

Information Integration for Public Safety Officers

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ABSTRACT

Information enabled by technology is used to support good decision-making in the public safety arena. In the information age, the current implementation includes the installation of laptop computers and other mobile computing technology into mobile environments including ambulances, fire vehicles and police cruisers. Typically, these computing devices are equipped with various multi-purpose and custom software applications to replicate the public safety officers' headquarters work environment. In our analysis, we have found that there are large amounts of publicly-available datasets that are not available to the public safety officer in the field, but if made available in a real-time environment, could greatly assist the decision-making tasks of the officer and increase the safety of the public entrusted to the officer's watch.

Information delivery and integration in the public safety environment are key elements required to maximize data support of public safety. Utilizing aspects of requirements engineering, we propose and develop a variety of applications that allow public safety officials to synthesize and interact with real-time data in the field. Information integration used to locate a topographic area map, satellite image, or immediate alert of the prevailing weather conditions assist in the timely decision-making process, especially in areas where such data is not available in the field. Public and private data sources are delivered according to agency protocols. Our environment takes advantage of the existing Project54 application and hardware, developed at the University of New Hampshire, as well as existing datacasting technology and other wireless mobile communications technologies.

Keywords: datacasting, public safety, application, requirements engineering, Project54, real-time data

1. INTRODUCTION

In nearly every data-intensive organization, information is used to support decisions. Bad or lack of information can often be used to eliminate good options in the vast set of directions to take. Good information, provided in the midst of a situation requiring rapid decision-making, however, is most beneficial. Leaders in the public safety field have had a long history of split-second decision making. Determining the best way to diffuse a situation in the field often requires knowing what has happened in the past, both recent and distant, and much of that information does exist for the public safety officer. However, having all of that information available to review in such a short time is often not possible. Old records are often in file cabinets and on paper, while new records and advances in information technology offer easily transferrable records. Current practice has been to install laptop computers and other mobile computing technology into remote environments, such as ambulances, fire vehicles and police cruisers. Typically, these computing devices are equipped with various multi-purpose and custom software applications to replicate the public safety officers' headquarters work environment.

While this information has been helpful to the officers, two problems surface in practice. Public safety officers are not information technologists. Yet, many solutions in the mobile field environments require those skills to install database information and keep that data current. Mobile communications technology has not caught up to the storage and retrieval capabilities of the mobile device. When public safety officers have access to good broadband network technologies in the field, the applications do not offer certain real-time information. Our research has discovered that there are large amounts of publicly-available datasets that are not available to the public safety officer in the field. If these data were made available in a real-time environment, they could greatly assist the decision-making tasks of the officer and increase the safety of the public entrusted to the officer's watch.

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Information delivery and integration into the public safety environment are key elements required to maximize data support of public safety. At the University of New Hampshire (UNH), a system has been developed to support communication and operations in the public safety arena called Project54™. Project54 is a collaborative research and development program at the UNH Consolidated Advanced Technologies Laboratory (CATLab). This project focuses on the incorporation of embedded mobile computing equipment and wireless networking into the patrol vehicles of the New Hampshire Department of Safety (NHDS), including State Police and Department of Motor Vehicles. Project54 systems integrate all in-car electronic devices and systems, software and user interfaces to offer advanced support for New Hampshire State Troopers [1].

Utilizing aspects of requirements engineering, we propose and develop a variety of applications that allow public safety officials to synthesize and interact with real-time data in the field. Information integration used to locate a topographic area map, satellite image, or immediate alert of the prevailing weather conditions assist in the timely decision-making process, especially in areas where such data is not available in the field. Public and private data sets are delivered according to agency protocols.

Our environment takes advantage of the datacasting technology of the New Hampshire Public Television (NHPTV) station and the Project54 application environment installed in police cruisers. As such, the cruisers have the option of maintaining the existing VHF communication link in areas where datacasting is not available, or using the cellular modem link to make a request for information, such as a registration or license check, and receive additional information or updates from the datacast link. Coupled with the on-board global positioning system (GPS) technology and the state communication mapping models of both DTV and police band radios, the Project54 system will select the most appropriate channel to get the most crucial information to the users in greatest need of that information [8] [9].

