MISSING NEIGHBOR ANALYSIS

For WiMAX networks

- WIMAX HANDOVER TYPES
- MISSING NEIGHBORS
- HOW TO IDENTIFY MISSING NEIGHBORS

WirelessLogix
E2E Network Solutions

WiMAX MISSING NEIGHBOR ANALYSIS

1. WiMAX Handovers

All mobile wireless technologies require handovers to allow the mobile station to seamlessly change from one base station to another while in a session. The IEEE 802.16e specification was created to address mobility within WiMAX networks. Handovers can be performed for several reasons such as:

- Mobile Station Movement
- Changing Radio Conditions
- Capacity Offloading, and
- To Raise Quality of Service (QoS).

This white paper presents an overview of handovers and how to identify an important system performance issue – missing neighbors. A missing neighbor condition exists when a candidate base station meets the requirements to accept a handover, but the mobile and/or current serving base station do not include the candidate on the neighbor list.

1.1 Mobile WiMAX Handovers Types

In most cases the mobile station will trigger the handover request, but the network, via the base station, may also initiate the handover. Mobile WiMAX supports two types of handovers:

1. Hard Handovers where the original link is broken, a new link is established and then service begins on the new link. This is the simplest type of handover, and

2. Soft Handover where a new link is made and service is transferred before the original link is broken. While this handover type is faster, it is more complex and requires the serving and target base stations to communicate with each other via the core network. Two types of optional soft handover are:

   a. Fast Base Station Switching (FBSS): This is a rapid handover where the mobile station is able to change base stations within a set of base stations without completing the entire network entry procedure, and

   b. Macro Diversity Handover (MDHO): In this type of handover the mobile station has simultaneous communication links to more than one base station for both uplink and downlink transmissions.

In Mobile WiMAX, only the hard handover is mandatory. Fast Base Station Switching (FBSS) and Macro Diversity Handovers (MDHO) are optional.

1.2 Handover Example

The following terms are used to model the network infrastructure involved in a handover and missing neighbor situation. These include:

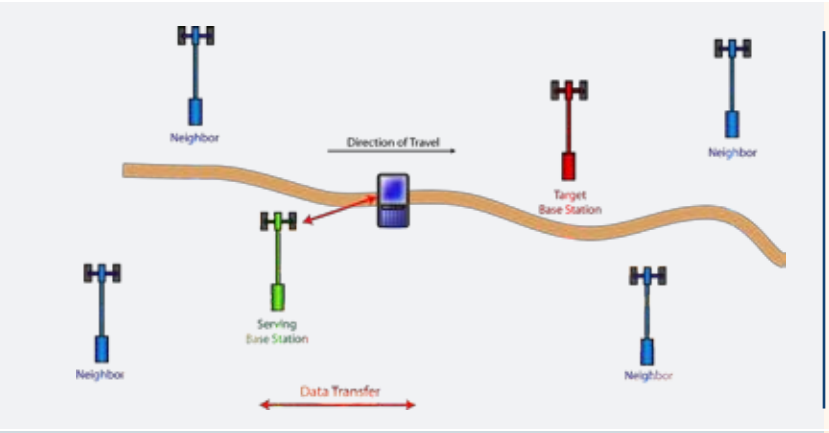
- Mobile Station (MS): The mobile station can be in the many forms such as a handset, laptop, etc.

- Serving Base Station: The serving base station is the base station that is currently communicating with the mobile station.

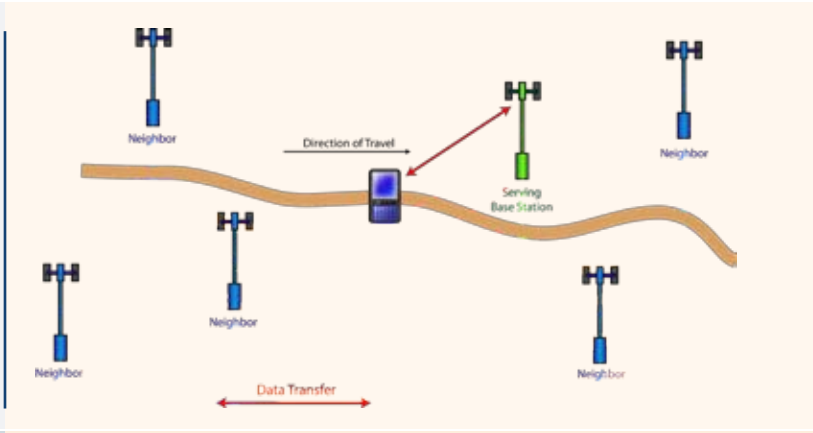
- Target Base Station: The target base station is the base station that will become the serving base station after the handover.

