Vehicle Collision Avoidance Application

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Abstract

This paper is presenting a student project in the vehicle to vehicle communication area. The project is part of an undergraduate class in Networks and Data Communications. The project required the students to work in teams and it has two parts, the research part and the simulation part. The students are asked to research the topic of Vehicle-to-Vehicle (V2V) communication and to present their research findings in a report. Then based on their research, they are asked to come up with a new system/application that can enhance the V2V communication and to develop a Graphical User Interface (GUI) for the system/application. Our team developed an application for Vehicle Collision Avoidance System. The goal is to create an application that will help in eliminating the amount of accidents on the road due to distracted drivers. The paper will first discuss the need for such an application, then it will describe in details how the GUI for this application is developed and how it alert the drivers to avoid a collision. The issue of security in V2V is discussed and it is followed by suggestions to make the application more secure. The performance of the system under different amount of traffic is simulated using PR-ALOHA MAC protocol, both throughputs and delays are discussed for different number of vehicles on the road. Finally, an examination of the marketability of the product is presented. This application will help in alerting drivers to potential dangers on the road which will hopefully reduce the number of accidents on the road.

Introduction

The National Highway Traffic Safety Administration reported that there is a decline in fatalities, 32, 719 people died in crashes on roadways during 2013 down from 33,782 in 2012[1]. About 520,000 people were killed or injured in car accidents involving a distracted driver[2]. Distractions are in high demand in modern society, it ranges from texting, to talking, to watching a video on YouTube, and many other activities. While distractions provide fun in our daily lives, they cannot be mixed with driving because they can be dangerous as they may attribute to human errors, causing the drivers to perform undesirable driving tasks[3] which could lead to fatal accidents on the road. One of the major distractions on the road are cellular phones and hand held devices. Studies have shown that talking on a cell phone increases the possibility of a collision by 30 percent and drivers sending and reading text messages while driving are 23 times as likely to cause an accident[4]. Using devices such as cell phones causes the driver's eyes to leave the road for a few seconds, which is an enough time for a car to move a few hundred feet. This can be extremely dangerous on any roadway, particularly in major cities and intersections.

Another main form of distracted driving is being drowsy while driving which causes the awareness and reaction time of the driver to be greatly decreased. About 3.6 percent of the fatalities of crashes in the United States are caused by drowsy drivers[5]. Studies show that the number of drivers who actually report the problem of driving while drowsy after an accident can almost be compared to the number of drivers who fail to report accidents due to alcohol related accidents[5]. This shows that many drivers are unaware that they are falling asleep while they drive. Out of all of the accidents that occur in the United States, 3.2 million accidents occur at or in an intersection which accounts for about 43 percent of all reported accidents[6]. Most of the accidents that occur at intersections happen because the line of sight of the driver is blocked until the vehicle is in the intersection. This problem stresses the importance of actions that need to be taken. This is where our vehicle avoidance application comes into play.

The application presented in this paper is intended to prevent accidents by notifying the driver of immediate obstacles and dangers found on the road. The application is based on broadcasting packets on a local network to communicate between vehicle to vehicle communications. The vehicle has a network of sensors from proximity, laser scanners, and global position system (GPS). The data is collected and computed by the on board computer that broadcasts the data to local area vehicles.

Theory of the Application

The goal is to create an application that will help to eliminate the amount of accidents due to distracted drivers. The quickest way to change this would be to change the driver, but this is not a feasible approach. Another way to help with distracted driving is to change the technology surrounding the car design which is what the application will do. This application will create a safer driving environment for its participants.

The application will define vehicle identification numbers to identify each car separately and it will run on a wireless network using peer to peer communication. This will allow the position, speed, and direction of different cars to be compared on a network. The application will be used to alert drivers of the obstacles that they are sure to encounter if they continue on the same path and speed. The application will alert the driver to the situation allowing them to stop or slow down. The alert will come in the form of position of the threat, speed of the vehicle being approached, and the type of the vehicle. The application will alert drivers with a beeping sound. For example it will beep to let the driver know of upcoming stopped traffic or school areas. The application takes into account the users car speed, location, type of the car and direction. It uses these variables to forward information to the car about upcoming stopped traffic. When alerting the driver to an approaching danger, in addition to the peeping sound the application will also say what type of car is involved. For example, the application will say, “A school bus is stopped ahead.” This application will allow the driver to have sufficient time to stop or slow the car down to avoid a collision. The application can be installed in different vehicles and can be used to transmit data between vehicles as well.

