

Enterprise



## **Signs Of Trouble: Locating E9-1-1 Callers Over Wi-Fi**

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## 1 Introduction

If we or a colleague make a 9-1-1 call, we want assurance that first responders can reach us as quickly as possible. In the United States this is assured by the E9-1-1 system, and the reliability of E9-1-1 is an important article of faith for most people, at home and at work. Very few of us have a good understanding of how E9-1-1 works. As we shall discuss in this paper, the legal requirements for E9-1-1 are fragmented, with only 16 states legally mandating E9-1-1 compliance for businesses as of early 2010. Nevertheless, TDM PBXs have incorporated sophisticated and dependable emergency call handling features, so whether mandated or not we have come to rely on E9-1-1 and it has performed well.

With the advent of voice-over-IP (VoIP) technology, emergency calls took on a new dimension, mainly as a result of phone portability. A VoIP phone can connect on any Ethernet port on the LAN, so its location can no longer be mapped to a physical cable run to the PBX. Therefore, new methods were developed for automatically determining the location of an emergency caller on a VoIP phone. All IP-PBX vendors have by now developed VoIP solutions for E9-1-1, most of them involving third-party appliances.

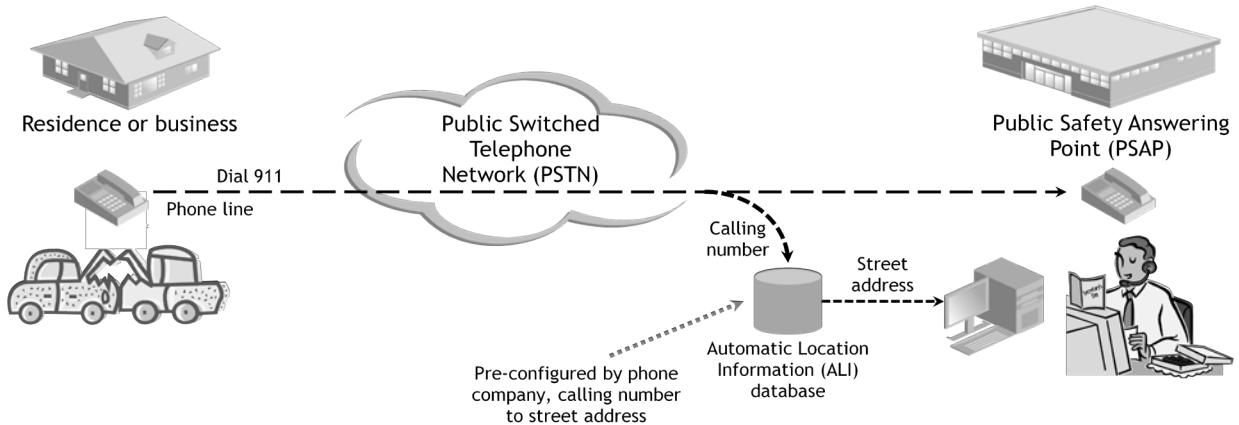
One of the requirements for a VoIP E9-1-1 server is to locate the caller. In the case of wired VoIP phones, discovery protocols such as SNMP and LLDP-MED are often used to identify the Ethernet switch and port to which the is connected. The caller's location is then inferred from these data. Unfortunately Wi-Fi phones do not have this capability; they cannot use LLDP over the Wi-Fi link. Existing solutions parse the Wi-Fi phone's IP address to determine its location, but this is unsatisfactory because it forces undesirable subnet addressing schemes, where subnets are constrained to cover small geographic areas. It is also inaccurate, especially when the phone is mobile

Aruba and RedSky Technologies, an E9-1-1 solution specialist, recognized this issue and have developed a comprehensive solution in which all voice-over-Wi-Fi (VoWiFi) devices on the wireless LAN (WLAN) are accurately and automatically located as they originate E9-1-1 calls, allowing first responders to be dispatched to the correct address, building and floor. This document explains the operation of this feature.

