UNITED STATES OF AMERICA

California State Polytechnic University, Pomona

BLUETOOTH QuickScan System

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1. Abstract

In 1983, The Communications Dispatch Center (CDC) was established and held promising hopes for the future of law enforcement communication. Since then advancements have been made to make the communication between dispatchers and peace officers more efficient. Some of the advancements made to the CDC include equipping police vehicles with Mobile Digital Terminals (MDT) or Panasonic Toughbook. Both MDTs and Toughbooks operate within a Local Area Network (LAN). LAN offers solutions to accessing information including photo ID's, streaming video, and finally, the ability to write and print reports of vehicles from the mobile units in the police car.

Despite the great features that the system already offers, we feel that the system can be modified to promote better safety for the public as well as the officer in the police vehicle. Under normal circumstances, a police officer would not verify that every car before him is of legal status. Only situations where the officer happens to see expired registration tags, broken taillights or suspicious activities in a vehicle would he be motivated to verify the legal status of the vehicle. This is one area that we feel is of significant risk to both the public and the officer. Suppose a police car passes a car reported stolen a day earlier. Chances are the officer will not go through the routine of verifying the legal status of that vehicle unless he sees something suspicious. The person driving the car has committed a crime and potentially will commit more serious crimes that could be prevented had the car not been overlooked.

QuickScan is a Bluetooth technology driven system that will eliminate 'overlooks' on vehicles by automatically scanning for legal statuses, including insurance, registration, overdue tickets, reported stolen, etceteras. The system requires that all registered vehicles to have a Bluetooth transmitter with pre-programmed, fixed address, where the VIN will be stored. As the police car draws near a vehicle, the Bluetooth transmitter in that vehicle transmits the vehicle's VIN (Bluetooth Address) to the police car's Bluetooth receiver where it is then quickly 'cross-referenced' with the police database using TCP/IP technology. A report will immediately be sent to the officer notifying him of any vehicles with illegal status. With the QuickScan system officers never again have to remove their eyes from the road to key in a license plate into a Toughbook to access vehicle information. Officers need only to recognize the alert sound, then view the LCD display of his laptop for the report sent to them notifying vehicles with illegal status. Law enforcement efficiency will drastically rise, as every car will be scanned and 'checked' automatically, independent of a police officer's judgment. With the QuickScan system, law enforcement agencies will eliminate a higher rate of illegal vehicles from public roads making them safer to be on.

2. System Overview

The QuickScan system consists of three distinct components (Figure 1): the Bluetooth device in the police officer's vehicle (QuickScan Device), the Bluetooth transmitter in the domestic vehicle (BT), and the police database.

The QuickScan device consists of a laptop with a Bluetooth transceiver connected to it. It is designed to:

- Receive the VIN (Bluetooth address) of the BT.
- Send the VIN to the police database.
- Receive information of illegal car(s) from the police database.
- Alert the officer regarding the illegal vehicle(s) through sound alert.
- Display the information of vehicles operating illegally.

The BT consists of a laptop with a Bluetooth transceiver connected to it. It was designed to:

- Transmit the VIN (Bluetooth address) to the QuickScan device.

The police database is stored in a separate laptop. It was designed to:

- Store registered vehicles' information.
- Receive the VIN from the QuickScan device.
- Analyze the VIN and determine vehicles' legal status.
- Send a report to the QuickScan device regarding vehicles that have 'illegal status'.

The Quick Scan system requires that every registered vehicle to be equipped with a Bluetooth transmitter. The Bluetooth transmitter, operating in simplex-mode, holds the VIN of the registered vehicle, which is "pre-programmed" and cannot be modified. These Bluetooth transmitters will be manufactured and provided by the Department of Motor Vehicles. The Bluetooth transmitter's main purpose is to transmit the vehicle's VIN (Bluetooth Address) when requested by the Bluetooth receiver in the QuickScan device. The Bluetooth receiver acts as a "master" by establishing connections (piconet), with the transmitters, "the slaves", that are within the range of 10 meters. Each piconet can have one master and up to seven slaves simultaneously, which means that a police officer can *automatically* "scan" up to seven VINs simultaneously with the QuickScan system. Any slaves that are not

within the operating range of 10 meters either cannot establish connections with a master or its connection will be broken. Once the Bluetooth receiver receives the VIN number(s), it will be transmitted to the police database. The VIN(s) will be routinely "cross-referenced" with the police database. To avoid missing the scanning of some cars during high speed passes a connection between the master and the slave is created and terminated as soon as the "scan" is accomplished. The data transmission will occur at an approximate rate of 1-Megabit per second, which is more than an ample rate to terminate each connection quickly.

A registered vehicle might be scanned more than once in a day, which is why we designed a redundancy checking system. The redundancy checking system avoids the scanning and cross-referencing of the same vehicle within a 24 hours period to conserve system usage.

2.1 Performance Requirements

The QuickScan system must meet certain operation requirements. The system has to provide responsive feedback (when necessary) to the police officer quickly. The Bluetooth devices must be able to establish connection, regardless of the speed of the moving vehicles. Each Bluetooth transmitter must store a vehicle's unique VIN as its address, and the address cannot be modified for security purposes.