Security

With the improvement in technology, new vehicles have network capabilities and different data can be transmitted from the vehicles using different devices, therefore data security is considered an issue. For example, vehicles have an In Vehicle Network (IVN), which is a combination of electronic control units (ECUs) that communicate over a communication bus and wireless network. The IVN needs to be protected against denial of service attacks (DoS), masquerading, jamming, and forgery. The system will need to implement the same technology as cell phones using public and private keys to encrypt the data being sent and received. Both in hardware and software security measures are needed to be implemented to prevent remote control of vehicle control systems. The system must be secure against internal and external threats or attacks. The National Highway Traffic Safety Administration has released a report[7] titled "Vehicle-to-Vehicle Communications: Readiness of V2V Technology for Application" in the report there are three system required securities. The first being communications (the medium, the message/data, the certificates, and any other element that supports message exchange), the second is the devices being used, and the third is the structure (organizational, operational, and physical). In order to make the vehicle to vehicle communication more secure; firewall, data encryption, and hardware security design will have to be developed and implemented. Communication addresses will use the IPv6 standard which is a combination of MAC address and computer ID. This will make it hard for spoofing of addresses to occur.

PR-ALOHA MAC Protocol

The Priority Reservation ALOHA (PR-ALOHA) Medium Access Control (MAC) protocol[8] is a medium access control protocol used in the Data Link Layer to establish data communication over shared bandwidth mediums. PR-ALOHA protocol classifies the data to high priority and low priority and it is based on ALOHA protocol which is a random access protocol, where vehicles can transmit data at any time. Because of the simplicity of ALOHA based protocols, they are considered a good choice in vehicle communications networks.

The PR-ALOHA protocol is used to simulate different behaviors of the amount of traffic based on the rate of successful packets sent and the delay time that was generated. This information is useful when deciding what to use for a router to relay information between vehicles and when deciding how many high priority slots can be used.

The graphs in Figure 1 show the throughput and delay simulation for the application. In the simulation, the maximum number of nodes that can be used on one router in an area was set to 200 where each node represents a vehicle on the road. Based on PR-ALOHA, a node must reserve a slot in the frame to be able to transmit the data. The assumption used in the simulation is, each node can transmit once every frame time. The frequency of traffic generation was set to a maximum of 5. The maximum number of high priority slots was 10. The total number of slots in each frame was set to 50 slots. The number of nodes that can transmit at the same time without significant delay is at about 60 nodes as shown in Figure1.