## 2 Current E9-1-1 architecture

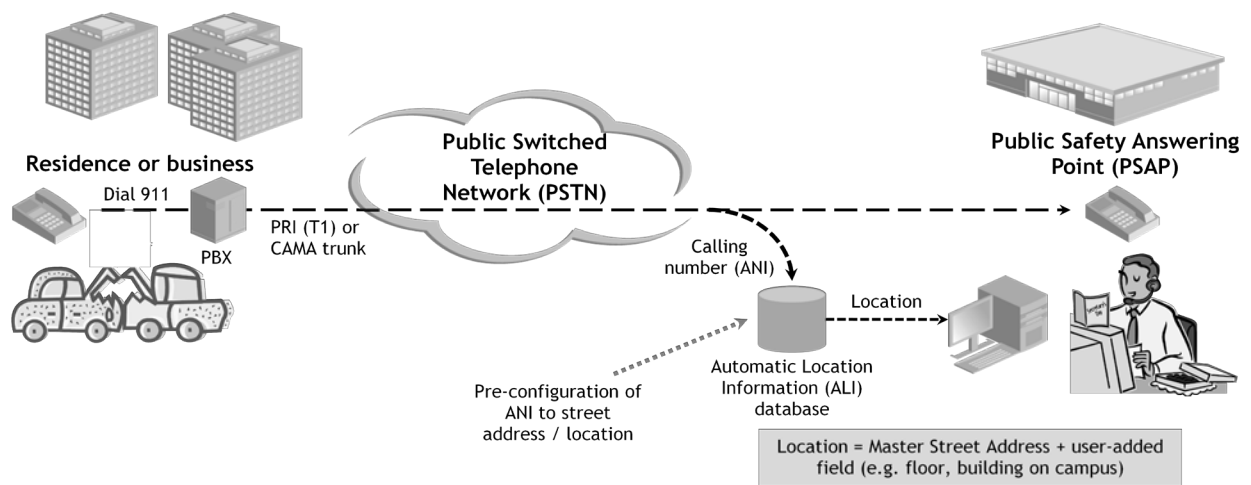
Although E9-1-1 for enterprise VoIP and VoWiFi is not an explicitly defined set of requirements, we can draw parallels from existing E9-1-1 legislation, and from FCC specifications for cell phones and domestic VoIP services. An appendix to this document provides further reading on the subject. To summarize, enterprise voice systems need to locate emergency callers using the correct street address, building, and floor (some states specify accuracy to within a 40,000 sq ft area), and delivered to the public safety dispatcher in a usable format.

Public safety dispatchers work from Public Safety Answering Points (PSAPs). These are communications centers serving county-wide or larger areas, and all calls dialed to 9-1-1 within the area are directed to the local PSAP. Upon arrival the call must have a valid Answering Number Identification (ANI) associated with it. This is familiar to us as the calling number, and is not a new feature, but it means that the call must leave the enterprise on a T1 PRI (or all but extinct analog CAMA) voice trunk. Residences and small businesses don't require this if their phone number is registered to their address, but larger businesses with many locations and phone numbers need a PRI trunk.



E9-1-1 calls for residences and small business locations

The ANI is used by the PSAP as a look-up pointer in the Automatic Location Information (ALI) database, which designates a physical location to each ANI phone number. The local ALI is populated by the phone company when a domestic line is installed. Businesses using E9-1-1 must gain access to the database and configure it using a 'private switch / ALI' (PS/ALI) service. When calls are received in the PSAP, dispatchers are presented with a street address in 'master street address guide' (MSAG) format, along with the floor of the building if added by the enterprise.