- Neighbor Base Stations: The neighbor base station(s) are any base station within range of the Mobile Station. Unlike other cellular technologies, there is no limit on the neighbor list defined by the network and stored in the mobile station.

As an example, this diagram illustrates a 'before' and 'after' handover scenario. The mobile station is in normal operation and transferring data with the serving base station. The network has transferred a list of potential neighbor sites to the mobile station via the serving base station and the mobile station scans those neighbors and chooses the most promising candidate. This site is labeled as a target base station.



BEFORE HANDOVER SCENARIO



AFTER HANDOVER SCENARIO

The network will define a signal quality threshold to trigger the handover when met. This may be a minimum CINR level, for example. When the mobile station's received CINR drops below the threshold, the mobile "hands-over" to the target base station. This involves a series of communications and messages that are beyond the scope of this white paper.

Once the handover is complete, the target base station becomes the serving base station and the process repeats itself as the mobile transverses the network.

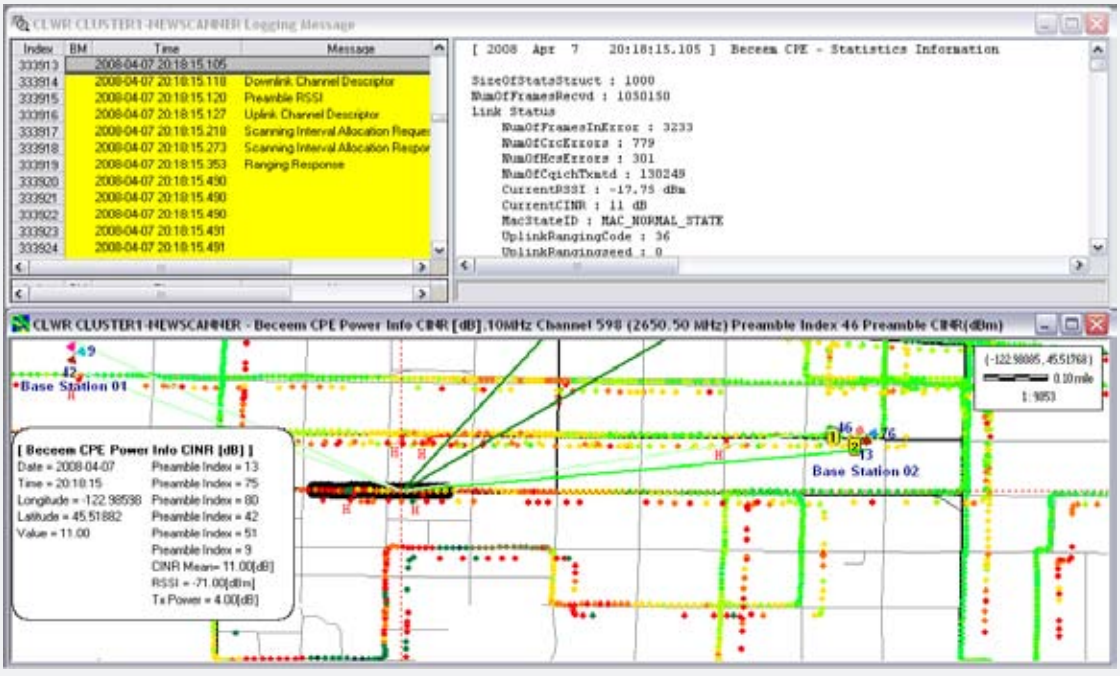
2. Neighbor List

The WiMAX mobile stations need to know the service availability of nearby base stations for immediately pending or future handovers. A list of neighbor sites is broadcast from the serving base station via the Neighbor Advertisement message. The mobile stations will use this list as a candidate list for handovers. The mobile station then scans those base stations to determine the best candidate. A missing neighbor condition exists when a valid candidate neighbor is missing from the neighbor list.