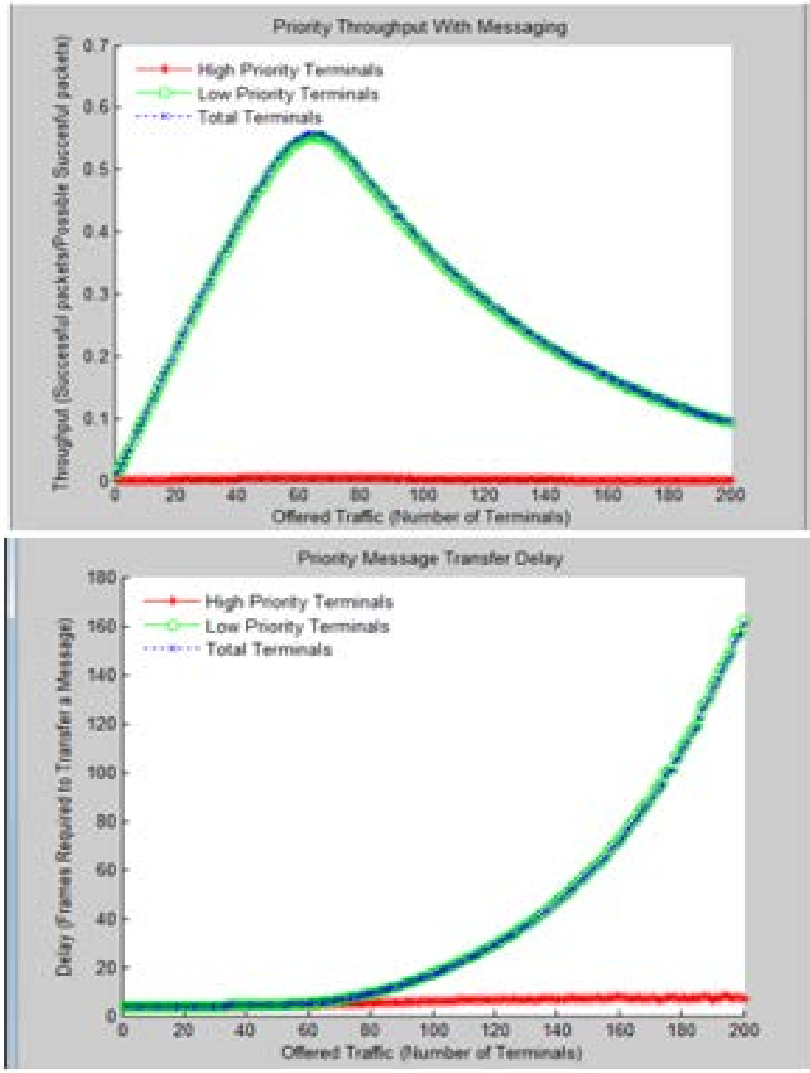

Figure 1: Throughput and Delay of the network for the simulated application using PR-ALOHA protocol.

The graphs in Figure 2 were generated by running a second simulation changing the frequency of traffic generation to 10 and changing the maximum number of high priority slots to 20. The rest of the parameters were left the same as the first simulation that was shown in Figure 1. The graphs show that as the frequency of traffic generation and the number of high priority slots increases, the maximum number of nodes that can be on one router at a time without significant delay is increased slightly from a previous 60 to 80 nodes.

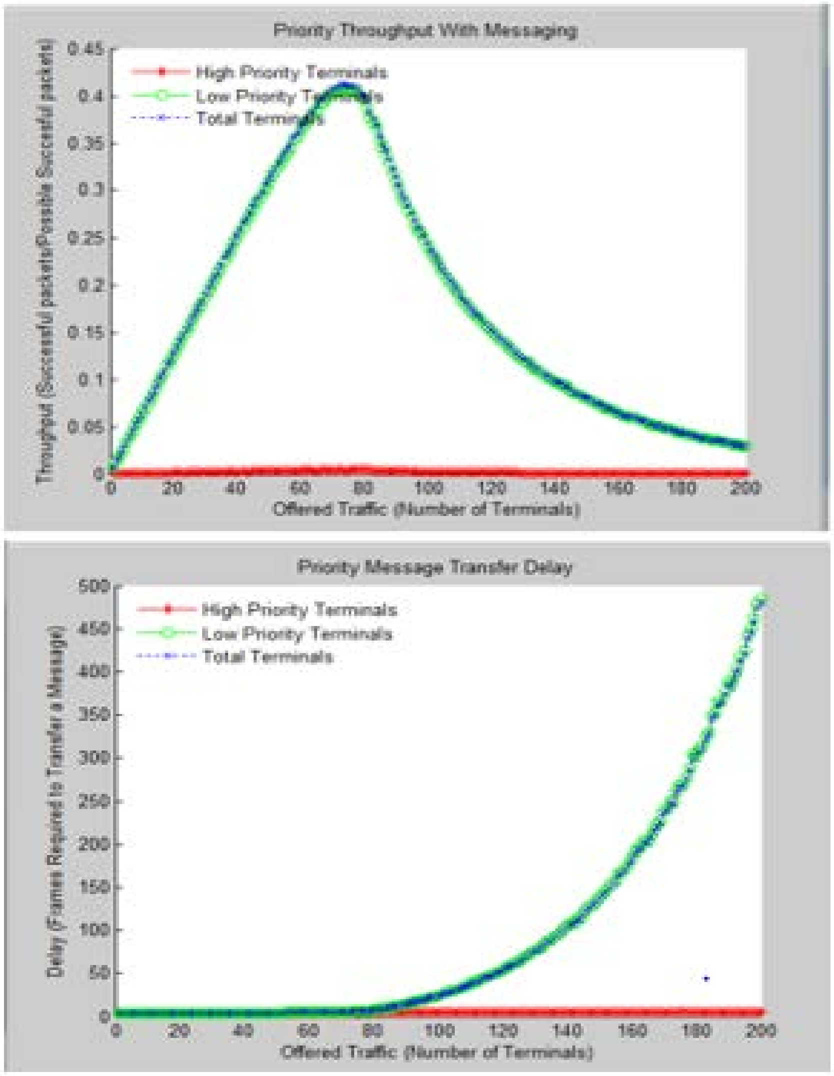

Figure 2: Throughput and Delay of the network for the simulated application using PR-ALOHA protocol.

