PERFORMANCE ANALYSIS AND IMPROVEMENT ON DSRC APPLICATION FOR V2V COMMUNICATION

01

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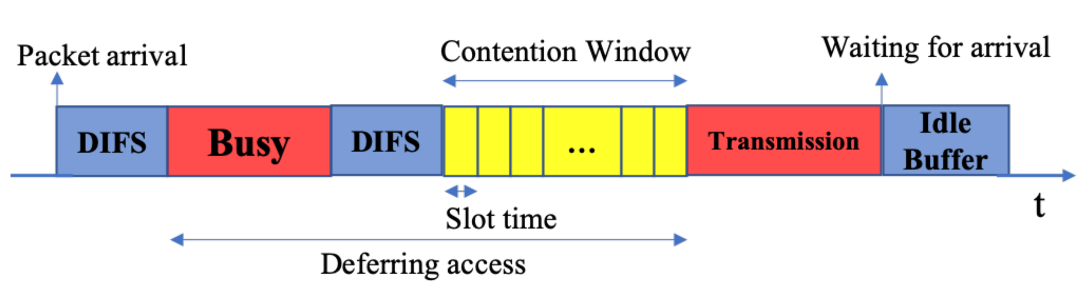
Abstract

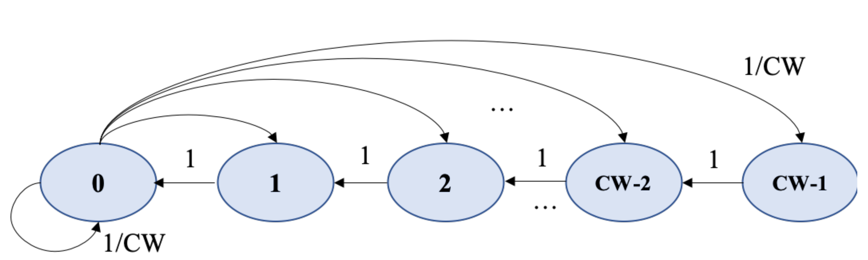
We study the vehicle-to-vehicle (V2V) communication based on the Dedicated Short-Range Communication (DSRC) application. We firstly propose a model to analyze the packet delivery ratio (PDR) and delay based on the IEEE 802.11p standard. With the characteristics of V2V communication, we then introduce the Semi-persistent Contention Intensity Control (SpCIC) scheme to improve the DSRC performance. Monte Carlo simulations are adapted to verify the results obtained by the analytical model. The simulations attest that the packet delivery ratio under the SpCIC scheme increases more than 10\% compared with 802.11p, especially in heavy vehicle load scenarios. Finally, we present the mean reception delay as another metric to verify that the SpCIC scheme improves DSRC performance.

