From Desktop to Field: Deploying Visual Incident Analysis for Law Enforcement

Bob Baddeley, Katarina Younkin, Rick Riensche, Daniel Best, William A. Pike, and Richard May
Pacific Northwest National Laboratory
bob.baddeley@pnl.gov

Abstract—*We present a prototype mobile application environment for law enforcement users to assist them in daily operations. This system supports the collection of real-time observations and allows users to quickly share their findings with team members. Mobile tools for law enforcement introduce safety and other operational constraints that must be considered in developing appropriate user interfaces. Our environment attempts to address these challenges and provide tools to increase information sharing among officers and, expedite form-filling and evidence collection. Moreover, real-time location tracking and mapping enables mobile users to view the locations of team members and to push data (such as field-collected images, video, or text) to them.*

1. Introduction

Law enforcement investigators need to detect patterns, trends, and entities of interest in streaming incident data. The amount and variety of information available through federated law enforcement query services, however, makes this difficult especially for officers in the field where rapid assessment of information is critical. Another need for investigators is the ability to collect new information in the field, such as interviews, photographs, and video, and to share this information with colleagues for incident investigation. To address these needs, the Pacific Northwest National Laboratory (PNNL) and the National Visualization and Analytics Center (NVAC) along with our partners at the Regional Visualization and Analytics Centers (RVACs) are transitioning advanced web-based and mobile incident analysis and collaboration technologies to front-line law enforcement and counter-terrorism personnel at several agencies This paper presents the mobile application environment to assist officers in daily operations.

2. Building a Tool for Mobile Law Enforcement

To develop our system, we have been working with a group of officers who have a range of roles, each with some unique requirements and constraints. We have identified common tasks across these groups and have developed tools to accomplish those tasks with each group in mind. Our current mobile work is focused on four main areas: querying, collecting data and evidence, location awareness, and collaboration.

2.1 Issues and constraints

Officer safety is of primary concern when developing application interfaces for mobile use. Constant situational awareness and attention to surroundings must be maintained. It is dangerous to work exclusively with the device and stop attending to external threats. Therefore, interfaces must be designed that emphasize simplicity and require a minimum of focused attention to operate.

A second issue is the tax on a dispatcher. Typically, an officer may call in a name or license plate and wait for the dispatcher to look it up in a database and read back a response. This ties up a radio channel, and with busy precincts can take up to a quarter hour or more before getting a response. Having direct access via a PDA to the same information as the dispatcher allows the officer to get in only a few moments more reliable information, with sometimes even a photograph to verify identity. Security measures on the device are required to ensure that unauthorized access is prevented and that sensitive information is not stored on the device in case it is stolen.

Yet another area of need is the collection of data and evidence. Many officers currently use a paper notepad, and sometimes use camera or audio recorders. Current information collection methods can be cumbersome and error-prone, especially considering the availability of converged devices that contain digital notepads, cameras, audio recorders, and are connected in such a way that the information can be automatically uploaded and shared.

There are additional concerns for officers under cover. Using a police radio is an immediate giveaway, as might be the use of a digital camera for capturing evidence. However, the ubiquity of mobile technology allows an officer to perform all of the same tasks while appearing innocuous. Further, since our application uses commodity devices, and the software can easily be

978-1-4244-1978-4/08/$25.00 ©2008 IEEE

hidden, even if the officer is compromised the device will not be incriminating. In the course of operations, it is often necessary to track the locations of officers and other assets. Mobile technology that follows officers whether in vehicle or on foot can provide real-time situational awareness to commanders and team members.

2.2 Service-oriented approach

The architecture behind our application is that of a typical web server with clients. We use standard web services technology to interact with a database. This approach is appropriate for many reasons, among them the ability to search large remote data sets, avoiding processing limitations of the mobile devices, reducing risk associated with local data storage, and the potential to introduce complex analytic techniques that exceed the capabilities of a single small device. It also allows us to create a desktop client with richer interactions that has the same method of communication with the data server (see [1] for a full discussion of the web-based analysis portal that leverages this architecture).

2.3 Client and Server Architectures

Our application uses a standard client-server architecture. A database on the server stores both incident data and field-collected data in XML form. Different data types follow different schemas but can be stored in the table, enabling complex searching and reducing bloated database structures. Metadata for multimedia files captured in the field are stored in the database as well.

Access to the web services is provided over SOAP. This common method allows for XML communication between the server and any kind of client, and the API is easily available for other developers to write applications that attach to the services smoothly.

