



White Paper

**Location-based services for cellular phones using
Wi-Fi:**

**The University of Cincinnati's system for emergency
call location**

Peter Thornycroft

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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, easy web browsing, GPS and navigation features, has made them increasingly valuable to businesses and consumers. Smartphone use is exploding and this is encouraging organizations to adapt their services to this new user and device population.

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

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

2 Methods for locating cellphones

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

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

Alternatively, an increasing number of cellphones today include a GPS receiver. GPS provides a location accurate to a few meters, but it is not a universal solution. First, the majority of cellphones still 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 a roof of any kind, and its altitudinal accuracy cannot identify the floor of a building. Third, GPS is a terminal-centric method, and the location coordinates for an emergency call must be transferred from the phone to the cellular network or the 911 dispatch center, this requiring special client software on the cellphone, for which standard are as yet unavailable.

Various other ideas have been pursued. Skyhook Wireless 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, as Wi-Fi signals are short-range. Skyhook also incorporates GPS and cellular base station locations, but it requires a special software application on the device, and does not give network-side location information.

3 University of Cincinnati requirements and architecture

The University of Cincinnati's requirement is to offer location-based services of several types to the entire on-campus population.

- General assistance, such as directions to specific destinations.
- Campus safety (non-emergency) calls such as requests for a late-night escort.

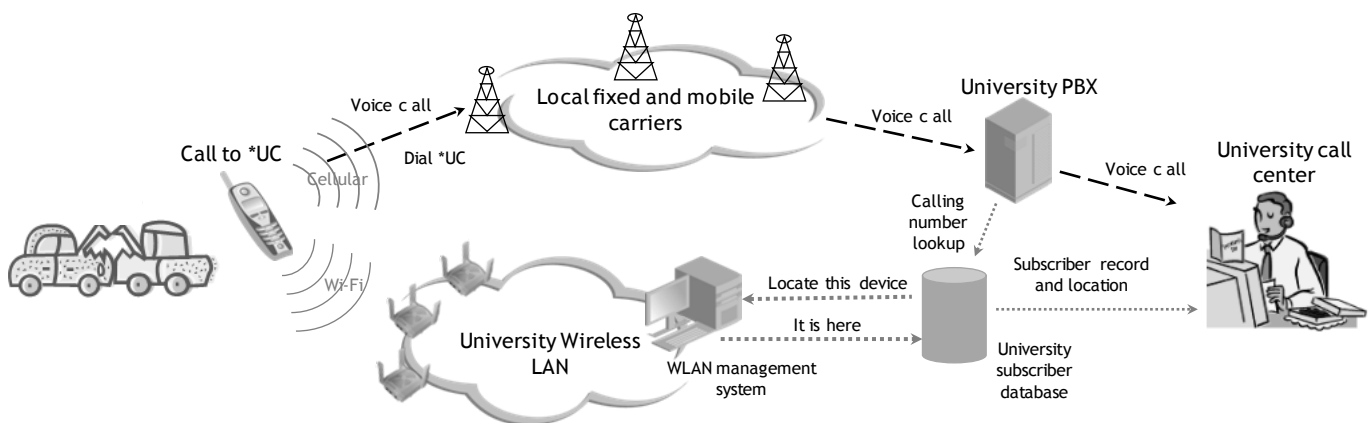
- Assistance with parking and other infractions.
- Account questions.
- Emergency call assistance.

The university, like most organizations, has a limited budget and does not have access to the cellphone 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: any solution must be widely applicable without requiring client software downloads.

4 Location-based services architecture

The solution developed by the University of Cincinnati includes a number of elements:

Figure 1. University of Cincinnati *UC application architecture



The services make use of 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. Here, it is identified as a call center call (by the incoming trunk ID) and the caller is identified from the automatic number identifier (ANI) on the call. This calling number is used for a database lookup, resulting 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, the application shows the caller's location on a campus map. This is the result of a query from the location application to the Aruba-AirWave software managing the campus WLAN. If the caller's device is within range of the campus Wi-Fi network, and 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 currently provides the *UC service, included in a number of subscriber packages. A daily update is provided to the university listing newly added and newly retired subscribers to this 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. *UC caller location screen

The screenshot shows a software interface titled "Mobile Help". At the top, there is a "Received Calls" section with a checkbox for "Show Handled Calls". Below this is a table with the following data:

Status	Phone Number	MAC Address	Name	Disposition	Timestamp
Unhandled	(616) 954-9556	00:02:8A:FC:FB:EA	Mark Perna		2/17/2009 3:06 PM
Unhandled	(513) 240-2077	00:1A:DC:46:35:E9	Nokia 6086 #1		2/17/2009 1:35 PM
Unhandled	(513) 205-8014	00:21:06:C5:AC:FD	Blackberry Curve 8320 #2		2/17/2009 1:07 PM
Unhandled	(513) 205-8014	00:21:06:C5:AC:FD	Blackberry Curve 8320 #2		2/17/2009 1:06 PM

Below the table, there is a "Location" section with dropdown menus for "Campus" (set to "West Campus"), "Building" (set to "Swift"), and "Floor" (set to "Floor 8"). A coordinate field shows "(100.50 , 43.50)" and a "Refresh" button. Below this is a floor plan map of the building with various rooms labeled (e.g., 820, 818, 816, 810, 608, 800, 817, 819, 815, 813, 809, 807, 805, 803, 801, 800). A red 'X' marks a specific location on the map. Below the map is a "Call Notes" text area. At the bottom, there is a status bar showing "4 new calls" and "Viewing last 2 days".

The carrier also maps *UC to a DID extension on the university PBX. Any arrival with this destination DID is a *UC call and is directed to the university public safety center where a dispatcher receives the call as well as 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 the AirWave network management system 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 the University of Cincinnati's architecture

This approach has a number of advantages over a 'classic' E9-1-1 system.

First, it is inexpensive. The widely-used E9-1-1 architecture is relatively rigid and cumbersome for most PBX-based organizations to integrate with, and E9-1-1 solutions for enterprises are consequently rather expensive and can require ongoing manual configuration. The University of Cincinnati approach uses an existing API on the WLAN management system to provide a location lookup and display function for very small incremental cost.

Second, it is more accurate. The University of Cincinnati was able to enhance the conventional E9-1-1 network by placing a monitor in the public safety dispatcher's office, and the underlying campus map and the accuracy of location – to about 10 meters – is a superior solution for campus public safety, enabling them to reach the caller more quickly than with a conventional E9-1-1 system.

Third, it strengthens the public safety department's response to many types of call. 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. It is true that 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 just a convenient feature. The phone must also include a Wi-Fi interface, and that interface must be configured to associate with the UC WLAN, but most new smartphones now offer Wi-Fi, and the University of Cincinnati 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.

Note that the phone does not need to offer voice services over the Wi-Fi interface: the University sees many phones including many running Windows Mobile, Apple iPhones, RIM BlackBerries, Nokia smartphones, Google Android phones and others. Users would need to register their phones MAC addresses into the database for location functionality

6 Conclusion

In this note we discussed a novel application from the University of Cincinnati enabling improved responsiveness by the campus call center. A cellphone caller is identified by the calling number, and this keys 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 'E9-1-1' application, as it does not use the standard interfaces and databases that county Public Safety Answering Points (PSAPs) 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.

The 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. And 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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