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Vehicular Localization Using Time of Arrival via Dedicated Short Range Communication

Byungjin Ko Sang H. Son

Department of Information and Communication Engineering
DGIST, Republic of Korea
E-mail: {byungjin.ko, son}@dgist.ac.kr

Abstract

In this paper, we survey the global positioning system (GPS)-less vehicular localization methods using dedicated short range communication (DSRC). Time of arrival (TOA), which is one of the radio-based ranging techniques, is used in the methods to localize a vehicle. Through the localization methods using DSRC, vehicles can handle GPS error or the situations of no GPS location data when they are in the downtown or tunnel.

Keywords: vehicular localization, time of arrival (TOA), dedicated short range communication (DSRC)

1. Introduction

With the recent advances in wireless communication technologies in vehicular networks, vehicular localization plays an important role to enable a variety of emerging applications such as the collision avoidance system, the collision warning system, the intelligent traffic flow control, etc. [1]. Global positioning system (GPS) is widely used to localize a vehicle, but it is difficult to localize the vehicle within a few meters due to GPS error. Moreover, GPS may incur a huge error near high-rise buildings, and it is useless in a tunnel or underground. In order to mitigate those problems, vehicular localization methods using time of arrival (TOA) have been researched. Time of arrival (TOA) is based on radio-frequency ranging techniques. In this paper, we survey the GPS-free vehicle localization through wireless communication.

2. Vehicular localization methods

TOA is the time that the radio signal spends from a transmitter to a receiver, and the distance between the transmitter and the receiver is calculated based on the speed of the radio signal [2]. A. A. Wahab et al. [3] proposed a GPS-free framework that uses two-way TOA to locate the vehicles based on communication with a single roadside unit (RSU). In order to localize the vehicle's location, the RSU and the vehicle follow the time line shown in Figure 1. The RSU transmits beacon message including the RSU's ID and location at time t. If the vehicle receives the beacon message, it transmits a ready to send for two-way TOA (RTS-T) packet including the vehicle's ID at time t_1. As the reply, the RSU transmits a clear to send two-way TOA (CTS-T) packet to the vehicle after the delay caused by a packet collision and the processing time in the RSU. The vehicle receives the packet at time t_2. As a result, the vehicle can localize

its current location by calculating the moving distance from t_1 and t_2 (i.e., the distance is calculated based on the propagation time of RTS-T and CTS-T and the delay).

C. Ou [4] proposed a localization scheme in which each vehicle estimates its location on the basis of beacon messages, which are containing the RSU identification, the RSU coordinates, the road direction, and the timestamp, broadcast periodically by pairs of RSUs deployed on either side of the road. In other words, the vehicle measures the distance from the RSUs through the TOA and the vehicle can estimate its current location by applying the concept of two intersecting circles to compute the vehicle's two possible positions as shown in Figure 2. Each radius is the measured distance through the TOA and the intersecting points are the estimated location. For the accurate location, the vehicle needs to wait until it receives the next beacon messages from the RSUs, and it can recognize the correct location through the variation of distance from the RSUs.

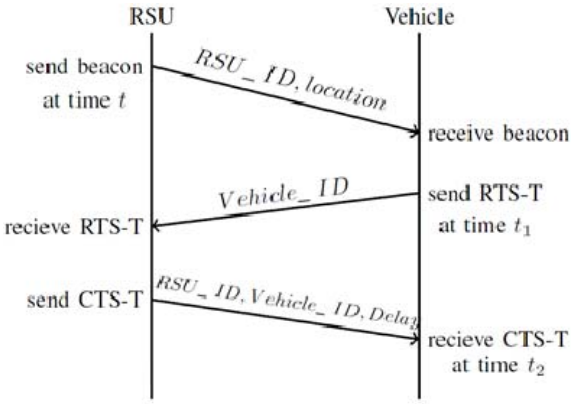

Figure 1. Time line of the two-way TOA packet handshake [3]

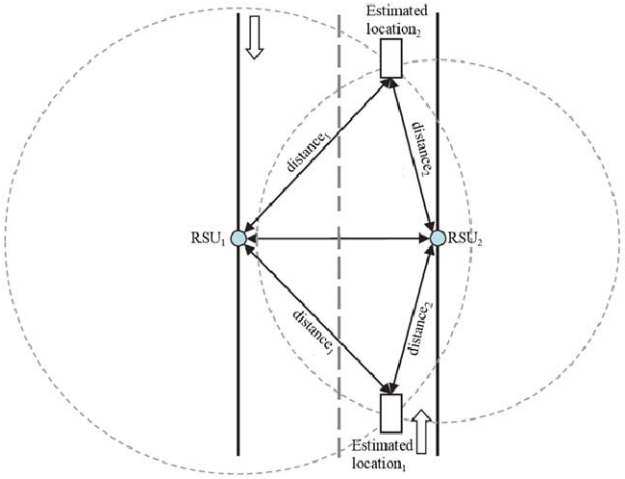

Figure 2. Position estimation in [4]

3. Conclusions

We introduce two methods to localize a vehicle through DSRC. To be specific, they applied the TOA technique, which is widely exploited in wireless sensor networks, to measure the distance between the vehicle and the RSU. Based on the above methods, we plan to work on developing methods to localize a vehicle at certain locations where GPS signal cannot reach.

References

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