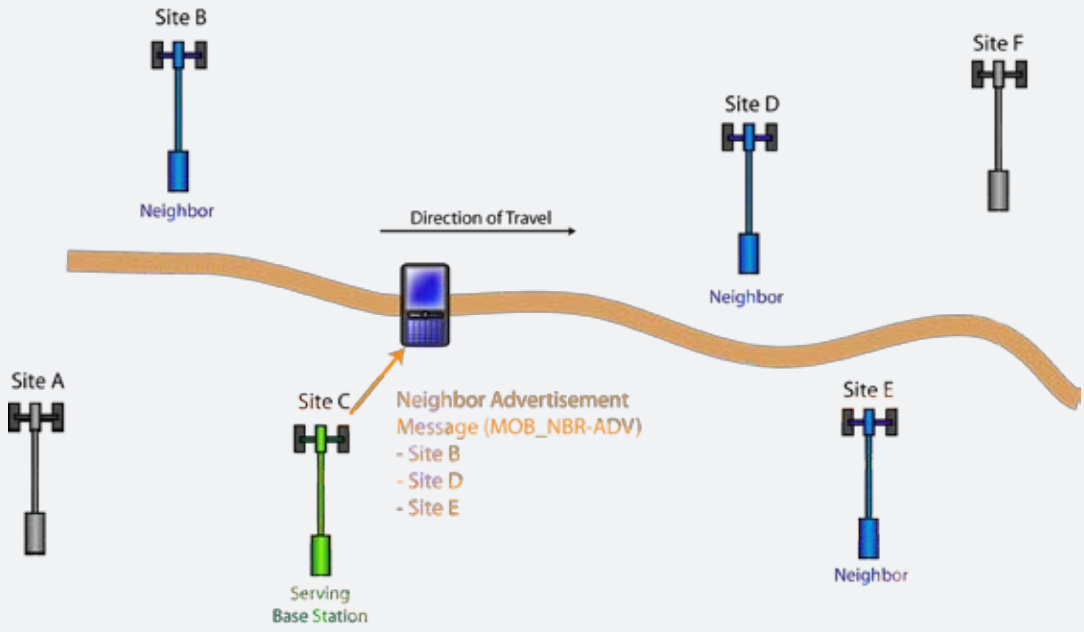
2.1 Neighbor Advertisement Messages

The serving base station broadcasts a Neighbor Advertisement (MOB_NBR-ADV) message at least once every 30 seconds to update the mobile station with the availability of nearby base stations. The serving station will gather synchronization information from the other neighboring base stations over the core network and send this information to the mobile station to assist with ranging and synchronization tasks during pending or future handovers. This helps the mobile station quickly synchronize with the target base station because it removes the need for the mobile station to monitor transmissions from the neighbor stations for ranging and synchronization information.

WirelessLogix XCAL-X collects all messaging from test devices. XCAP-X includes message and table displays to view MAC Management Messages, including Neighbor Advertisement messages. Synchronization tools are useful to identify areas of interest on the map and then synchronize that area for analysis in the messaging window.



The Neighbor Advertisement message includes the number of neighbors defined in the message, the Operator ID, trigger criteria for handover and settings that define what optional information is included. Optional information may include additional handover optimization and quality of service information.



NEIGHBOR ADVERTISEMENT - MOB_NBR-ADV

This diagram helps to visualize the messaging flow between network elements. The first component of a handover involves the mobile station learning about the neighbor base stations in the immediate area via the mobile neighbor advertisement message.

