CDMA Technology

2G - cdmaOne

cdmaOne: The Family of IS-95 CDMA Technologies
cdmaOne describes a complete wireless system based on the TIA/EIA IS-95 CDMA standard, including IS-95A and IS-95B revisions. It represents the end-to-end wireless system and all the necessary specifications that govern its operation. cdmaOne provides a family of related services including cellular, PCS and fixed wireless (wireless local loop).

IS-95A: The first CDMA cellular standard
TIA/EIA IS-95 (Telecommunications Industry Association / Electronic Industries Association Interim Standard - 95) was first published in July 1993. The IS-95A revision was published in May 1995 and is the basis for many of the commercial 2G CDMA systems around the world. IS-95A describes the structure of the wideband 1.25 MHz CDMA channels, power control, call processing, hand-offs, and registration techniques for system operation. In addition to voice services, many IS-95A operators provide circuit-switched data connections at 14.4 kbps. IS-95A was first deployed in September 1996 by Hutchison (HK).

IS-95B: 2.5G
The IS-95B revision, also termed TIA/EIA-95, combines IS-95A, ANSI-J-STD-008 and TSB-74 into a single document. The ANSI-J-STD-008 specification, published in 1995, defines a compatibility standard for 1.8 to 2.0 GHz CDMA PCS systems. TSB-74 describes interaction between IS-95A and CDMA PCS systems that conform to ANSI-J-STD-008. Many operators that have commercialized IS-95B systems offer 64 kbps packet-switched data, in addition to voice services. Due to the data speeds IS-95B is capable of reaching, it is categorized as a 2.5G technology. IS-95B is categorized as a 2.5G technology. cdmaOne IS-95B was first deployed in September 1999 in Korea and has since been adopted by operators in Japan and Peru.

2G - cdmaOne Advantages
When implemented in a cellular network, cdmaOne technology offers numerous benefits to the cellular operators and their subscribers:

1. Capacity increases of 8 to 10 times that of an AMPS analog system and 4 to 5 times that of a GSM system
2. Improved call quality, with better and more consistent sound as compared to AMPS systems
3. Simplified system planning through the use of the same frequency in every sector of every cell
4. Enhanced privacy
5. Improved coverage characteristics, allowing for the possibility of fewer cell

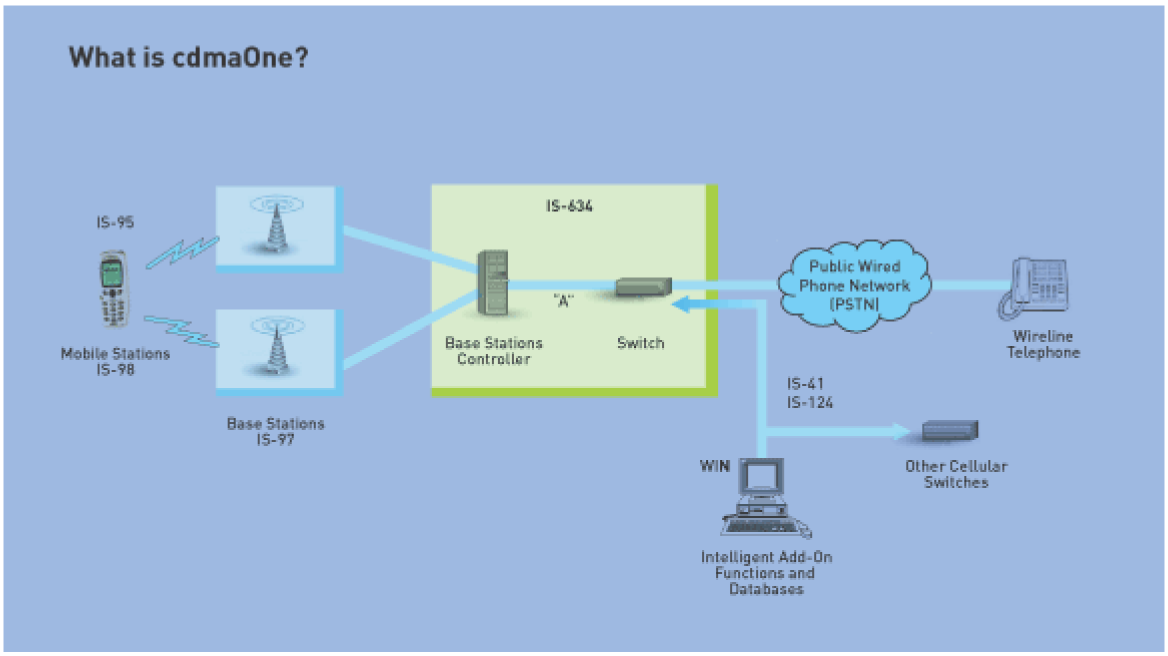
sites

6. Increased talk time for portables
7. Bandwidth on demand

2G - cdmaOne Deployments

cdmaOne is the fastest growing 2G wireless technology reaching 100 million subscribers after only six years of commercial deployment.

cdmaOne Network diagram



cdmaOne Roaming

Roaming is a key functionality for wireless systems and cdmaOne offers many advantages to enable roaming.

