

Tech Brief |



Looking For Trouble: Emergency Call Handling Using Aruba Wireless LANs

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1 Introduction

Should we or a colleague need to make an emergency services call, it is imperative that it be processed and acted upon as quickly as possible. In the United States this task is handled by the E9-1-1 system, and compliance with E9-1-1 is an important article of faith for most employees. Few engineers, even in the communications field, have a good understanding of how E9-1-1 is supposed to work, still less how networking systems comply with it. As we shall discuss in this paper, the legal requirements for E9-1-1 are fragmented, with only 14 U.S. states mentioning E9-1-1 compliance for businesses in legislation as of early 2009. Even so, TDM PBXs have over the years developed sophisticated emergency call handling features that are very dependable and successful.

With the advent of voice over IP (VoIP) technology, emergency calls took on a new dimension, mainly as a result of phone portability. If a phone can connect on any Ethernet port on the LAN, then its location can no longer be mapped to a physical cabling run to the PBX. This resulted in new methods for automatically determining the location of an emergency caller and all IP PBX vendors have implemented some form of E9-1-1.

The most popular IP PBX today is Cisco's Unified Communications Manager (UCM), formerly known as Cisco Communications Manager, (CCM). The challenges of emergency call handling are handled by an adjunct server called Cisco Emergency Responder (CER). Not every UCM customer deploys CER, but it is the most prevalent solution for emergency call handling on UCM.

When used with wired VoIP phones, CER uses a sequence of protocols to identify the Ethernet edge switch where the phone is connected, extracting a pre-configured location from that switch. This location is applied to the emergency call as it is dialed from UCM. However, Wi-Fi phones present a further challenge, as the phone connects to a Wi-Fi access point, which in turn connects to the Ethernet switch, and, once registered, a Wi-Fi phone may roam around a building or campus. CER has developed techniques to accommodate Wi-Fi phones making emergency calls, this note we will explain the architecture used.

In this document we detail how an Aruba wireless LAN (WLAN) can interface with UCM/CER to deliver an E9-1-1 solution. Aruba's WLAN is a drop-in replacement for Cisco's less capable WLAN in the UCM/CER architecture.

2 Emergency Call Requirements

While most of us assume that 'E9-1-1' is a uniform and comprehensive standard, the legal requirements are set by state legislation. RedSky, an independent provider of enterprise E9-1-1 solutions, has a comprehensive library of relevant legislation on its web pages http://www.redskytech.com/e911_information_center/e911_legislation/. These pages include state-by-state extracts from E9-1-1 legislation and network managers should become familiar with local requirements.

This means that for most businesses operating a PBX, an E9-1-1 solution is a 'best practices' rather than a legal requirement. The following list covers major requirements:

- **Location.** An emergency call should include location information, so the public safety dispatcher need not ask the caller for their location. For domestic phone lines and small businesses, and even for some larger enterprises, the phone company reports the address where its lines are terminated at the time of 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 911 is dialed, together with accurate location information.

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

- The Federal Communications Commission (FCC) has introduced requirements for locating cellphone emergency calls. This was 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 cellphone 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.
- The FCC recently confirmed that providers of residential VoIP service must comply with E9-1-1 in the same way as the traditional local phone company. 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. Only when there is no cellular signal will the phone attempt the call over Wi-Fi. 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.

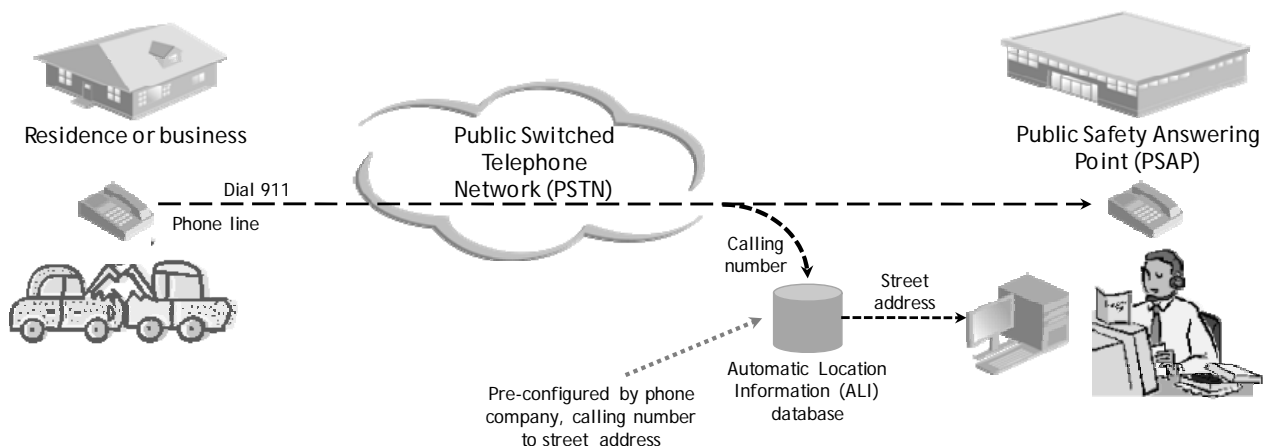
2.1 E9-1-1 and the Public Safety Answering Point