2. PROJECT54

The Project54 system, developed by the Consolidated Advanced Technologies for Law Enforcement Program (CAT Program) at the University of New Hampshire, is a highly integrated hardware/software system that emphasizes interconnections based on industry standards, facilitating equipment interoperability and interchangeability [1]. The system combines general computing capabilities with voice and data radio communications and special purpose devices such as radar, lights, sirens, video units and global positioning systems (GPS). The core system software coordinates the control of all devices and provides multiple methods of control and input, such as voice command, LCD touch screen and traditional keyboard and mouse. Typical data access is available in the computing environment, such as license and registration checks, computer aided dispatch, vehicle navigation, report form entry and other typical public-safety applications.

Project54 is deployed throughout the New Hampshire Department of Safety (NHDS). As of February 2008, 898 public safety agency vehicles utilize the Project54 system operating throughout the state of New Hampshire and include 156 participating out-of-state agency vehicles [6].

2.1 Hardware

Using APCO Project 25 digital RCP in the Project54 system, on-board systems and databases can be kept current by exchanging digital packets with the HQ server over a 9600 baud, VHF link [4]. While this link eliminates a voice request to the dispatcher at HQ, very small amounts of data can be transmitted. Thus, for any significant update of the on-board software systems or databases, non-wireless network methods are used to accomplish this task, typically USB memory stick data transfers or complete hard drive replacements.

All mobile units contain an on-board global positioning system (GPS) receiver, which receives signals and records location, as well as velocity, altitude, heading and synchronized date and time figures for the mobile unit.

The Microsoft Windows 2000 or Microsoft Windows XP laptop or embedded computers that operate the Project54 software integrate all hardware components together using an industry standard in-vehicle communications bus (CAN version 2.0B) [2]. Systems in New Hampshire use a small commercial embedded PC module mounted in the center console containing a LCD touch screen and a keyboard/mouse device. Officers can control the Project54 computer, software and hardware via recognized voice commands in the Project54 application. A detailed voice grammar for each

Project54 application provides the standard input to control screen selections and complete user data interface inputs, all without requiring the officer to remove his eyes from the road or his hands from the wheel.

2.2 Software

Project54 in-vehicle software is designed to be fully modular and configurable, similar to that of the hardware design. This flexibility allows each cruiser to incorporate the desired hardware appropriate to their patrol, while allowing a corresponding software application module to bridge between the hardware control and other software modules in the Project54 system.

Software application modules that control individual hardware components communicate with each other using a concise messaging system within the core Project54 system. The clearinghouse of this messaging system is called the Application Manager. This messaging system allows unique and focused cruiser components to be isolated from other components, significantly increasing overall system reliability over the life of the system. In addition, the messaging system supports the exchange of information and command/control functionality between modules, offering the full benefits of an integrated system. Services shared between application modules are implemented as operating system drivers or run-time libraries, giving the Project54 system a common look-and-feel.

The GPS software module polls the GPS receiver every second and forwards the gathered data to the Application Manager. All other application modules that require use of the GPS data will receive the resulting data via the messaging system. The digital radio software module reports the status of the radio display to the Application Manager, and other application modules receive the required data via the messaging system in the same way. The Project54 messaging system used by the individual application modules is not proprietary, and is detailed in the Project54 distributed documentation. As a result, any hardware or software vendor can develop modules and applications for the Project54 environment that will participate in this messaging system. In this way, new hardware and software technologies can be immediately supported by vendors in the Project54 environment and individual law enforcement agencies can contract with local software consultants to develop compatible modules providing custom capabilities.

3. DATACASTING

Digital television (DTV) signal bandwidth in the United States has the capability to broadcast both DTV signals and other non-television digital data over the same spectrum. When digital television broadcasters allocate their bandwidth to support high definition television (HDTV) and standard definition television (SDTV) channels, they inevitably have a small slice of bandwidth that remains unallocated and nearly continuously available. This available bandwidth and the delivery of non-DTV data within that bandwidth is the technology known as datacasting [3].