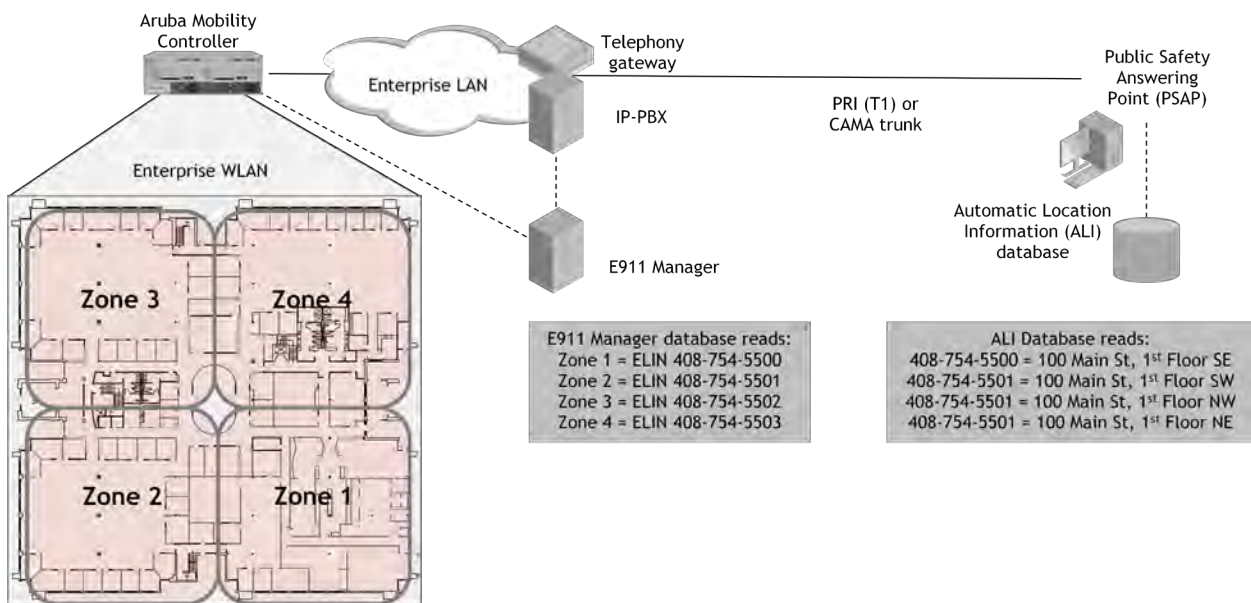


E9-1-1 calls for larger businesses

### 3 E9-1-1 Architecture for WLAN phones

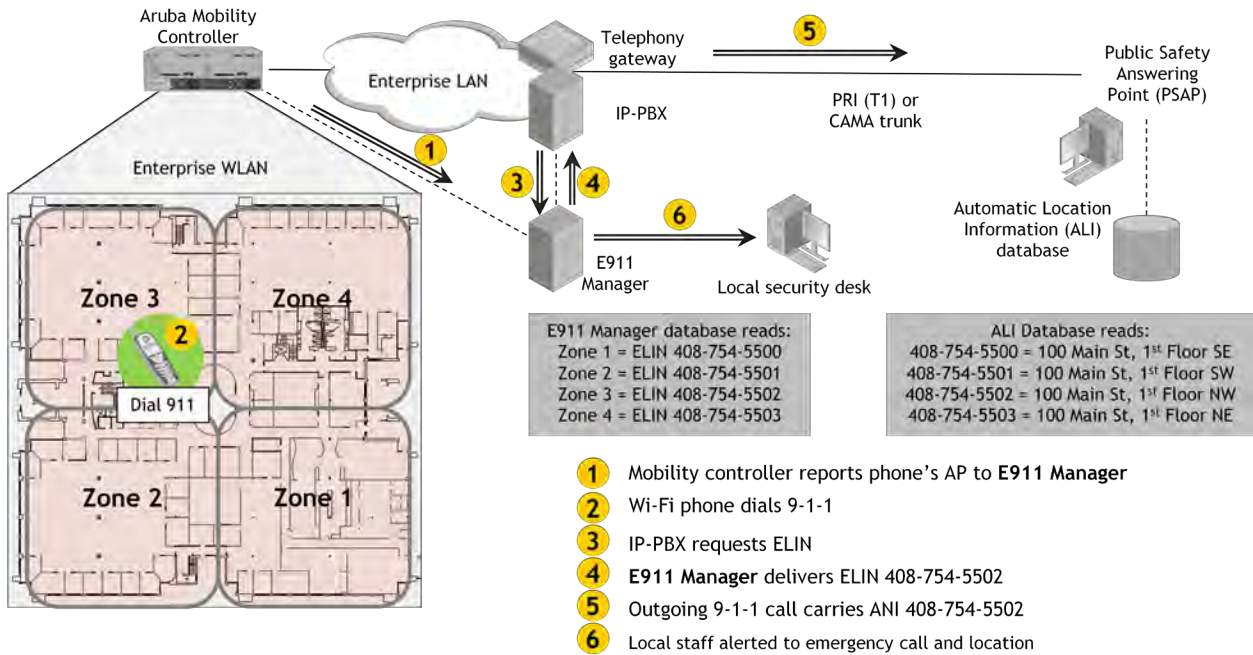
The E9-1-1 architecture required for a WLAN is different from that used for wired phones. By way of background we'll examine the architecture used in an Aruba WLAN equipped with Wi-Fi phones, and supplemented by RedSky's E911 Manager. The E911 Manager has supported wired VoIP phones for years, and is certified for use with a wide range of IP-PBXs and phones.