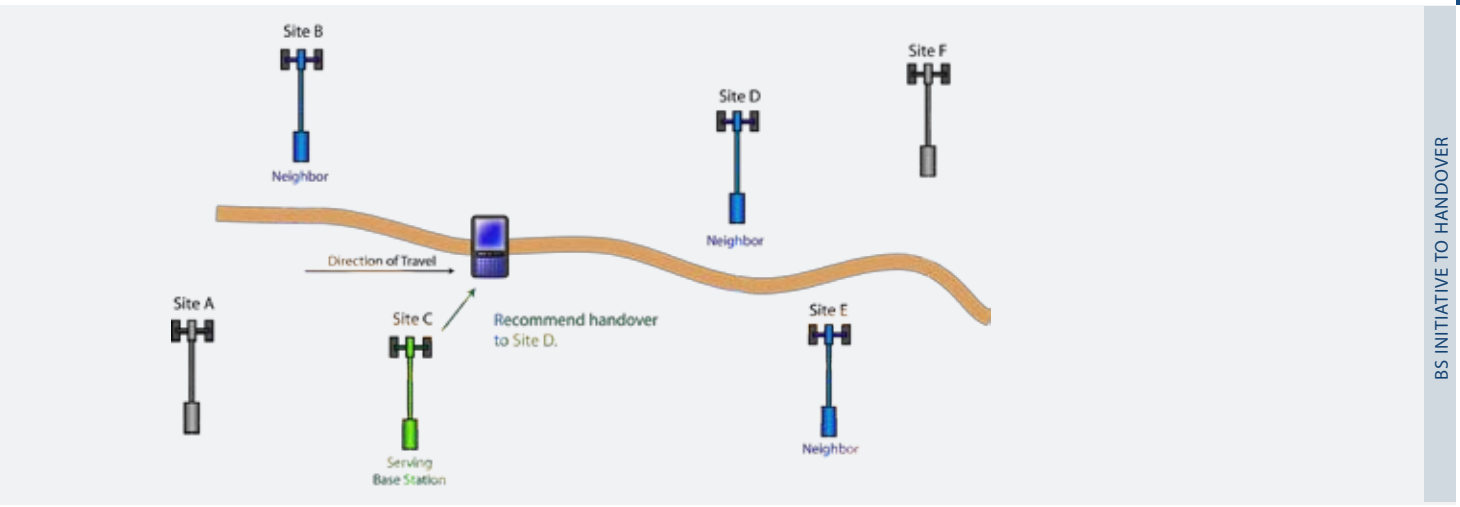
If for example, Site D was excluded from the Neighbor Advertisement message, but was a viable candidate, we would have a missing neighbor condition.

3. Handover Decision and Initiation

Handover requests may be initiated by the mobile station or the base stations.

3.1 Base Station Handover Initiation

Base stations may trigger a handover to offload traffic should the base station approach its capacity limits as determined by loading and the interference due to increase signal level in the area.



When a base station initiates a handover via the base station handover request message (MOB_BSHO-REQ), the base station chooses one or more possible target base stations. This may be done to recommend target base stations to the mobile station to increase expected performance and to ensure mobile station QoS requirements. The serving base station may communicate with the core network to check the available performance of neighboring base stations to assist in the handover process. The mobile station will respond with a mobile handover indication message (MOB_HO-IND) indicating the start of the handover.

If the base station enables the Network Assisted HO support flag in the mobile base station handover request message, the mobile station may handover to any base station among the recommended base stations without notifying the serving base station of a selected target.

While it is recommended that the mobile station handover to a base station defined in the base station handover request message, the mobile station may attempt a handover to a base station that was not included. When this occurs, the mobile station will signal rejection of the serving base station through the handover indication (MOB_HO-IND) message. At that point the base station will reconfigure the neighbor base station list and retransmit the Base Station Handover Response message with a new neighbor base station list.

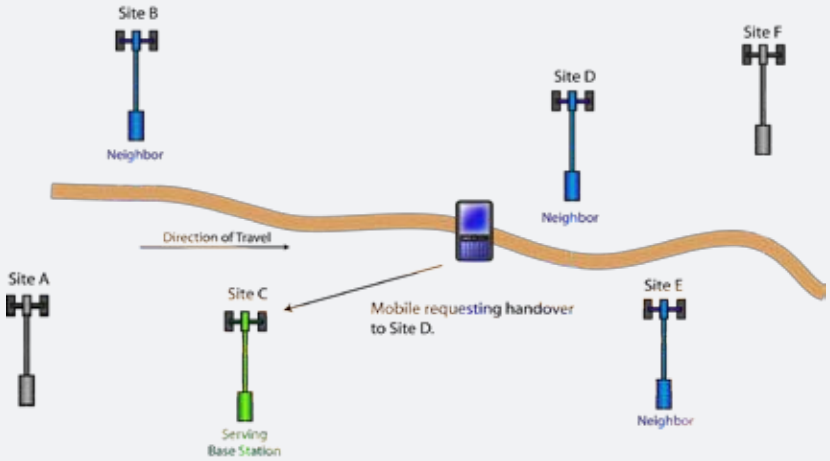
The mobile station has priority in the handover process and the mobile station handover message receives priority over the base station handover messages.