2.4 Query tools

The officers with whom we have been working currently have PDAs and access to a few mobile web query tools. These are essentially web pages in a browser that are designed for mobile screens and provide officers with access to databases containing information about driver licenses, arrest history and photos, license plates, and pawn slips, among others. Each of these sites requires a separate login that expires after a certain amount of time without use. These tools already save a significant amount of time for the users and reduce radio traffic, but their use is stymied by limitations of the single-window Internet Explorer on mobile devices. Users have to log out of one query site in order to log on to another, and do this repeatedly through out the day.

While there are mobile web browsers that have tabbed browsing, such as Opera, we wanted to create a solution that would be interoperable with the rest of our mobile application (to allow query results to be immediately shared with collaborators, for instance). Ultimately, the goal is to allow the user to enter a single query term and have that single point of entry search multiple databases simultaneously. This would have been impossible using a third-party tabbed browser.

Figure 1 - The tabbed browser.

We were able to build a tabbed browser (Figure 1) customized for law enforcement applications that allows the user to have a virtually unlimited number of open tabs at once. Users specify the law enforcement databases that they want to have opened automatically when they enter the application. Users can create a group of favorites as well, and open the entire group at once instead of opening each one individually. This allows the user to immediately start with all of the tools they need throughout the day. Closing the browser does not quit the application, so the tabs and open pages are still available when the user goes back to the browser. This part of the tool is a compromise step; we are providing the same information in the same browser format they have been using, but solved their single window issue. Steps in the future will move towards a single interface capable of querying multiple databases and providing the results in a single formatted window.

2.5 Evidence collection

As technologies converge, it becomes easier to collect a wide array of types of data. PDA phones now have built-in cameras, GPS, touch screens, even accelerometers and tilt sensors. With a connection to the Internet, they can be used to gather photos, video, audio, location, drawings, etc. Further, using Bluetooth these devices can work with other devices that have not yet converged, like barcode scanners and fingerprint readers. Essentially, these PDA phones are nodes with an array of sensors that work together to make a network of data collection as large as politically possible and practically efficient.

We have implemented software that allows the user to collect a variety of different data types and upload those artifacts to a central server in real time. These 'notes' could be a photo of a suspicious person or crime scene, a video or audio interview of a witness, a sketch described by a witness or drawing of a crash scene, the current GPS coordinates of the officer, plain typed text, or even a URL of a relevant web page. Document data is stored in XML with a common format across each data type. The metadata of the XML contains the time stamp and user that uploaded the document. If a GPS device is connected, it will automatically tag the document with the GPS location as well. The user can attach a comment to describe the note; especially useful for giving a photo context.

When a note is created, it is immediately uploaded to the web server; notes are not stored on the local device by default for security. We do have the ability to cache notes locally to reduce network bandwidth use, but this setting is disabled by default. When uploaded, the note is added to a table of documents that can be searched. Each user has a 'notes group' which contains a list of references to documents. Whenever the user creates a note, a reference to that note is added to their notes group, giving them easy access to the notes they've captured. A user may remove this note from their list, but the document itself is not deleted from the database, as it may be used later for another case or by another user.

Users can also add documents to shared groups as well, making it instantly accessible to other members of those groups.

Finally, a user can annotate one note with another note (Figure 2). For example, an audio interview could be annotated with a photo of the person and a GPS coordinate, as well as a sketch of the suspect. This annotation of annotations works to any level of nesting. One additional acquisition method is enabled specifically through nesting; sketching over photographs. Since the photo is taken separately from the sketch over it, the two layers can be separated or work together.

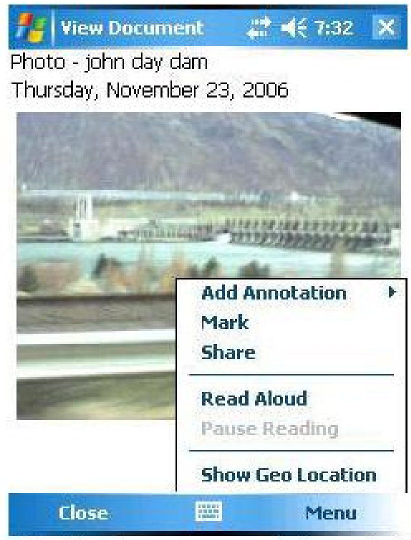

Figure 2 - Viewing a document. It can be further annotated, shared with other groups, viewed on a map, or read aloud using text to speech.

Ultimately, this system for data collection allows for far richer and more accurate data than can be achieved through a pen and paper notebook alone, and the real-time uploading of the information to a central server allows for immediate dissemination to an entire precinct or higher. Automating some aspects of data collection, such as regular GPS updates, further reduces the burden on the officer.

2.6 Electronic forms

Officers spend a considerable amount of time doing paperwork, and fill out paper forms in the field that are often transcribed to digital form back in the office by the officer or by other staff. This is time-consuming, potentially redundant, and can lead to inaccuracies. We have begun to solve many of these issues through the availability of electronic forms on the mobile device.