2.2 Design Strategies

The first step in designing the QuickScan system was researching the Bluetooth technology. The QuickScan system was chosen to be the application, and the specifications of the application were decided. The system overall was broken into three major components. Decisions on what software, hardware, and operating system to use, and how the QuickScan system will operate were the next steps. We came up with a schematic of the Quickscan system and assigned tasks to each team member. We had to quickly learn Visual Basic and MFC, the software languages we used.

The backbone of the system is being able to receive, transmit, read, and write the VIN (Bluetooth Address). The reason we learn MFC is because the "Manufactured Bluetooth Program" from Ericsson is written in MFC. We needed to be able to understand and make proper modifications to the 'codes' to function the way we desired. We used Microsoft Visual Basic to develop all other software and GUIs required for testing and simulations.

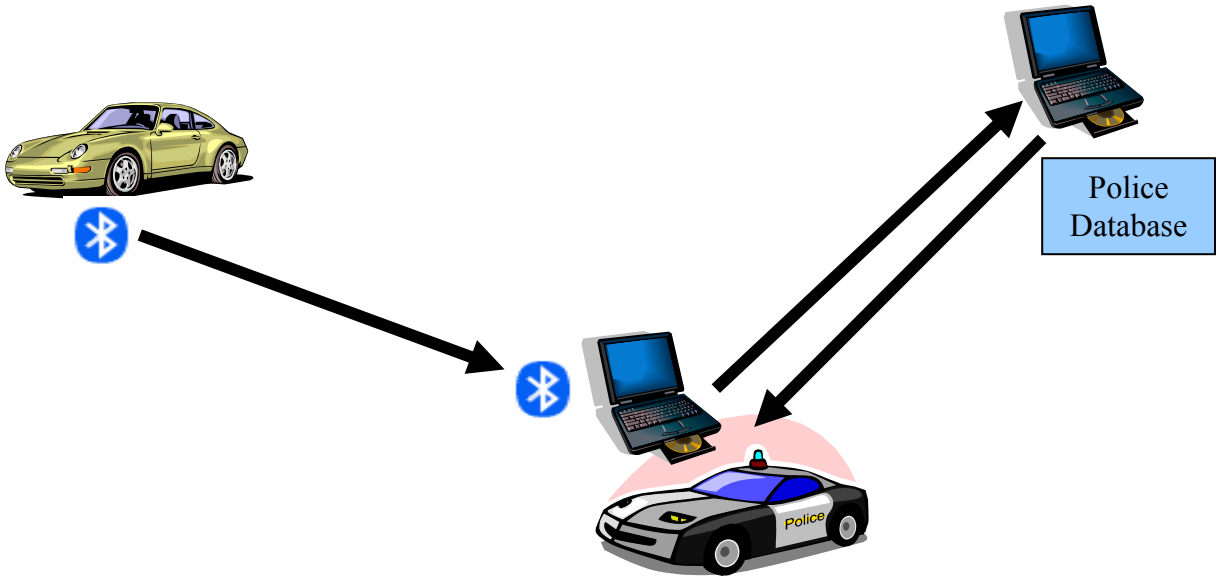


Figure: 1.1a.

