Why VANET Beaconing is More than Simple Broadcast

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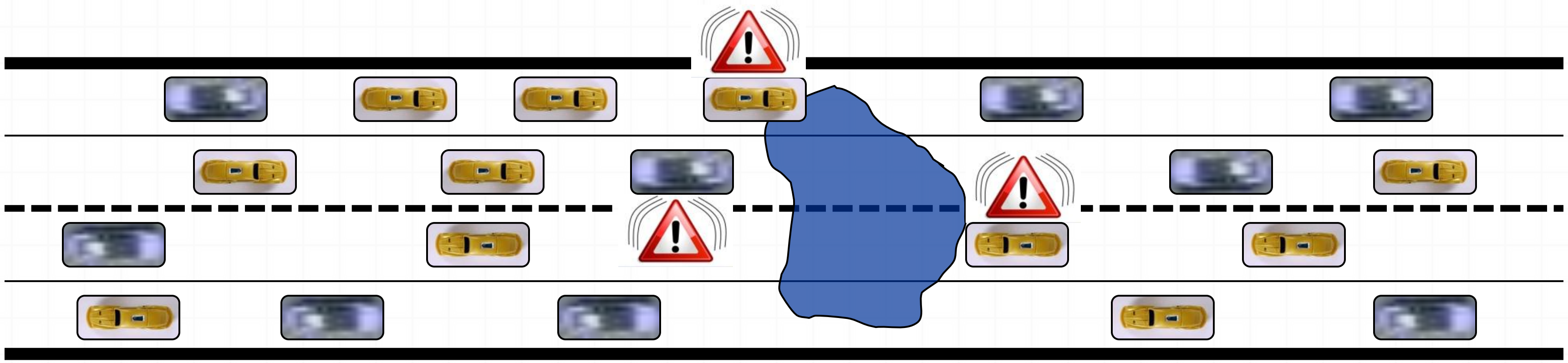
- Safety Communication in Vehicular Networks
- Particularities of the VANET Control Channel
- Analytical Model for Safety Beaconing
- Application Example: Study of the Minimum Contention Window

VANET objective: Building an accurate image of the exterior world



- ❑ Cooperative Awareness Message (CAM)
- ❑ Decentralised Environmental Notification (DEN)

USA Spectrum Allocation

CH172	CH174	CH176	CH178	CH180	CH182	CH184
5.860	5.870	5.880	5.890	5.900	5.910	5.920
G5SC4	G5SC3	G5SC1	G5SC2	G5CC		

Europe Spectrum Allocation

- ❑ **Service channels (SCH) – non-safety (usually IP-based) applications**
- ❑ **Control channel (CCH) – safety applications**

