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A survey on the usage of DSRC and VLC in communication-based vehicle safety applications

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Abstract

This paper addresses the issues related with the employment of wireless communication in vehicle safety applications. It focuses on the usage of the 5.9 GHz dedicated short range communications (DSRC) under the 802.11p standard and highlights the vulnerabilities associated with the DSRC usage. The usage of visible light communication (VLC) is discussed as well. It was found out that the two are complementary technologies, each of them being suitable in the scenario in which the other one is vulnerable.

Introduction

- **Traffic accidents** (yearly**)**:
  - *1.3 million deaths;*
  - *20 – 50 million injured people;*
  - *9th cause of death;*
  - *1st case of death for people aged between 15 and 29;*

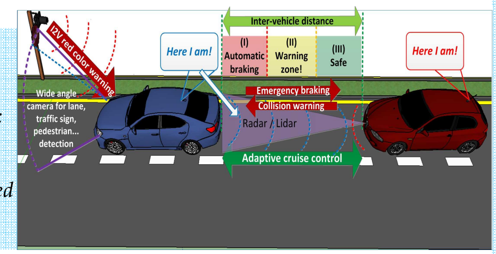

Fig. 1: Sensors and wireless communication fusion for traffic safety applications.

- *Help people survive accidents?* ⇨ Passive safety systems;

or

- *Help people avoid accidents?* ⇨ Active safety systems (ABS, ESP, etc);
- Communications can further enhance the active safety systems;
- Vehicle to Vehicle (V2V) and Infrastructure to Vehicle (I2V) communications address up 81% of the traffic accidents.

Requirements in communication-based vehicle safety applications

- ***Requirements***:
  - high packet delivery ratio;
  - reduced latencies: below 100 ms or even 20 ms;
  - medium communication ranges: up to 300 m.

Table. 1: High priority communication-based safety applications and their requirements.

Application	Max. Range [m]	Rate [messages/s]	Max. Latency [ms]	Message Length [bits]	Type
Traffic Signal Violation Warning	250	10	100	528	I2V
Curve Speed Warning	200	1	1000	235	I2V
Emergency Electronic Brake Light	300	10	100	288	V2V
Pre-Crash Sensing for Cooperative Collision Mitigation	50	-	20	435	V2V
Cooperative Forward Collision Warning	150	10	100	419	V2V
Left Turn Assistant	300	10	100	904 208	I2V and V2I
Lane Change Warning	150	10	100	288	V2V
Stop Sign Movement Assistant	300	10	100	208 416	V2V and I2V

5.9 GHz DSRC

Numerous well-known advantages:
- Long communication range - up to 1000 m;
- Omni-directional communication – increased mobility;

Major issues affecting DSRC performances:
- ***Channel congestion*** – the major impediment for a reliable communication;
- Each vehicle (node) creates **interferences** on an area wider than the communication range;
- Vulnerability of CSMA/CA;
- The ***hidden node*** problem – affects the reliability;
- The ***Doppler spread -*** caused by range and velocity;
- ***Multipath –*** favored by the dynamic nature of VANETs;
- The ***line of sight (LoS)*** obstruction (LoS obstructed by buildings, vegetation, vehicles, etc) causes communication breakdown;
- Expensive deployment;

*Conclusion: 5.9 GHz DSRC cannot ensure time critical message distribution and has reliability problems, **especially in high-traffic**.*

Visible light communications

Major limitations:
- Reduced communication range (currently up to 80 – 100 m) ;
- Stringent LoS communication affecting the mobility;

Advantages:
- ***Huge bandwidth available free of charge***;
- Relatively ***free from mutual interferences*** due to the stringent LoS;
- Relatively ***free from multipath***;
- Ubiquitous technology, already half-integrated in transportation;

*Conclusion: due to the limited communication range VLC is **suitable mostly in high-traffic densities**.*

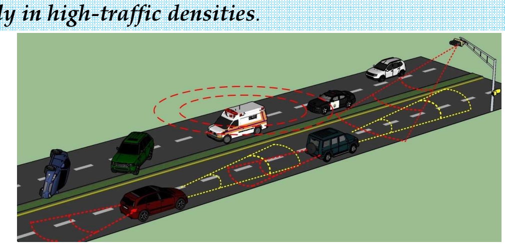

Fig. 2: Visible light communication usage in a highway scenario.

Conclusions

- The reliability of 5.9 GHz DSRC under the IEEE 802.11p is rather questionable;
- DSRC is suitable mostly in low traffic densities for long range communication;
- VLC offers lower latencies and higher reliability but its communication range is limited;
- DSRC and VLC are complementary technologies;
- The integration of the two (as in ISO 26262) can increase the overall reliability.

Acknowledgments

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