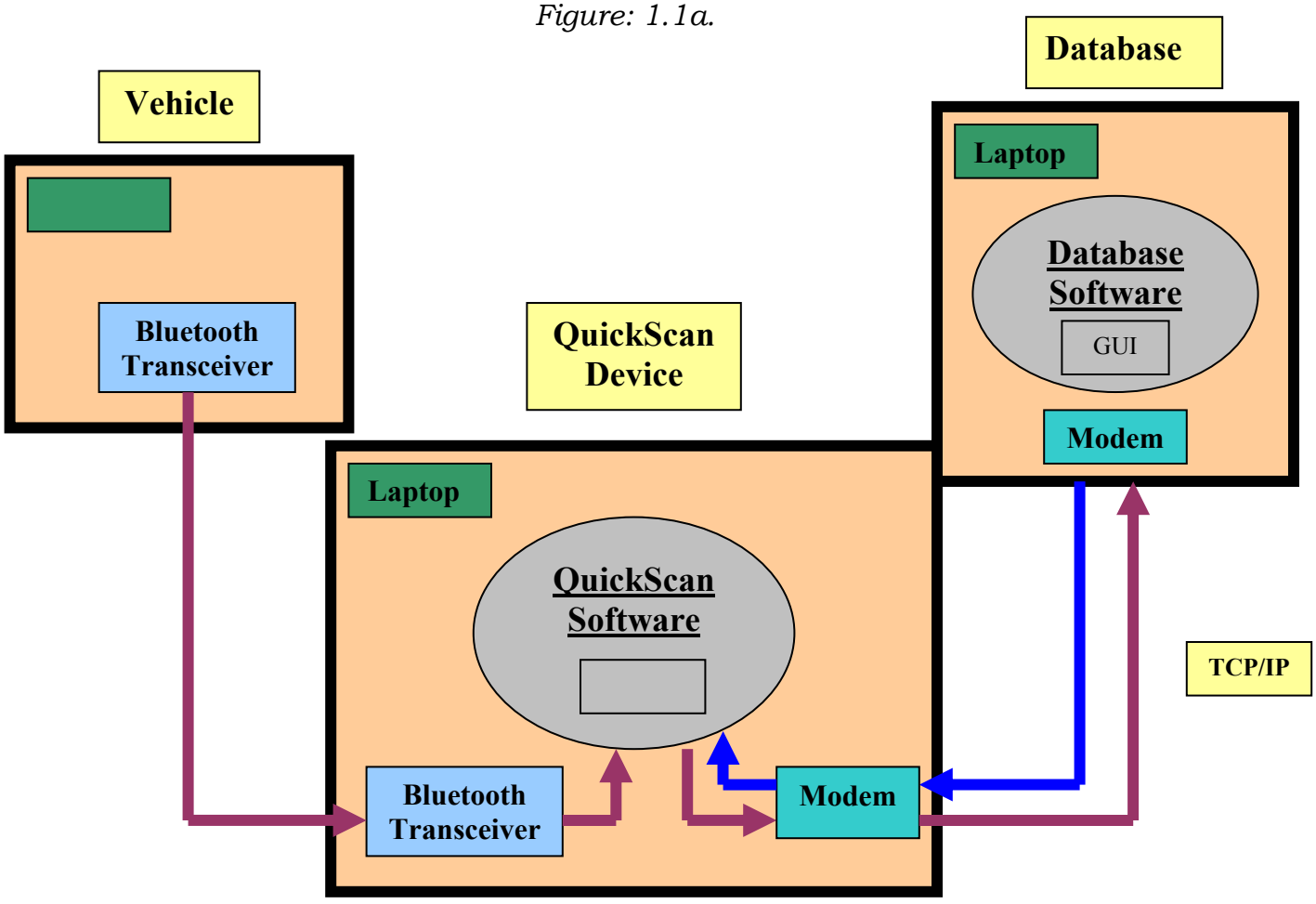


Figure: 1.1b.

Figure 1: System Overview

2.3 Design Goals

The QuickScan system was originally designed to promote safety. We feel that an officer is at risk once he takes his eyes off the streets and turn his attention to an alert screen, such that of a police laptop LCD screen. The QuickScan system enables an officer to keep his eyes and focus his attention on the roads. If the system scans the VIN of a vehicle and determines that the vehicle is operating illegally, a "beeping" sound will alert the police officer. Only then will the police officer look at the laptop screen to view the information of that vehicle. Only at this point will the officer's attention be momentarily directed away from the road ahead of him. Another goal of the QuickScan system is to enhance the safety of both the publics. This can be achieved if we can eliminate a higher number of illegal vehicles from public roads. This QuickScan system will decrease the number of vehicles operating illegally, which ultimately leads to safer streets and a safer community.

2.4 Innovation

As mentioned earlier, many police departments currently use Mobile Digital Terminals (MDT) or Panasonic Toughbook in patrol vehicles. These MDT and Toughbooks establish connection to a LAN to access vehicles' information. We also mentioned that an officer is required to manually key-in a license plate number to access information. What makes the QuickScan system so unique and so advantageous is because it is equipped with the Bluetooth technology. This system goes through the same process in accessing vehicle information as an officer would with his MDT or Toughbook, but what set this system apart is that it *automatically* scans vehicle within its range for information which allows officers to keep their eyes on the roads. In addition, the QuickScan system can be embedded into the Toughbook laptops currently used in police vehicles.

3. Implementation

3.1 Simulation

When designing and testing the QuickScan system, we used three laptops as simulation for the QuickScan device in the police vehicle, the Bluetooth transmitter (BT) in the domestic vehicle, and the police database (Figure 2). The first laptop's responsibility, the BT, is simply transmits the Bluetooth Address where it will be received by the second laptop, the police vehicle. We are simulating that the 'non-

programmable' Bluetooth Address of a Bluetooth transceiver is the unique VIN of a domestic vehicle. The Bluetooth transceivers automatically detect each other within the 10 meters range and automatically form a piconet where the VIN is transferred.

Figure 2: System components.

3.2 Design Overview

The block diagram of the QuickScan system is shown in Figure 3.