The term datacasting comes from the words data and broadcasting, and the technology is designed to provide a variety of digital data such as text, audio, graphics and video, with a unidirectional transmission channel from the broadcast center to remote stations.. The DTV channel bandwidth is 6 MHz, which when coupled with the encoding scheme, supports the transmission of 19.38 Mbps. As HDTV and SDTV signals are transmitted, video images that have small variation between frames require a smaller number of data packets from the transmitter to the receiver. As a result, there is a significant amount of bandwidth that goes unused with every DTV broadcast, sometimes as much as 2.5 Mbps of bandwidth. Most DTV broadcast markets tend to allocate some bandwidth to datacasting, even after a sufficient allocation of channel bandwidth.

4. SERVER PROCESS

The datacasting equipment installed in the NHPTV broadcast center consists of a variety of components working together to provide real-time information to officers in the field. The broadcast center equipment communicates with the remote receivers to define the complete datacasting data path from origination to reception. To process simultaneous requests from several remote clients, we utilize a non-blocking server. This system uses the socket channels, selectors and keys to allow the secure transfer of data through the public and private networks available to public safety. The channel transfers data using the buffer object. If a client is attempting to establish a connection or a write operation, the selector informs the application to process the request. The selector creates the keys and each key holds information about the client making the request along with the type of the request. The system waits until a connection request is

received and creates an acceptable key when the client applications request a connection. The writeable key is constructed when the client applications attempts to write data, which may not represent the entire information stream that the client is sending to the server. The selector divides the client data into sub-requests identified by the keys. If more clients continuously send data to the server, the selector will create more keys, which will be processed according to a time-sharing policy [5]. The architecture of this type of server-client is illustrated in Figure 1.

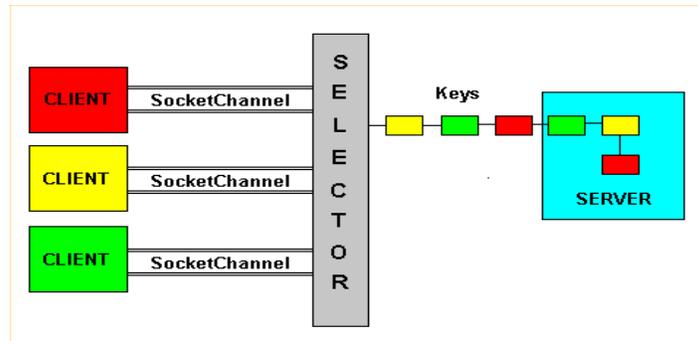


Fig. 1. The Architecture of the Client-Server System.

The server listens for the requests coming at port '5456' on the public server. The streams of data sent by the client contain key informational elements: date, time, latitude, longitude, car number and identification field. For example, the request for a topographic map from the client will appear as a stream of data with the format "06042007,133328,43 08.2248 N,70 56.0940 W,SV001,0". When the data arrives at the server, the stream is parsed for the car number, latitude, longitude, and identification. The identification corresponds to the three different application calls currently supported by the server (topographical maps, weather radar maps, or weather alert information). The latitude and longitude are converted to degrees and the car number is used as a reference to track the request through the system. After identifying what the client requests, the server uses public web-based resources to gather the requested information. Our present system uses Yahoo Maps [7], National Weather Service text-based products [10] and the Weather Underground radar maps [11]. The datapath and component linkages are illustrated in Figure 2.

