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Are we there yet?
Directions to Follow on the Road to Phase II

by Mark Drennan and Terri Thornberry

PSAPs throughout the country are beginning the journey to enhanced emergency call handling for wireless telephone users. With over 118,000 wireless 9-1-1 calls being made daily in the continental United States, a speedy trip is a necessity. The Federal Communications Commission's Phase II wireless 9-1-1 guidelines spell out the destination and the general timeline for getting there. But the road is not well marked, and the journey is littered with many potential hazards. Following are some of the key considerations that relate to this wireless E9-1-1 journey for both the public safety industry and the carriers.

The Groundwork

Wireline E9-1-1 infrastructure in the U.S. has been working for nearly 30 years. It is primarily analog, and it uses a complex network of telephone switching centers, databases and sophisticated data communications equipment to deliver the call and the accompanying data to the PSAP responsible for dispatching emergency services to the caller's area. The challenge in integrating wireless and wireline technologies is to provide the PSAPs with the clear and actionable information they are accustomed to receiving from the wireline E9-1-1 system.

Wireless Phase I requires that the calling party's call-back number be delivered to the PSAP, along with the location of the cell site antenna that received the call. Wireless Phase II requires that wireless carriers provide latitude and longitude information that defines a more precise position of the wireless 9-1-1 caller. Network-based solutions must provide location information within 100 meters for 67 percent of calls and within 300 meters for 95 percent of calls; handset-based solutions must provide location information within 50 meters for 67 percent of calls and within 150 meters for 95 percent of calls.

PSAPs wondering whether Phase I is worthwhile—and whether it would be more prudent to put all efforts into Phase II—should realize that they cannot proceed to Phase II without first adopting the basic functionality delivered in connection with Phase I. In addition, Phase I provides default routing information if the position determination equipment (PDE) that provides the x/y coordinates fails to locate the caller in time to route the call. Phase I and Phase II wireless 9-1-1 solutions can be implemented in parallel, although early implementation of Phase I helps facilitate deployment of Phase II. The majority of Phase II solutions, whether they are network-based or handset-based, add a level of complexity to the network that can be a major effort for the carrier.

There are several location-determination solutions in varying stages of development, and wireless carriers face the challenge of determining which ones will work most efficiently, effectively and economically with their own infrastructure. These technologies often require that

new elements be placed within their networks and that new skills be acquired by their engineers. Phase II is truly the integration of a communications network and a navigational network.

Position Determination Equipment
Three categories of location determination technologies are being developed to satisfy Phase II location requirements for PDE—network-based, handset-based and a combination of both.

Handset-based technologies rely on the Global Positioning System (GPS), the satellite-based radio navigation system operated by the U.S. Department of Defense. A GPS receiver added to a mobile phone collects signals from satellites and calculates the caller's position using known elements of velocity, time and distance. Although this method is considered to be one of the most accurate, GPS signals—which are transmitted by satellites—tend to be weak on Earth's surface, cannot penetrate buildings or heavily wooded areas and can vary in accuracy depending on weather conditions.

Network-based technologies can use a variety of tracking methods. Time difference of arrival (TDOA) determines the location of a handset by comparing the arrival times of the handset's signal as received by three different cell sites. Timing is so precise that speed and direction of travel can also be estimated through triangulation calculations. Angle of arrival (AOA) determines where the caller is through calculations based on the angle at which a radio signal approaches several cell sites. The location is determined from the point of intersection of projected lines drawn from the cell sites at the angle from which the call originated. One approach from U.S. Wireless uses proprietary Location Pattern Matching technology to determine a wireless caller's location by measuring the distinct radio frequency (RF) patterns and multi-path characteristics of radio signals arriving at a cell site from a single caller. The unique RF pattern, or "signature", of the call is matched to similar patterns stored in a centralized database.

Network-based implementations have the advantage of providing coverage for the entire base of wireless phones at once, including the early "brick-sized" phones. But as wireless technology standards change, network-based hardware and software may need to evolve to accommodate those standards. Some wireless carriers may choose to use more than one location technology, depending on the geographic location or customer.

Mobile Switching Center
The mobile switching center (MSC) is the switch, located within the wireless carrier's facilities, that provides stored-program control for wireless call processing. The MSC uses sophisticated computing capabilities to identify the electronic serial number of the caller's handset and the call-back number of the phone. The majority of the switches used as wireless MSCs are digital and usually communicate messages into the E9-1-1 network using digital protocol, such as Signaling System 7 (SS7).

When an MSC recognizes a wireless call as a 9-1-1 call, it is forwarded to a specialized wireline switch called the selective router, typically owned and operated by the incumbent local exchange carrier (ILEC). A series of complicated messages between different pieces of hardware within

the network determines the location of the caller as well as the path that the voice and associated data need to travel to reach the correct selective router and then the PSAP.

One challenge is that some existing PDE cannot perform the calculations quickly enough to route the call before the switch is required to do so. This means that some Phase II calls will first route on Phase I information. Depending on the technology, the Phase II data might be delivered to the PSAP shortly afterward, either automatically or based on the call taker requesting it—that is, "pulling it"—from the ALI system.

Mobile Positioning Center

When it comes to providing Phase II location data, the mobile positioning center (MPC) serves as the data hub to the wireless network, the wireline E9-1-1 system and the location determination technologies. The MPC is a new element added to the wireless carrier's network. Using the information from the MSC, the MPC determines whether a query to the PDE is necessary.

