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The Wireless 9-1-1 Network: What is it? What does it look like? Why should I care?

By S. Verdette Hall

As we all know by now, the FCC promulgated rules (and they keep extending the deadlines) on how Wireless 9-1-1 is supposed to work and what technologies will be used to provide the location of the caller. Known as FCC Docket 94-102, it describes "Phase I" and "Phase II" criteria for identifying the location of a person calling 9-1-1 from a wireless telephone (Cellular or PCS). However, also within the rules is something *we* call "Phase 0".

In effect, Phase "0" says, *without charge to your PSAP*, wireless providers are required, at your request, to send 9-1-1 calls to your PSAP over a 7-digit line provided by you. You don't get callers' telephone numbers or any location information, but at least you get the emergency calls originating from tower sites in your jurisdiction (and sometimes with enough negotiation, the antennas facing you) to help protect your tax-paying citizens. The implementation of Phase "0" has no impact on your existing 9-1-1 network, or on your current PSAP equipment (other than requiring a separate line on your phone). While you don't get any information about the caller or their location, as will be seen from the description that follows, the "location technology" used in Phase "0" is about the same as that provided in Phase I.

The Phase I Network Maze

The next level of sophistication in wireless caller location is Phase I. Implementation of this capability not only requires major network changes, *in accordance with the FCC rules, you must also have some "mechanism" in place (collection of wireless 9-1-1 fees) to pay for the changes and services provided, before you can ask the wireless providers to deliver these services*. What are these extra services? (Editor's note: in autumn 1999, the FCC eliminated the cost recovery requirement for Phase I and II. Therefore, the wireless carrier obligation to provide location services is no longer contingent upon a formal cost recovery mechanism—NN)

The extra services are the delivery of the 9-1-1 caller's 10-digit telephone number, for callback purposes, and the street address of the cell site (tower) from which the call originated. In most cases, the wireless company can and will also furnish the "antenna face" handling the call. All wireless towers have three sets of antennae, in a triangular array, typically facing north, southeast and southwest. By knowing which of the three antenna are in communication with the 9-1-1 caller's phone, you can more closely determine the geographic area they are calling from (visualize a triangle extending outward from the tower site).

Even with Phase I, those PSAPs with a mapping capability to visually display the calling location geography for a call taker will have an improved capability to help define specific locations when the 9-1-1 caller cannot tell the call taker where they are located. In one study this was 42 percent of the callers—the nationwide average is 25 percent.

The method of delivery of the telephone number and location information to the PSAP in current Phase I systems, in most cases, is through an interconnection between your normal Local Exchange Carrier (LEC), Master Street Address Guide (MSAG) database and the database computer of a Third Party Database Provider (TPDP). The third party database provider has been contracted by the wireless company to deliver the necessary data to you. This is accomplished by utilizing a mechanism frequently known as pseudo ANI, or p/ANI.

The 8- to 10-digit p/ANI data stream is transmitted from the wireless company's Mobile Switching Center ("MSC"—the wireless equivalent of a central office) to the tandem switch in the same manner a landline telephone number is transmitted from a 9-1-1 caller's local central office. The 8- or 10-digit "phone number" is then transmitted to the PSAP over a regular 9-1-1 CAMA trunk.

In order to determine the correct routing of the wireless 9-1-1 call, and later the acquisition of the telephone number and address data by the PSAP, the following steps take place:

1. The cell site (tower) receives the voice call, the digits dialed (9-1-1) and the caller's telephone number (your phone always communicates its number to the cell site, otherwise they would not know how to bill you for the call).
2. The cell site passes this information, combined with its ID (which describes the tower's street address) and the communicating antenna, along to the Mobile Switching Center (MSC).
3. The MSC then transmits this information to the TPDP, which looks up the appropriate PSAP, based on cell site address and antenna being used (the general geography covered by the transmitting antenna that lies within your jurisdiction).
4. The TPDP assigns a temporary p/ANI whose digits contain routing information (like an ESN used for landlines) for the tandem switch and a unique number identifying this particular call for later use. This p/ANI becomes what is known by some providers as an Emergency Services Routing Key or "ESRK."
5. The ESRK is sent back to the MSC to be transmitted as a "phone number" to the tandem.
6. Based on the routing code, the tandem selects the appropriate 9-1-1 trunk route and rings the ANI controller in the PSAP.

