Advantages of CDMA2000

CDMA2000 benefited from the extensive experience acquired through several years of operation of cdmaOne systems. As a result, CDMA2000 is a very efficient and robust technology. Supporting both voice and data, the standard was devised and tested in various spectrum bands, including the new IMT-2000 allocations.

There is tremendous demand for new services and operators are looking to provide these to many more subscribers at reasonable prices.

The unique features, benefits, and performance of CDMA2000 make it an excellent technology for high-voice capacity and high-speed packet data. The fact that CDMA2000 1X has the ability to support both voice and data services on the same carrier makes it cost effective for wireless operators.

Due to its optimized radio technology, CDMA2000 enables operators to invest in fewer cell sites and deploy them faster, ultimately allowing the service providers to increase their revenues with faster Return On Investment (ROI). Increased revenues, along with a wider array of services, make CDMA2000 the technology of choice for service providers.

**Increased Voice Capacity**

Voice is the major source of traffic and revenue for wireless operators, but packet data will emerge in coming years as an important source of incremental revenue. CDMA2000 delivers the highest voice capacity and packet data throughput using the least amount of spectrum for the lowest cost.

CDMA2000 1X supports 35 traffic channels per sector per RF (26 Erlangs/sector/RF) using the EVRC vocoder, which became commercial in
1999.

Voice capacity improvement in the forward link is attributed to faster power control, lower code rates (1/4 rate), and transmit diversity (for single path Rayleigh fading). In the reverse link, capacity improvement is primarily due to coherent reverse link.

Click here for more information on CDMA capacity

Higher Data Throughput
Today's commercial CDMA2000 1X networks (phase 1) support a peak data rate of 153.6 kbps. CDMA2000 1xEV-DO, commercial in Korea, enables peak rates of up to 2.4 Mbps and CDMA2000 1xEV-DV will be capable of delivering data of 3.09 Mbps.

Frequency Band Flexibility
CDMA2000 can be deployed in all cellular and PCS spectrum. CDMA2000 networks have already been deployed in the 450 MHz, 800 MHz, 1700 MHz, and 1900 MHz bands; deployments in 2100 MHz and other bands are expected in 2004. CDMA2000 can also be implemented in other frequencies such as 900 MHz, 1800 MHz and 2100 MHz. The high spectral efficiency of CDMA2000 permits high traffic deployments in any 1.25 MHz channel of spectrum.

Increased Battery Life
CDMA2000 significantly enhances battery performance. Benefits include:

- Quick paging channel operation
- Improved reverse link performance
- New common channel structure and operation
- Reverse link gated transmission
- New MAC states for efficient and ubiquitous idle time operation

Synchronization
CDMA2000 is synchronized with the Universal Coordinated Time (UCT). The forward link transmission timing of all CDMA2000 base stations worldwide is synchronized within a few microseconds. Base station synchronization can be achieved through several techniques including self-synchronization, radio beep, or through satellite-based systems such as GPS, Galileo, or GLONASS. Reverse link timing is based on the received timing derived from the first multipath component used by the terminal.

There are several benefits to having all base stations in a network synchronized:

- The common time reference improves acquisition of channels and hand-off procedures since there is no time ambiguity when looking for and adding a new cell in the active set.
- It also enables the system to operate some of the common channels in soft hand-off, which improves the efficiency of the common channel operation.
- Common network time reference allows implementation of very efficient "position location" techniques.

**Power Control**

The basic frame length is 20 ms divided into 16 equal power control groups. In addition, CDMA2000 defines a 5 ms frame structure, essentially to support signaling bursts, as well as 40 and 80 ms frames, which offer additional interleaving depth and diversity gains for data services. Unlike IS-95 where Fast Closed Loop Power Control was applied only to the reverse link, CDMA2000 channels can be power controlled at up to 800 Hz in both the reverse and forward links. The reverse link power control command bits are punctured into the F-FCH or the F-DCH (explained in later sections) depending on the service configuration. The forward link power control command bits are punctured in the last quarter of the R-PICH power control slot.