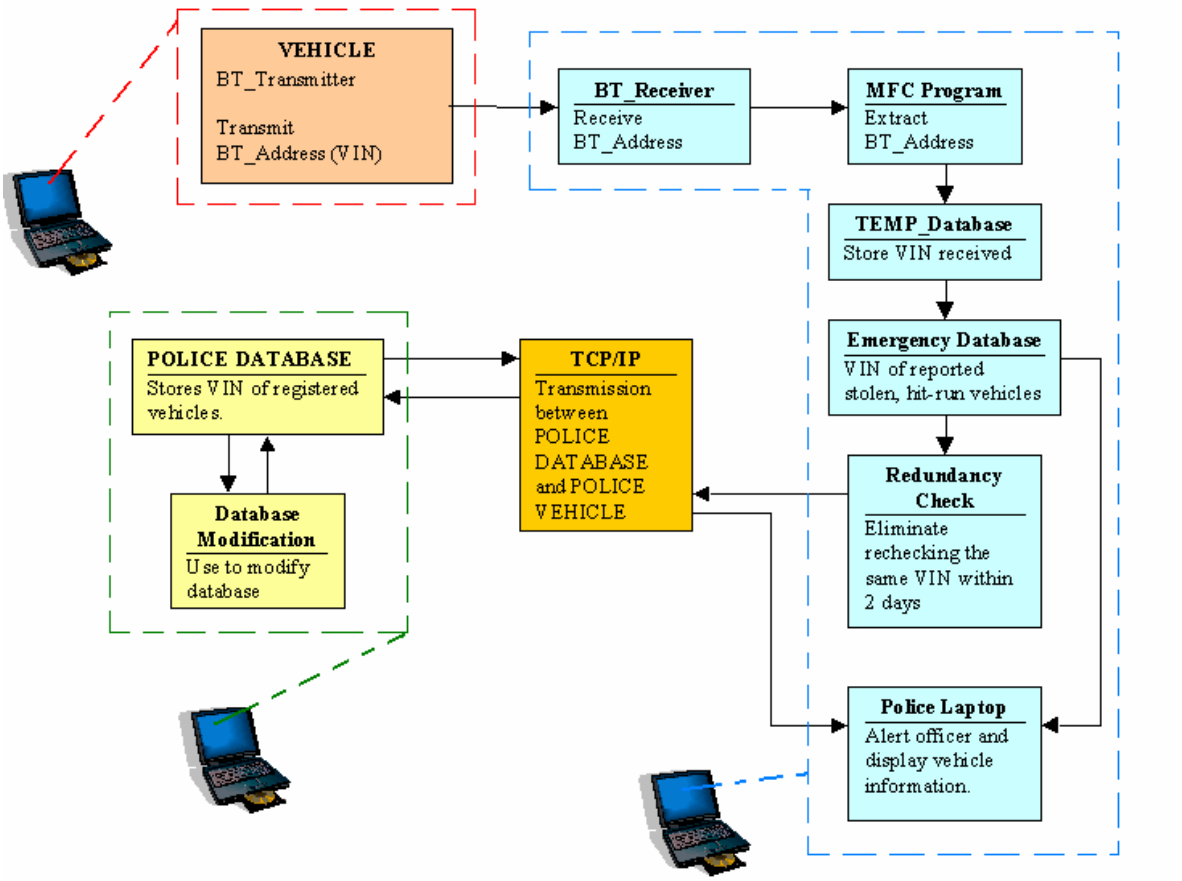


Figure 3: QuickScan block diagram.

When the domestic vehicle and the police vehicle are within 10 meters, the Bluetooth transmitter in the vehicle sends the VIN (Bluetooth Address) of that vehicle to the police car's Bluetooth receiver. Upon reception of the VIN, an MFC VIN_Extraction program will 'extract' and 'store' that VIN in a TEMP_Database. Next, the VIN will be 'scanned' through an Emergency_Database to check if the vehicle with this VIN is listed under 'urgent cases' (the vehicle is reported stolen, hit-run, or if the registered owner of the vehicle has a criminal status), and will alert the officer if necessary. Next, a Redundancy_Check will be performed on the VIN to eliminate the unnecessary 'rechecking' of the same vehicle within the same day. Once the VIN 'passes' the Redundancy_Check step, meaning it has not been scanned within that day, it is transmitted to the Police_ Database using TCP/IP and quickly cross-referenced with the database. The Police_Database will send a 'vehicle report' to the officer only if that VIN reportedly has an illegal status. Once a report is sent to the Police_Laptop, a Visual Basic Alert_System will alert the police officer. The Police_Database can be modified with the Database_Modification program. As discussed earlier, the police car's Bluetooth receiver is capable of handling; perform checks up to seven vehicles simultaneously.

3.3 The QuickScan Device

The QuickScan device in the police officer's vehicle consists of an Ericsson Bluetooth application toolkit and a laptop (Figure 2).

3.3.1 The Bluetooth Application Toolkit

The Bluetooth Application Toolkit (transceiver) was simulated to be a receiver in the police vehicle (Figure 4). It was provided to our team from past senior project teams. The kit provides low cost, convenient hands-on training involving Bluetooth wireless technology. The tool kit was developed by Ericsson and enables students in higher education to understand both the theory and applications of Bluetooth short-range radio communication. All communications between the Bluetooth devices were predicated upon the Host Controller Interface (HCI) commands specified in the Bluetooth Specifications. These Bluetooth toolkits have their unique pre-programmed address from the manufacturer, and cannot be modified. We simulate that the permanent address of the Bluetooth Kit is the unique VIN of a vehicle. We used the USB connection, which ensures ease of use and full Bluetooth data/voice transfer speed.