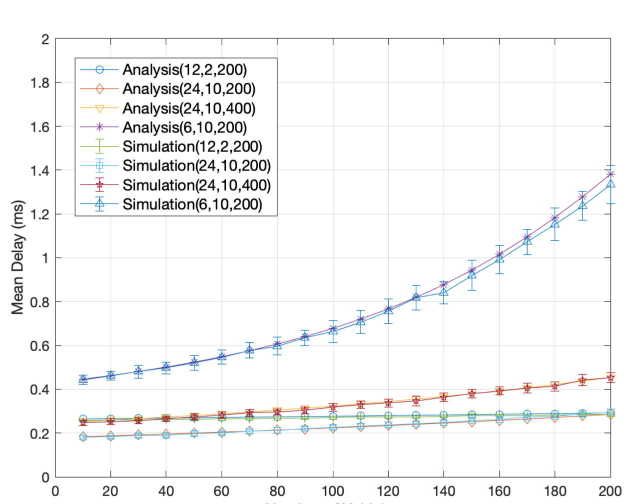
Abstract

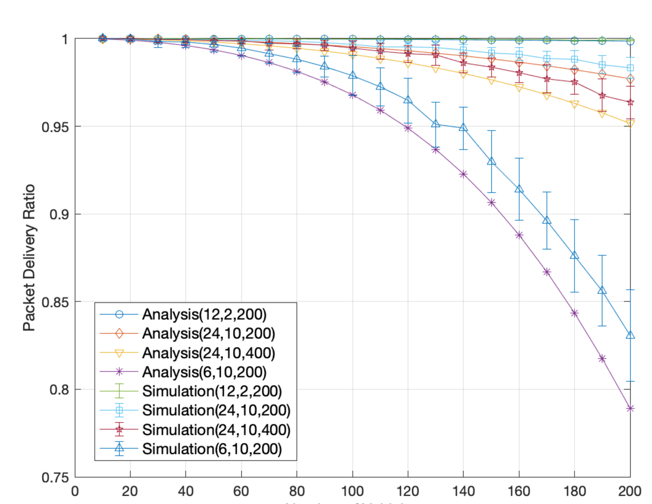
- Packet delivery ratio (PDR) : The probability that a BSM from the tagged vehicle is successfully broadcasted to all other vehicles in its range.
- Mean delay: The interval between the time when a packet is generated to the time when the packet is successfully delivered.
- Reception delay: How long other vehicles can receive from the tagged vehicle, which is caused by the service time and the collision delay.

Performance analysis for IEEE 802.11 p



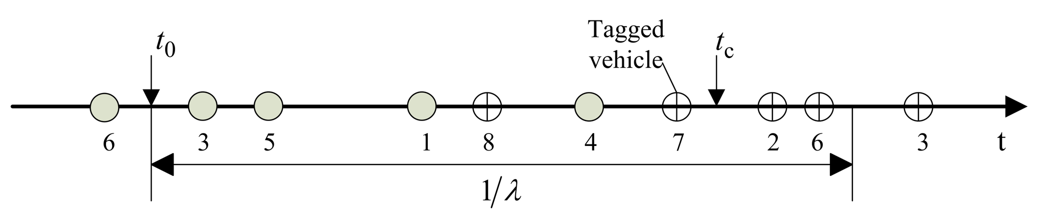


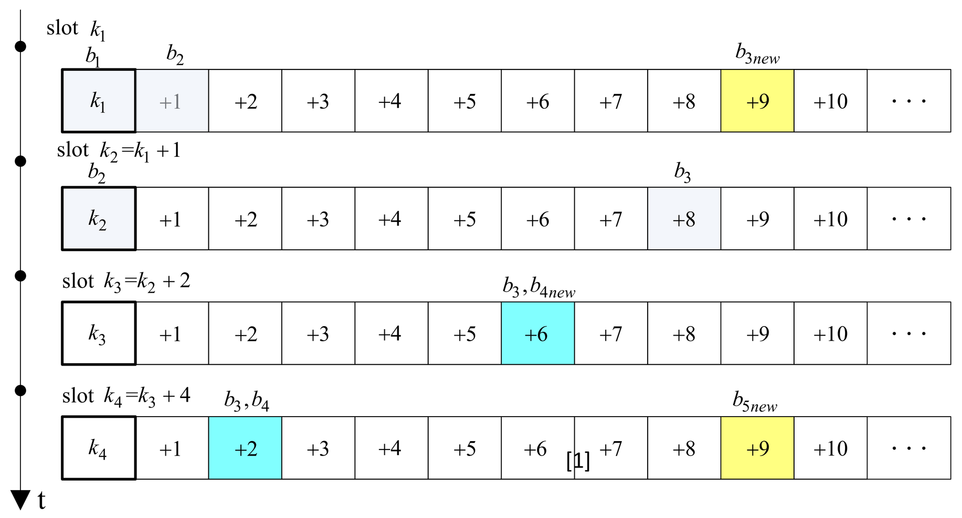




Improvement on DSRC performance

Contention Intensity Estimation: The term contention intensity refers to the number of BSMs that are either waiting for channel access or currently transmitting at a given slot. Each vehicle maintains a timeline and marks the slots at which each vehicle generates a BSM based on the BSMs received in the last period. In the transmission cycle of a vehicle, when a new BSM is received from a neighbor vehicle, the corresponding state of that vehicle is changed to indicate that the message is no longer contending for channel access. Then, the BSMs that have been generated by neighbors and not yet received from the beginning of the current cycle to the slot that the tagged vehicle generates the packet are contending for channel access. Counting the number of such BSMs gives the instantaneous contention intensity.



