Enhanced CDMA2000 1X technology boosts network capacity

Enhanced CDMA2000 1X technology can greatly reduce the carrier frequency capacity required by voice services, and help to develop both CDMA2000 1X voice services and EV-DO data services based on limited spectrum resources. By fully using the existing carrier frequency, operators can enhance their competitiveness.

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Most global operators still generate more than 50% of total revenue from voice services. Amid growing competition between similar products, revenues are dropping despite increasing traffic. Low-cost voice services are what operators need to keep their competitive edge, and enhanced CDMA2000 1X technology is an ideal cost-cutting solution for CDMA voice services.

Improved voice coding technology

The enhanced CDMA2000 1X technology introduces enhanced variable rate codecs (EVRC-B), or 4th generation vocoders (4GV), using condition-specific frames of different sizes to achieve conversions between high voice quality and large system capacity.

As shown in Fig. 1, frames in 4GV-COP0 (capacity operating point 0) are distributed in a format similar to the current EVRC. Then, full-rate frames will gradually give way to low-rate frames. Emulation results show that four-rate frames, which transmit background noise and do not transmit any valid information but use 14% of the forward power per user. The smart blanking of 1/8 rate frame reduces the number of 1/8 rate frames considerably by sending “only the first 1/8 rate frame in every four consecutive frames” or “only the changed 1/8 rate frames”. The 1/8 rate frame power consumption is greatly lowered and the technology is being used in the 3G VoIP field.

Closed-loop power control

The closed-loop power control lowers the power control frequency from 800Hz to 400Hz. Emulation results show that the single-user forward power is reduced by up to 17%.

Smart blanking of 1/8 rate frame

1/8 rate frames are designed to transmit background noise and do not transmit any valid information but use 14% of the forward power per user. The smart blanking of 1/8 rate frame reduces the number of 1/8 rate frames considerably by sending “only the first 1/8 rate frame in every four consecutive frames” or “only the changed 1/8 rate frames”. The 1/8 rate frame power consumption is greatly lowered and the technology is being used in the 3G VoIP field.

Early termination

Speech frames are somewhat repeated during physical coding. The lower the frame rate, the more frames are repeated. If the air interface functions properly, the receiver is able to decode speech frames in advance. In the CDMA2000 1xEV-DO solution, the hybrid automatic retransmission request (HARQ) technology is based on this principle. The enhanced CDMA2000 1X technology also introduces early termination to reduce code repetitions.

Specifically, the receiver will make a decoding attempt at an interval of several power control groups (PCGs). If decoding is successful, the receiver sends an ACK message to the sender over the power control subchannel. Then, the sender stops sending frames and the PCG will be empty. This technology can reduce interference per user in the sector and enhance sector capacity.

The terminal will send data continuously if the terminal used in the existing network does not support early termination regardless of whether the BTS decodes reverse frames successfully. Presently, the enhanced CDMA2000 1X technology can work out later service symbols according to decoding-generated reverse frames and eliminate interference caused by subsequent PCGs.

The three power optimization technologies can be combined to reduce the forward transmit power per user by up to 40%, significantly boosting the system capacity.
Interference cancellation

The CDMA system operates in a co-frequency mode. Interference between users is a key factor that determines the system capacity and its cancellation is the most effective and simplest approach to increase CDMA system capacity. The interference cancellation is designed to remove decoded signals from incoming signals to avoid interference on remaining signals (not yet decoded). In this way, the signal-to-noise ratio (SNR) will be increased for subsequent user decoding, facilitating signal demodulation.

Based on the total channel capacity, the following analysis examines uplink interference cancellation in the enhanced CDMA2000 1X system. Suppose that three users (A, B, and C) in the system are using the uplink channel of enhanced CDMA2000 1X service at the same time. They share the uplink channel through scrambling codes. Assuming that the noise level is 1, the total user power received by the system is 7, and the signal power is allocated at the ratio of 4:2:1 (A:B:C). The theoretical capacity of this channel should be 3bps according to the Shannon formula.

When the interference cancellation technology is used, the BTS first decodes the incoming signals of user A. At this time, the system cannot recognize signals from users B and C as these signals interfere with those of user A. Thus, the signal power for user A is 4, the interference power 3, and the noise power 1. According to the Shannon formula, the capacity for user A is to be 1bps.

After user A’s data is decoded correctly, the BTS proceeds to decode the signals of user B. Now, as the data of user A is already decoded correctly, the BTS can scramble user A’s codes, that is, recover user A’s data, and then remove the recovered signals of user A from incoming uplink signals. After user A’s signals are eliminated, received uplink signals contain only signals of user B and C, in which user C’s signals interfere with the signals of user B. The signal power of user B is 2, the interference power 1, and the noise power 1. The capacity for user B will be 1bps. Similarly, the capacity for user C is also 1bps and the system will be allocated a total capacity of 3bps.

In other words, interference cancellation helps to realize the maximum theoretical capacity for the channel. Actual emulation results show that when the interference cancellation technology is used for 20 users, system spectrum utilization can be improved by an impressive 55%.

Dual-antenna terminal receiving diversity

The use of multiple antennas for receiving diversity helps increase the system capacity significantly. In the absence of additional spectrum resources in the BTS, this method can linearly enhance the incoming SNR. However, excessive antennas may complicate terminals considerably and increase their prices greatly. The enhanced CDMA2000 1X technology is designed on the assumption that a terminal supports dual-antenna technology. The use of two antennas can generate a gain of at least 3dB, and increase the forward link capacity by 2.5dB and the capacity gain by 80%.

In addition to the range of technologies, including voice codecs, power adjustment, interference cancellation, and terminal receiving diversity, the enhanced CDMA2000 1X technology also uses the quasi orthogonal function (QOF) to significantly increase the maximum capacity of each sector to 240 users so that a single carrier (TRX) can support 120 users.

Within a 10MHz bandwidth, the technology can support up to 840 users. This has created sharp competitive advantages over UMTS and LTE networks and enables CDMA operators to attract more voice and data users without additional band resources or reconsolidation of the industry chain.

Suppose operator A currently has five bands with four used for CDMA2000 1X and one used for the CDMA2000 1xEV-DO data services. By upgrading the system to the enhanced CDMA2000 1X technology, operator A can reduce the number of bands used for CDMA2000 1X voice services to two. Therefore, three bands become available for CDMA2000 1xEV-DO data services. When the number of voice users reaches its peak, the operator can support multi-carrier DORA or DORB rapidly for data services.

When it comes to capacity, bigger is always better and enhanced CDMA2000 1X, the right choice.

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