How to plan and optimize WiMAX networks

Fine WiMAX network planning and continuous network optimization can improve interference control, enable effective coverage and enhance user experience to meet new business development needs and maximize profits.

By Lai Guoting

Fine network planning

Good network planning at the beginning sets the stage for successful building and operation of WiMAX networks. It is recommended for proper network planning to fully consider the following three aspects.

Optimal spectrum planning

Though some operators have sufficient spectrum resources, these resources can be irregularly and loosely distributed. Capacity requirements are not high during the early phases of network building, but networks are sensitive to coverage and interference.

Networking with multiple frequencies can be used to reduce interference in the early phases of network building.

For example, operator P has 3 frequency bands of 35M: 12M+10M+13M. Because adjacent frequency bands of the 12M and 13M bands are used by other operators for WiMAX networks, operator P adopts the Partial Usage of Subchannels (PUSC) with all 2×3×6 networking. The bandwidth of each channel is 5M, while 2M and 3M are used as protective bands on both sides. Compared to PUSC with all 1×3×3 networking with a channel bandwidth of 10M, though the uplink coverage is somewhat limited, the spectrum efficiency of operator P’s WiMAX network is reduced by 0.2 bps/Hz and the uplink coverage is increased by 6%.

Improved spectrum utilization is a primary concern when operators build WiMAX networks, while coverage should also be ensured. Fractional frequency reuse (FFR) based on denser frequency multiplexing can better resolve the dilemma. FFR 1×3×3 hybrid networking fully addresses the need for interference control and spectrum efficiency—in areas with poor signal quality, PUSC 1/3 is adopted; while in all areas with good signal quality, PUSC with all is adopted. For example, if the channel bandwidth is 10M and FFR is used, more terminals with poor signal quality can access PUSC 1/3, improving the access rate of terminals by 25%.

The uplink coverage of WiMAX is somewhat limited, so attention should be paid to reducing uplink interference and improving uplink signals. Compared with the traditional receiving technology...
of maximal-ratio combining, the combination of interference cancellation is used to better remove inherent correlation of signals, to reduce or inhibit related interference signals, and to improve uplink signals. Increase of interference sources and interference correlation can improve the gains of interference cancellation combination.

Simulation results indicate that the gain from a combination of interference cancellation is in proportion to the number of receiving antennas if the other parameters are the same. Gain from the combination of interference cancellation = increased percentage of antennas × previous antenna gain.

Complete service application planning

Currently, WiMAX is positioned to provide broadband access for homes, enterprises and governmental departments. Considering the need for high speed broadband services, it is necessary to use multiple antennas and other technologies to increase capacity and fulfill requirements for broadband data services. For dense urban areas such as CBDs, capacity can be increased through the combined use of technologies such as multiple antennas, beam-forming and power control. Compared with the traditional transmit/receive antenna selection of 2×2 self-adaptation, 4×4 self-adaptation and beam-forming can increase capacity by 10% and 30% respectively.

Different technologies may be used as needed during different phases of network building and for different service applications (voice traffic models) and application scenarios. When an operator builds a network in the suburbs or ordinary urban areas in the early stages, multi-antenna self-adaptation can be used for it is more mature and stable. A capacity solution that is more suitable and competitive for commercial use can then be adopted to facilitate network building and commercialization.

To accommodate high speed data services that need a lot of bandwidth, multi-antenna, hybrid automatic repeat request (HARQ) and other technologies can improve the quality of the entire link, plus reduce the packet error ratio and packet loss ratio of specific services.

After 1–3 hybrid repeated transmissions, HARQ can optimize the packet error ratio to meet QoS requirements for the applications at coverage edges with poor signal quality.

Unified cross-layer planning

WiMAX has introduced a number of new technologies and features, and service applications on various layers have different overheads. The impact of overheads on WiMAX link budgets and capacity planning are all important considerations for operators.

The HARQ of the physical layer requires the addition of a cyclic redundancy check (CRC); the MAC layer requires addition of a generic MAC header, packing subheader and fragmentation subheader. IP and TCP layers need to handle the encryption overhead and 22–29 bytes should be reserved, depending on the number of fragments.