This section includes a brief explanation of the public infrastructure supporting E9-1-1, as any enterprise solution must work with these services.

Public safety dispatchers work from Public Safety Answering Points (PSAPs). These are communications centers covering county-wide or larger areas to which all local calls dialed to 911 are directed. An E9-1-1 call must be routed to the local PSAP serving the caller's location.

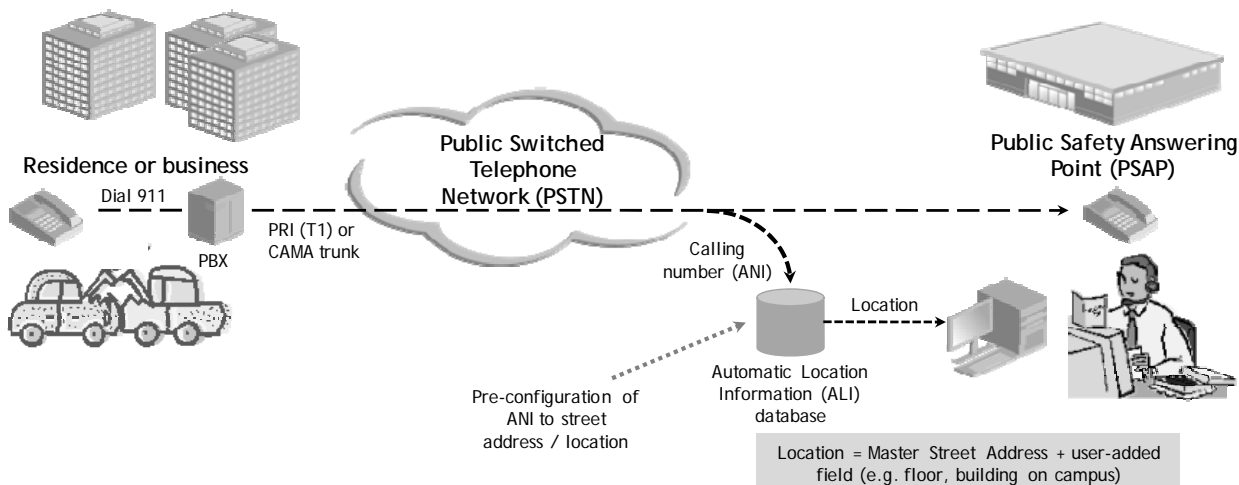
When a call arrives at the PSAP, it must have a valid Answering Number Identification (ANI) presented with it. This is the usual calling number indication, but it means that the call must leave the enterprise on a T1 PRI (or CAMA, but these are well-nigh extinct) voice line. Residences and small businesses don't require this if their phone number is registered to their address, but larger businesses with many locations and phone numbers will need PRI.

E-911 calls for residences and small business locations



The ANI is used in the PSAP as a lookup in the automatic location information (ALI) database, which designates a physical location for each ANI phone number. The local ALI is populated by the phone company when a domestic line is installed, but businesses using E9-1-1 must gain access and configure it, using a 'private switch / ALI' (PS/ALI) service. When calls are received in the PSAP, dispatchers can read on their screen a street address in 'master street address guide' (MSAG) format, along with the floor of the building, etc. if added by the enterprise.

E-911 calls for larger businesses



At this point the E9-1-1 system such as CER has done its work, except to distribute internal notifications and to ensure that should the call be dropped the dispatcher can dial the ANI and reach the caller.

Note that PSAPs may have different capabilities, and are in the midst of an upgrade program.

