

Education



**Location-based Services for
Cellular Phones using Wi-Fi:
University of Cincinnati's System
for Emergency Call Location**

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1. Introduction

Two key attributes of mobile wireless devices are convenience and portability. The integration within these devices of many functions, including email, instant messaging, web browsing, GPS and navigation features, makes them increasingly valuable to businesses and consumers. Smartphone use is exploding, which drives encouraging organizations to adapt their services to this new user and device population.

Virtually every new smartphone coming to market has Wi-Fi functionality, and Wi-Fi is preferred for data services because of its high performance and low cost. Many universities already offer Wi-Fi in lecture theaters, cafes and residence halls, and are now expanding their wireless LANs (WLANs) to cover entire campuses.

This note describes a novel system developed by University of Cincinnati that enables on-campus, location-based services for conventional voice calls from cell phones by recognizing and locating the Wi-Fi signal associated with the handset via the campus WLAN.

2. Methods for Locating Mobile Phones

Several mechanisms are used today to locate cell phones, but none is fully comprehensive.

The most common method is to detect the signal from several cell towers (base stations) simultaneously, and then triangulate based on signal strength. This method is effective, but the accuracy can be several hundred meters, particularly if only one or two towers are in range. A similar approach uses the angle of arrival of the signal at the cell tower, combined with signal strength, to give a measure of distance. This approach can work even when only a single cell tower is in range, but its accuracy is still not good.

An increasing number of cell phones have a GPS receiver. GPS provides a location accurate to a few meters, but it is not a universal solution. First, the majority of cell phones don't include GPS. Second, indoor reception of GPS signals is poor, so it is often impossible to get a good location indication in urban canyons or under any kind of roof, and its altitudinal accuracy cannot identify the floor of a building. Third, GPS is a terminal-centric method, so the location coordinates for an emergency call must be transferred from the phone to the cellular network or the 911 dispatch center. Transferring the location coordinates requires special, proprietary client software on the cell phone.

Other ideas have been pursued. For instance, Skyhook Wireless, a provider of location services, uses the Wi-Fi signature of a location based on surveys and a pre-populated database. Since the MAC address of an access point is globally unique, passive scanning of Wi-Fi beacons can reveal a location with a good degree of accuracy, because Wi-Fi signals are short-range. Skyhook also incorporates GPS and cellular base station locations, but it requires a software client on the device and it does not give network-side location information.

3. University of Cincinnati Requirements and Architecture

University of Cincinnati wanted to offer location-based services to its entire on-campus population. Use cases include:

- General assistance, such as directions to specific destinations
- Campus safety (non-emergency) calls such as requests for a late-night escort
- Assistance with parking and other infractions
- Account questions
- Emergency call assistance

Like most organizations, the university has a limited budget and does not have access to the cell phone carriers to extract any network-side location information. Also, the university needs to offer service to a broad range of subscribers with different devices and technology. Therefore, any solution must be widely applicable without requiring client software downloads.

4. Location-based Services Architecture

University of Cincinnati developed a solution that includes a number of elements:

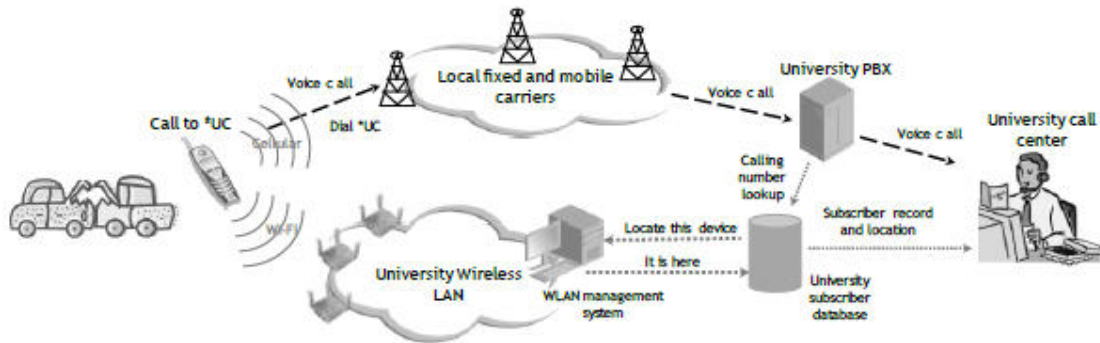


Figure 1: University of Cincinnati's *UC application architecture.

The services use a short-dial code offered by the cellular carrier on a number of calling plans available to university employees and students. As part of these calling plans, the *UC code provides access to campus public safety. The location-based application screen pops up the caller's record, campus map and location information without any further intervention by public safety.

When a user dials *UC, the call is routed by the carrier to the main PBX at University of Cincinnati, an Aastra-Intecom switch. The call is identified by the incoming trunk ID as a call-center call and the caller is identified from the automatic number identifier (ANI). The calling number is used for a database lookup, which results in the caller's database record being automatically pushed to the call center operator's screen as the ACD presents the call. At the same time as the database record is popped up, the application shows the caller's location on a campus map. This location information is the result of a query from the location application to the AirWave Wireless Management Suite™ from Aruba Networks, which University of Cincinnati uses to manage its campus WLAN. If the caller's device is within range of the campus Wi-Fi network and it is connected to it ('associated'), its location is determined and displayed, along with other devices in the vicinity and associated phone numbers.

If the caller requires assistance from campus public safety, the initial answering agent forwards the call and the public safety dispatcher has access to the same caller's record, campus map and location information without any further intervention.

