Emerging Wireless Technologies

CDMA 1X Technology–High Speed Data and Voice

Foreword: The Public Safety Wireless Network (PSWN) Program is conducting an ongoing assessment of advancements in the wireless communications industry. The scope of this assessment is to identify emerging wireless services and technologies for potential public safety use in the near future and beyond. This article focuses on the third generation CDMA-based 1x technologies. This technology allows for high-speed data and enhanced voice quality and capacity over CDMA networks.

With the unparalleled growth of the Internet and Web-based products, mobile users are continually looking for high-performance wireless Internet technology to enhance their communications capabilities. Third generation (3G) wireless technologies promise to take users into a new realm of mobile computing, ranging from receiving and sending e-mails, to watching streaming videos, or even attending a video teleconference. For the public safety community, this would translate to the ability to access National Crime Information Center (NCIC) information such as still images and fingerprints at a relatively higher speed than with current private wireless systems or with Cellular Digital Packet Data (CDPD) technology.

1xRTT and the derivatives of CDMA2000 1x (i.e., 1xEV-DO and 1xEV-DV) are 3G wireless technologies that will help deliver these more efficient and capable wireless technologies. These technologies span a broad range of capabilities and functionalities that overlaps with the needs of the public safety community. This article discusses the evolution of these three technologies and presents the viable benefits they may provide the public safety community.

Code Division Multiple Access (CDMA) is one of the wireless air interface standards that is currently in the process of transitioning from second generation (2G) wireless to 3G wireless technology service offerings. CDMA2000 1X technology is the standard that delivers the first of three 3G modes. CDMA2000 1x, delivers raw data rates of up to 153 kilobits per second (Kbps). CDMA2000 1xEV, which includes a data-only network as well as a data and voice network, delivers raw data rates of 2 megabits per second (Mbps) and 5 Mbps, respectively. This article will explore these suites of 3G wireless technologies and their applications that will benefit the public safety community.

CDMA2000 1x

CDMA2000 1x is a standard that aims to bring high data rate capabilities to wireless communication products. It supports both voice and 153 Kbps of data using the same bandwidth configuration as legacy IS-95A[1] CDMA networks (i.e., 1.25 megahertz (MHz) channel bandwidth). This commonality gives 1x technology backwards compatibility with IS-95A – the standards can co-exist in the same system. When 1x technology is fully implemented, users will not be required to discard their IS-95A handsets; however, the additional capabilities offered by 1x technology will not operate on IS-95A handsets. 1x

[1] *IS-95A is the standard that outlines the protocol for cellular subscriber user/device mobility and uses CDMA as the air access technology*

technology not only supports high-speed data rates, it also effectively doubles the number of voice channels available on today's IS-95A systems.

Sprint, Verizon, and Nextel (driven by a major investment from QUALCOMM) are some of the network providers migrating to CDMA 1x technology for their next generation services. Verizon has already begun launching its Express Network™, which will cover 20 percent of the carrier's nationwide footprint. The Express Network™ will launch in three initial markets: along the eastern seaboard from Virginia to Portland, Maine; in the San Francisco Bay/Silicon Valley area; and in Salt Lake City. Verizon expects to roll out the rest of its Express Network by the end of 2002.

CDMA2000 1xEV

1xEV is an enhancement of the current CDMA technology, developed by QUALCOMM (i.e., the IS-856[2] TIA/EIA standard). 1xEV is a high-performance, cost-effective solution that offers high-speed, high-capacity wireless Internet access with minimal impact to network and spectrum resources.

New technologies that will be available in the market include wireless-capable Personal Digital Assistants (PDA), Smart Phones, and PCs-on-a-chip, which will allow consumers and business professionals the ability to communicate at anytime with "always-on" access to the Internet. 1xEV is the ideal technology for providing these Internet-based applications. Because 1xEV is built on an Internet Protocol (IP) backbone using standard IP network elements, a solid economic base and network infrastructure is already available for use.

1xEV is designed and optimized for packet data transmission. Because voice and data have very different packet transmission requirements, the combination of these two services leads to inefficiencies in the network. 1xEV alleviates these transmission inefficiencies by requiring separate CDMA carriers for data and voice channels. According to QUALCOMM, even with a separate CDMA carrier, 1xEV remains fully compatible with IS-95/1x, from a radio frequency (RF) perspective. The 1xEV technology uses the same 1.228 Mbps symbol rate, link budgets, network plans, and RF designs for access terminals (i.e., handsets and other wireless devices) and infrastructure. Also, allocation of voice and data on separate carriers simplifies system software development and avoids load-balancing tasks.

In a wireless, internet-based environment, data-enabled equipment usually receives more data from the network infrastructure than is transmitted in the reverse direction. This being the case, 1xEV provides asymmetric data rates on both the forward link (i.e., from the base station to the subscriber) and reverse link (i.e., from the subscriber to the base station).

1xEV's peak data rates are—

- Forward link = 2.457 Mbps/sector
- Reverse link = 153.6 Kbps/sector.

This entire high performance data throughput is achieved with only 1.25 MHz of spectrum. According to QUALCOMM, given a loaded sector with a number of users distributed uniformly across the coverage area, the average forward link throughput in a three-sector cell is—

[2] *IS-856 is the standard that defines the 1x Technology, specifically for the 1x-DO, the high data rate, data-only derivative of 1x Technology.*

Forward link:

Pedestrian Environment
- 3.1 Mbps/cell (single receive antenna)
- 4.0 Mbps/cell (dual receive antenna)

Low Speed Mobile Environment
- 2.0 Mbps/cell (single receive antenna)
- 3.1 Mbps/cell (dual receive antenna)

High Speed Mobile Environment
- 1.3 Mbps/cell (single receive antenna)
- 2.5 Mbps/cell (dual receive antenna)

The most important factor for data optimization is the capability of the forward link. Because most Internet applications (Web-browsing, e-mail, etc.) have asymmetric bandwidth requirements[3], optimizing the forward link is especially important for the wireless Internet. There are two factors that should be improved when increasing the forward link capabilities of 1xEV – the burst rate and multiplexing efficiency. The burst rate is defined as the data rate the subscriber sees when receiving packets from the base station. Multiplexing efficiency is the measure of how well the base station divides air resources among many active subscribers.

