IntelliCarTS: Intelligent Cars Transportation System

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***Abstract*— We propose IntelliCarTS (Intelligent Car Transport System), a Vehicle-to-Vehicle (V2V) anti-collision mechanism that determines, estimates and absolves collision courses between moving vehicles based on a correlative and cooperative wireless networking scheme. The problem of collision avoidance is abstracted to the generic problem of location awareness and subsequent periodic information exchange (between vehicles). To enable location awareness, the mechanism uses a Global Positioning System (GPS) receiver. Two nearby vehicles periodically exchange information about their own movement in terms of their respective position and local clock time. Using these inputs, vehicles determine whether or not they are on a collision course with each another. A *Communication Cluster* (based on the concept of mobile ad-hoc P2P networking) is formed, that facilitates the creation of a vehicular network characterized by self-organization, fault-tolerance, scalability, cooperation and cost efficiency. These characteristics enable avoidance of collision between vehicles in an adaptive and dynamic set up. The paper shows simulation results of the proposed IntelliCarTS concept by emulating the streets of Manhattan.**

***Index Terms*—Anti-collision, location awareness, periodic information exchange, communication cluster.**

1. INTRODUCTION

ROAD accidents account for a severe threat to human lives from both an injury as well as a financial perspective. Given that vehicles are designed to facilitate a smooth means of transportation, manufacturers have long been in the process of designing vehicles based on principles of reliability and safety. However, due to reasons such as human-error, circumstantial error and negligence, accidents occur. Today, special attention is focused on the technologies that can reduce traffic accidents. Services provided by the Intelligent Transportation System (ITS) include collision warning; collision avoidance; and automatic control are eventually expected to result in a reduction of critical traffic accidents [1]. What is desired is a simple in-service upgradeable method for avoiding collisions amongst moving vehicles. Vehicular communication (V2V) resulting from ad hoc and peer-to-peer networking has recently gathered significant attention [2], [3], [4] as a low-cost method for collision avoidance. V2V technologies are also expected to augment the ITS. V2V technologies are simple to implement primarily because of their reliance on wireless communication. A wireless location aware ad hoc network of mobile nodes (vehicles) facilitates a framework for collision avoidance. Creating a wireless ad hoc location aware communicating infrastructure however is a non-trivial task. Several components are involved – location awareness, real-time communication, mapping of mobile entities and taking appropriate action. IntelliCarTS is a solution developed that satisfies the aforementioned components leading to effective collision avoidance.

2. INTELLICARTS

The central idea of IntelliCarTS is to enable vehicles within each other's proximity to be aware of their own location and then estimate their position with respect to other vehicles. The location awareness problem constitutes of three sub-problems: determining the exact location using a GPS receiver (at discrete intervals), applying corrections to the measured location using continuous-time dead-reckoning sensors (e.g., accelerometer, odometer and rate gyroscope) and then sharing this information with other vehicles using Inter-Vehicle Communication (IVC). The IntelliCarTS system is shown in Fig. 1.

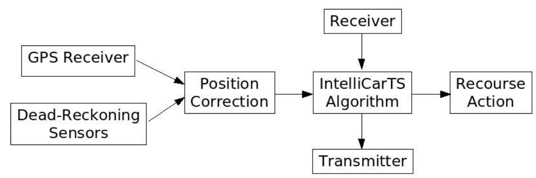

Fig. 1. IntelliCarTS System

The above mentioned aspects are used by the IntelliCarTS framework to enable a vehicle to estimate collision course with another vehicle. The estimation of collision course is done through a wireless network that enables periodic information exchange between vehicles (which also have computed their individual locations using GPS). The process of collision course detection involves several periodic iterations of information transfer.

2.1 Inter-Vehicle Communication (IVC)

Prediction of collision course between two vehicles occurs when they are in a power-limited wireless proximity to each other. A group of vehicles within each other's power limited range form a *communication cluster* [5]. A communication cluster is analogous to a single-hop ad hoc network. Two nodes, part of the communication cluster, are able to predict a collision course by exchanging relevant information periodically. Two aspects of information are exchanged: pertaining to a vehicle's own movement and pertaining to a vehicle's observation of another vehicle. Through a set of consecutive asynchronous information transfers, vehicles are able to compute the path being followed by other vehicles.

Let us assume that two moving vehicles are within a communication cluster (marked by a power-limited wireless zone) and hence they are able to directly communicate with one-another. This communication enables transmission and reception of *Information Packets*. These packets contain data pertaining to Geographic location of the vehicle, collision zone radius, velocity, displacement and direction.

