an hourly basis such that it can be tailored to allow use of traffic data down

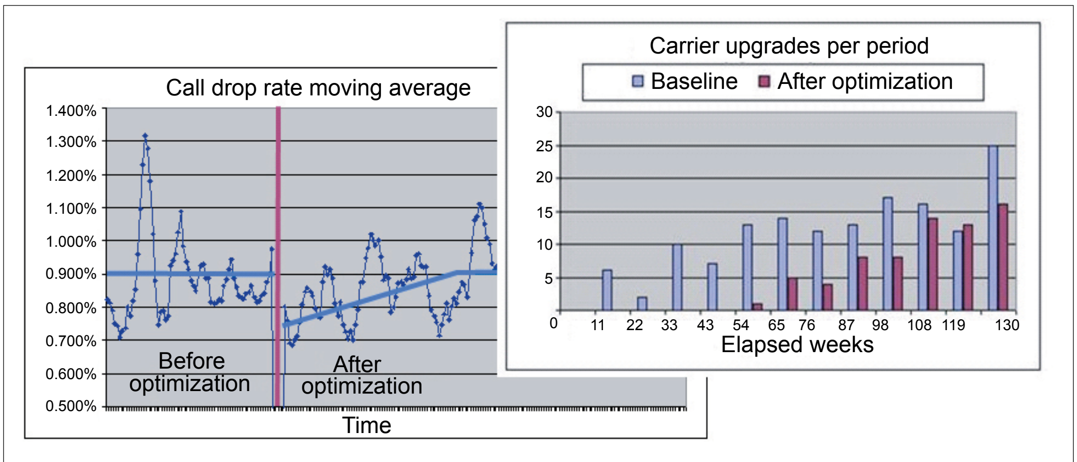

Figure 1: RF optimization solutions can improve call drop rates and delay the need for carrier upgrades per period.

to the hour-by-hour level for environments in which higher levels of aggregation produce ineffective solutions.

Simulation model—Using hourly traffic inputs and daily network configuration data inputs, the simulation model mimics a live network as closely as possible. The detailed software simulation model features:

- Integration of forward and reverse link models into a combined simulation model;
- Vendor-specific carrier assignment; and
- Monte-Carlo techniques which instantiate users and consider separately the SIR requirements, traffic models and level of mobility for each user type.

The simulation core allows the analysis to proceed at a level of fidelity not possible when using general analytical and heuristic approaches.

Calibration—It is necessary to calibrate the simulation model against the actual network to ensure that the simulation's response to network changes accurately reflects the response of an actual live network. This process is time-consuming and requires significant case-by-case insight into the workings of the actual network and the simulation model. The solution discussed here provides automatic calibration in which the simulation adapts itself to more closely resemble the actual network. Simulated metrics are compared against actual measurements from the network. If the measurements do not match within a prescribed tolerance, an iterative adaptive calibration procedure is used to perturb the probabilistic model of network usage.

Optimization—CDMA-based systems such as the current cdma2000 and UMTS networks enable the adjustment of many parameters, but service providers often adhere to the manufacturer's default settings. This is because manual modification of these parameters can produce