In the reverse link, during gated transmission, the power control rate is reduced to 400 or 200 Hz on both links. The reverse link power control
sub-channel may also be divided into two independent power control streams, either both at 400 bps, or one at 200 bps and the other at 600 bps. This allows for independent power control of forward link channels. In addition to the closed loop power control, the power on the reverse link of CDMA2000 is also controlled through an Open Loop Power Control mechanism. This mechanism inverses the slow fading effect due to path loss and shadowing. It also acts as a safety fuse when the fast power control fails. When the forward link is lost, the closed loop reverse link power control is “freewheeling” and the terminal disruptively interferes with neighboring. In such a case, the open loop reduces the terminal output power and limits the impact to the system. Finally the Outer Loop Power drives the closed loop power control to the desired set point based on error statistics that it collects from the forward link or reverse link. Due to the expanded data rate range and various QoS requirements, different users will have different outer loop thresholds; thus, different users will receive different power levels at the base station. In the reverse link, CDMA2000 defines some nominal gain offsets based on various channel frame format and coding schemes. The remaining differences will be corrected by the outer loop itself.

**Soft Hand-off**

Even with dedicated channel operation, the terminal keeps searching for new cells as it moves across the network. In addition to the active set, neighbor set, and remaining set, the terminal also maintains a candidate set.

When a terminal is traveling in a network, the pilot from a new BTS (P2) strength exceeds the minimum threshold TADD for addition in the active set. However, initially its relative contribution to the total received signal strength is not sufficient and the terminal moves P2 to the candidate set. The decision threshold for adding a new pilot to the active set is defined by a linear function of signal strength of the total active set. The network
defines the slope and cross point of the function. When strength of P2 is
detected to be above the dynamic threshold, the terminal signals this
event to the network. The terminal then receives a hand-off direction
message from the network requesting the addition of P2 in the active set.
The terminal now operates in soft hand-off.
The strength of serving BTS (P1) drops below the active set threshold,
meaning P1 contribution to the total received signal strength does not
justify the cost of transmitting P1. The terminal starts a hand-off drop
timer. The timer expires and the terminal notifies the network that P1
dropped below the threshold. The terminal receives a hand-off message
from the network moving P1 from the active set to the candidate set. Then
P1 strength drops below TDROP and the terminal starts a hand-off drop
timer, which expires after a set time. P1 is then moved from candidate set
to neighbor set. This step-by-step procedure with multiple thresholds and
timers ensures that the resource is only used when beneficial to the link
and pilots are not constantly added and removed from the various lists,
therefore limiting the associated signaling.
In addition to intrasystem, intrafrequency monitoring, the network may
direct the terminal to look for base stations on a different frequency or a
different system. CDMA2000 provides a framework to the terminal in
support of the inter-frequency handover measurements consisting of
identity and system parameters to be measured. The terminal performs
required measurements as allowed by its hardware capability.
In case of a terminal with dual receiver structure, the measurement can be
done in parallel. When a terminal has a single receiver, the channel
reception will be interrupted when performing the measurement. In this
instance, during the measurement, a certain portion of a frame will be lost.
To improve the chance of successful decoding, the terminal is allowed to
bias the FL power control loop and boost the RL transmit power before
performing the measurement. This method increases the energy per
information bit and reduces the risk of losing the link in the interval. Based on measurement reports provided by the terminal, the network then decides whether or not to hand-off a given terminal to a different frequency system. It does not release the resource until it receives confirmation that hand-off was successful or the timer expires. This enables the terminal to come back in case it could not acquire the new frequency or the new system.

**Transmit Diversity**
Transmit diversity consists of de-multiplexing and modulating data into two orthogonal signals, each of them transmitted from a different antenna at the same frequency. The two orthogonal signals are generated using either Orthogonal Transmit Diversity (OTD) or Space-Time Spreading (STS). The receiver reconstructs the original signal using the diversity signals, thus taking advantage of the additional space and/or frequency diversity.

Another transmission option is directive transmission. The base station directs a beam towards a single user or a group of users in a specific location, thus providing space separation in addition to code separation. Depending on the radio environment, transmit diversity techniques may improve the link performance by up to 5 dB.