There are several communication paths where viable neighbors may be missed:

- Serving base station fails to receive a message over the core network from a viable candidate neighbor
- Mobile station may alter the neighbor base station list and remove a viable neighbor.

3.2 Mobile Station Handover Initiation

A mobile station may initiate a handover via the mobile station handover request message (MOB_MSHO-REQ) to the base station with one or more possible target base stations.



MA INITIATE TO HANDOVER

The mobile station evaluates the target base station(s) through previously performed scanning activity. The base station will respond with a base station handover response (MOB_BSHO-RSP) message and the handover will commence when the mobile station sends the mobile station handover indication message (MOB_HO-IND).

4. Missing Neighbor Analisys

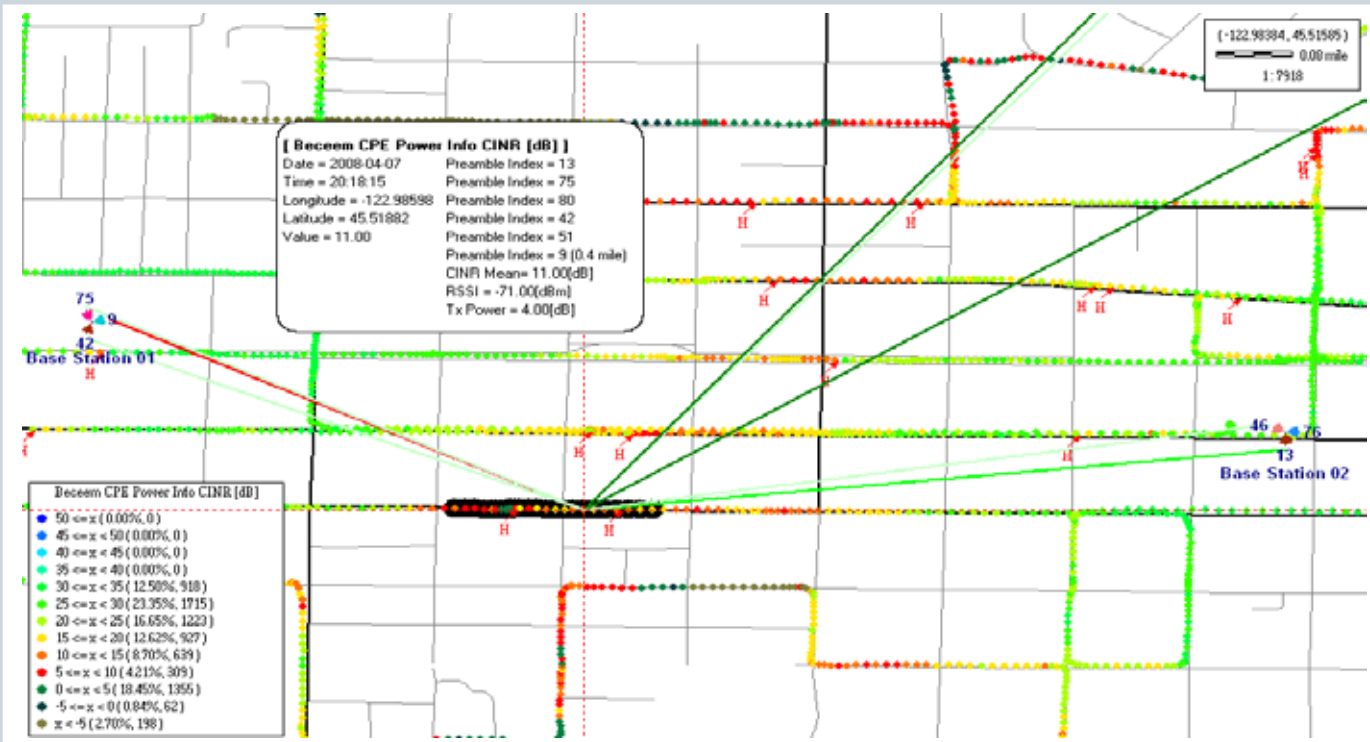
If a mobile station stops communication with its serving base station before the normal handover sequence occurs, it is considered a drop. If a mobile station drops, it can either attempt network re-entry with the target base station through the normal cell reselection process previously described, or the mobile station may resume communications with the serving base station by sending the mobile handover indication (MOB_HO-IND) message with a request to cancel the handover. Failed handovers may be the result of missing neighbors. A missing neighbor condition exists when viable neighbors are available, but not on the neighbor list. Missing neighbors contribute to inefficient use of capital resources due to "ping ponging" or increased levels of signal in an area where the actual serving base station is further than necessary due to missing a handover to a closer neighbor.