4.1 Network Components and Interfaces

Cincinnati Bell Wireless provides the *UC service, which is included in a number of subscriber packages. The service provider sends a daily update the university which lists newly added and newly retired subscribers to the service along with their names and phone numbers. This information is used to form seed database records for all *UC subscribers and to purge old records.

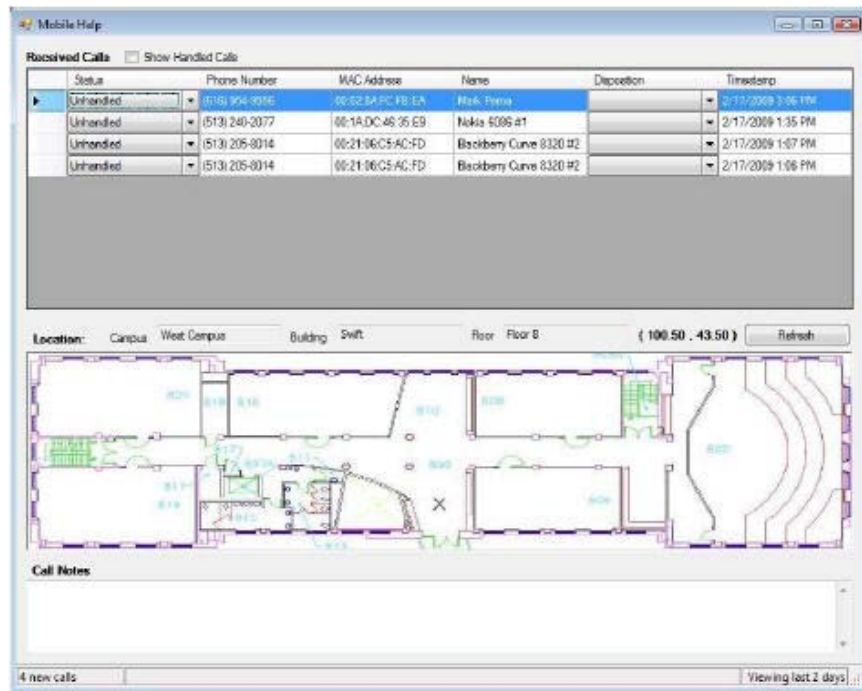


Figure 2: The *UC caller location application screen. University of Cincinnati uses an API on AirWave Wireless Management System to provide a location lookup and display function at very small incremental cost.

The carrier also maps *UC to a DID extension on the university's PBX. Any arrival with this destination DID is designated as a *UC call and is directed to the university public safety center where a dispatcher receives the call and the on-screen subscriber record and location.

The Aastra-Intecom PBX notifies the database application of *UC calls using the standard Intecom CTI interface. The calling number or ANI on the call is part of this notification. The database application uses the calling number to retrieve the subscriber's records from the database and present them on-screen to the public safety dispatcher. The database application simultaneously looks up the Wi-Fi address (MAC address) of the phone and queries AirWave for the subscriber's location. The management system returns coordinates from a known datum which the database application uses to show the caller's location on a campus map.

If the call requires campus public safety assistance, the call is transferred to the campus police station where the dispatcher is presented with the same on-screen information.

5. Strengths of University of Cincinnati's Architecture

This approach has a number of advantages over a 'classic' E911 system.

First, it is inexpensive. The widely used E911 architecture is relatively rigid and cumbersome for integration with most PBXs, which makes enterprise E911 solutions rather expensive and require ongoing manual configuration. University of Cincinnati's approach uses an existing API on AirWave to provide a location lookup and display function at very small incremental cost.

Second, it is more accurate. University of Cincinnati enhanced its conventional E911 network by placing a monitor in the public safety dispatcher's office. The underlying campus map and the location accuracy – to about 10 meters – is a superior solution for campus public safety, enabling them to reach the caller more quickly than with a conventional E911 system.

Third, it strengthens the public safety department's response to many types of calls. For instance, the caller's location can be used to automatically select a local video surveillance feed and enable a more informed, efficient response.

Fourth, it is tied neither to a particular phone nor a particular carrier. To get a *UC dialing plan, the caller must subscribe to the local cellular carrier, but a 7-digit number would be equally effective. The *UC shortcut is a convenience. The phone must include a Wi-Fi interface, and that interface must be configured to associate with University of Cincinnati's WLAN, but most new smartphones have Wi-Fi, and the University's IT group finds that many users already understand the benefits of browsing and email over Wi-Fi rather than the cellular data channel, so they seek out Wi-Fi capable smartphones.

The phone does not need to offer voice services over the Wi-Fi interface. The University sees a variety of many phones, including Microsoft Windows Mobile, Apple iPhones, RIM BlackBerries, Nokia and Google Android. Users need to register their phones MAC addresses into the database for location functionality.

6. Conclusion

With location-based services, University of Cincinnati's campus call center is more responsive. A cell phone caller is identified by the calling number, which keys into a database lookup to display the subscriber's name and other details. Simultaneously, dual-mode phones are located on a campus map using the Wi-Fi interface's signal and the campus-wide WLAN network.

This is not a classic E911 application, as it does not use the standard interfaces and databases that county public safety answering points require. But when the local public safety department is linked to the campus, as in the case of many universities, it offers a cost-effective means of providing important caller location information to the campus information center, first responders and emergency services.

University of Cincinnati intends to further develop this location system, integrating it more closely with the county emergency dispatch center. The same architecture for caller location can be adapted for 911 calls from PBX extensions, for instance. Many campus information center applications can benefit from the automatic identification and location of the caller, including resource identification and navigation functions.

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