Aruba's WLAN provides toll-quality voice services to Wi-Fi phones, and the sole requirement for a phone in the context of E9-1-1 is that it be recognized as a 'voice' endpoint using a recognized voice signaling protocol. Currently supported protocols include SIP, H.323, Cisco SCCP 'skinny', Polycom/Spectralink SVP, Vocera signaling protocol, and Alcatel NOE.



Initial configuration of RedSky E911 Manager and an Aruba WLAN

The first stage in setting up an E911 Manager deployment is to decide how precisely the emergency caller should be located, by designating a number of zones on the floor plan. A zone often covers a single floor of a building, but can be smaller. Each zone is mapped in E911 Manager to a dummy PBX extension number configured on the IP-PBX, known as the 'emergency location identification number' (ELIN). Once the floor plan has been divided into zones, the network engineer assigns an ELIN to each and populates the local PSAP's ALI database, mapping each ELIN to the street address and location description of its zone.



Emergency call information flow with RedSky E911 Manager and an Aruba WLAN

When a Wi-Fi phone joins the network, it is recognized as a voice device by Aruba's Mobility Controller and identified as requiring E9-1-1 notification. This takes the form of an SNMP trap, sent from the controller to RedSky's E911 Manager. This trap is sent on initial association, and also every time the phone roams to a new WLAN access point, so that E911 Manager always has the phone's most current 'associated AP.'

The phone also registers to the IP-PBX, and E911 Manager receives notification of its IP or MAC address from the IP-PBX. In its database, E911 Manager associates the VoIP server registration with the trap received from the WLAN controller, thereby maintaining a mapping of Wi-Fi phones to their current location.

E911 Manager continues to track the movement of phones, updating fields in the IP-PBX or updating its own database. With some vendors' IP-PBX architectures, when the phone dials 9-1-1, the IP-PBX already has the latest location and outputs the ELIN to the PSAP. Alternatively, with other vendors, when the phone dials 9-1-1, the IP-PBX requests the correct ELIN from E911 Manager and substitutes the ELIN for the DID ANI.

When the E9-1-1 call is received at the local PSAP, the ALI database looks up the dummy number and the correct location pops up on the dispatcher's screen. E911 Manager notifies enterprise security and local first-responders of the exact location of the caller, saving valuable response time. Enterprises normally prefer emergency services to be met at the campus entrance and guided to the incident, regardless of E9-1-1 location process. Where the enterprise has volunteer responder teams, they can be dispatched directly by E911 Manager.

If the call is dropped and the PSAP dispatcher calls back, the dummy extension number is recognized in the IP-PBX and redirect to connect to the original 9-1-1 caller.

## 4 Multi-site enterprises

Public E9-1-1 infrastructure assumes that an emergency call is directed to the PSAP serving the area. While it is possible to dial E9-1-1 and to report an emergency for a distant dispatch center, the transfer process may be time consuming. Thus, an enterprise with multiple, geographically distant offices – especially one with a centralized IP-PBX – presents a challenge for an E9-1-1 system; the caller must first be located and only then routed to the PSAP serving their area.