4.1 Identifiying Potential Missing Neighbors

One indication of a potential missing neighbor occurs when the received signal from a base station is strong, but the base station does not report that specific neighbor in the neighbor list messages. These areas can be identified using a combination of RF scanning receivers and test mobile devices during a drive test. The RF scanning receiver will record measurement from all base stations in the area and thus provides verification of adequate signal level for candidate neighbors. The test mobile device provides actual handover performance data for the network. In the example below, Wireless Logix XCAP-X analysis software shows the drive route color coded by CINR (dB) values with the location of handovers shown as a red "H" with an arrow pointing to the actual handover location.

The base station locations with sector information including the preamble index for each sector are overlaid on the drive test route. In this case, XCAP-X is configured to display the serving sector with the distance to that sector plus the neighbor candidates.

MAP 1 - Drive Test with Handover Locations



MAP 1 - DRIVE TEST WITH HANDOVER LOCATIONS

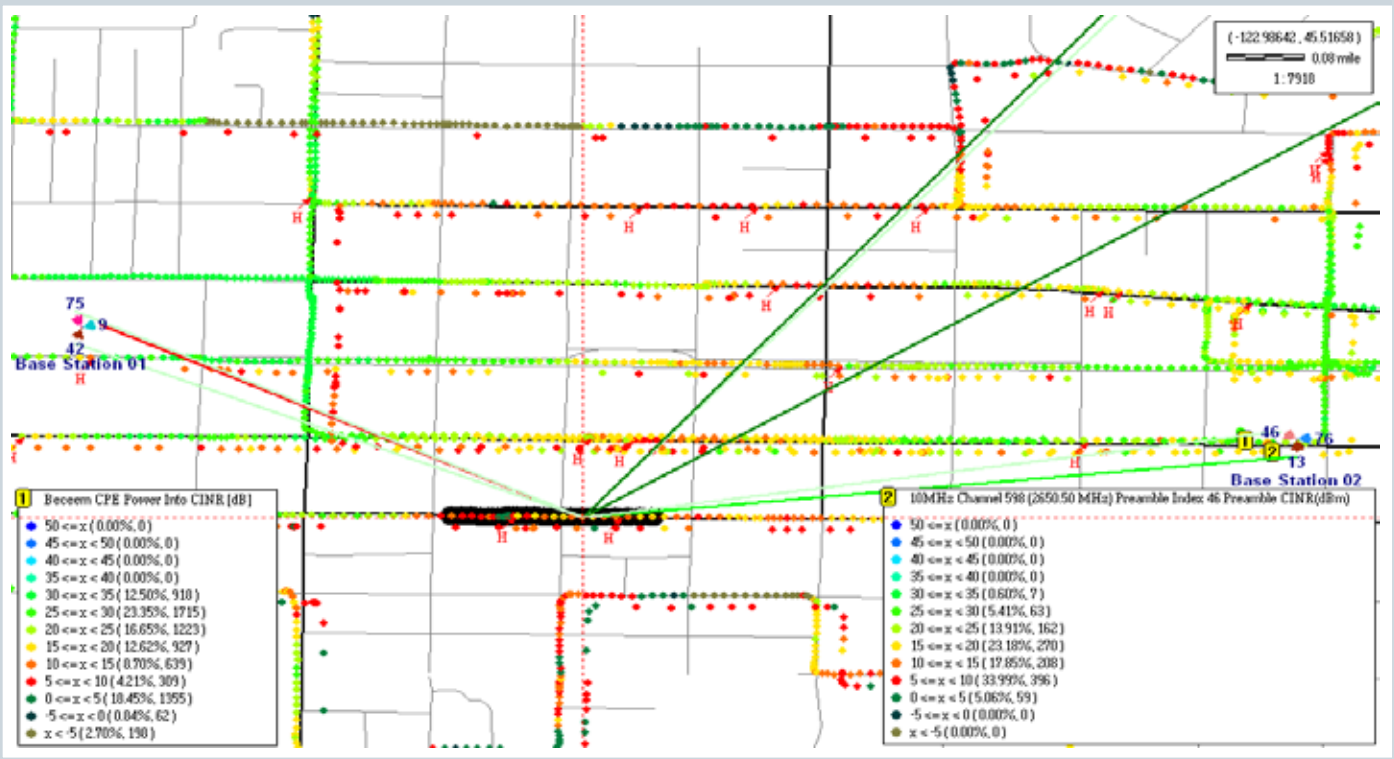
The user may simply click on any point on the map to view key parameters at that location. The red crosshairs show the reference location and the pop up window shows the parameters. In this analysis, the serving sector preamble index at the selected point is 9 from base station POR008 on the left side of the map. A red line is drawn from the serving sector the data collection point with a reference to distance shown in the pop up window (0.4 miles).

