Design and Evaluation of a Vehicle Data Distribution and Collection System

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Abstract

A key component of today's law enforcement is quick access to updated and relevant information. The emergent use of embedded computers in police vehicles provides a platform for displaying and interacting with large amounts of data making this access to information possible. Distributing and collecting this data however is a significant challenge. In this paper we describe the design of a system being developed and deployed for the New Hampshire State Police and Highway Patrol that allows for the distribution and collection of data using state operated WiFi hotspots. We also describe some example uses as well as challenges in designing this system.

1. Introduction

Developed at the University of New Hampshire Consolidated Advanced Technologies Laboratory in collaboration with the New Hampshire Department of Safety, Project54 is a technology system designed to create a pervasive computing environment within the police cruiser where officers can effortlessly exchange information and interact with computers and electronic devices [1]. Through a consolidated system and a speech user interface, the system seeks to solve the problems in integrating and controlling electronic devices within police vehicles [4]. Project54 is also designed to facilitate communication between mobile officers and law enforcement agencies. This communication can consist of verbal radio communication, driver and vehicle record queries, or any data transfer between officers and their central headquarters. Currently, information transfer to and from police vehicles is done over the airwaves using radio data channels. This type of data transfer has two distinct drawbacks: slow transfer speed and limited availability.

The data update system currently being developed at the CATLab is designed to address these problems. By providing police vehicles with temporary, high-speed wireless access, large amounts of data can be transferred to the car and stored locally for later use. Furthermore, the architecture allows for cars to quickly upload large amounts of data to a central location for the purposes of data collection and auditing.

2. Architecture

Due to the emergence of embedded computing platforms in cars, telematics is likely to be a major new development in mobile computing [3]. One of the major target application areas for vehicle telematics is in local area hot spots. This is the approach the architecture of the Project54 data update system is designed around.

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The data update system architecture is designed in three layers as shown in *Figure 1* below. The top layer consists of a master update server. This is typically the starting point for all data distribution and the end point for all data collection. The master update server is responsible for making available to the middle layer any data that is to be distributed.

The middle layer consists of several update servers at remote locations. These remote locations are typically troop headquarters and car refueling stations. These sites are chosen to eliminate the need for officers to make special stops in order to perform a data update. For example, when a police officer pulls his or her car up to a gas pump, they touch a button to wirelessly connect the in-car computer to the remote update server, and the data update process runs automatically. In this way, any data transfers can be done concurrently with the refueling of the car. This saves the officer from spending any extra effort or time. The data available at these remote update servers can be placed there manually, or more commonly, the servers periodically connect to the master update server to pull back the necessary information. The remote update servers can also push data collected from the vehicles up to the master update server.

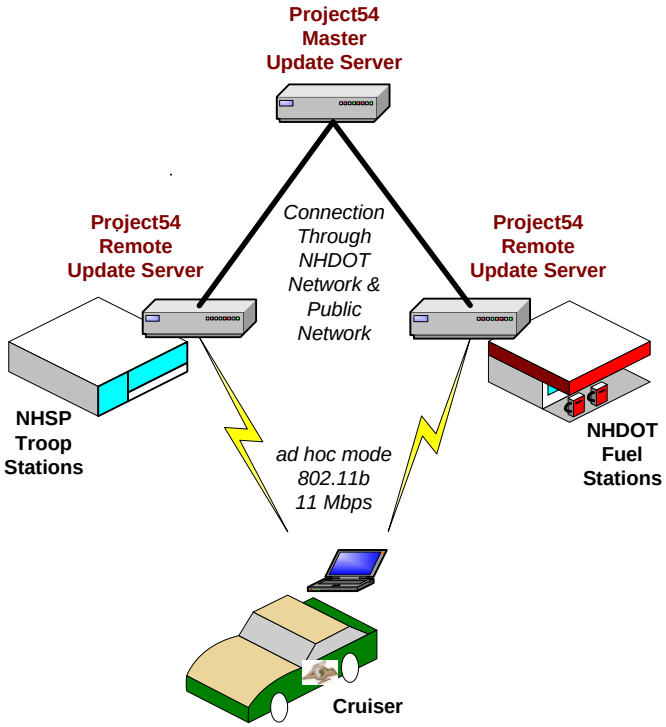

Figure 1: Project54 Data Update System Physical Network Architecture

The final and bottom layer of the data update system architecture consists of the mobile data units (usually police cruisers). Data originating at the master update server is made available over a high speed wireless connection to the mobile units at the remote update locations. Information such as diagnostic logs can also be uploaded to these remote update servers and eventually the master update server.

It should be noted that this three layer hierarchy can be expanded or collapsed to as many layers as desired. The file transfer service that runs on the update servers can serve any client regardless of whether or not that client also serves clients of its own. This creates an extremely flexible architecture for distributing and collecting data.