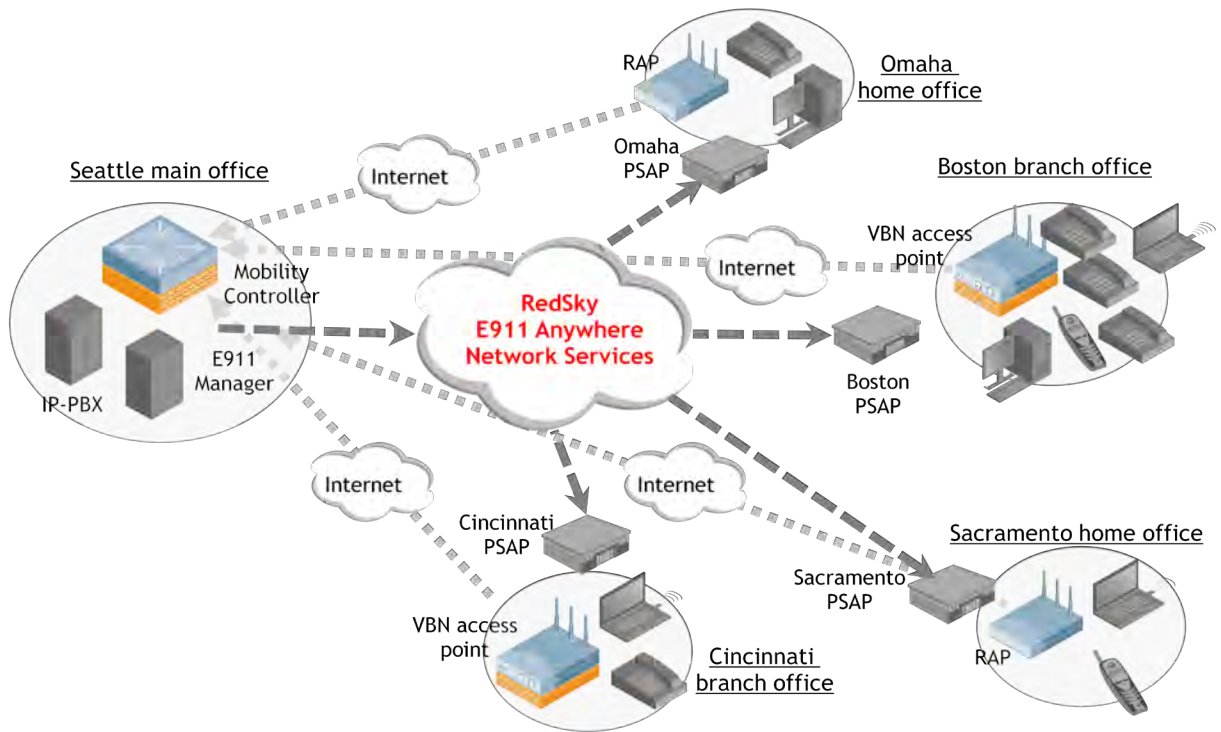
An emergency call on a RAP is re-directed to the correct PSAP via RedSky E911 Anywhere Network Services

For example, an emergency call originating from a branch office in Boston must be dialed out of a trunk from that office, even if the IP-PBX is in Seattle: A call to the Seattle dispatcher asking for an ambulance in Boston may ultimately be successful, but will consume valuable time as it is transferred. While it is possible to configure such call routing with most IP-PBXs, it can be cumbersome to maintain.

RedSky offers a superior solution for dependent-site E9-1-1. Called “E911 Anywhere Network Services” it is a cloud service that can accept and route a 9-1-1 call to any PSAP in the U.S. and Canada. RedSky eliminates any special IP-PBX programming by redirecting the call to the correct PSAP, together with the caller location address. This solution is ideal for Aruba’s Virtual Branch Network (VBN) deployments which tend to be spread across hundreds or thousands of branch and home offices.