The pop up window has been configured to show the neighbor preamble indexes as well. We can see that sectors with preamble index 13, 75, 80, 42 and 51 are on the neighbor list. Base station POR011 on the right includes sectors with preamble indexes 46, 13 and 76. We would expect that the sector with preamble index 46 would be on the neighbor list. The distance line tool within XCAP-X shows that sector 46 is only 0.486 miles away, where as sector 80 (which is on the list) is 0.895 miles away. This preliminary analysis shows that sector 46 can be added to the neighbor list and is referred to as a missing neighbor.

4.2 - RF Scanning Verification

Potential neighbors can be verified by adding scanning receiver data to the map to check the coverage at this point from the sector with preamble index of 46. WirelessLogix data collection tools support simultaneous data collection from a range of WiMAX test devices and WiMAX scanning receivers. The user simply drags the scanning data for Preamble Index 46 to the map to create a layer next to the original data collection route.

MAP 2 - WiMAX Scanning Data with WiMAX Test Device Data



As can be seen, there is adequate signal level at this location for the POR011 sector with preamble index of 46 to be considered a valid neighbor. The systems engineers may consider changing the handover algorithms so that preamble 46 is considered a valid neighbor and remove the sector with preamble index of 80.

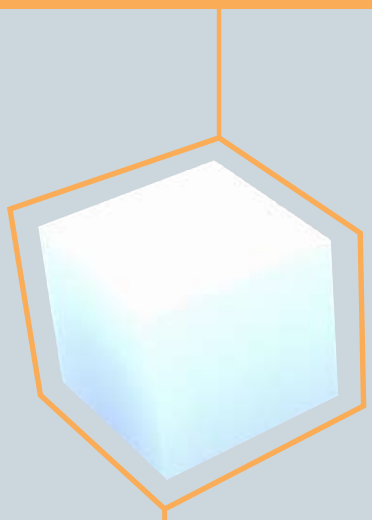
Summary

Handovers play a critical role for mobility in mobile WiMAX networks. The mobile WiMAX specification 802.16e provides a variety of hard and soft handover techniques for system design and performance engineers to utilize during deployment.

WirelessLogix provides the data collection and analysis tools necessary to optimize handover operation, including the ability to isolate missing neighbor conditions. The WirelessLogix tools include:

- XCAL-X: Data collection tool that supports a variety of WiMAX test devices and simultaneous collection of WiMAX scanning data.
  - Real Time Display
  - Map, graph, message and tabular displays with user defined tabs
  - Integration of street and base station data
  - Replay capability for field analysis
- XCAP-X: WiMAX data analysis tool with advanced features.
  - Map, graph, message and tabular displays
  - Simple drag and drop functionality to perform complex analysis of inter related parameters
  - Complete user configurable auto reporting tool
  - User friendly tools and support for a variety of data formats

Contact WirelessLogix to learn more.



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