3. Uses

While not restricted to any particular use, the data update system has three planned functions. The primary function of the data update system that is currently in limited use is to provide NH State Police and Highway Patrol cruisers with an updated copy of the state vehicle and driver record database. The Project54 records application that allows officers to query driver records using the in-car computer is configured to query the local hard drive database if the central database cannot be reached using the radio channel. This allows troopers to query driver and vehicle records even while

out of radio range with headquarters, and is seen as an extremely valuable asset. The data update system ensures that the record being queried is only as old as the time that the last update was done.

A secondary function of the data update system is to provide a means of data collection from police vehicles. For example, this is currently being used to collect information about public television signal coverage in New Hampshire. State police cars are equipped with antennae that samples signal coverage, and the samples are stored in the vehicle's computer. The collected samples are then uploaded to a central server using the data update system so they can be processed and analyzed.

A third planned function of the data update system is to provide police vehicles with updates to the Project54 software. New features or bug fixes would normally only be applied to the in-car computers when they come in for repairs or maintenance. However, using the data update system, critical and non-critical updates alike can be distributed to the cars during data updates.

4. Challenges

There are two major challenges associated with the data update system: data synchronization and security. To address the problem of data synchronization, a simple timestamp method is used. Update servers store a database of the files that are available for download along with the timestamp of when the files were last modified. Clients store a single timestamp that describes when the last data update was done. If the timestamp of the files on the server is newer than the client's timestamp, the file is downloaded. This allows clients to download only the files which it has not already retrieved. When configuring a new client, the timestamp can be manually set so to the current date and time so that only new files will be downloaded. Clients also store an identification string that the server can use to decide what files are available to what clients. For example, a new client can be configured to download some files but not others, whereas a second client can be configured to download all available files. In this way, data can be served to specific clients or made available to everyone.

Due to the documented unreliability of wireless security, the privacy of transmitted information is a concern, particularly in instances where the information is sensitive, as in the case of driver records [2]. A number of steps have been taken to provide security. To ensure a secure wireless transmission, the file transfer software uses OpenSSL to encrypt any data that is transferred between servers and clients. In the case of the driver and vehicle records, the database fields are also encrypted with a private key only to be decrypted on the fly by the Project54 software when a record query is done. On top of this, any sensitive files that are transmitted over the wireless connection are encrypted using 128-bit AES private key encryption. The client computers are configured ahead of time to decrypt these files so that the private key is never transmitted wirelessly. The final step in ensuring security is to limit the availability of a wireless connection to the client. The Project54 software in the police vehicles is configured to only enable the wireless device when an officer manually chooses, such as when a data update is done. This limits the opportunity to detect and exploit the wireless connection.

5. Results

The data update system has been successfully tested in two capacities. As part of a project to measure public television signals in the state of New Hampshire, nine State Police and Highway Patrol cruisers have been outfitted with wireless devices and configured with the update client software. Over the past three months, officers have been able to upload collected data through two

wireless hotspots that have been set up by the CATLab, and that data has been automatically uploaded to the master update server. This test has proven that the data update system has the capacity to be a successful data collection system. It has been a valuable tool for researchers who would otherwise have had to schedule data collection with the State Police and Highway Patrol.

Starting in August of 2006, the data update system has also been successfully tested as an efficient data distribution system. As part of a project to provide State Police and Highway Patrol with a local copy of the New Hampshire driver and vehicle database, three cruisers have been configured to use the data update system. Officers have been able to connect wirelessly to the remote update servers and download updates to the in-car database. The use of this database is audited and the audit logs are uploaded through the data update system. This testing has shown that the data update system is able to provide cruisers with frequent data updates without disrupting the busy schedules of the officers using the system.

6. Conclusions and Future Work

Through a well designed architecture, the data update system being developed by the CATLab at the University of New Hampshire has proven to be an extremely useful and flexible system. The ability to distribute and collect data from mobile police units has opened up a number of exciting possibilities which include providing police with a local set of driver and vehicle records for use when out of radio range, efficiently collecting measurements gathered by instruments placed in police vehicles, and providing software updates quickly and transparently to a wide, decentralized fleet of vehicles. Simple and efficient solutions have been provided for the problems of data synchronization and security that is associated with data distribution.

Future work in the data update system will involve state-wide deployment and the development of new applications. Currently, the data update system is set to be deployed throughout the state of New Hampshire for use by the New Hampshire State Police and Highway Patrol departments. This powerful and flexible system will also be used by many new applications in data distribution and collection with police vehicles. For example, this system will be used to collect speech samples from cruisers to evaluate the Project54 speech user interface.

7. Acknowledgements

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8. References

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