## 5 Virtual Branch Networking

VBN provides branch offices, teleworkers, and road warriors with secure connection to enterprise data, voice, and video applications. The solution uses a family of low-cost, centrally managed Remote Access Points (RAPs) to connect to the data center via a range of different WAN links. To properly support E9-1-1, the street address of each RAP must be configured manually in E911 Manager as the network is deployed, and whenever an access point is moved.



Emergency calls with Virtual Branch Networking are located by E911 Manager and delivered over E911 Anywhere

In the event of an emergency at a RAP-equipped site, the caller's Wi-Fi phone is identified by the Aruba network as a voice device, and its associated access point reported to the central E911 Manager. Next, E911 Manager maps the access point to its correct street address and location descriptor. Finally, E911 Anywhere ensures that 9-1-1 calls are routed to the correct PSAP local to the caller.

RAPs support both wired VoIP and Wi-Fi phones, and caller location and call routing are managed in the same way for both.

## 6 Designing the WLAN for E9-1-1 performance

Aside from ensuring the reliable and clear transmission of the emergency voice call, the WLAN's key role is to ensure that the information reported to E911 Manager accurately reflects the caller's location. To make this happen the phone must associate to a nearby access point, and the Aruba controller must accurately and promptly update E911 Manager with the appropriate access point reference.

In a standards-based Wi-Fi deployment, it is the client rather than the infrastructure that chooses with which access point to associate. The client makes this decision primarily on the basis of received signal strength. In most situations a Wi-Fi phone will usually choose the closest access point, however, that's not always the case. Access points are usually spaced roughly every 20 meters (60 ft), so even an association two access points away gives an accuracy of 3,600 sq meters (35,000 sq ft), well within the 40,000 sq ft accuracy quoted in some legislation.

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Directing first responders to the correct floor of a multi-story building is an ever present concern, and perhaps even more important than lateral accuracy. Best practices for Aruba WLAN planning suggest staggering access points vertically from floor to floor, avoiding vertical alignment. This provides the best coverage and avoids some interference effects, but client devices sometimes see signals ‘bleeding’ through the floor, causing them to associate across floors. The key parameter is floor construction: reinforced concrete buildings present 10-20dB of RF attenuation floor-to-floor, and are not susceptible; wooden floors, however, are relatively transparent to RF. In these buildings, an RF survey may be required to ensure the signal from same-floor access points is always 10dB stronger than adjacent floors. If it’s not then access points should be more closely spaced.

Once access point mounting is complete, only normal commissioning is required to enable an Aruba WLAN to support E911 Manager. Access points are positioned on the floor-plan as they are configured, and this establishes the basic location information which is then entered in E911 Manager. Zones are established covering 1 to 10 or more access points, a ‘master street address guide’ (MSAG) address and location for forwarding to the local PSAP’s ALI is entered, and the set-up is complete.

Thereafter a phone’s association status is sent via SNMP by the controller trap to E911 Manager within milliseconds of a phone handover. Multi-controller, multi-site, and RAP deployments all support the same architecture.

## 7 Conclusion

Emergency call handling is widely considered a necessity when providing voice services. While few U.S. states to date have legislated E9-1-1 requirements applicable to VoIP and Wi-Fi phones, ‘best practices’ demand that all organizations with significant voice deployments follow E9-1-1 guidelines to ensure the well-being of those using the facilities.

Aruba and RedSky have introduced a new API between the WLAN and E911 Manager that allows the latter to be updated in real-time with the location of every voice-capable device on the WLAN. This enables E911 Manager to deliver E9-1-1 services to VoWiFi devices using a rich feature set superior to previously-available alternatives based on IP addressing. No cumbersome equipment or special subnet designs required. E9-1-1 services can be extended uniformly across TDM, wired VoIP, and Wi-Fi phones, and accurate location information delivered to first responders so they can promptly deliver any assistance required.

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## 8 Appendix: Emergency call requirements

While most of us assume that 'E9-1-1' is a uniform and comprehensive standard, the legal requirements are set by individual states. RedSky has a comprehensive library of relevant legislation which can be found at [://www.redskytech.com/e911\\_information\\_center/e911\\_legislation/](http://www.redskytech.com/e911_information_center/e911_legislation/). Information includes state-by-state extracts from E9-1-1 legislation, and network managers should become familiar with local requirements.