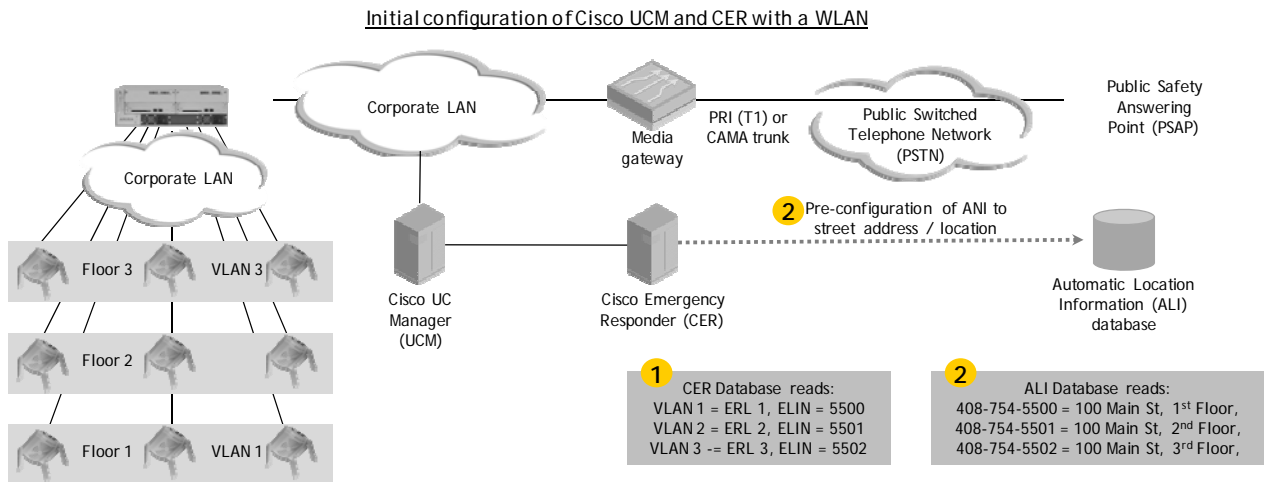
- A 'Phase 1' PSAP has no capability for automatic location indication. Callers must tell the dispatcher their location when they make the call;
- The notes above describe a 'Phase 2' PSAP, which relies on the ALI database to automatically locate an emergency caller;
- In the future, PSAPs will be designed 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 trials, under the auspices of the Next Generation E9-1-1 (NG9-1-1) System Initiative.

2.2 Cisco Emergency Responder and Wi-Fi phones

In this section we will deal only with the architecture used by CER with Wi-Fi phones. Wired phones are a different case, and one that is different from WLANs, neither Cisco's nor Aruba's. Cisco's comprehensive CER application notes are available here.

http://www.cisco.com/en/US/docs/voice_ip_comm/cer/7_0/english/administration/guide/e911plan.html . Jump to the section titled 'Configuring IP Subnet-based ERLs'

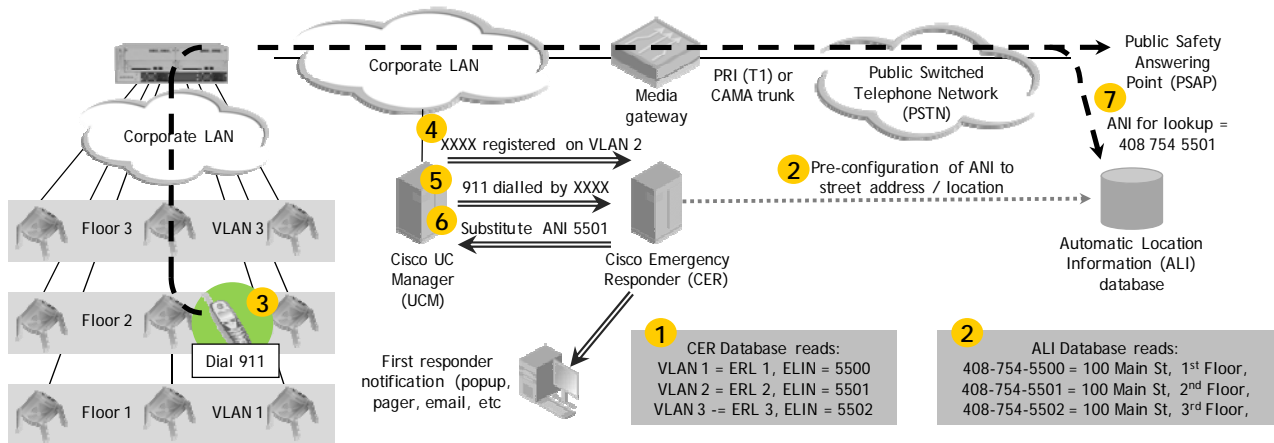


As we mentioned above, CER is an adjunct server associated with UCM. The first stage in setting up a CER deployment is to decide how accurately the emergency call should be located, designating a number of 'emergency response locations' (ERLs) on the floorplan. An ERL often covers an entire building or at most a single floor. Each ERL is mapped in CER to a dummy PBX extension number configured on UCM, known in Cisco terminology as the 'emergency location indication number' (ELIN). Subsequently, the installer populates the local PSAP's ALI database, mapping each ELIN to the street address and location description of its ERL.