Our method relies heavily on XML to describe the forms. One XML document is used as an index to the available forms. Our application reads this file and parses the information to create an interface that gives the user access to the available forms with a description of their purpose. Once the user selects a form, the appropriate XML document is read and parsed to generate an electronic form. This method allows the organization to make changes to their forms, add and remove forms, and pre-fill some values, without having to recompile the application.

The format of these XML documents allows for a wide variety of options in the forms. Most inputs will be plain text, but wherever possible we encourage the use of dropdown selections to enforce consistency among users and to allow for fast input without having to type. Other input options include date and time, and checkboxes. Forms can be divided into sections, which can be required or limited to a single instance. For example, a Field Interview form (Figure 3) consists of a required section that contains the officer, date, time, and reason for the interview. There are additional optional sections for 'vehicle' 'property' and 'interviewee.' Optional sections are available through a menu, and clicking on the menu option adds the appropriate fields to the form. One advantage of this method is that only the fields that are relevant are visible, and the user can add multiple sections without having to fill out a new field interview report for each.

Another possibility for electronic forms is the integration of the data collection described in the previous section. Electronic forms can be annotated with any of the media types described, so the field interview that describes the interviewee can be accompanied by a photograph of the person or a distinguishing tattoo, reducing discrepancies caused by different interpretations by different officers.

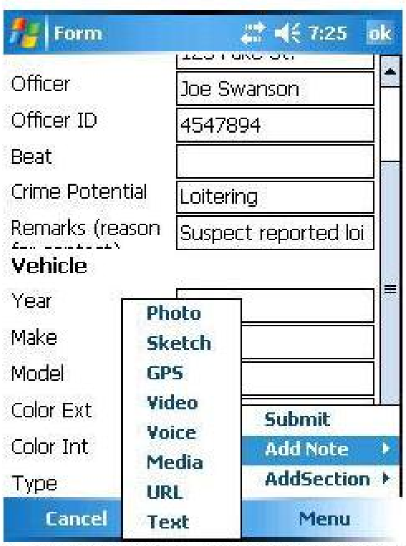

Figure 3 - A typical form allows the user to enter text information and attach other types of annotations like photographs and GPS locations.

Results from these forms can be stored in XML and uploaded to the central web server in real time, allowing for more immediate responses and collaboration.

Electronic forms have the potential to greatly reduce the amount of time spent on documentation, as well as reduce the number of errors and inconsistencies, and provide the potential for much faster operations. Annotating the forms with additional rich media further adds to the benefits of using the mobile device over traditional methods.

2.7 Location awareness

Location awareness is vital for the overall situational awareness of a group of officers. This information is essential not only for dispatch to send the appropriate officer to a call, but is also critical for officer safety, resource allocation, and coordination of joint activities.

Our system takes advantage of GPS capabilities integrated with, or external to, mobile devices to automatically keep the officer and others aware of the location of relevant groups (Figure 4). When a GPS signal is available, a web service is used to upload this information through to the central database. This web service not only stores the current location and the time that location was updated, but also a decaying history of the device. Records are deleted as they get older so that a detailed history of the most recent past is very available in great detail while an older history is less resolute. Using this history, we can view the path of a single device or group of devices over time. We can also plot the current location of all devices or a group of devices. The mobile software allows the user to see their location as well as the locations of other units on an interactive map. Public web services (in this case, Yahoo) are used to get the map data, so the maps are not stored on the device.

Figure 4 - A map shows locations of other devices. Users can search for addresses, pan and zoom, view different groups of devices, and send messages.

With location awareness, officers can perform searches against a database for things near their current location. They can search for addresses instead of asking the dispatcher for directions. They can coordinate movements to have better coverage or successfully surround a location. It is possible to have groups of devices, as well, so that individual groups can coordinate with each other while not broadcasting location information outside of a selected team.

In one scenario the device could even be used as a temporary lojack; with the officer attaching a device to a suspicious vehicle and tracking it using another mobile device. Because the device would be uploading its location every few seconds or minutes, it could easily be tracked and retrieved. Since this would require putting a sensitive device essentially in the hands of the other side, steps would have to be taken to ensure that it is locked down and unable to do anything besides upload coordinates.

2.8 Officer Collaboration

In previous sections we have mentioned some of the ways in which users can collaborate to share information and coordinate operations, as well as provide more accurate real-time information to dispatchers and commanders. In this section we will detail how our software enables these and other collaborative possibilities.

There are currently three ways in which users can collaborate; through shared notes, location awareness, and messaging.

