V2P Communications for Safety

오돈고스티븐요부, 주지훈, 한동석
경북대학교
odongoste@gmail.com, jhihoon@gmail.com, dshan@knu.ac.kr

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Odongo Steven Eyobu Jhihoon Joo Dong Seog Han
Kyungpook National University

Abstract

In any mobile ad hoc environment, collision amongst mobile objects is always likely to occur unless there is a certain level of intelligence to detect and avoid the collision. This phenomenon of detection and avoidance is the key attribute for safety applications in vehicle to pedestrian (V2P) communications systems. In this paper, we propose a V2P communications concept for collision detection and avoidance.

1. Introduction

The number of road accidents in the world today attests that the conventional vehicle-to-pedestrian (V2P) accident detection and avoidance communication systems are naturally limited. The reasons are diverse. Some are but not limited to: - poor driving, poor road infrastructure, inability by some pedestrians to read or interpret road signs, driving vehicles which are in a poor mechanical condition, etc. This is currently leading to an evolution of technology assisted V2P communications studies and research. Computer Vision approaches for vehicle detection by pedestrians' mobile devices emerged first [1]-[3] but these applications are limited by poor visibility conditions.

Radio communication is the major workbench candidate for technology assisted V2P communication. Anaya et al., mentions a few of wireless oriented V2P safety projects including Ko-TAG, WATCH-OVER in [4, 5]. Anaya et al., also developed V2PRoVU which determines collision points using the geographical destination area (GDA) algorithm [5]. Technology assisted V2P safety applications requires that once collision points are known, the pedestrian and the motorists must be alerted and given some time to respond in order to avoid the collision. This is mainly because of the delays caused dynamicity of the wireless channel characteristics and also the time for human perception. In this paper, we propose a collision detection and avoidance concept based on direction of motion, position, velocity, and time stamp. First, we present the concept using a scenario view point, visualize it by performing a dry run, construct the state diagram, and provide the experimentation plan and then finally the evaluation plan.

The wireless access in vehicular environments (WAVE) standard has come out to provide a framework for vehicular communications on wireless domain. We propose to adopt and configure WAVE interfaces in our communication devices (both the vehicle and the pedestrian). Due to the limited energy retention capacity of the pedestrian mobile devices, we propose and plan to have collision detection processing at the vehicle end and the mobile device to simply send its location information including time, direction of motion and speed to the vehicle through cooperative awareness messages (CAMs).

2. V2P Communications Scenario Viewpoint

Consider a car moving in a given direction defining its trajectory and has a WAVE interface with a defined coverage area and there exists a number of pedestrians in the vehicles wireless domain each of them with a mobile device with a WAVE interface. The pedestrian devices each send CAMs to the vehicle advertising their presence in the vehicles domain after every one second. The information sent to the vehicle includes the position, speed, timestamp and direction of motion. The information at this level exists in the receiving buffer of the Vehicular system.

From the received information, the vehicular end system then eliminates pedestrians whose motion isn't towards the vehicle trajectory from the receiving buffer of the vehicle system.

For all the nodes whose direction of motion is towards the vehicle trajectory, collision point detection is done. At this point the pedestrian trajectory is predicted and the