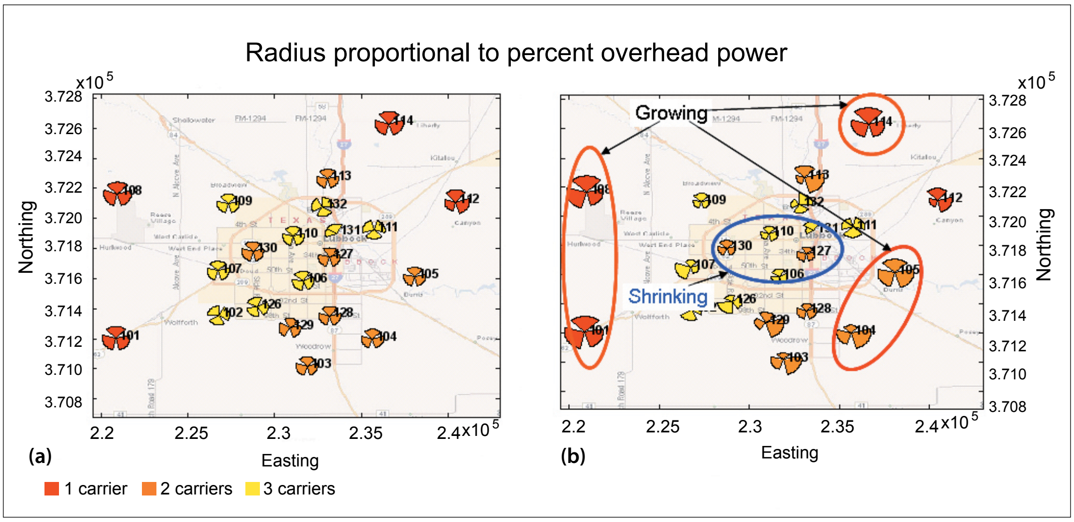

Figure 3a and 3b: Heavily loaded sectors were surrounded by lightly loaded sectors, requiring only one or two carriers (a). Overhead power adjustments were recommended for the region to grow certain sectors while shrinking others (b).

poor network performance, given the complex, non-linear interrelationship between these parameters. The proposed solution computes needed adjustments in RF overhead power to balance the network load in a way that increases network traffic-handling capacity. It does so by shifting the network load from heavily loaded sectors to lightly loaded ones, ensuring that coverage holes are not created in the process. Similar optimization algorithms can also be applied to tilt optimization when the network has remote tilt antennas.

Prediction—The proposed solution provides predictive graphical and tabular reports for the set of recommended RF overhead power adjustments provided by the optimization algorithms. Graphical reports aid in providing visual insight into the consequences of the changes in terms of coverage and service availability. These graphical reports include a best server plot that shows the strongest pilot signal level E_C, another best server plot that describes the chip energy to noise and interference power spectral density ratio E_C/I_O as well as an estimate of locations with available voice services. Tabular reports are used to inspect the proposed changes before they are automatically uploaded into the network. There is a report for each sector, which includes a list of the network parameters extracted automatically from the network management system and used as input to the simulation model. There is also another report for each sector in which overhead channel power modifications are recommended. The latter report includes the values of the pilot, paging and sync channels as they currently exist and as they should be set after deployment.

Deployment—Recommended RF overhead power adjustments can be deployed instantaneously in a network via Deploy and Restore scripts, thus saving the cost of sending field crews to the site. Employing the proposed solution allows these changes to be easily uploaded into the network, enabling the changes to be made more frequently than before. This allows designers to perform network optimization in near real-time to meet temporal changes in the geographic distribution of customers.

Data collection—After the deployment of recommended RF power adjustments, real-time data is collected on the network to verify the results and responses predicted in the simulation model. Several key performance metrics are monitored for this. Using this data, designers can track the period when new RF optimization recommendations are needed. The system also learns from this data such that it can perform better in the next implementation.

Verification—The effectiveness of the recommended RF overhead power adjustments can be analyzed after several weeks of deployment, in which sufficient data has been collected. The proposed solution includes several tabular reports. One report will show the pilot channel power and average power loading before and after the deployment for each sector in which overhead channel power modifications were made and for relevant sectors in the vicinity of those sectors. Another report will tabulate key performance metrics both in the pre- and post deployment periods for each sector in which overhead channel power modifications were made and for relevant sectors in the vicinity of those sectors.

Case study

Using the proposed solution, a trial was conducted for a service provider in a market where several sectors were near carrier exhaust, already using three carriers. A fourth carrier was already planned for the region. In **Figure 3a**, heavily loaded sectors were surrounded by lightly loaded sectors, requiring only one or two carriers. Several overhead power adjustments were recommended for the region to grow certain sectors while shrinking others (**Figure 3b**). Note that a sector is represented as a pie that shrinks or grows proportional to its overhead power setting. In this trial, the deployment of the proposed RF power changes delayed the need for the additional fourth carrier by nine months.