IEEE 802.11p on the CCH

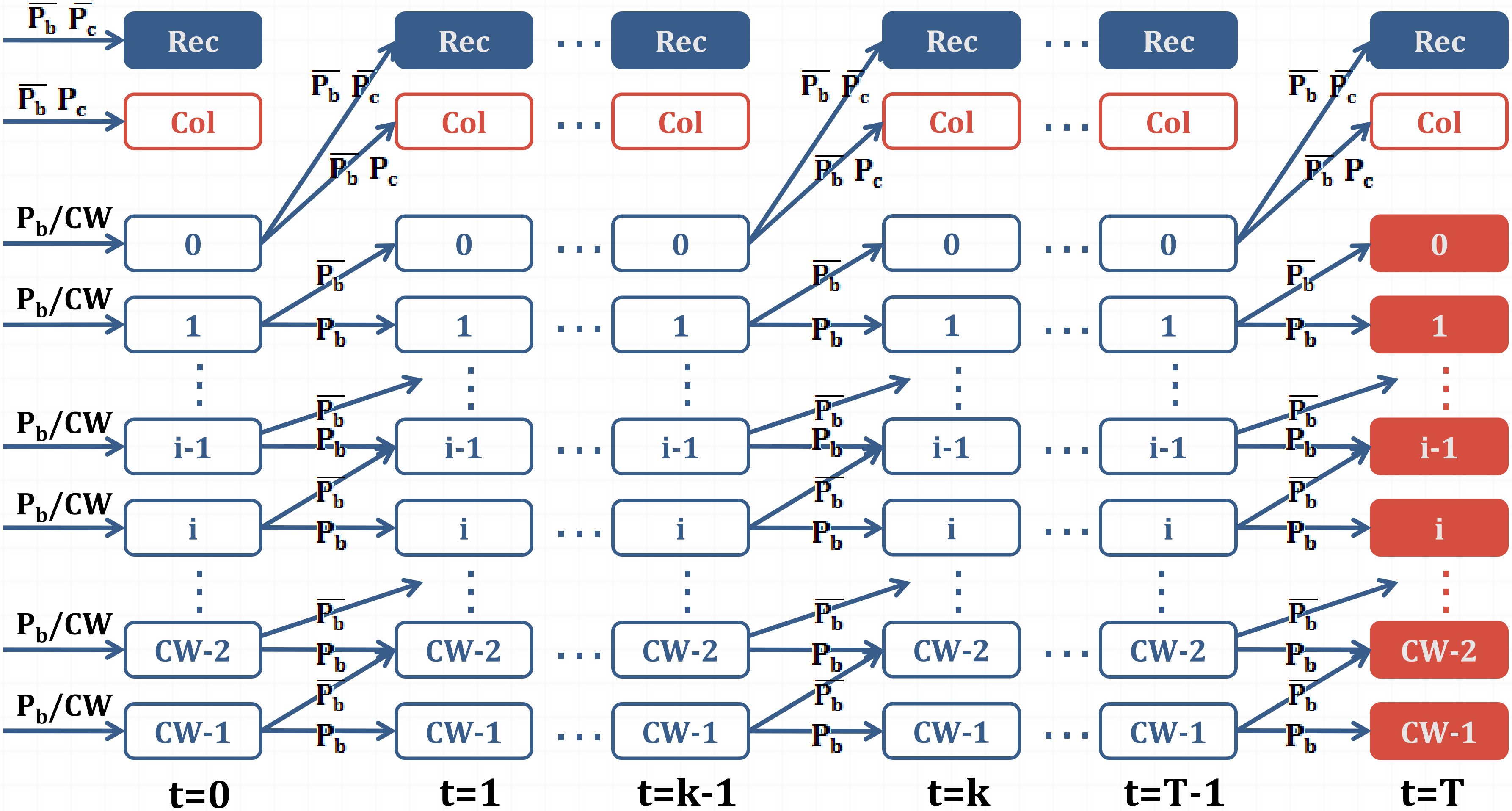
- 100% broadcast communication
- No RTS/CTS handshake
- No ACK message
- Collisions can not be detected
- BEB mechanism deactivated
- Always use the minimum value for CW

Safety beaconing

- A beacon expires if the next CAM is produced
- Expiration – another source of losses
- Practically no internal contention on the CCH
- MAC delay automatically considered in the expiration probability
- Metric of interest: reception probability

Existing work

- ❑ A series of models using unicast communication
- ❑ Ma et al. (2007), Vinel et al. (2008)
- ❑ Extended (in fact simplified) Markov chain Bianchi model for broadcast communication
- ❑ Expiration probability is not taken into account


Rec
Col
0
1
i-1
i
CW-2
CW-1
$\overline{P_b}\,\overline{P_c}$
$\overline{P_b}\,P_c$
P_b/CW
$\overline{P_b}$
P_b
t=0
t=1
t=k-1
t=k
t=T-1
t=T

Our approach (details in the paper)

- Use mean values over one beaconing period ($P_b = N_b/N_T$)
- A non-linear system with P_b, P_{exp} and P_{col}
- Solve the system using an iterative method for the desired numerical values (e.g. equivalent to IEEE 802.11)

Assumptions

- The computation of P_b considers a collision takes place between 2 nodes only
- The capture effect is not taken into account
- P_b is independent for every slot