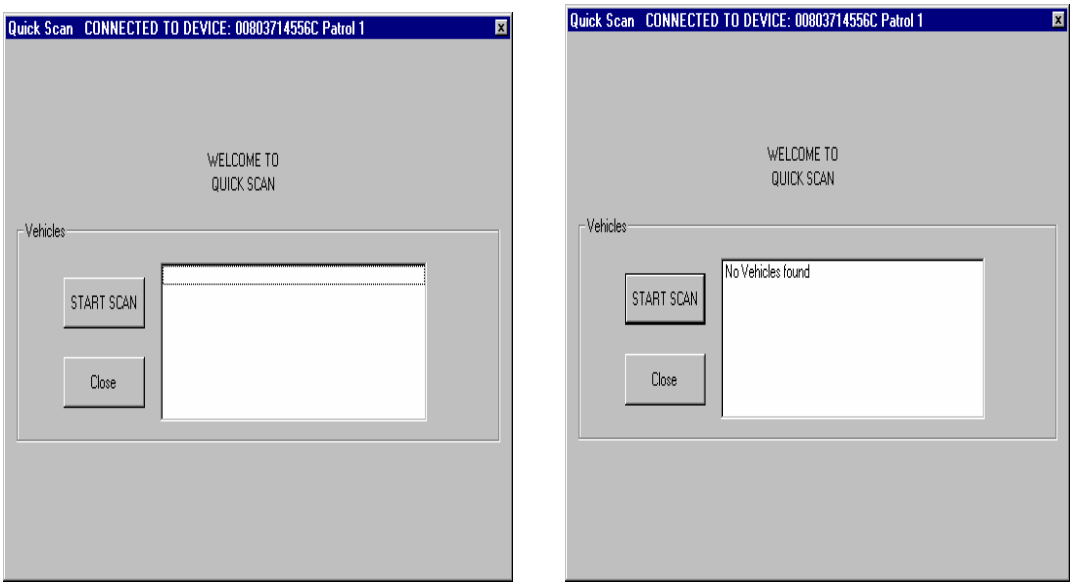
Figure 4: The Ericsson Bluetooth Development Toolkit.

3.3.2 The Laptop

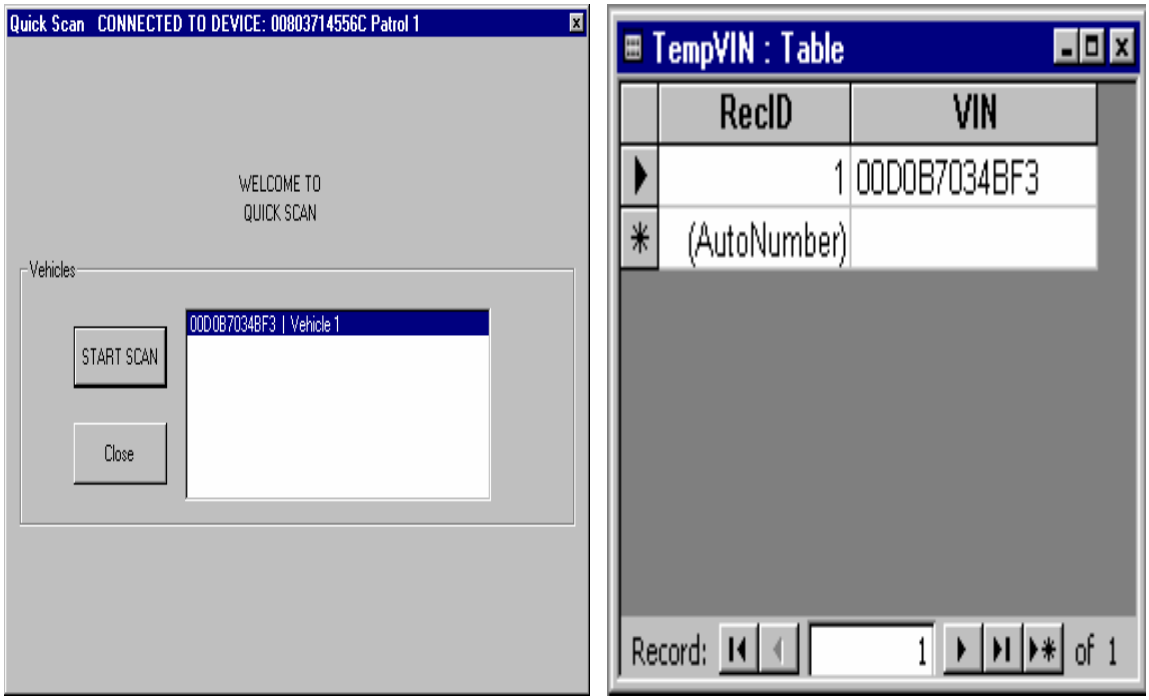
The laptop in the police vehicle is a vital component of the QuickScan system. An advantage of the QuickScan system is it uses the resources, the laptops, which are currently used by police officers. Connected to the laptop is the Bluetooth Development Kit. The MFC Vin_Extraction program, the Redundancy_Check program, the Temp_Database, the Emergency Database, and the Visual Basic Alert_System are in the laptop.

3.3.2.1 The MFC VIN_Extraction Program

The VIN_Extraction program receives the VIN (Bluetooth Address) from the transmitter that the receiver is connected to, and stores the VIN in the Temp_Database (Figure 5).



a) *b)*



c) d)

Figure 5: The MFC VIN_Extraction Program.