CDMA2000 1X is an ITU-approved, IMT-2000 (3G) standard that was the first 3G technology to be commercially deployed (October 2000).

International Roaming Using CDMA

[redacted]

(Courtesy of TSI)

International roaming allows users of CDMA wireless phones to travel to a foreign country and enjoy many of the same services there that they can at home.

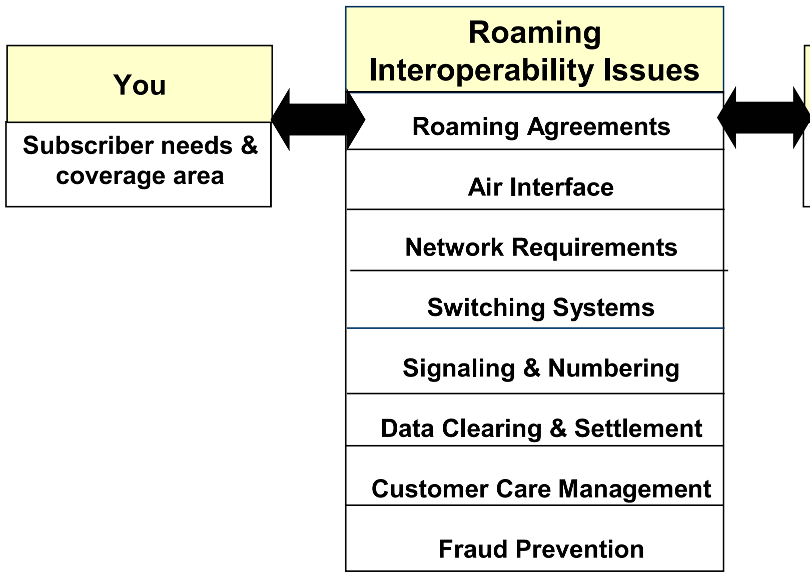
While there are still many challenges to obtain fully seamless international roaming, CDMA subscribers can enjoy some of the finest international roaming available. And, it will only get better in the future.

What is Roaming?

Roaming is the ability of a system to provide the same services to customers ('roamers') from other systems, even from other countries. This involves the resolution of a number of business and technical challenges. Some of the major services that can be provided are:

- The ability to make a call ('Mobile Origination'). While this sounds simple, this fundamental service requires a wireless system to verify that the customer's subscription is valid, that the phone is not stolen, that it is not illegally emulating another phone, and to ensure that the type of call being made is not restricted.
- The ability to receive a call ('Mobile Termination' or 'Call Delivery'). This is technically much more complex, and requires the roamer's phone to first register in the system in which it wishes to receive calls. This is done automatically, and causes an exchange of information over the SS7/ANSI-41 network to the home system. When a call comes in to the home system it already knows where the mobile is, and can route a call to it.
- Inter-system handoff. This allows a mobile call to continue uninterrupted when the mobile crosses the boundary between two cellular systems.
- Short Message Service. When an SMS message comes in to the home system it will be forwarded to the mobile, wherever it is.
- Calling Name/Number Presentation. When receiving a call, the number of the caller or even their name will be displayed on their handset.
- International dialing. Some phones provide a "+" key or equivalent menu option that makes it easy to place an international call without knowing the local access number.