With shared notes, each user is a member of multiple groups. Supporting membership in multiple groups was a requested feature as was creating groups on the fly. When a user wants to share information with other people in a group, they mark the note as shared and select the appropriate group. This capability allows one person to take a photo of a scene and instantly make that photo available to others. Shift briefings, for example, could happen in real time with rich media and improved situational awareness.

The second method, location awareness, was described in the previous section. In addition to being able to track fellow officers in near-real time, they can select a unit and see the name of the user and get an indication of the last time their location was updated. Further, a message can be sent directly to that person. The concept of groups is applied to location tracking as it was for notes; a user can be a member of a group and select a map view that only contains the locations of members of that group.

The messaging system deployed in the field is the most rudimentary and much is expected to be learned through feedback from officers. Currently, it allows a user to select a person and compose a text message over SMS to that person without knowing their phone number. This can be accomplished from the map view, or the messaging option off the main screen. The recipient receives the message just like any other SMS.

The messaging system under development sends specifically coded messages over SMS, and intercepts them on the recipient device. These messages are then parsed and presented in a variety of ways. Each message has a priority level set by the sender. Priority ranges from low, where a small notification of receipt is displayed to the user but their actions are not interrupted, to high, where the message pops up interrupting the user and the text is read out loud through a text to speech library. Messages can be either plain text, or they could be a reference to a document or note, in which case the note would be presented.

2.9 Speech Technologies

Officers in the field are accustomed to using radios for communication. This allows for hands-free interactions that don't take the attention away from the user. PDAs require both hands and attention, and thus make the user more vulnerable and less aware. To address this issue, we are working to incorporate text to speech and speech to text into our application. Text to speech libraries are commercially available, and we are currently using one to provide speech output of select fields of data. This allows the user to hear appropriate information without needing to look at it.

Voice recognition is also heavily requested, as typing input on the small devices requires concentration and dexterity on often occupied and gloved hands. Fortunately, users have indicated that an extremely limited library consisting of letters (Alpha, Bravo, Charlie, etc.), numbers, and states (for license plates), would accomplish all of their needs for voice recognition. We have not yet found a suitable library for mobile devices for doing speech recognition.

3. Related Work

Our approach has focused on streamlining the user interface model for data collection and sharing on mobile devices. Other efforts, such as COPLINK Collaboration, support automated messaging to officers based on reporting criteria they specify [2]. COPLINK Mobile also supports information query, although our model is designed to support the integration of field-collected data with existing law enforcement databases. There has also been increasing attention paid to the development of thin client visual interfaces for display of geographic data on mobile devices [e.g., 3], which could be used to improve the asset tracking maps deployed in our application. Finally, visual interface design is challenging for mobile applications, and further work is needed to define appropriate visual metaphors for use in field operations [4].

4. Conclusions

We are currently field testing this application and deploying it to select agencies with our client that have self-identified as interested in experimenting with these new capabilities and methods. This group of officers is using the tool in the field and providing feedback so that we can improve its capabilities and address their issues in day-to-day operations. As they become more aware of the possibilities of the technologies, their requests become more complex, indicating that they are successfully able to integrate our software into their operations.

We are enthusiastic about the possibilities of speech to text but further work is needed in this area. Text to speech is fairly developed and being integrated into our application now, however. We also anticipate the availability of external BlueTooth capable devices for fingerprint scanning, barcode reading, and other sensors which will allow us to collect more diverse data and potentially reduce the amount of typing.

While the individual pieces of the software we have developed have existed for a couple years, it is the integration of all of them that provides a great advantage to the users, who can now share data from a variety of sensors and databases quickly and efficiently. We continue to address safety and methods of providing information without demanding full attention, but also on efficiency and providing as much capability on a small device as possible.

Acknowledgements

This work is supported by the National Visualization and Analytics Center, a U.S. Department of Homeland Security program operated by the Pacific Northwest National Laboratory.

References

[1] Pike W, May R, Baddeley B, Riensche R, Bruce J, and Younkin K (2007). Scalable Visual Reasoning: Distributed Analysis for Collaboration Support. 2007 International Symposium on Collaborative Technologies and Systems, Orlando, FL, May 21-25.

[2] Chen H, Zeng D, Atabakhsh H, Wyzga W, Schroeder J, 2003. COPLINK: Managing law enforcement data and knowledge. Communications of the ACM 46(1), p 28-34.

[3] Eick SG, Eick MA, Fugitt J, Horst B, Khailo M, Lankenau RA, 2007. Thin Client Visualization, IEEE Symposium on Visual Analytics Science and Technology, Computer Society Press, p 51-58.

[4] Pattath A, May R., Collins T., and Ebert D, 2008. "Real-time Scalable Visual Analysis On Mobile Devices," Conference on Multimedia on Mobile Devices, 20th Annual IS&T/SPIE Symposium on Electronic Imaging, San Jose, CA.