2.2 Collision Detection

Consider two vehicles *A* and *B* as shown in Fig. 2. Vehicle *A* computes collision course with vehicle *B*, when its *collision zone* overlaps with that of vehicle *B*. To estimate if there is an impending collision, vehicle *A* records two consecutive instances of Information Packets received from vehicle *B*, say at times t_1 and t_2 such that $[t_1, t_2] = T$, the periodicity of information exchange between two peer mobile nodes. At these two instances, vehicle *A* also records its own position (through GPS) as well as the path traced between the two instances. Through the information carried within the two successive Information Packets received from vehicle *B*, vehicle *A* computes the course of vehicle *B* and then matches it with its own scheduled course (or one a straight line extended from its positions at times t_1 and t_2). Vehicle *A* now estimates if the two courses are collision centric. If vehicle *A* detects an impending collision then it communicates this information to vehicle *B* in its next Information Packet. This Information Packet also contains information pertaining to *A*'s estimates of distance to collision, time to collision and the *recourse action* that will be or is being taken to avoid this collision. The recourse actions might be a combination of lane change, acceleration or deceleration.

Fig. 2 illustrates how two vehicles *A* and *B* deploy the protocol of periodic information exchange to avoid collision. The two inner circles are collision zones of vehicles *A* and *B* and the outer circle is communication cluster of *A*.

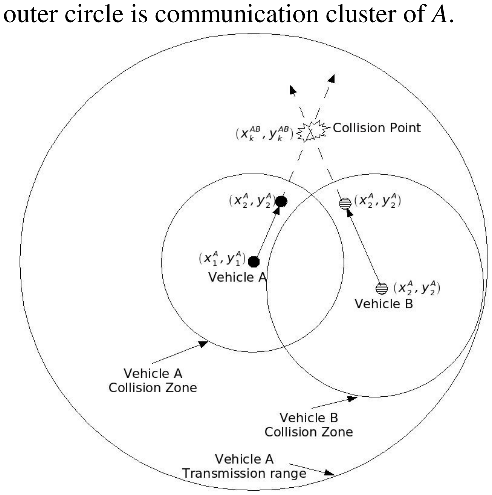

Fig. 2. Graphical illustration of two vehicles A and B and their collision path

3. SIMULATIONS

The simulation model consists of 8x8 streets network in 5x5 km area. Every road contains 8 lanes, 4 in each direction. Vehicle arrival is Poisson distributed with an initial arrival rate of 10 vehicles per second. The simulator calculates the source and destination for every vehicle and computes the *Vehicle-Path Matrix*. The roads and intersections (destinations) that the vehicle follows to reach the destination are computed randomly among all the possible shortest paths between source and destination. Collision zone radius of vehicle is assumed at 50 meters. Vehicle's velocity varies from 0 km/h to 60 km/h. Vehicle begins recourse action once it detects an impending collision. Detection of impending collision usually takes duration of *5T*, where *T* is the time-cycle duration. A good choice of *T* hence is critical for success of our scheme. We assumed *T* to be 1 second, but this could be lowered for more traffic and faster vehicles. The simulation was performed for 100 seconds resulting in a confidence interval 90 %.

Fig. 3 shows the variation of blocking probability for four different road configurations (different number of lanes in a road). Blocking probability is defined as the ratio of number of collisions that happened to the number of collisions detected. It can be seen that IntelliCarTS scheme offer excellent collision avoidance due to the very low value of blocking probability (around 0.1 for an 8 lane system). Note that, the blocking probability decreases as the number of lanes increases. This is because with more lanes a car has more options to avoid collision.

Fig. 4 shows the comparision of number of collisions detected to the number of collisions avoided. It can be seen that a major number of collisions detected are avoided using the IntellCarTS protocol.

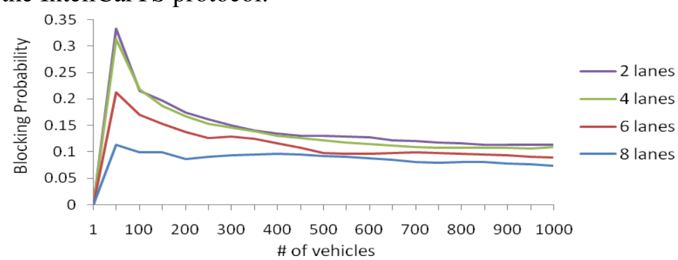

Fig. 3. Comparison of blocking probability across different lane sizes

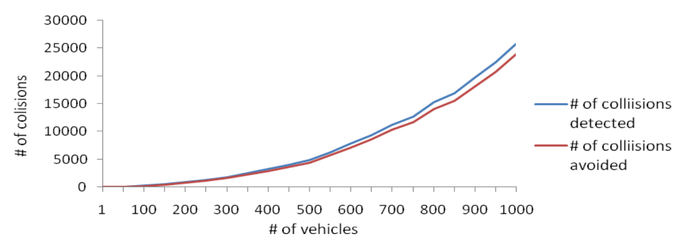

Fig. 4. Comparison of number of collisions detected and number of collisions avoided in an 8 lane system

4. CONCLUSION

We have studied and proposed the IntelliCarTS scheme for collision avoidance using ad hoc wireless concepts. The proposed scheme is efficient and can reduce drastically the probability of collision. The scheme has been evaluated by the simulations model and preliminary results presented.

5. REFERENCES

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