Elements of International Roaming

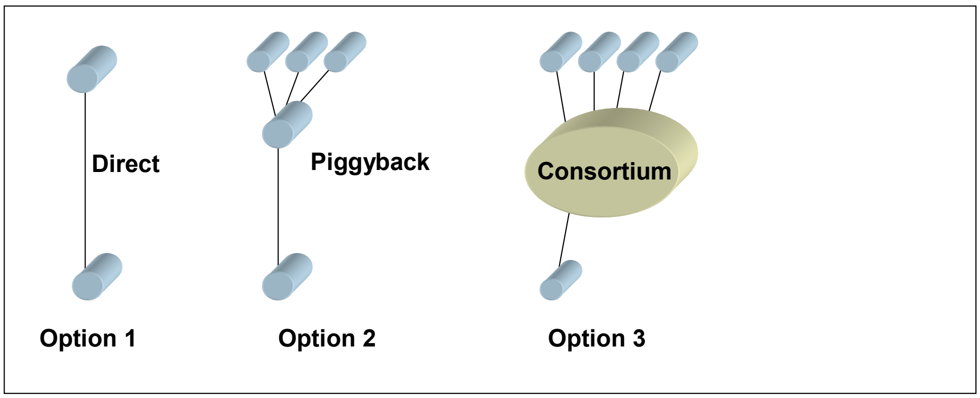


Roaming Agreements

- Fundamental Issues
  - Strategic partner vs. competitor
- Interstandard Roaming Issues
  - Settlement and billing formats
- Technology Issues
  - Analog vs. Digital, CDMA, TDMA, GSM
- Network Issues
  - Reliability, feature compatibility, cost
- Fraud Issues
  - Visibility, liability, international dialing

Roaming Agreement - Options

Three ways to get roaming agreements



What Makes CDMA Roaming Work?

A standard known as ANSI-41 (aka TIA/EIA-41 or IS-41) provides roaming services for AMPS and CDMA systems. It is a good example of a Mobile Application Protocol (MAP), which is a high-level protocol that allows major elements of the wireless network to communicate. The major network elements are:

- Base Station. Contains the radio equipment for one or more cells.
- MSC (Mobile Switching Center). Connects mobiles to other mobiles or to phones in the telephone network or on other cellular systems.
- HLR (Home Location Register). Contains information about a subscription, including the types of services which are to be provided.
- AC (Authentication Center). Contains cryptographic information that allows the network to determine that a mobile is valid. Usually contained within an HLR.
- MC (Message Center). Stores and forwards short messages.

Some of the more important roaming capabilities that are provided by ANSI-41 are:

- Authentication, Registration and Location Management
- Call Delivery

- Short Message Service (SMS)
- Mobile Originations

Internationalization of ANSI-41

ANSI-41 is often criticized for its international roaming capabilities. This was a valid criticism in the mid-1990's, but since then ANSI-41 has been upgraded with international roaming capabilities that make it fully equivalent with GSM. Some of the capabilities that have been added are:

- Support for international digit strings in IS-41 Revision C (1996)
- Support for International Mobile Subscription Identifiers (IMSI) in TIA/EIA/IS-751 (1998).
- Assignment of International Roaming MIN's by IFAST (1998).
- Support for SS7 global titles in TIA/EIA/IS-807 (1999).
- Enhancements for calling number identification, '+' code dialing and callback (2001).

Although the roaming capabilities of ANSI-41 and GSM are largely comparable, there are some ways in which ANSI-41 is superior:

- Call forward no-answer/busy can be handled more efficiently by ANSI-41 systems. Calls are forwarded from the home system, with the connection to the serving system being released. GSM systems forward from the serving system, often resulting in calls looping from home system to serving system and back to the home system.
- Inter-system handoff is supported more efficiently in ANSI-41. It is performed directly by neighboring MSC's, without requiring a special gateway MSC, as in GSM.
- ANSI-41 supports mobiles that can operate in multiple technologies (e.g. analog and CDMA).
- Authentication of mobiles can be done locally. In GSM authentication calculations must be performed by the AC, requiring one transfer of authentication data for every call. In practice, GSM carriers often avoid this, which reduces the level of security that their systems provide.

What is SS7?

Telephony networks contain many highly computerized elements, that need to communicate by sending messages. This is known as signaling. SS7 (Signaling System Number 7) is a digital signaling system that connects the telephony network together. It has largely replaced older, tone-based signaling systems, particularly in the core network. SS7 is ideally suited for transporting ANSI-41 messages. It has the ability to transport messages between any two points on the network (e.g. between an MSC and an HLR) quickly, reliably and because it is purely packet oriented, without setup delay. SS7 messages are addressed either by point-code (a unique numeric address assigned to every telephony network) or by global title (use of a telephony-oriented address, such as a calling card number, IMSI or phone number). The point-code corresponds to the IP address on the internet (it even has a subsystem number that corresponds to the port number used by TCP and other higher-level IP protocols) and the global title corresponds to a domain name.

Most ANSI-41 networks either use the ANSI SS7 network, or have a method of directly addressing ANSI point codes. Use of global titles is a future development.