Figure 5a shows the GUI of the program an officer would see on his laptop. Figure 5b shows the GUI of the program when there are 'no vehicles found', meaning that there are no vehicles within 10 meters of the police vehicle. Figure 5c shows the GUI when there is one vehicle within range. The VIN of the vehicle within range is 00D0B7034BF3, which also the unique address of the Bluetooth transceiver. Figure 5d shows the Temp_Database where the VIN is stored temporarily.

3.3.2.2 The Emergency Database

The Emergency_Database stores the VIN of vehicles that are listed under "urgent" status. Such "urgent" statuses include but not limited to the car is stolen, and convicted hit-run. All VINs received from Bluetooth transmitters are scanned through the Emergency_Database before the Redundancy_Check program. If a VIN being scanned happens to be in the Emergency_Database, the officer will be alerted immediately. The Emergency_Database is shown in Figure 6.

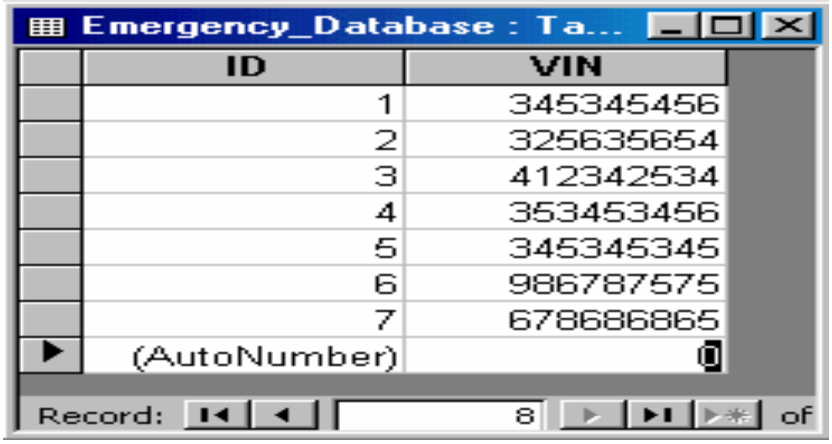


Figure 6: The Emergency_Database

3.3.2.3 The Redundancy_Check Program

The purpose of this program is to avoid scanning the same vehicle within the same day. This is because the probability of a vehicle's status changing within one day is very low. This program reduces the number of scans the QuickScan system makes within a day, hence improving system performance.

This program's function is simply 'If the VIN's date last scanned is the same with today's day, then remove the VIN from the Temp_Database, else do nothing. The block diagram of the program is shown in Figure 3.

3.3.2.4 The Alert_System

This system was designed to alert the officer of any vehicles with illegal status. Once a report is received from the Police_Database, the Alert_System will get the officer's attention by sound alert and visual alert. As mentioned earlier, the purpose of the sound alert is to help the officer focus on the road and to not constantly having to operate his laptop. The purpose of this alert system is to enhance the safety of the officer. Figure 7 shows the visual alert of the system. This is what an officer would see on his laptop LCD screen if the QuickScan system happens to 'spot' an illegal vehicle with VIN number 22222. The alert screen displays the driver's name, address, VIN, license plate number, and the 'problem' with the car.

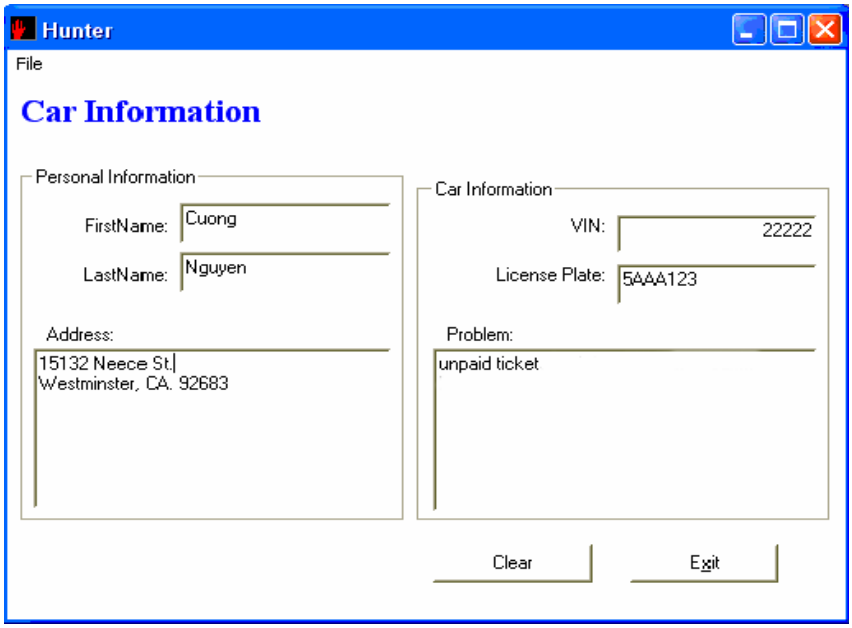


Figure 7: The alert screen seen on the police laptop.