At the same time, for the overhead of IP, RTP and UDP headers at the IP and TCP layers, header compression needs to be considered for service applications when traffic models and service rates are to be decided. Take VoIP of G.729a for example. With header compression, the bandwidth for the service can be reduced to 74.2% of the previous. Capacity planning in this manner is more inclusive and relevant to actual commercial use scenarios.

Three measures for network optimization

Besides fine network planning during preliminary phases, continuous network optimization is necessary in follow-up operations to improve the competitiveness of WiMAX networks. There are three measures for network optimization.
Optimizing interference control

Based on network planning, the preliminary interference control can be performed for the entire network, through adjustment of bearing angles, heights, transmission power and beam directions of antennas.

For example, operator D encountered high uplink code error ratio and frequent network connection failures due to co-channel interference at overlapping areas of WiMAX. Various methods had been used, but the source of failure had not been identified. Later, the operator tried to turn off cells of the same frequency at adjacent base stations and keep the standing-wave ratio at about 1.4dB. As the result, the downlink Carrier to Interference-plus-Noise Ratio (CINR) was notably improved, but it still did not match corresponding received signal strength indication (RSSI).

Finally, the failure was resolved by taking measures to reduce the inference of the back lobe of the sector antenna with other cells of the same frequency. After correction, the downlink CINR of terminal has been stable. High-order modulation can be used and the error code ratio of the uplink remains low.

After the interference control of the entire network has been preliminarily controlled in terms of algorithm cooperation, interference can be further controlled through a power control algorithm, system load algorithm and HARQ.

For example, operator N’s network was not able to meet QoS requirements or caused increased interference with neighboring systems due to improper settings of the power control algorithm after the outer loop power control was enabled.

The problem was solved by correcting the settings for relevant parameters. In addition, in the case of low interference and weak interference correlation, maximal-ratio combining can be used for the uplink. In case there is severe local interference and concentrated interference sources, a combination of interference cancellation can be used to reduce interference for the uplink.

Improving network coverage

Based on interference control, operators can improve network coverage at various aspects.

First, it is necessary to consider the impact on coverage caused by external transmission environments and physical devices. In the example mentioned above, after operator D found that signals were poor around WiMAX base stations, they analyzed and examined network elements one by one and found that all network elements worked well. Finally it was discovered that a microwave antenna blocked the WiMAX antenna and led to poor coverage around the base station. Operator D properly adjusted the bearing angle and beam direction of the microwave antenna and solved the problem.

In another example, operator M found that the downlink coverage around a base station was poor and loss of signals was severe. All devices and their connections were found to be working well after examination of network elements and other factors. The problem was the antenna and after replacement the system worked fine.

Second, if transmission conditions and devices have no problem, the improvement of overall coverage mainly depends on novel networking schemes and frequency multiplexing to ensure competitive coverage. FFR networking is an option, because it takes into account coverage and spectrum effectiveness.

When analyzing a WiMAX network optimization project, Huawei recommends giving priority to a PUSC 1/3 when terminals access the network. This improves successful access rate. To increase system capacity and spectrum utilization once the network is accessed, PUSC with all should be used if possible. In the case of inter-zone handover, PUSC 1/3 can be used again when the signal quality cannot support QPSK 1/2. The PUSC with all 1×3×3 networking has a network access rate of 75%; while FFR 1×3×3 and FFR 1×3×4 will allow the network access rate to increase to 93% and 97% respectively.

Maximizing the QoS experience

The QoS experience is mainly related to algorithms and their relationships. If certain algorithms are not properly set or combined, specific applications may stop working normally and affect QoS experience of users.

For example, operator P encountered a situation where no uplink service was possible. No abnormality was found after examining one by one the parameters and related factors. The failure was eventually traced to version upgrading and resolved after removing the bug in the new version.

Another operator had terminals that were not able to access the network or conduct uplink services after access, due to improper settings of QoS parameters at the terminal and system sides. The solution was correcting settings of QoS parameters at the terminal and system sides.

More algorithms do not necessarily mean better commercial use conditions. If both ARQ and HARQ are enabled, speeds available to users are no higher than those when either one is enabled. When HARQ is enabled, the PER of the system is considerably improved. ARQ is more suitable for situations with high PERs. In the case of a low PER, the overhead due to repeating would overshadow benefits of the capacity increase, and the capacity is actually decreased. 

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