Roaming with GSM

The other major network standard in the world is the GSM MAP, that supports the GSM radio interface. GSM roaming is usually done with a SIM, a Subscriber Identity Module, also known as UIM or 'Smart Card'. Originally, the SIM was credit-card sized, but now it is just a computer chip packaged so that it can be safely removed. Roaming with a SIM requires removing it from your phone at home and then placing it in a rented phone at your destination. Because your subscription identity (IMSI) is on the SIM, billing will be to the same account. Taking your phone would seem to be more convenient, but is not possible if the destination country uses different frequencies, or even requires different plugs or voltages for your charger.

Many CDMA companies are implementing SIM-roaming with GSM systems, or even putting a SIM in their own phones. If a CDMA phone does not support a SIM, the CDMA carrier can still provide them to their customers for use when they roam in countries that only support GSM systems.

Future Challenges

No system is perfect, and although ANSI-41 international roaming provides a high level of service, there are still has some improvements that should be made. Most of these have already been incorporated in standards, but still remain to be implemented by carriers. Some of the major future challenges for this network are:

- Transition to global title. This will simplify routing between network elements in different countries. Current international roaming systems work well, but cannot use standard international SS7 signaling gateways.
- International TLDN (Temporary Local Directory Number). This is very important to routing and should be an internationally formatted phone number, as allowed by IS–41–C and TIA/EIA–41–D. The use of national numbers requires some complex digit translations.
- Transition to IMSI (International Mobile Station Identity). The use of IMSI will allow each country to assign identifiers to its mobile phones independently. The use of the IRM (International Roaming MIN) requires

coordination of each block of one million mobile identifiers through the International Forum on ANSI-41 Standards Technology (IFAST) organization.
- Roaming with GSM. Several groups are working at improving the services that can be provided to subscribers who roam from a CDMA area, including the GSM Global Roaming Forum (GGRF) G-95 group. This involves interworking of signaling (ANSI-41 and GSM MAP's) as well as billing issues and many business and implementation issues.

How did ANSI-41 Evolve?

ANSI-41 has grown incrementally through a number of major revisions. Between each revision a number of application-specific interim standards (IS's) have been produced. The major revisions are:

- **1983** – AMPS analog cellular started commercial service as standalone systems in Chicago and Washington/Baltimore. It quickly spread throughout the US, into Canada and into other countries. This provided a single standard cellular protocol while Europe had a large number of incompatible standards, each available in only a handful of countries.
- **1988** – IS-41 Rev. 0 provided inter-system handoff and subscriber validation capabilities. These capabilities were not, in the grand scheme of things, all that important. What was important was that inter-system operations were a reality. They worked and worked well. This standard was published in 1988 and the first field trials were in 1989.
- **1991** – IS-41 Rev. A added true networking, through the use of SS7 protocols, and the all-important capabilities of location management (letting the HLR know where a mobile is), call delivery, subscriber validation and profile transfer. It was published in January, 1991.
- **1991** – IS-41 Rev. B was an incremental release over Revision A. The most important advance was to add forward/backward compatibility capabilities to ensure that a mixture of revision levels could co-exist. This was published in December, 1991 and is still in widespread use in systems that just did basic roaming capabilities - making and receiving calls.
- **1993** – The first CDMA digital standard (IS-95 Revision 0) was published. IS-41 was quickly adapted to provide support for CDMA systems. Although there were now two different digital systems in North America (CDMA and TDMA), nationwide coverage was ensured by dual-mode analog/digital phones, with seamless roaming provided by IS-41.
- **1996** – IS-41 Rev. C was a major advance over previous revisions, including the ability to incorporate 'Intelligent Network'-like capabilities. This allows the development of services such as PBX-dialing extended worldwide. By querying the HLR, an MSC anywhere can translate an office extension into the real telephone number on a subscriber-by-

subscriber basis. Itwas published in 1996. This version incorporated further support for CDMA digital systems.

- **1997** – TIA/EIA-41 Rev. D was the first version to be approved by ANSI. It included only incremental improvements over IS-41-C. It was published in 1997.
- **2002** – TIA/EIA-41 Rev. E is nearing completion. Several parts of this very large standard are already being balloted. It further extends the international capabilities of ANSI-41. It includes many enhancements, but notably incorporates IS-751 (IMSI) and IS-807 (global title recommendations), as well as the Wireless Intelligent Network (WIN), Calling Name presentation, data services, over-the-air programming and other capabilities that are currently available as separate IS documents
- **2002/3** – TIA/EIA-41 Rev. F is being planned. It is likely that this will have enhancements to support better interworking with GSM, packet data support and location-based services.