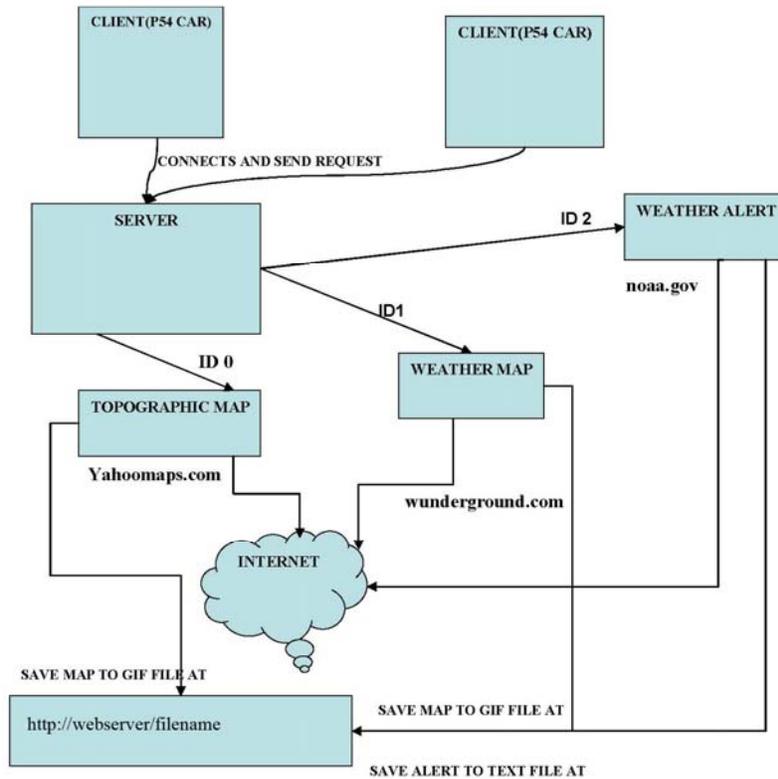


Fig. 2. The Functionality Outline of the Server System.

When the server prepares to extract mapping information from the web, the converted latitude and longitude values of the current client location become seed data for external requests to the public data sources. Each map request, once received, is saved to a gif file, with specific naming in the system based on the client requesting the data. Topographic maps are stored as TMAP files, while weather maps are stored as WMAP files. Text-based alert files are retained as text files and stored with filenames beginning with ALERT. Each file has the CARXXX component to the filename in order to distinguish files destined for different cars.

The Project54 environment requires all images to be displayed as bitmap images. Therefore, all gif files are converted to bitmap files using the Imagemagick software at the server, prior to transmission to the remote clients. The data stream has a parameter to allow the client to request a relative zoom factor for each graphical maps, which can be controlled by the value of the zoom, transx and transy values, which allows for the public safety officer in the field to manipulate data in real time.

When weather alert data is generated and requested from the client, state and county boundary information must be extracted from the GPS coordinates. Reverse geo-coding [12] allows the server to parse the pertinent weather alert information that is received through the National Weather Service text products specified for New Hampshire and relative to the location of the mobile client. Amongst all of the data being processed for clients, the server system is logging all transactions, initially for two-way datacasting coverage and statistics in the research phase of this project, but eventually for audit tracking of requests and field operations of the mobile clients.

At present, a source file in the datacasting system can reside on any computer networked to the Internet, and that file can be placed on the datacast file server using the appropriate password, or automated using pull technology residing on the datacasting server. Once a file is placed on the file server located at NHPTV, the file server packages the file to be transmitted and sends the data to the IP encapsulator and multiplexer, where the file is converted into appropriately sized IP packets, weaving those packets into the MPEG2 data stream appropriate to digital television (DTV) transmission.

The DTV stream is sent to the transmitters via microwave uplinks to NHPTV's Saddleback Mountain facility. The signals are radiated from an antenna positioned 44.9 meters above ground at a frequency of 731 MHz (Channel 57) with an effective radiated power of 589 KW. Remote datacast receivers monitor the DTV stream and extract the data transmitted over the datacast program information channel (PID), decoding the stream back into IP packets, reassembling those packets back into files and storing the files on the mobile receiving computer.

5. CLIENT PROCESS

The Project54 environment is developed using Microsoft Visual Studio 6.0, and our application components integrate into the Project54 Application Manager 2.0. Using a common graphical user interface (GUI) library, P54Guilib.lib, our applications can maintain the look-and-feel of other Project54 tools available to public safety officers in New Hampshire and other jurisdictions that have adopted the Project54 environment. Our datacast test application has the unique identifier in the Project54 environment tied to the common name dctest. This application runs as a dynamic linked library (DLL) to communicate with other modules in the Project54 environment, as well as maintain operations specific to the dctest application. The typical main screen visible in the Project54 environment will display a dctest button on the right-most button field as is shown in Figure 3.