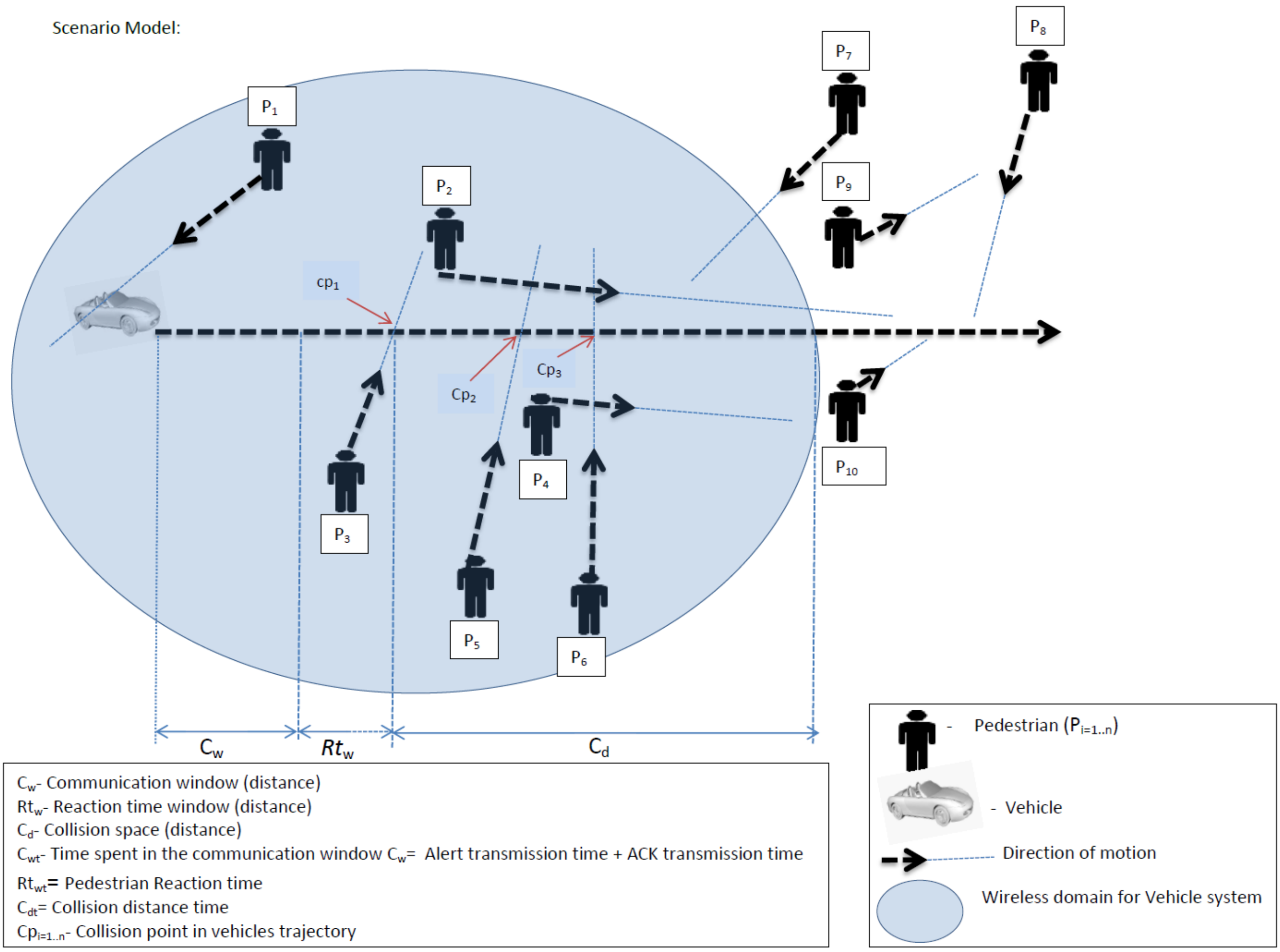

Fig. 1. Scenario model

time to reach a point in the vehicles trajectory is found. If the time to reach the point is the same, for both the vehicle and the pedestrian in their trajectories, then there exists a collision point. Otherwise the pedestrian node is also eliminated from the receiving buffer of the vehicular system. Pedestrians with a collision point are sent to the alert buffer implying that an alert message should be sent to the pedestrian.

Again, if at this same level, the collision point exists but is outside the wireless domain of the vehicle, such a pedestrian is eliminated from the receiving buffer. Only nodes with collision points in the wireless domain of the vehicle are candidates for message alert dissemination.

The alert beacon sending buffer is then organized in a FIFO manner based on the nearest collision point in the vehicles trajectory. That is; the pedestrian whose collision point is the first to be reached by the vehicle is the first one in the alert beacon transmission queue hence will receive the alert beacon first.

This communication process is cyclic implying that there will exist state changes in the system so long as there is a change in any of the parameters communicated to the vehicular system. These state change behaviors are presented in section 4 of this paper.

3. Dry Run of the Scenario Model

Consider Fig. 1. A dry run of the above scenario model is expected as follows:-

The vehicle will receive beacons from pedestrians (p1, p2, p3, p4, p5, p6), respectively.

Pedestrians (p1, p2, and p4) will be eliminated from the receiving queue since their motion is not towards the vehicle trajectory or reach the trajectory outside the wireless domain.

If we assume that only p3 reaches the collision point in the vehicle trajectory at the same time as the vehicle. Then, P5 and P6 will be eliminated from the receiving queue.