2G - cdmaOne Operators

Canada

Aliant Telecom Mobility
Bell Mobility
MTS Mobility
NorthwesTel
SaskTel Mobility
Telus Mobility

China

China Unicom

United States

3 Rivers Wireless
Alaska DigiTel
ALLTEL
Blackfoot Communications
CellCom
ClearTalk
CMS St. Cloud
First Cellular of Southern Illinois
Leap
Nebraska Wireless Telephone Company
NorthCoast PCS
NTELOS

Penasco Valley Telecom
Pine Belt Telephone & Wireless
PYXIS Communications
Qwest Communications
Snake River PCS
Souris River Telephone
South Central Utah
Sprint
UBTA
US Cellular
Verizon Wireless
WirelessNorth

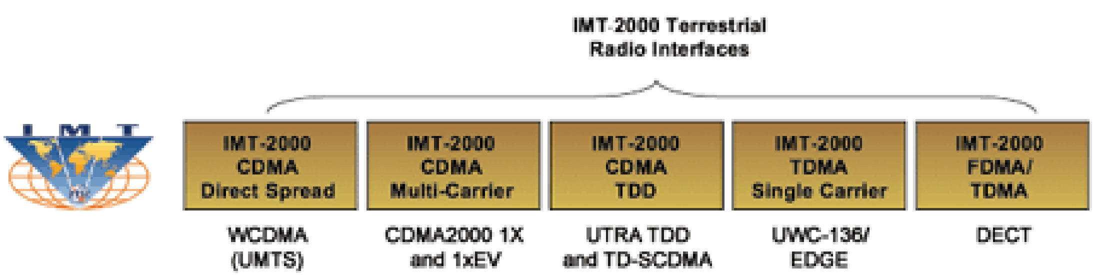
3G-CDMA2000

CDMA2000 is 3G

3G is the term used to describe next generation mobile services which provide better quality voice and high-speed Internet and multimedia services. While there are many interpretations of what 3G represents, the only definition accepted universally is the one published by the International Telecommunication Union (ITU). ITU, working with industry bodies from around the world, defines and approves technical requirements and standards as well as the use of spectrum for 3G systems under the IMT-2000 (International Telecommunication Union-2000) program.

The ITU requires that IMT-2000 (3G) networks, among other capabilities, deliver improved system capacity and spectrum efficiency over the 2G systems and support data services at minimum transmission rates of 144 kbps in mobile (outdoor) and 2 Mbps in fixed (indoor) environments.

Based on these requirements, in 1999 ITU approved five radio interfaces for IMT-2000 standards as a part of the ITU-R M.1457 Recommendation. CDMA2000 is one of the five standards. It is also known by its ITU name IMT-CDMA Multi Carrier.



CDMA2000: Delivering on 3G

CDMA2000 represents a family of technologies that includes CDMA2000 1X and CDMA2000 1xEV.

- CDMA2000 1X can double the voice capacity of cdmaOne networks and delivers peak packet data speeds of 307 kbps in mobile environments.
- CDMA2000 1xEV includes:

  - CDMA2000 1xEV-DO
    - CDMA2000 1xEV-DO delivers peak data speeds of 2.4Mbps and supports applications such as MP3 transfers and video conferencing.
  - CDMA2000 1xEV-DV
    - CDMA2000 1xEV-DV provides integrated voice and simultaneous high-speed packet data multimedia services at speeds of up to 3.09 Mbps.
  - 1xEV-DO and 1xEV-DV are both backward compatible with CDMA2000 1X and cdmaOne.

The world's first 3G (CDMA2000 1X) commercial system was launched by SK Telecom (Korea) in October 2000. Since then, CDMA2000 1X has been deployed in Asia, North and South America and Europe, and the subscriber base is growing at 700,000 subscribers per day. CDMA2000 1xEV-DO was launched in 2002 by SK Telecom and KT Freetel. The commercial success of CDMA2000 has made the IMT-2000 vision a reality.

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.

1. Increased Voice Capacity
2. Higher Data Throughput
3. Frequency Band Flexibility
4. Increased Battery Life
5. Synchronization
6. Power Control
7. Soft Hand-off
8. Transmit Diversity
9. Voice and Data Channels
10. Traffic Channel

11. Supplemental Channels
12. Turbo Coding
13. Connectivity to ANSI-41, GSM-MAP, and IP networks
14. Full backward compatibility
15. Improved service multiplexing and QoS management
16. Flexible channel structure in support of multiple services with various QoS and variable transmission rates

CDMA2000 Deployments

The first 3G networks to be commercially deployed were launched in Korea in October 2000 using CDMA2000 technology. CDMA2000 dominates the 3G market today and analysts forecast that it will continue to lead in the future.

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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 animportant 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.

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 and 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-DCCH (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.