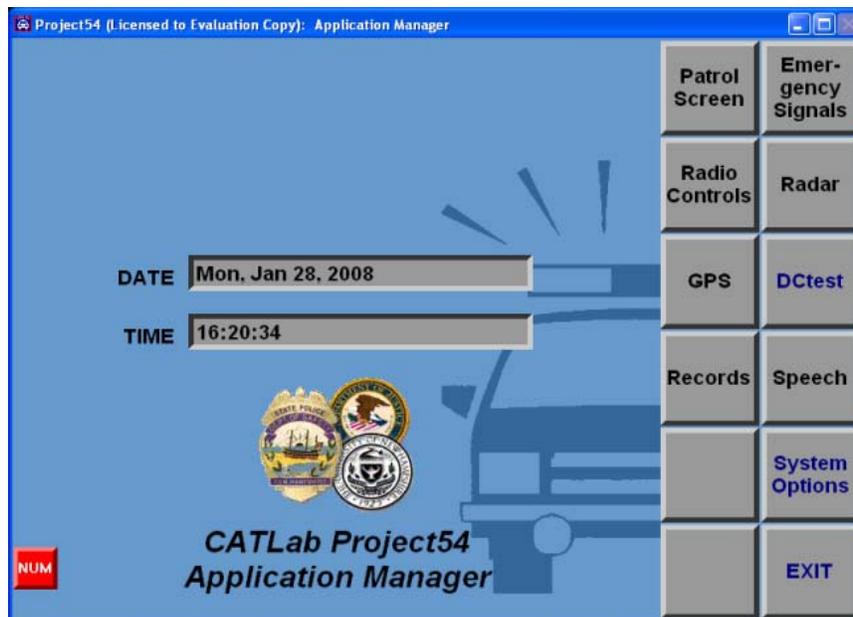


Fig. 3. Project54 Environment Main Screen.

When the officer in the field selects the dctest application button, either via a touch screen device or voice command, the application manager brings the corresponding application to the front of the stacked active windows. The initial dctest application user interface is shown in Figure 4.

Two threads are continuously operating in the dctest application—a GUI thread for interaction with the public safety officer and a network monitoring control thread, which is used to maintain active connectivity levels with the data server and check for received datacast files. The application control thread sends periodic pings to the data server and reports availability status on the monitoring screen. These upstream pings are sent across the cellular modem interface and allow us to determine where cellular coverage is supported for two-way datacast communication. On the right side of the application screen is a set of options that the public safety officer can request, such as a topographic map, a weather radar map and a weather alert. The status lights indicate the current state of the cellular modem signal ability to reach the data server, the available of a locked datacast signal from NHPTV, and the successful reception of the requested data from the server, which is an artifact of the dctest application not displaying received data. The user interface also displays the current latitude, longitude and the velocity of the car, which is extracted from the live GPS installed in the mobile device.