QUALCOMM states that the 1xEV design employs a shared forward link and can serve a user at any instant. When a user is being served, an access terminal receives the full power of the base station transmitter. The access terminal (handset) calculates the received signal's carrier-to-interference ratio (C/I) and coordinates with the access point (base station) to attain the highest data rate possible to receive information. This allows the access point transmitter to operate at full power and transmit data at the highest possible data rate for each access terminal request. Dynamic power control and automatic rate fallback techniques are also used to allow the base station and user equipment to coordinate to achieve the highest data rates possible given the status of the link.

Another benefit of the shared forward link is the scheduling algorithm, which optimizes the data transmission on the forward link for multiple users. As more subscribers access the 1xEV system, the scheduler assists in improving the traffic flow by proportionally scheduling data to each subscriber's average throughput – a technique known as load-balancing.

1xEV allows a maximum of 60 active users (per serving antenna sector) to request and receive packets simultaneously. Depending on a specific activity factor (i.e., traffic loading), a much larger number of users can use the system. For example, if users in a given sector are operating applications with an estimated 10 percent activity factor, then 600 users can effectively be served at a time.

CDMA2000 1xEV-DO

As indicated, QUALCOMM will roll out 1xEV in two phases. The first phase, called 1xEV-DO (1x Evolution–Data Only) will only provide data. 1xEV-DO incorporates a new air interface technology designed specifically for packet data transmission and offering a bandwidth efficiency for data traffic that is three to four times greater than the current 3G standard, 1xRTT. 1xEV-DO has a peak data rate of 2.45 Mbps on the forward link, while using only 1.25 MHz of spectrum.

Because the 1xEV-DO technology is used exclusively for packet data, data rates are adjustable. Current cellular CDMA voice systems are designed to provide a constant bit rate (typically between 8–16

[3] *Asymmetric access allows for faster download speeds, which directly supports user expectations and satisfies requirements for high-speed, data-intensive applications.*

Kbps for each voice call). The base station adjusts its transmit power based on power control feedback (received from the handset) to maintain the target bit rate in the presence of varying channel conditions. If the bit rate drops below the target rate, the voice call can be lost.

Guaranteed data rates are not necessary for packet data, as long as some minimum performance level is maintained. More important, with an adjustable data transmission scheme, packet data users can achieve significantly improved data rates over current systems. With these factors in mind, an air interface designed specifically for wireless Internet access should provide the highest data rate possible at any given time, and requires a system that can adapt the data rate based on the channel quality seen by each subscriber.

1xRTT has voice-centric designs that are optimized for a fixed data rate, with no efficient mechanism for varying the data rate based on a subscriber's channel quality. The result is a significant loss in capacity. For example, a user may be served at 32 Kbps, even when the channel conditions would have allowed for a much higher data rate.

1xEV-DO has an adaptive scheme that allows the base station to shift its data rate for each active user every few milliseconds. This adaptive scheme is possible because the active terminals constantly measure the channel conditions based on received pilot signals from all surrounding base stations. The base stations then report back to the network with the maximum data rate at which each terminal can receive, thus making the entire network more efficient.

The possibilities and applications for using wireless high-speed data to ensure the safety of the public are virtually endless.

1xEV-DV

The second phase of the 1xEV rollout, called 1xEV-DV (1xEvolution–Data and Voice), is expected to become available several years after the data-only phase and will provide both data and voice services. This next evolution in wireless technology is designed to provide integrated voice with simultaneous high-speed packet data, and video conferencing capabilities. 1xEV-DV is the 3G evolution of CDMA2000 1x wireless communications, which will provide a peak data rate on a single 1.25 MHz carrier, specifically, 5 Mbps with an average throughput of 1.2 Mbps. This is about twice the speed of the 1xEV-DO throughput. 1xEV-DV will be backward compatible with IS-95A/B and CDMA2000 1x, allowing for a graceful operator migration from currently deployed systems.

What Does This Mean for the Public Safety Community?

As these 1x technologies are deployed, the public safety community will realize benefits along with commercial and business users. Applications such as tele-medicine and video conferencing could greatly impact how emergency medical personnel perform duties on the scene. Also, high-speed data communications could allow for real-time video feeds to/from police vehicles, promoting officer safety.

Further, 1x technology offers an upgrade path to faster, more efficient data capabilities than the existing CDPD networks. Other multimedia services such as NCIC will be available with the high data

rates offered by 1x technology. And finally, since 1x technology is CDMA based, if the public safety community uses 1x technology they will benefit from the inherent security associated with CDMA (i.e., low probability of detection and interception). The possibilities and applications for using wireless high-speed data to ensure the safety of the public are virtually endless.

Conclusion

These three evolutionary technologies look to provide business professionals, consumers, and public safety agencies with an array of new features and products that could greatly enhance their respective communication methods. The rollout of the 1xRTT technology has already begun, with 1xEV-DO and 1xEV-DV not too far behind. Soon, these high-speed data protocols will become commonplace, and the way mobile devices are used will once again change, likely for the better.

References

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