Figure 1. Indicates, at a high level, the conventional network for landline 9-1-1 services, including the landline selective router, and shows the path of the wireless data from the cell tower to the MSC, to the TPDP back to the MSC, and on to the tandem switch. After the tandem signals the ANI controller in the PSAP and it answers, the p/ANI is transmitted in conventional manner (DTMF tones). In the same mode as a landline call, the ANI controller passes the digits to the ALI controller, so that it can request information about the "telephone number" from the MSAG. The "telephone number" is transmitted over the two regular data channels from the PSAP to the LEC's MSAG database.

The MSAG computer recognizes that the digits sent are not a landline telephone number resident in its database, and forwards the p/ANI to the TPDP. The TPDP database has held the information previously sent by the MSC and "tagged" with the ESRK number. Using the ESRK to look up the data, the actual 10-digit wireless unit's telephone number and location information (cell site street address and antenna face) is transmitted by the TPDP back to the MSAG, which

in turn sends the information along to the ALI controller for display to the call taker, just like a conventional landline data stream.

Note, however, until all of the above actions have been completed, the call taker has no knowledge of the phone number that is calling or where the caller is located (in a general geographic area from the antenna). The normal ANI display for the call taker will only show the p/ANI numbers, which of course are meaningless until translated by the TPDP. The call taker will, however, have the voice caller and normally the ALI data display will occur at about the same speed as on a typical landline 9-1-1 call.

A couple of variations of this data exchange are used in some areas of the country. These occur where the wireless provider is the LEC or has negotiated with the LEC to provision either SS7 (see more about SS7 in Phase II discussion) or Enhanced MF Signaling. In both cases, 20 digits of information are sent through the tandem to the CPE in the PSAP. The first 10 digits actually represent the wireless phone callback number to be displayed on the ANI screen, and the second 10 are p/ANI. Many of the CPE vendors offer software upgrades for their more modern 9-1-1 PSAP systems, wherein the CPE will display the call-back number and send the second set of 10 digits back to the MSAG to acquire location information, as previously described for p/ANI. Since the benchmark lab testing for CAMA trunks requires sending the normal first eight digits within three seconds of answer by the CPE, and it requires 0.25 seconds per digit, theoretically, it should not take over four seconds to send the entire 20-digit data stream.

Mapping Out Phase II

Now comes Phase II—*big change*. While there have been some Phase II demonstrations around the country (well publicized in this magazine), everybody seems to have a different idea and an "axe to grind" about how the Phase II network is going to operate and, the big "hot button," which technology will be used to find the caller and send the location to the PSAP. When I initially read the FCC rules about "within 125 meters with 67% accuracy," my first thought was "you mean it does not have to work for one-third of the year?" Hopefully, by the time all of the delays in actually implementing Phase II have passed, the location technology will have far surpassed the location requirements first envisioned by the FCC as reasonable to expect.

The primary network change that will occur between Phase I and Phase II is support for the new requirement to send you, instead of a fixed cell site street address, a multi-digit description containing, hopefully, the caller's latitude and longitude (each normally expressed by a 6-digit number), combined with direction and speed of travel. The new data stream must still include the caller's 10-digit wireless telephone number. This new data block could result in a 20- to 35-digit (or more) data stream. Obviously, this amount of data cannot be sent to you over the existing CAMA trunks that, today, connect the tandem to your PSAP in the form of 9-1-1 trunks. They were never designed to support that amount of data, since their original use was to send a 7-digit phone number for long distance billing purposes.

Our firm has received technology briefings from the location technology folks (Angle Of Arrival or "AOA", Timed Distance Of Arrival or "TDOA," & GPS), the third-party database providers (TPDPs) and the CPE (9-1-1 equipment) manufacturers. Each one is very confident their products are the answer for Phase II. However, when discussing with them the network and the

data transmission systems required to link the three components together, it's like the old cartoon with the cloud in the center of a complex network diagram labeled "and then a miracle happens."

Each vendor is confident his or her piece of the puzzle will work, and it usually does. While the location technology folks are each vying for their share of the Phase II pie, the final decision on whose product to use rests with the wireless carrier. Depending on their network design and switching equipment, only one technology may be the best solution for individual carriers. Alternatively, all three might function well for a particular carrier. Therefore, the final decision could be a matter of cost to implement. The cost to implement, combined with other revenue opportunities envisioned by the wireless provider, will also be a driving factor in the end cost to PSAPs to provide Phase II location technologies to their 9-1-1 callers. Remember that your local Public Utility Commission does not control the wireless folks' rate—they are independent corporations whose only price controls are dictated by competition in your local area.