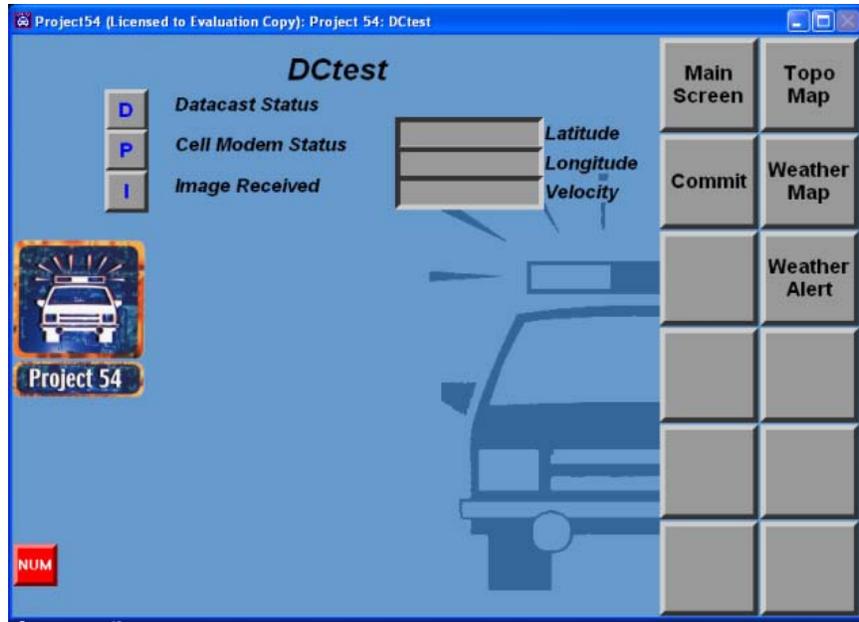


Fig. 4. Project54 dctest Application Startup Screen.

When the officer requests a topographic map, the dctest application reads the current data from the GPS and populates the fields in the user interface and constructs the request in the format readable by the server as described above. The small data packet is then sent to the data server and a notation of the request is made in the mobile device's log file for audit tracking. If the connection is successful the application waits for 70 seconds for the image to be received. Once the image is received the application manager updates all of the status lights to "GREEN", updates the image display and logs the request as successful. If the image reception fails, the datacast and the image received status lights will be updated to "RED". A successful topographic map reception is displayed in Figure 5.

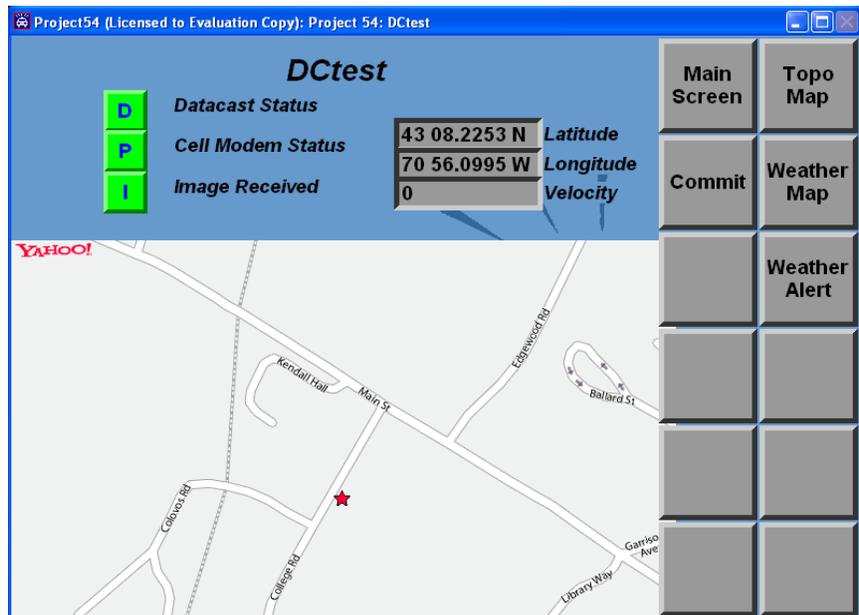


Fig. 5. Mapping Application Display in Project54.

After a period of thirty (30) seconds, the status lights on the application turn back to their initial state of grey, signifying to the officer that another request may be made. In a similar set of procedures, a successful request for the current weather radar map for a given GPS location is displayed in Figure 6.