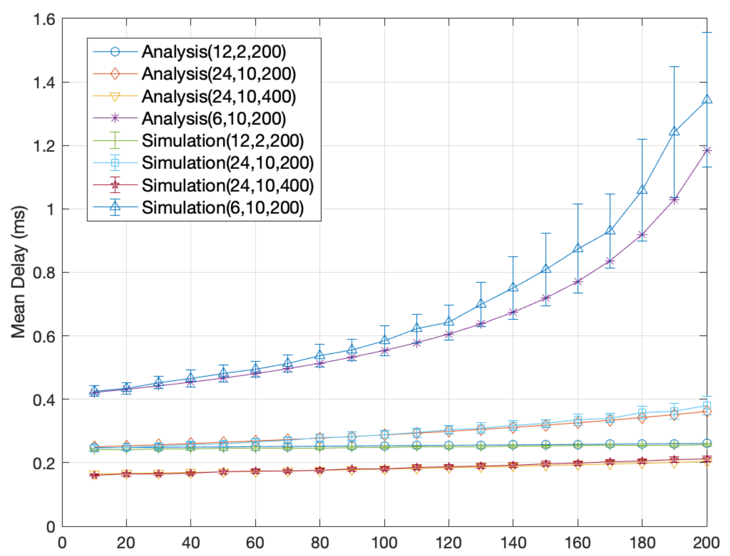


Algorithm 1 Framework of Semi-persistent Contention Intensity Control

Require: Maintaining a list of timeline of packets each vehicle generate based on the last period of $1/\lambda$.

Ensure: A packet of tagged vehicle is generated and just arrives at the buffer, waiting to be sent.

```
if S(k) = 1 then
    b(k[m]) = C · (c(k) + Σ_{s=1}^{m} n_a(k[s])), m ∈ V
    if ℝ = 1 then
        b(k[m]) = b(k[m]) + ω, ω ∈ {−1, 0, 1}
    else
        b(k[m]) = b(k[m])
    end if
    S(k + b(k[m])) = 1
    c(k+1) = c(k) + Σ_{s:s∈V} n_a(k[s]) − n_t(k)
else
    b(k[1]) = C · (c(k) + n_a(k[1]))
    if ℝ = 1 then
        b(k[1]) = b(k[1]) + ω, ω ∈ {−1, 0, 1}
    else
        b(k[1]) = b(k[1])
    end if
    S(k + b(k[1])) = 1
    c(k+1) = c(k) + n_a(k[1])
end if
```

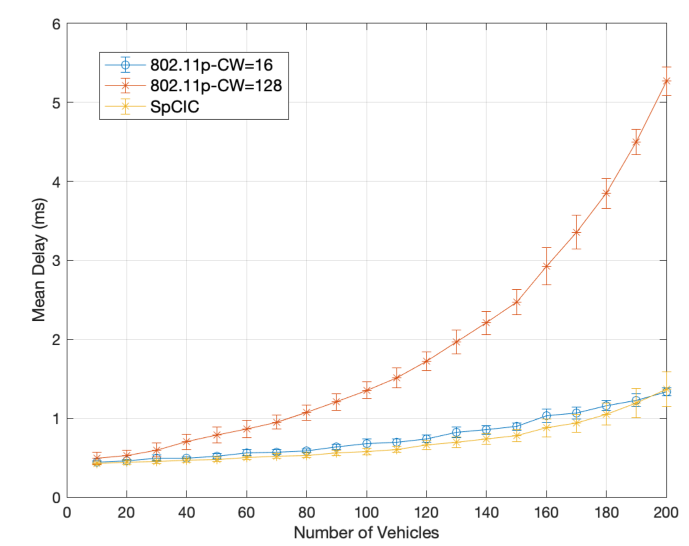


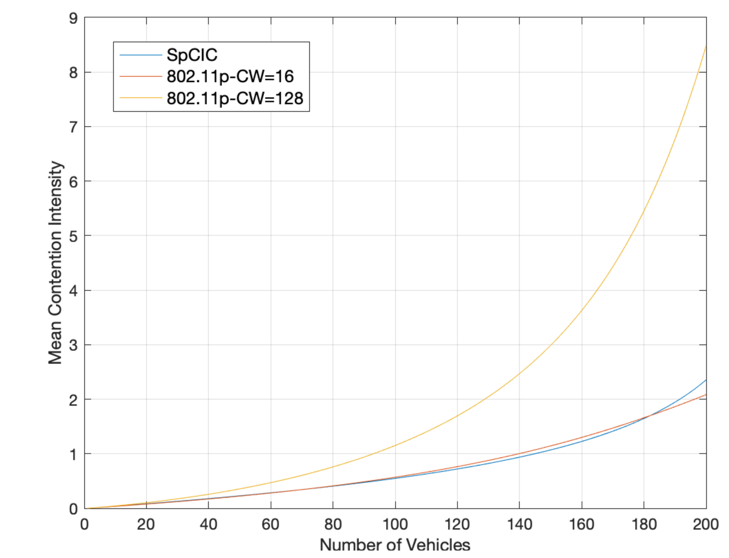
The objective of this section is to develop a distributed scheme - Semi-persistent Contention Intensity Control (SpCIC) for safety message broadcast that improves the performance substantially compared to 802.11p in the fully connected vehicle network.