Whenever a Wi-Fi phone joins the network, it is allocated an IP address. The WLAN has a key part to play, matching each device to an available VLAN often using SSID to VLAN mappings, although in Aruba's case there is more flexibility. When the phone subsequently registers with UCM, CER receives notification of its IP address. In the CER database, the subnet identifies the ERL where the phone is located: hence CER can maintain a mapping of Wi-Fi phones to their current location ERL.

No further activity is required until the phone makes an emergency call. Now the UCM notifies the CER of the call. UCM intervenes, mapping the phone to its ERL and substituting the ERL's dummy extension number for the usual DID ANI as the 911 call is dialed. When it receives the call, the local PSAP maps the dummy number to the pre-configured address in its ALI database, and the correct location pops up on the dispatcher's screen.

WLAN emergency calls using Cisco UCM and CER



Meanwhile CER will notify local first-responders, according to its configuration. Enterprises normally prefer emergency services to be met at the campus entrance and guided to the incident, regardless of E9-1-1 location process.

If the call is dropped and the PSAP dispatcher calls back, the dummy extension number is recognized in UCM and CER directs it to connect to the original 911 caller.

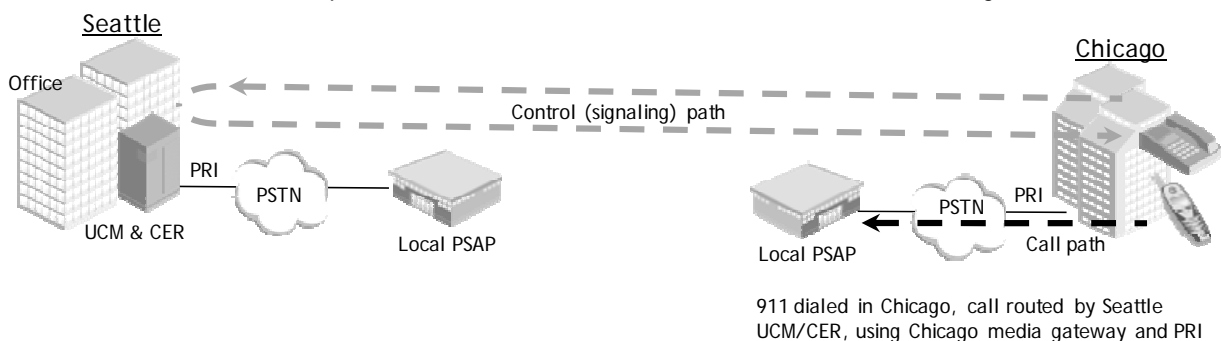
3 Enterprises With Multiple Locations

Public E9-1-1 infrastructure assumes that an emergency call should be directed to the closest 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 presents a challenge for an E9-1-1 system, especially with a centralized UCM, as the caller must first be located, then the call routed to the correct PSAP.

For instance, an emergency call from a branch office in Atlanta must be dialed out of a trunk from that office, even if the UCM is in New York: A call to the New York dispatcher asking for an ambulance in Atlanta may ultimately be successful, but will burn valuable time as it is transferred.

Where sites are large enough to have their own UCM installation with CER and PRI, the solution is as we described above, but replicated for each site.