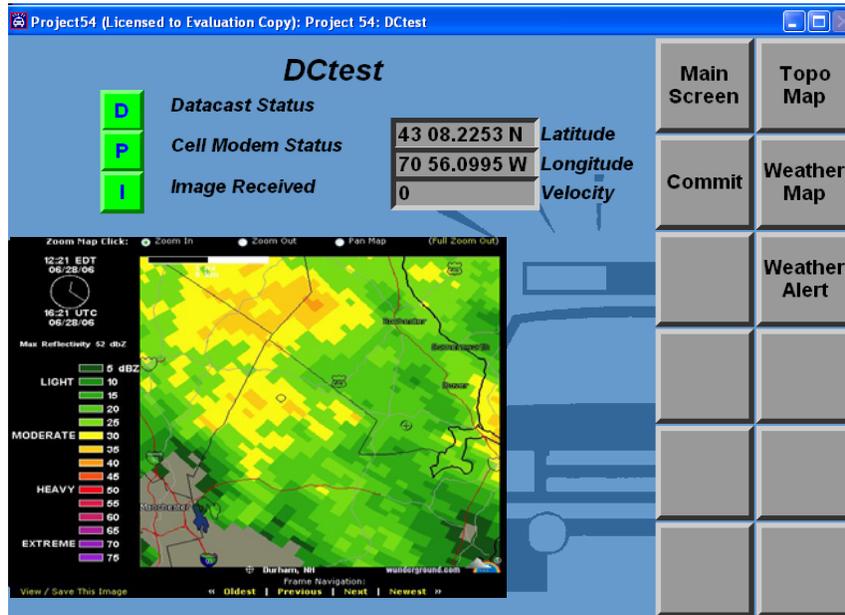


Fig. 6. Weather Radar Mapping Application Display in Project54.

Displaying the weather alert announcement in response to a request is work currently being addressed in the Project54 environment.

6. AREAS OF IMPACT

Real-time data in support of public safety officers often makes the difference in critical situations. Topographic map information can give the officer more localized physical presence data than that provided by personal memory, radio directions or paper maps. The topographic map application places a red star in the center of the map to show the officer where the cruiser is located according to the GPS. Additional information on the mapping graphic show the surrounding street information, state level information, interstate names, and other related information. Using the location mapping application, an officer can quickly record the location of an incident for report generation and processing later, when danger has passed.

The weather radar maps indicate the location where the GPS request is made with a crosshair, and contains information about current rain, mix, and frost in nearby areas. If a weather system is slated to enter an area near the officer's location, provisions can be made to alert the public to the impending weather situation and protect life and property with this highly-localized data. Public safety officers, in a traditional environment, have no provision to know the current weather conditions relative to their position unless they make a specific request to Headquarters or an announcement over the VHF radio is made. In situations where the patrol officer sees a large cloud bank in the distance but not knowing the weather conditions prevailing in that area, the officer may drive to that area and into the face of bad weather conditions. With the ability to see the weather radar map in advance of travel, the officer can change the intended plan of action.

7. TWO-WAY DATACAST COVERAGE

One aspect of our research is to determine the best locations and conditions where two-way datacast transmission is available in New Hampshire. Our software uses datacasting as a download channel and a cellular modem as an upload

channel, and when connected, a complete transmission path exists. Our field testing of this system provides a confirmation that the system is feasible and operational. The system was installed in a single vehicle and stopped at various locations throughout the state of New Hampshire. A request was made via the cellular upload channel, as described above, and a Yahoo street map referenced to the GPS location of the vehicle was downloaded via the datacast channel. The knowledge gained from the limited two-way coverage study is purely a proof of concept. The software was successful in the field at many locations primarily due to the fact that cellular modem coverage in the state of New Hampshire is nearly ubiquitous in the state of New Hampshire. Where work still remains is in the area of datacast reception where poor reliability of datacast signal in the mobile environment poses the greatest challenge. Causes of a failed datacast transmission include poor propagation circumstances, constant moving nearby vehicles causing multipath interference, and very slow data rates due to being on the threshold of reception. In order to deploy this set of public data applications for public safety officials sooner, we need to address the ability of mobile devices to receive broadband data in as ubiquitous a fashion as VHF radio.

8. CONCLUSION

Information can be the key puzzle piece missing from decision-making, especially in critical, life-threatening situations. Information delivery and integration in the public safety environment are key elements required to maximize data support of public safety. Using the Project54 model and environment, we have proposed and developed a variety of example applications that demonstrate the ability to integrate real-time, public data with public safety officials in the field. With more study of the kinds of problems that face public safety officers and the possible real-time data missing from their remote environments, we believe that our two-way datacast environment can offer an inexpensive and broad-reaching method for developing solutions.

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