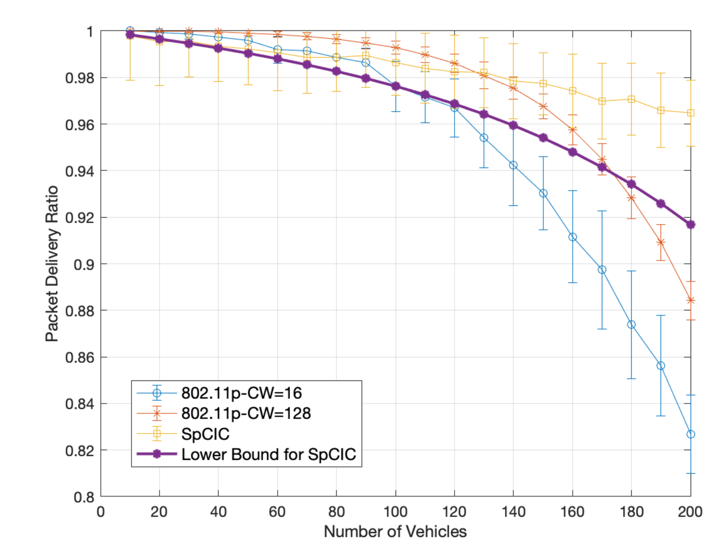
Comparison between SpCIC scheme and IEEE 802.11p

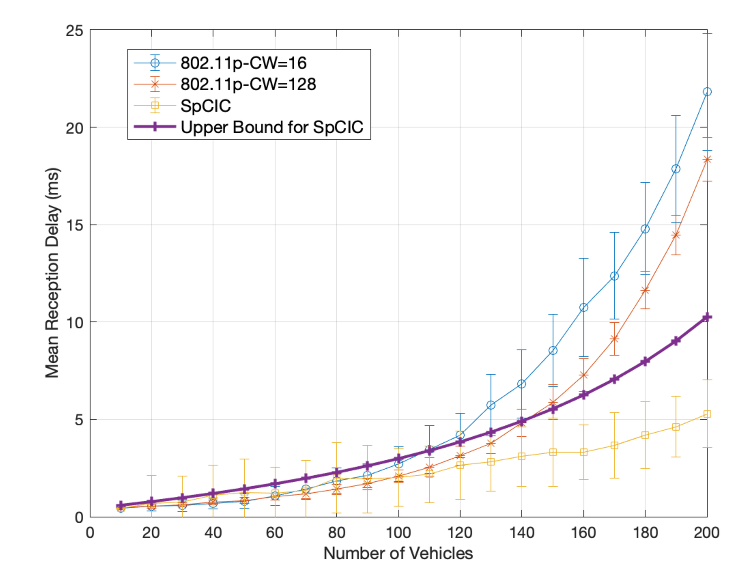
We present the simulation setup used to validate our analytical model and give validation results. The computation for analytic models and corresponding simulations are conducted in Matlab. All assumptions are the same in the simulation and analytic models. Each vehicle on the lanes is equipped with DSRC wireless capability. The control of DSRC is exclusively used for safety-related broadcast communication.

Parameters	Values
Transmission/Sensing range, R	0.5 km
Packet length (payload), $E[P]$	200, 400 bytes
PHY preamble	28 us
MAC header	50 bytes
Message rate, λ	2, 10 packets/sec
Slot time, σ	16 us
Propagation delay, δ	0 us
PLCP header	4 us
Contention window, CW	16
Number of vehicles	10, 20, ..., 200
DIFS	64 us
Data rate, R_d	6, 12, 24 Mbps









References and Acknowledgments

[1] Md. Imrul Hassan, Hai L and Taka Sakurai. Performance Analysis of the IEEE802.11 MAC Protocol for DSRC Safety Applications. IEEE Transactions on Vehicular Technology, 60(8): 3882-3896, 2011.

[2] J. Gao, M. Li, L. Zhao. Contention Intensity Based Distributed Coordination for V2V Safety Message Broadcast. IEEE Transactions on Vehicular Technology, 67(12): 12288-12301, 2018.

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