The following list covers major legal requirements for E9-1-1:

- **Location.** An emergency call dispatch center uses the originating phone number associated with a call to look up a database, delivering a street address. When the lookup is successful, the public safety dispatcher need not ask the caller where they are calling from. For domestic phone lines and small businesses, and even for some larger enterprises, the address in the database is reported by the phone company at the time of phone line installation, and no further work is necessary to locate the call. However, multi-building campuses and multi-site PBX installations do require attention to the caller location information passed with an emergency call, to ensure emergency services respond to the correct address and location. Very few states include figures for how accurate this location should be: at a minimum, it should identify the street address the emergency services should be dispatched to. For nearly all cases this is sufficient, but many large organizations prefer to give a building identification (if on a campus), floor and even which geographic corner of the building the call was made from.
- There must be a valid callback number, so if the call is dropped the public safety dispatcher can dial back and reach the caller. This requirement is trivial for domestic phone lines, but can be challenging for PBX switches.
- Many organizations have internal security and first-responder teams, and for their benefit they require notification by pager, message service or screen pop-up when a 9-1-1 call is dialed, together with accurate location information.

Even states with E9-1-1 legislation do not explicitly cover VoIP in their requirements, much less Wi-Fi phones. But it is possible to draw parallel requirements from two other emergency call regulations:

- The Federal Communications Commission (FCC) has introduced requirements for locating cell phone emergency calls. This was staged in phases and deployment is not yet complete, but the target accuracy is 50-300 meters, depending on the technology used. Note that cellular carriers have an additional requirement: any phone, even if it's not authorized to be on the network, must be allowed to originate an emergency call. Neither of these cell phone network requirements applies directly to enterprise Wi-Fi phones, but standards bodies and WLAN vendors are aware of them as they develop E9-1-1 requirements and solutions.

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- The FCC recently confirmed that providers of residential VoIP service must provide E9-1-1 service in the same way as traditional local phone companies. Service providers such as Vonage comply with this by requiring subscribers to report their home address as a condition of service. But of course this is a manual procedure and if a subscriber moves and fails to update the service provider, the location will no longer be valid. For enterprise-class E9-1-1 solutions we aim to automatically locate the phone, avoiding manual configuration by the user.
  - Handset vendors marketing dual-mode cellular/Wi-Fi phones and service over Wi-Fi use ‘revert to cellular’ as their initial response. Even if a phone is connected to Wi-Fi, an emergency call will use the cellular network wherever it’s available: the phone will only attempt the call over Wi-Fi when there is no cellular signal. This is a valid approach for dual-mode cellular/Wi-Fi phones in enterprise settings, but it does not remove the requirement for a voice over Wi-Fi E9-1-1 solution.

## 9 PSAP capabilities

PSAPs are in the midst of a long-term upgrade program and currently have a range of capabilities:

- ‘Phase 1’ PSAP has no capability for automatic location indication. Callers must tell the dispatcher their location when they make the call. Only a small fraction of the 7,000 PSAPs in the U.S. are still at Phase 1;
- “Phase 2’ PSAP relies on the ALI database to automatically locate an emergency caller. Nearly all PSAPs are at Phase 2 capability;
- In the future, PSAPs will be designed to accept VoIP calls directly using a ‘presence information data format location object’ (PIDF-LO) field standardized by the IETF as RFC4119 (pending amendments). Here the location is presented with the call setup information using the SIP protocol. This signposts the way to an all-VoIP network, but there are no Phase 3 PSAPs in service today. The technology is still in trial under the auspices of the Next Generation E9-1-1 (NG9-1-1) System Initiative.

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## About Aruba Networks

Aruba is the global leader in distributed enterprise networks. Its award-winning portfolio of campus, branch/teleworker, and mobile solutions simplify operations and secure access to all corporate applications and services – regardless of the user’s device, location, or network. This dramatically improves productivity and lowers capital and operational costs.

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