Application

The application uses a heads up display that will display warnings on the windshield of the vehicle. The warning messages are generated based on the latitude, longitude, speed, and direction. The vehicle uses onboard Global Positioning System (GPS) to track the vehicle's position and speed. This information is then passed to the application where it is broadcast to other vehicles in the region. If two vehicles approach a certain distance from each other, a heads up display will tell the drivers of the danger present. Figure 3 shows the system in a safe status. Safe status means that there are no oncoming threats to the vehicle, so the driver may continue on his current path.

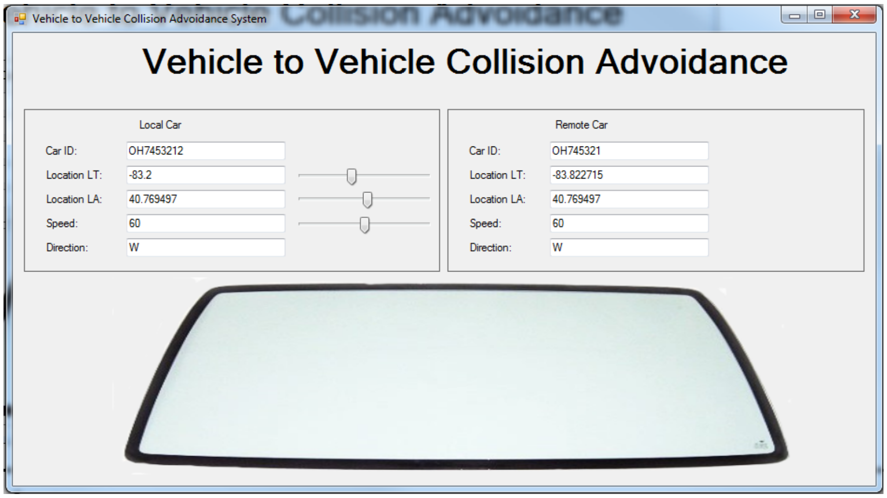

Figure 3: The user interface with no heads up display warnings.

Figure 4 shows the application notifying the driver of a collision ahead if action is not taken immediately, then an accident will occur. Figure 4 also shows that the collision will occur from the front of the vehicle. The heads up display will help to reduce the number of accidents that occur due to advanced warning.

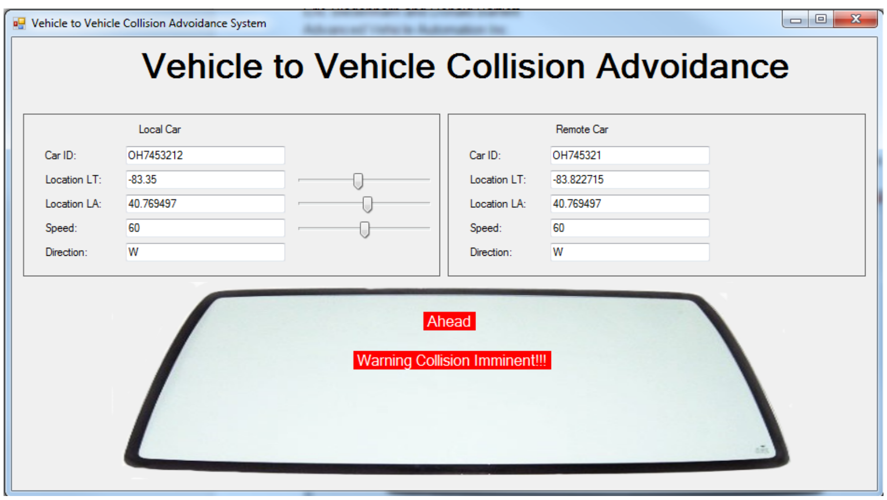

Figure 4: The user interface with heads up showing collision warning from ahead.

Figure 5 shows the application notifying the driver of a collision ahead if action is not taken immediately, then an accident will occur. Figure 5 also shows that the collision will occur from the rear of the vehicle. The heads up display will help to reduce the number of accidents that occur due to advanced warning.

