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CROWD SOURCING-BASED TRUE COVERAGE HOLE AND RADIO FREQUENCY ISSUE DETECTION

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ABSTRACT

Techniques are described herein for collecting wireless data from client devices to provide a true picture of a Radio Frequency (RF) coverage model. This is used by the wireless infrastructure (controller) to better optimize the RF coverage model, steer clients to a better network, alert users to coverage holes in their area, and provide historical feedback to users about the quality of coverage in various areas.

DETAILED DESCRIPTION

In hybrid deployments (e.g., 5G, Long-Term Evolution (LTE) / Wi-Fi®) a new spectrum controller can solve the Radio Resource Management (RRM) issue of optimizing spectrum data. However, current coverage hole detections are Radio Access Technology (RAT)-specific (Wi-Fi or cellular) and are based on infrastructure perspective (inter-AP radio reports, and/or view, from the AP, of the client's signal) rather than real-time user perspective. This is a problem in existing systems because different clients experience RF environments in different ways, depending on radio type, receiver (Rx) sensitivity, etc.

Described herein is an approach to locating Radio Frequency (RF) problem areas (including coverage holes) in both pure Wi-Fi and hybrid (cellular and Wi-Fi) deployments by leveraging client-side analytics. As RF dynamics continually change, wireless infrastructure components can have difficulty adapting to optimally cover a space, often leaving coverage holes or areas with poor RF performance. With the increasing importance of network intuitiveness, understanding coverage holes and areas with RF issues needs to take a client-side perspective as compared to the traditional infrastructure driven approach. In turn, the infrastructure can feed back information about prospective RF coverage to a new client before that client enters a difficult area.

A method is presented wherein the controller uses client-side information to improve infrastructure coverage, alert users to areas where there is weak coverage, and apply historical data to learn where the systemic problem areas are. This goes far beyond simply crowdsourcing to gain contextual information; this information is used by the controller for better RF management, radio steering, and feedback to the client devices.

The techniques described herein involve three components: (1) crowd sourcing the client issues (building the client-side perspective); (2) Machine-Learning (ML) based predictive analytics to find problem areas; and (3) proactive actions with client information and suggested radio steering.

When users experience poor wireless performance, the Key Performance Indicators (KPIs) for those clients are reported to a central manager where they are translated into a visual client-side perspective heatmap. The stored parameters are then analyzed using a ML-based predictive algorithm based on both the locations of poor performance and the cause of potential RF issues. If there is a reoccurring issue (e.g., a coverage hole, high retry issues, low Signal-to-Noise Ratio (SNR), etc.) the area is tagged as a problem area for either Wi-Fi or cellular. Subsequently, when future mobile devices approach the same area, notification and proactive radio steering may be used to improve performance for the client.

A first example step involves collecting client radio and contextual data. This invention uses a wayfinding-like concept to discover poorly performing wireless areas and holes in a coverage area using information fed back to the infrastructure from the clients (rather than an infra-only perspective). As clients move throughout an area, their signal is located and their position recorded. They periodically report performance issues that are being encountered (e.g., a high number of retries, poor SNR, declining application quality, etc.). The clients increase their reporting intervals as a function of performance degradation. As the clients report the performance issues, each reported parameter/dimension is stored in a graphical representation of the time-space, similar to a multidimensional temporal heat map. This temporal heat map presents the client's perspective of the network, not the infrastructure's perspective.

This is a method of "crowdsourcing" RF dynamics and performance of the environment. Over time, a consolidated picture of the RF environment is created in a central network manager. This mapping is performed for each RAT for which reporting is enabled on the client (Wi-Fi, LTE, Citizens Broadband Radio Service (CBRS) and/or others), so as to produce a differentiated performance heat map of the spectrum and coverage at each location. This data may be timestamped to model a time-differential coverage structure.

Figure 1 below illustrates a consolidated RF spectrum map (Wi-Fi and cellular), which is created based on client reporting (i.e., a client view of the spectrum).

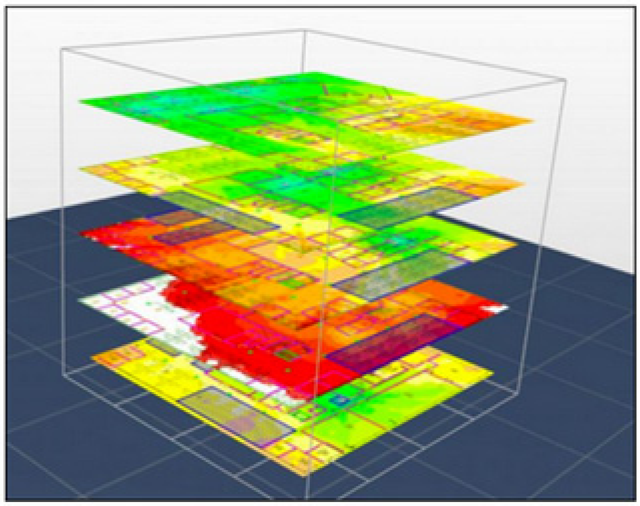

Figure 1

A second example step involves analyzing coverage. Once these client-view RF coverage maps are created, an ML Artificial Neural Network (ANN) is used to analyze various dimensions recorded (e.g., for each RAT, performing regression on the parameters recorded, clustering over the time dimension, and clustering between RATs to compare radio performances). This exposes areas of temporal abnormal performances, but also areas of persisting low performances.