Call path with centralized UCM/CER but distributed PRI trunking



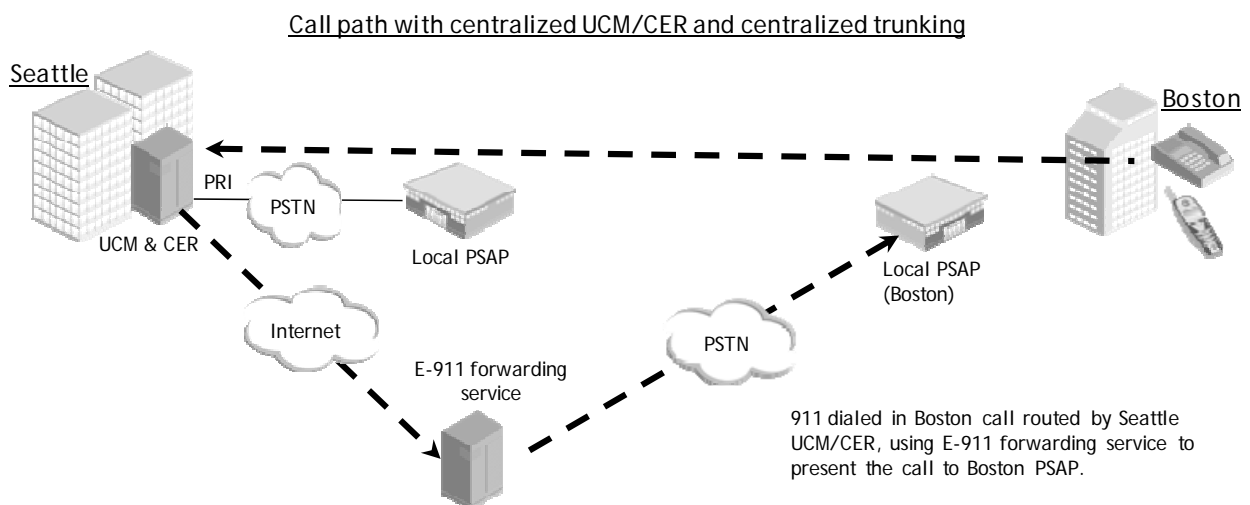
In deployment architectures where a central UCM serves multiple sites and each site has a local PRI connection, the call must be redirected so it is presented to the local PSAP for that site. In the example above, the UCM in Seattle must identify that the caller is in Chicago and direct the call back so it reaches the Chicago PSAP: there is no easy way to dial the Chicago PSAP directly from Seattle.

However, in scenarios where there is no local connection to the public telephone network, it is usually necessary to send the call to a hosted E9-1-1 forwarding service, such as RedSky's 'E9-1-1 Anywhere' or Intrado's 'V911'. Here, the forwarding service is responsible for identifying the required PSAP and delivering the call, with all relevant location information.

The WLAN's place under CER in this architecture serves these cases in the usual way, but the network engineer should be aware that the overall system design is more complex.

4 Designing the WLAN for E9-1-1

In the explanation above it is clear that the key part played by the WLAN is to ensure the IP address of the phone originating an emergency call accurately reflects its location. With Aruba's centralized architecture, the IP address of each client is allocated when it associates to the WLAN, based on the VLANs available on the northbound port of the mobility controller.



Normally, each ERL defined in the CER database must be reflected in a subnet of the VLAN available to the mobility controller. Since most E9-1-1 ERLs will cover a whole building or at least a floor, this may result in a larger number of subnets / VLANs than usual, but it should not be unmanageable.

Note that since ERLs map to subnets, Wi-Fi phones will see a discontinuity when trying to hand over to a new access point at the edge of an ERL. The phone will have to get a new IP address and re-authenticate, which will take considerably longer than a 'normal' inter-access point handover. This is a network design tradeoff – as the ERL gets smaller, location accuracy increases but more calls will suffer slow inter-ERL handover.

If many remote offices or home offices with remote access points are extended from the mobility controller, it may be cumbersome to assign each an individual subnet and VLAN. At some point, 'revert to cellular' will become a more feasible option than configuring and updating many home locations in CER, particularly as they may be in other PSAP territories and require E9-1-1 forwarding services. This is a decision for the network designer.

5 Conclusion

Emergency call handling is widely misunderstood. There are few states with comprehensive requirements applicable to VoIP and Wi-Fi phones, so the impetus for compliance is more often the enterprise wanting to follow 'best practices' than legal compliance. But the lack of legislation should not allow Wi-Fi telephony to be excluded from such a solution. Location of the caller to the correct street address, building and floor is more than sufficient accuracy for E9-1-1 purposes.

The robust performance of Aruba's WLANs make them an ideal companion for Cisco's UC Manager and Emergency Responder to deliver comprehensive E9-1-1 services.

While there are some aspects of the architecture that could be improved, a UCM-CER-Aruba combination is E9-1-1-compliant today and can be configured with relative ease.

About Aruba Networks, Inc.

People move. Networks must follow. Aruba securely delivers networks to users, wherever they work or roam. Our mobility solutions enable the Follow-Me Enterprise that moves in lock-step with users:

- Adaptive 802.11a/b/g/n Wi-Fi networks optimize themselves to ensure that users are always within reach of mission-critical information;
- Identity-based security assigns access policies to users, enforcing those policies whenever and wherever a network is accessed;
- Remote networking solutions ensure uninterrupted access to applications as users move;
- Multi-vendor network management provides a single point of control while managing both legacy and new wireless networks from Aruba and its competitors.

The cost, convenience, and security benefits of our secure mobility solutions are fundamentally changing how and where we work. Listed on the NASDAQ and Russell 2000® Index, Aruba is based in Sunnyvale, California, and has operations throughout the Americas, Europe, Middle East, and Asia Pacific regions. To learn more, visit Aruba at <http://www.arubanetworks.com>.



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