**Voice and Data Channels**
The CDMA2000 forward traffic channel structure may include several physical channels:

- The Fundamental Channel (F-FCH) is equivalent to functionality Traffic Channel (TCH) for IS-95. It can support data, voice, or signaling multiplexed with one another at any rate from 750 bps to 14.4 kbps.
- The Supplemental Channel (F-SCH) supports high rate data services. The network may schedule transmission on the F-SCH on a frame-by-frame basis, if desired.
- The Dedicated Control Channel (F-DCCH) is used for signaling or bursty data sessions. This channel allows for sending the signaling information without any impact on the parallel data stream.
The reverse traffic channel structure is similar to the forward traffic channel. It may include R-PICH, a Fundamental Channel (R-FCH), and/or a Dedicated Control Channel (R-DCCH), and one or several Supplemental Channels (R-SCH). Their functionality and encoding structure is the same as for the forward link with data rates ranging from 1 kbps to 1 Mbps (It is important to note that while the standard supports a maximum data rate of 1 Mbps, existing products are supporting a peak data rate of 307 kbps).

**Traffic Channel**

The traffic channel structure and frame format is very flexible. In order to limit the signaling load that would be associated with a full frame format parameter negotiation, CDMA2000 specifies a set of channel configurations. It defines a spreading rate and an associated set of frames for each configuration.

The forward traffic channel always includes either a fundamental channel or a dedicated control channel. The main benefit of this multichannel forward traffic structure is the flexibility to independently set up and tear down new services without any complicated multiplexing reconfiguration or code channel juggling. The structure also allows different hand-off configurations for different channels. For example, the F-DCCH, which carries critical signaling information, may be in soft hand-off, while the associated F-SCH operation could be based on a best cell strategy.

**Supplemental Channels**

One key CDMA2000 1X feature is the ability to support both voice and data services on the same carrier. CDMA2000 operates at up to 16 or 32 times the FCH rate—also referred to as 16x or 32x in Release 0 and A, respectively. In contrast to voice calls, the traffic generated by packet data calls is bursty, with small durations of high traffic separated by larger durations of no traffic. It is very inefficient to dedicate a permanent traffic channel to a packet data call. This burstiness impacts the amount of available power to the voice calls, possibly degrading their quality if the
system is not engineered correctly. Hence, a key CDMA2000 design issue
is assuring that a CDMA channel carrying voice and data calls
simultaneously do so with negligible impact to the QoS of both.
Supplemental Channels (SCHs) can be assigned and deassigned at any
time by the base station. The SCH has the additional benefit of improved
modulation, coding, and power control schemes. This allows a single SCH
to provide a data rate of up to 16 FCH in CDMA2000 Release 0 (or 153.6
kbps for Rate Set 1 rates), and up to 32 FCH in CDMA2000 Release A (or
307.2 kbps for Rate Set 1 rates). Note that each sector of a base station
may transmit multiple SCHs simultaneously if it has sufficient transmit
power and Walsh codes. The CDMA2000 standard limits the number of
SCHs a mobile station can support simultaneously to two. This is in
addition to the FCH or DCCH, which are set up for the entire duration of
the call since they are used to carry signaling and control frames as well
as data. Two approaches are possible: individually assigned SCHs, with
either finite or infinite assignments, or shared SCHs with infinite
assignments.
For bursty and delay-tolerant traffic, assigning a few scheduled fat pipes is
preferable to dedicating many thin or slow pipes. The fat-pipe approach
exploits variations in the channel conditions of different users to maximize
sector throughput. The more sensitive the traffic becomes to delay, such
as voice, the more appropriate the dedicated traffic channel approach
becomes.

Turbo Coding
CDMA2000 provides the option of using either turbo coding or
convolutional coding on the forward and reverse SCHs. Both coding
schemes are optional for the base station and the mobile station, and the
capability of each is communicated through signaling messages prior to
the set up of the call. In addition to peak rate increase and improved rate
granularity, the major improvement to the traffic channel coding in
CDMA2000 is the support of turbo coding at rate 1/2, 1/3, or 1/4. The turbo code is based on 1/8 state parallel structure and can only be used for supplemental channels and frames with more than 360 bits. Turbo coding provides a very efficient scheme for data transmission and leads to better link performance and system capacity improvements. In general, turbo coding provides a performance gain in terms of power savings over convolutional coding. This gain is a function of the data rate, with higher data rates generally providing more turbo coding gain.