Figure 2 below illustrates a consolidated coverage hole and RF issue classification.

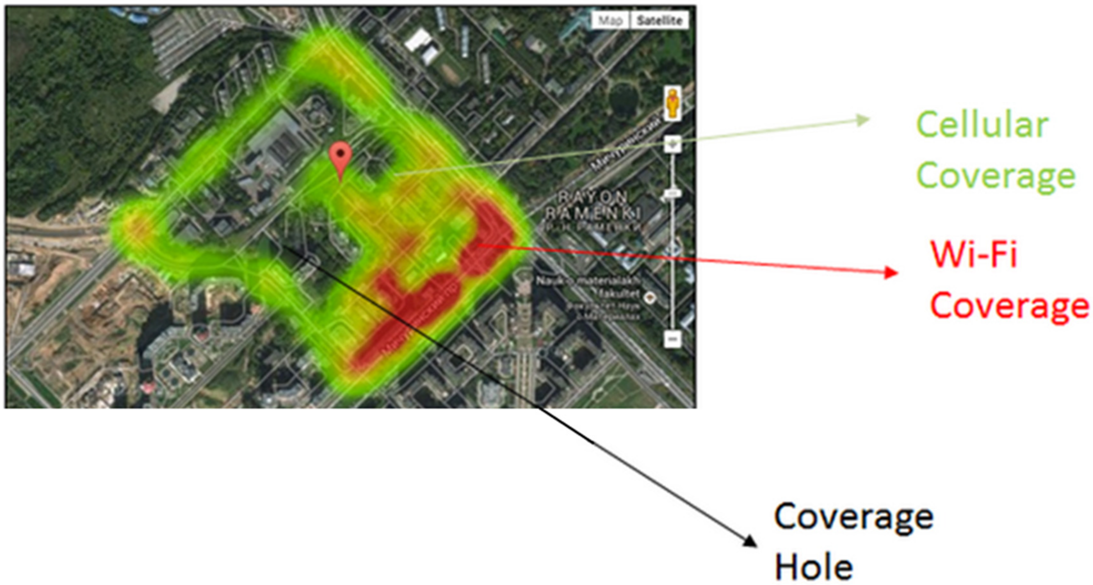

Figure 2

A third example step involves interfacing with client devices. Once coverage holes and problem areas are discovered and tagged by the ANN, the next step is to warn users as they enter these areas and optionally help them dynamically switch from one RAT to the other before they encounter the problem area. As a mobile user begins walking toward an area of poor wireless performance, based on RAT, location, direction, mean speed over interval, etc., the management tool sends a proactive alert to the user telling them that they are approaching an area of performance for their current radio. The warning may be generic or more specific (e.g., "your video is likely to lose resolution," "voice call is unlikely to be maintainable," etc.). Also, the warning may be addressed to the user of the device, or to the client device Operating System (OS). In all cases, when the device has an alternate RAT that has been detected by the system, the infrastructure may also provide comparative performance information (e.g., "voice would likely work on LTE").

Once the mobile device OS has been alerted by the management station (i.e., when messaging is sent to the OS, not to the user), the device can switch dynamically to the alternate radio well before entering the problematic area (e.g., 10-20 seconds before performance problems become noticeable), meaning the user may never even realize that they have entered an area of poor Wi-Fi coverage.

When messaging is sent to the user, the expression of the warning may be performed through direct OS messaging or an application. In both cases, the warning may be richer than RAT information alone. For example, if the client is entering a meeting room, labelled as such on the map, the system may present a list of alternate meeting rooms that are available which have more reliable wireless coverage for the client's current RAT.

Additionally, a historical record may be kept of radio coverage in different areas. The client may be warned of areas that are systemically bad (e.g., "your performance was poor in this location last time," "last time your performance was good here," etc.).

A fourth example step may involve RRM. Today's RRM tools operate completely from the infrastructure's perspective (i.e., APs detecting signals from other APs). By crowdsourcing the radio data from the clients and comparing this information using geolocation (location analytics), a much better perspective of RRM may be obtained than by relying on the APs alone. In this step, the controller analyzes coverage holes and locations with poor RF coverage (from the client's perspective). It may begin adapting the RRM algorithm in an attempt to fill in these holes. As it does so, it continues to receive feedback from any client in this area to determine whether improvements are being made and balance the radio spectrum usage.

A fifth example step involves spectrum sharing/control. Another method of improving coverage is to optimize the spectrum that is being used by the Wi-Fi or LTE/5G network. Once the client-side RF feedback is taken into account, the spectrum may be dynamically adjusted based on the client's perceived demands. For example, if the clients report poor coverage for unlicensed 5G, but Wi-Fi is performing well, a software-defined spectrum controller may integrate the client-side data to adjust spectrum allocation dynamically in the problem areas.

Figure 3 below illustrates ML based next affected user route prediction.

Figure 3

In summary, techniques are described herein for collecting wireless data from client devices to provide a true picture of an RF coverage model. This is used by the wireless infrastructure (controller) to better optimize the RF coverage model, steer clients to a better network, alert users to coverage holes in their area, and provide historical feedback to users about the quality of coverage in various areas.