If we had more than one pedestrian in the receiving queue, the scheduling for sending the alert messages would be based on which pedestrian has a collision point nearest to the vehicle. Hence creating a First In First out structure

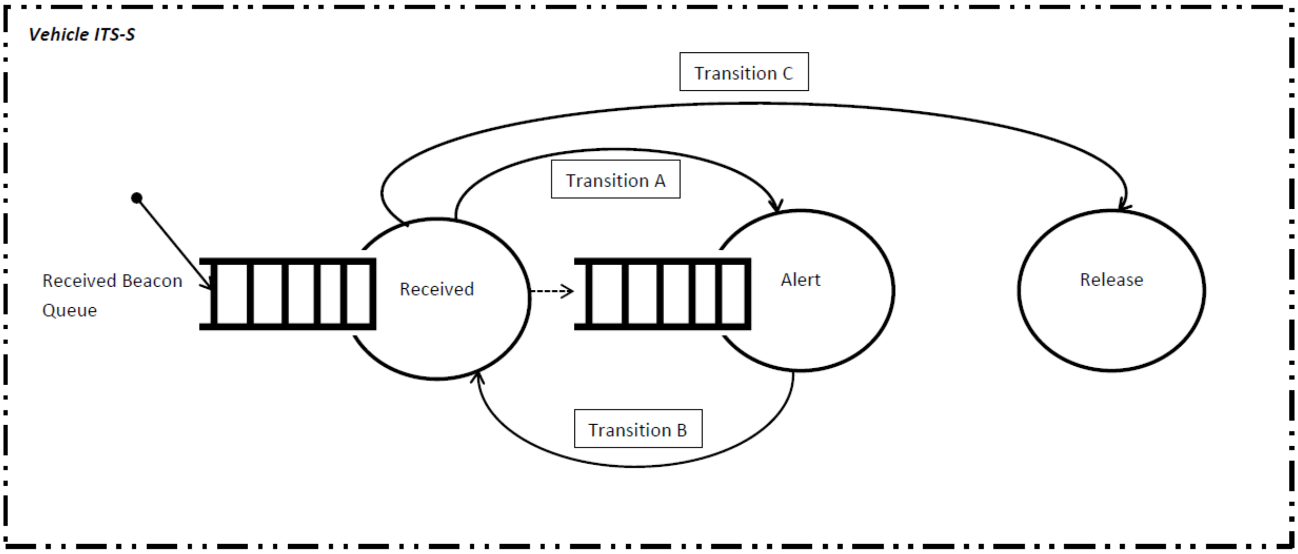

Fig. 2. State transition diagram

based on closeness. The whole process above is repeated every time a CAM is received from a pedestrian device.

4. State Diagram

Consider Fig. 2. Transition A: If a received beacon from a pedestrian has information which satisfies 1) the pedestrians trajectory is towards the vehicles trajectory, 2) there exists a collision point for both trajectories after a time (t) shared by the vehicle and the pedestrian with in the wireless domain of vehicle.

Transition B: If beacon is in Alert queue waiting and an update from the pedestrian has been received by the vehicle.

Transition C: If 1) beacon information does not give trajectory predictions towards the vehicle trajectory, 2) there exists no collision point for both trajectories in the wireless domain of vehicle at any shared time (t) 3) pedestrian is no longer in the wireless domain of vehicle.

5. Conclusion

For the experimentation plan, we shall conduct simulations for the scenario. The major setups for our simulation experiments shall be on mobility, setting up WAVE interfaces, building vehicular receiver and alert message transmission buffers plus predicting the pedestrian trajectories. We intend to use the Kalman Filter for our trajectory predictions.

For the performance evaluation plan, we shall be interested in finding the Vehicle system Utilization factor, service rates at the alert buffer; mean time which pedestrian information set spends in the vehicle system, mean time spent at any of the waiting queues, and also the mean number at the waiting queue. We expect to vary the speed of the vehicle to test systems performance based on the above parameters.

For the evolution plan, we intend to acquire and set up WAVE interfaces on user mobile devices and cars. Then develop an intelligent application whose design shall be based on the V2P communication process proposed in this paper. We shall then expect to conduct a measurement based study of our communication system.

We believe that once our system produces acceptable results, it shall be a good shot to the V2P communications research and applications.

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