3.4 The Bluetooth Transmitter (BT)

Like the QuickScan device in the officer's vehicle, the BT in the domestic vehicle consists of an Ericsson Bluetooth application toolkit and a laptop (Figure 2).

3.4.1 The Bluetooth Application Toolkit

The Bluetooth Application Toolkit (transceiver) was simulated to be a transmitter in the domestic vehicle. Please see section 3.3.1 for more information on the toolkit.

3.4.2 The Laptop

Connected to the laptop is a Bluetooth transmitter that holds the pre-programmed VIN of a vehicle. The driver for the Bluetooth transmitter is installed in the laptop. The transmitter will transmit its VIN (Bluetooth Address) into space once a Bluetooth receiver is within range.

3.5 The Police Database

The Police Database consists of a laptop storing a Microsoft Access database and a Visual Basic Database_Modification program.

3.5.1 The Laptop

3.5.1.1 The Database

Figure 8 shows the police database that stores the information of all registered vehicles. The database displays the vehicle owner's name, address, the car's VIN, license plate number, and the 'problem(s)' of the car if there are any.

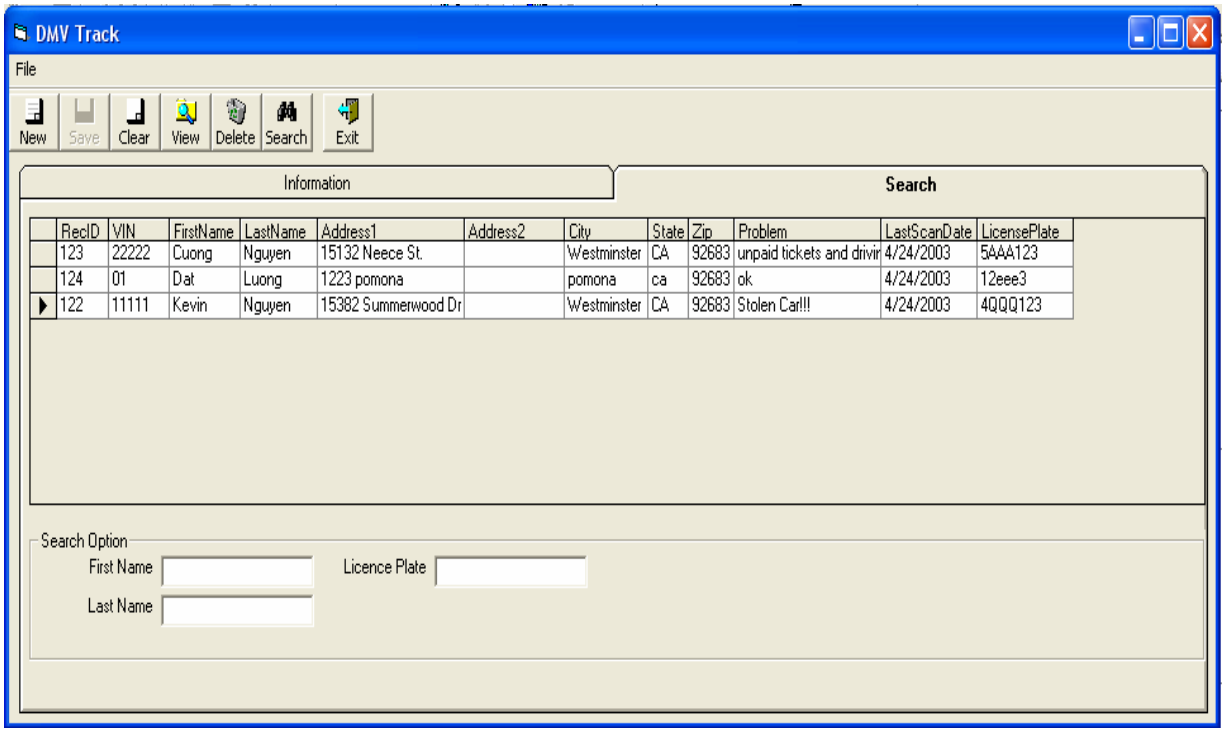


Figure 8: The police database.

3.5.1.2 The Database_Modification program

This program allows the DMV to modify the police database. Figure 9 shows the GUI of this program. Information of any registered vehicles can be updated using this program. Also, newly registered vehicles can be entered into the system with this program.