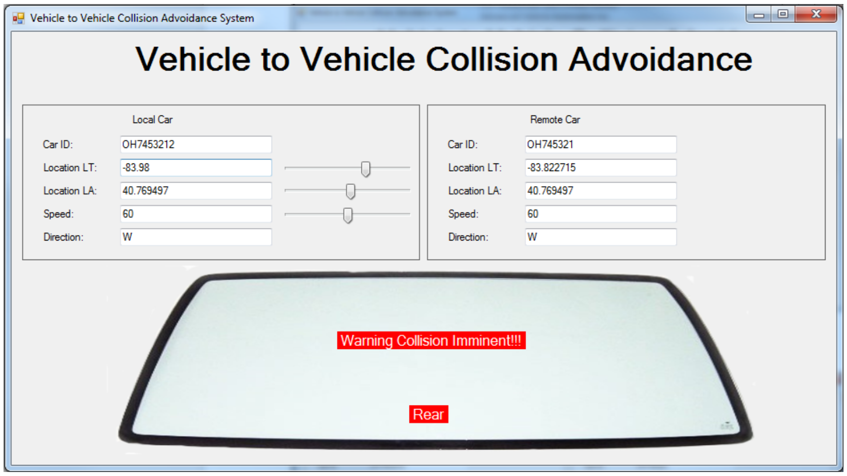

Figure 5: The user interface with heads up showing collision warning from the rear.

Figure 6 shows the heads up display indicating that the vehicle has collided with a vehicle ahead of it. The purpose of this heads up is to alert the driver that a collision has occurred and emergency personal have been contacted.

Figure 6: The user interface shows a heads up that a collision has occurred in the front of the vehicle.

Figure 7 shows the heads up display indicating that the vehicle has collided with a vehicle behind it. The purpose of this heads up is to alert the driver that a collision has occurred and emergency personal have been contacted.

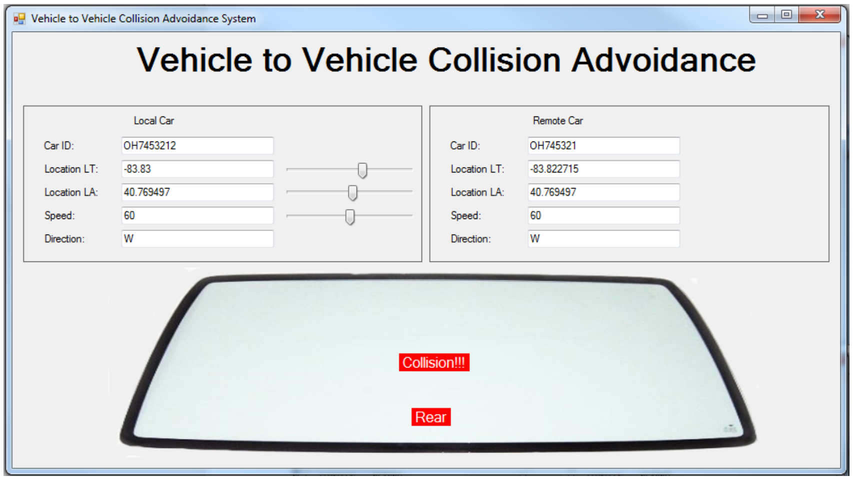

Figure 7: The user interface shows a heads up that a collision has occurred in the rear of the vehicle.

The program would run on a wireless based system using peer to peer communication. The ability to run thousands of vehicles on the network is a key problem to the implementation of the application. With the current technology, more routers must be implemented over small radii in order to decrease the number of vehicles on a router at a given time. The decrease in the radius of the router would require the use of more routers, which would increase the cost of implementing the application. The future will bring better technologies that will allow for the increase in capacity of traffic over a wireless network.

Market Outlook

The application being designed would be marketed to major car companies such as Ford, Honda, Toyota, GM, Chevy, Mitsubishi, Volkswagen, and many others. The application would be sold as software and an idea. Updates and new technological advances would also be sold to the different car companies. In order to implement this application, there would be about a thousand man hours involved to incorporate this into the application into the design of the cars. This time equates out to about six or seven months.

Suggestions for Improvement

This application could be improved if the routers used had a much larger range than what they have now as this would simplify the network. The application could also include stop sign and red light alerts. Eventually, the application could be brought to a level where it can tell you where other cars are located on the same road or even the application can be applied in a self-driving vehicle. A satellite communication could be used for the application. The system could be used as in OnStar or Garmin to provide early warning and detect accidents or problems in the roadway. The satellite system would be fairly easy to implement considering that the technology already exists and could be tapped into.

Conclusion

The application will help drivers avoid accidents by being more aware of their surroundings. This awareness comes from the decrease of distracted drivers due to the early warning system in the application. The application uses real time data from a network of cars that alerts drivers to upcoming dangerous situations. The main security issues are denial of services, masquerading, jamming, and forgery. These security problems can be solved by implementing hardware security and public private key encryption. The simulation shows that even with higher numbers of high priority data being transmitted, the network throughput and delay is acceptable. This application could be improved in the future with wider ranged equipment and could also alert the driver to other upcoming stops besides those of the vehicles around it.

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