When asked how they expect to transmit the wireless caller's location to the correct end PSAP, each of the location technology vendors we met with basically said the same thing. That was not their responsibility, they only delivered information to the wireless carrier—how it got to the correct PSAP was somebody else's responsibility.

Mapping displays, indicated as a very nice-to-have capability for Phase I wireless, will be mandatory in the PSAP to handle Phase II calls. Obviously, sending a call taker a text message, containing eight digits each of latitude and longitude information, will be an inadequate solution to advise the location of a 9-1-1 caller. The first challenge for a PSAP manager will be acquiring, and keeping up-to-date, an accurate map of their area of responsibility. Those jurisdictions with a good GIS department will be fortunate.

In today's modern world of technology, new "map centric" Computer Aided Dispatch (CAD) systems are being offered by an ever-increasing variety of CAD vendors. These CAD systems geographic files are actually based on GIS data and maps, which can be displayed on the CAD CRT, as opposed to "flat file" listings of streets in older type systems. Additionally, many of the manufacturers of 9-1-1 CPE equipment also offer PC-based systems, with a map option to provide an icon on a CRT screen map, indicating the callers location. While a mapping option in the 9-1-1 system may cost less than acquisition of a new CAD system, neither is "cheap" and these costs must also be considered as part of the expense to move forward to Phase II wireless.

Configuring the Phase II Network

Now, to the actual Phase II network. There appear to be two possibilities for how the network will be configured. Figure 2 attempts to indicate both within the same general network overview. The first possibility, and perhaps the most likely near-term solution, will be to continue the "NCAS" solution described for Phase I, with the new latitude and longitude location information substituted for tower address. At least one database provider (SCC Communications) has announced this as their current solution. This would leave the Phase I network in place and allow location information to be returned to the PSAP through the MSAG computer, via the TPDP, just as previously described. Ideally, the location would be transmitted in the form of latitude and longitude, speed, direction, etc., assuming that your PSAP's 9-1-1 or CAD system can handle this information and convert it into a map icon. Alternatively, in less

sophisticated systems, the location data might be converted by the TPDP into a street address file, with an address selected that is nearest the latitude and longitude sent by the location technology.

The second, and possibly superior alternative, may take much longer to come to fruition. This would involve Signaling System 7 (SS7) technology. SS7 has been around for years, but has generally been limited to supporting long distance traffic. It provides the capability to send large quantities of data along with, or ahead of a voice call. The call set up and call routing data is transmitted over a data path external to the voice communication.

However, in this scenario, SS7 would only be a part of the, generally termed, "Advanced Intelligent Network" (AIN). SS7 would route 9-1-1 calls to a Switching Transfer Point (STP) wherein an "AIN Trigger" would tell the network to go to another computer, or computers, for information which could house all of the data about the 9-1-1 wireless provider and subscribers, along with the current 9-1-1 callers location. Similar information requests are handled by the existing SS7 networks today when they need a lookup table of 800 numbers for call routing. However, a lot of future work will be required to design an AIN to handle the information needs of wireless 9-1-1 service.

With SS7 and AIN, in the future you could change routing quickly, on an as needed basis. For example, you could set up a special group of call takers and trunk routes to handle calls from one central office area where a special event or disaster was taking place. In summary, SS7 combined with AIN, has the capability to pass a large block of data, which could include caller location, speed and direction of travel, altitude, the 10-digit phone number (both permanent and temporarily assigned roaming), and possibly the caller's name and/or name of the wireless provider through the 9-1-1 "Network of the Future". NENA Recommended Standard 02-010, which includes the format for Wireless Data Exchange, lists all of the fields and number of characters that could possibly be used to send all Phase II information. Exclusive of p/ANI as default for a Phase I street address if other data is not available, the total character set is 100 Bytes. You can't do that over a CAMA trunk.

In the meantime, the "good 'ol CAMA Trunk" is all we have to work with to connect our PSAPs. We'll just have to continue to be as inventive as NENA members have in the past in making the best use of the available network technologies to provide the greatest emergency telephone system in the world.

I understand that there is an old Chinese curse that says, "May You Live In Interesting Times". I'm afraid that the "interesting times" for all of us are right around the corner with the label "Wireless 9-1-1."

Author's Note: The author has attempted to describe, as generically as possible, the various systems and operations of the Wireless 9-1-1 Network. This information is not intended as a specific description or recommendation of any vendor's systems or equipment—SVH.

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