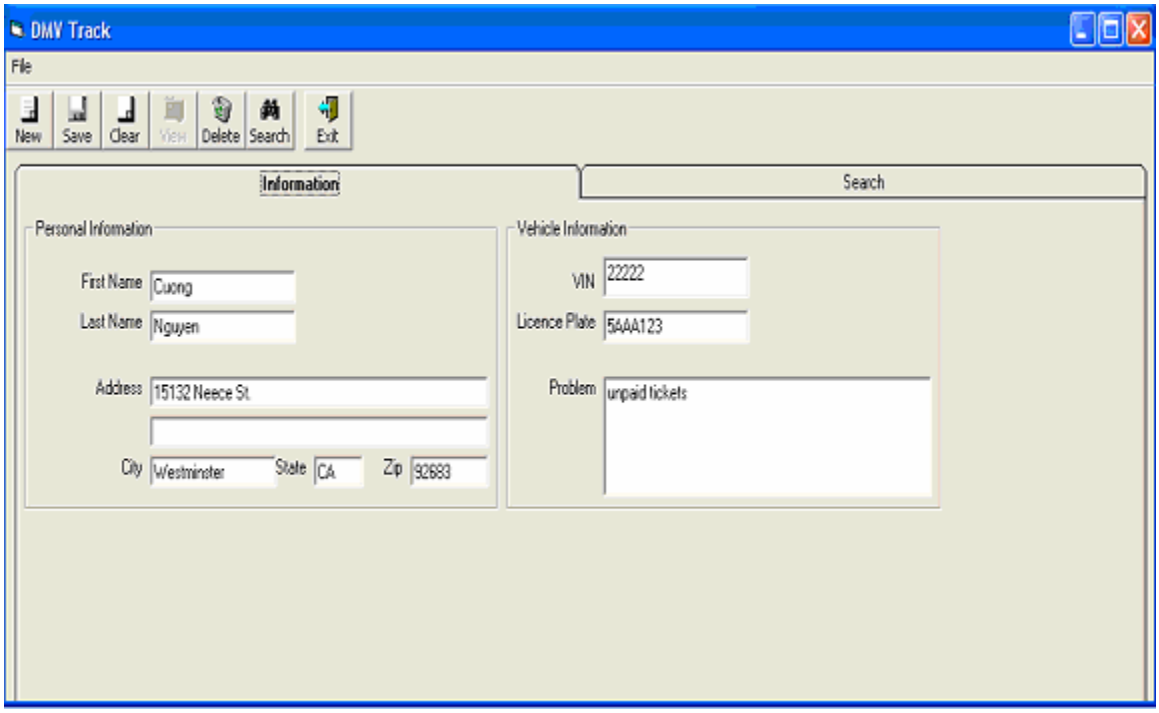


Figure 9: Database_Modification Program.

3.6 TCP/IP Connection

When establishing the TCP/IP connection between the police laptop and the police database, we used a Multimode 5GHz PC Dual Band Wireless Adapter along with a Tri-Mode Dualband Wireless Access Point (WAP) (Figure 10). These simulation devices provided connection with a range of up to 150 meters.

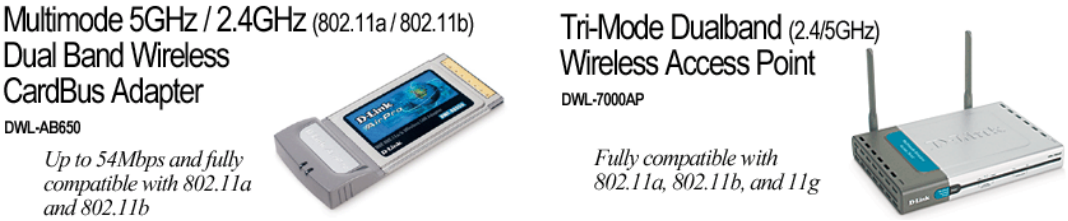


Figure 10: TCP/IP Connection.

3.7 Testing and Verification

The incremental software development model was used during the development of the QuickScan system. Every component was individually tested. This ensured that all the components worked correctly independently of each other before the system was integrated. Furthermore, we needed to make minor changes to our design during and after the system integration phase.

3.8 Limitation

When we first began working the QuickScan system, we had envisioned a design of a portable QuickScan device. The use for this handheld device is limitless. Scanning vehicles public parking structures, and scanning vehicles crossing state borders, just to name a few. But due to resource constraints (time and budget), we have limited the system to be embedded into a police laptop and operate in a police vehicle.

3.9 Costs

All of the software components used in our project were either free (shareware) or were used only for development purposes, and therefore are not included in the final cost. The Bluetooth Development Toolkits were provided by past senior project teams and therefore not included in the cost analysis. Costs for all remaining components are given in the table below.

Books:	120.00 USD
PC Card and WAP	150.00 USD

4. Summary

In designing the QuickScan system, we wanted to achieve two primary goals. First, we wanted our design to enhance the safety of the public. This goal can be achieved if we can find a way to eliminate a higher rate of illegal vehicles off public roads. The QuickScan automatically scans every vehicle within range automatically, not relying on police officer's judgment, and could potentially help achieve this goal.

Second, we wanted to improve the safety of police officers on duty. This can be achieved if the system allows and officer the keep his attention on the road at all time. The QuickScan system does not require any 'input' from the police officer; hence the officer is never distracted. The system will alert the officer only when necessary.

Currently, the design of the QuickScan system is working effectively. Still in the design process is the Emergency_Database and the Redundancy_Checking. We expect the system to be complete in the upcoming weeks.

The potential for improvement and application of the QuickScan system is limitless as mentioned earlier. Future enhancement of the system in hardware design, making the QuickScan device portable, is the next goal. We feel that the portable QuickScan device will gradually play a major role in police operations in the years to come.

5. Reference

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