Once location information for the call is identified, the MPC compares the data with the PSAP boundary database and determines which PSAP responds to that specific call location. Location data is delivered by the PDE in Phase II or the wireless network in the case of Phase I. The MPC then takes the data and provides instructions to the switch as to where the call should be routed.

Coordinate Routing Database/Call Routing Determination

Implementation of Phase II service requires that the wireless network have the ability to perform dynamic call routing on a call-by-call basis, determined by the geographic position of the caller. Location technology determines the location of the wireless caller shortly after the call is made. A routing decision based on that information must be made to enable a dynamic routing process to take place in the wireless network. Accurate call routing depends on the establishment of accurate boundary mapping for thousands of PSAPs across the entire country. The coordinate routing database (CRDB) performs an extremely complex task that involves point-in-polygon determination of the caller's location against the PSAP boundary map to determine the appropriate PSAP and proper call routing to deliver the call.

The actual delivery of wireless 9-1-1 calls through existing 9-1-1 systems requires the use of routing numbers that simulate the functions of ANI digits. The routing digits enable access to an ALI record built on a one-to-one relationship with an individual cell sector, which provides the call taker at the PSAP with the information about the wireless 9-1-1 call.

The process also includes decision making on alternate and default routing. Default routing occurs when the destination for routing cannot be determined by the switch, for example, routing numbers are not recognized or the numbers are corrupted. Alternate or overflow routing occurs when the destination is known but the trunks between the MSC and selective router or the selective router and PSAP are busy or unavailable.

CAS vs. NCAS

E9-1-1 networks are comprised of a number of network components that operate together to deliver a 9-1-1 wireless call, along with caller data, to a PSAP. First, the wireless service

provider must connect a voice and signaling path from an MSC to the E9-1-1 selective router to enable transport of the caller's voice to the PSAP. Second, to meet the requirements of Phase I, the call-back number of the caller must be identified as well as the antenna through which the 9-1-1 call was received. Third, to meet Phase II requirements, the latitude/longitude coordinates of the caller's location must be recognized.

There are various methods for delivering the required data stream over voice networks. Call-path associated signaling (CAS) uses the normal call setup signaling path through the E9-1-1 network to provide for the caller's number and routing digits to be delivered along with the caller's voice to the PSAP. Many PSAPs across the country are currently unable to receive more than 8 digits over the voice path, so deploying a CAS solution requires upgrades to the local E9-1-1 selective router. It also requires signaling modification between the selective router and the PSAP in order to handle the extra routing digits, and may require changes to customer premise equipment (CPE) at the PSAP.

A more readily available alternative developed to minimize the changes required within the existing E9-1-1 infrastructure involves non-call-path associated signaling (NCAS). The NCAS solution places new functionality into the wireless network, rather than into the existing E9-1-1 system.

NCAS employs a service control point (SCP) that provides routing of all necessary data to both the MSC and the ALI database. The SCP specifies the routing of 9-1-1 calls from the cell site to the PSAP by using a database with routing and control information and determining where the call should be sent. The voice call and assigned routing number are delivered to the PSAP via the local exchange carrier's 9-1-1 selective router. When the voice call is received by the PSAP, the routing number is used to retrieve a record containing the call back number and the location data from the ALI database.

Database/Database Management

It is absolutely necessary for the database to be maintained and updated and, where possible, for all corrections to be made *immediately* to ensure the PSAP's ability to respond to emergency calls. This includes cell coverage overlays, PSAP boundary mapping, coverage area descriptions, call routing recommendations, routing validation, data record placement to E9-1-1 systems, verifying data integrity, investigating misrouted or missing data records and discrepancies and error correction.

Regulatory Compliance

The FCC, in its *Guideline for Testing and Verifying the Accuracy of Wireless E911 Systems* (OET Bulletin NO. 71, March 31, 2000), provides guidance on testing for compliance with the accuracy standards on an ongoing basis. It is imperative to assess and identify potential installation concerns and resolve them prior to cutover, as well as to conduct system acceptance testing and certify the compliance with FCC guidelines.

The critical and timely nature of wireless emergency calls makes it imperative that testing be comprehensive but transparent to wireless callers.

Are We There Yet?

Multiple carriers, PDE methods, network techniques, signaling approaches and support center functions must coexist to provide a viable Phase II solution. Every PSAP must work closely with the ILECs and/or the 9-1-1 network providers and wireless 9-1-1 service providers in their area to understand which technology is being implemented and what the ramifications might be.

Careful preparation will help you avoid costly detours and ensure that your arrival takes place when and where you want to be. We're not there yet, but the end of the trip is definitely in sight.

***Mark Drennan**, Director, Wireless Network Engineering, is responsible for all engineering support of SCC Communications' Wireless Enhanced 9-1-1 services to internal and external customers. Mr. Drennan provides technical and industry standards leadership and direction to the personnel and staff of SCC's Wireless Business Unit. He is responsible for managing all aspects of maps and wireless Geographic Information Systems (GIS) for the Wireless Business Unit. Mr. Drennan is an active member of NENA and participates in the Network Technical, Non traditional Technical and Wireless Committees.*

***Terri Thornberry** is responsible for establishing and maintaining quality standards and procedures in SCC's Wireless Business Unit as Director, Quality and Process Improvement. Ms. Thornberry oversees the continual improvement of core processes and operations within the Wireless Business Unit. She is also responsible for establishing training programs, mentor programs and PSAP visits for Wireless Business Unit employees.*