Contention Window in unicast IEEE 802.11

- ❑ If channel free – send directly
- ❑ If channel busy – back off for n idle slots
- ❑ n= random (0, CW)
- ❑ Initially CW= CW_{min}
- ❑ If collision – CW= CW*2

broadcast

Contention Window in ~~unicast~~ IEEE 802.11

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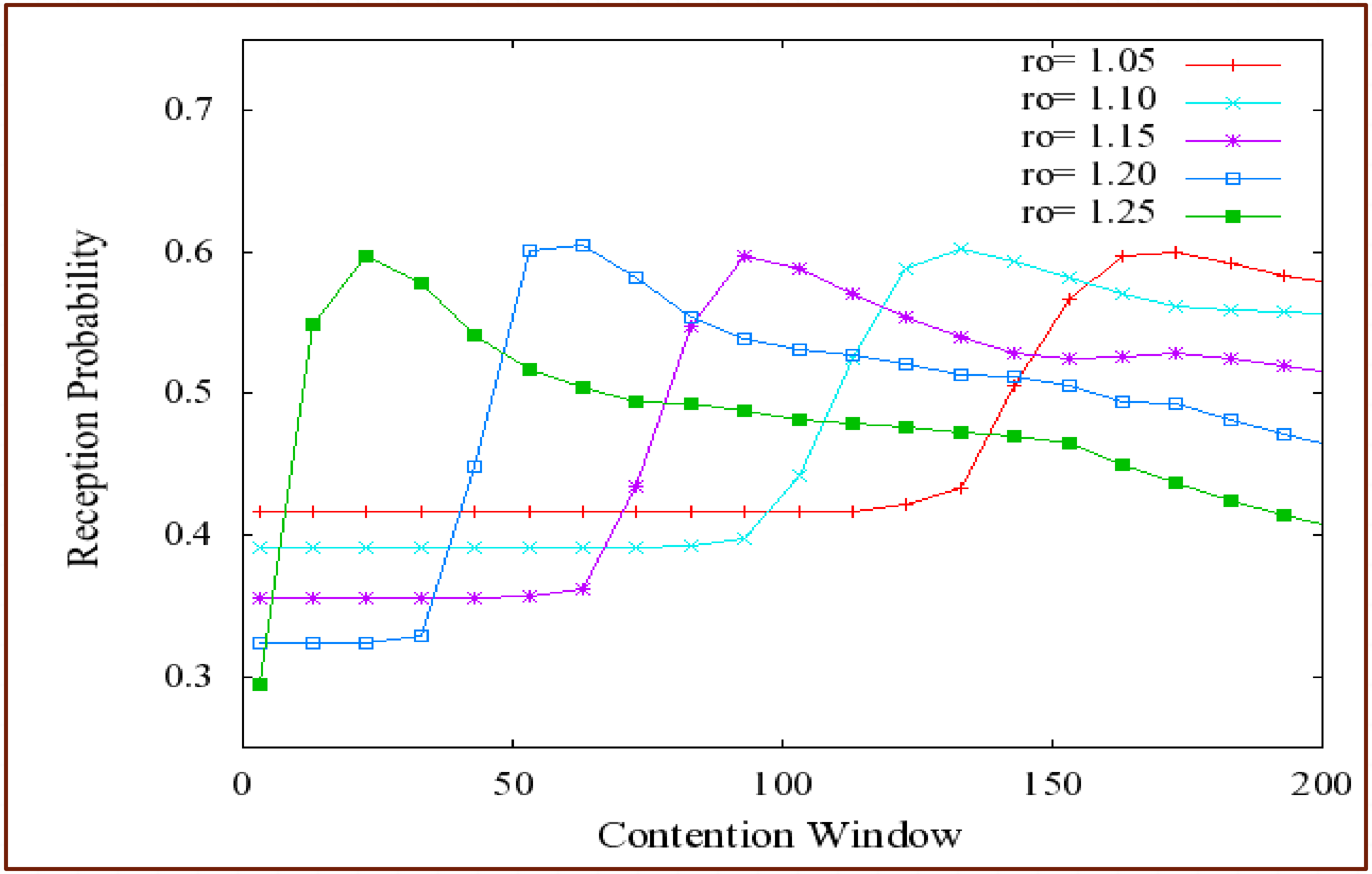
Beaconing Reception Probability for different values of the Network Load



Impact of the Minimum Contention Window

- ❑ Small CW – increased number of collisions
- ❑ High CW – increased number of expired beacons
- ❑ An expired beacon is lost for all the neighbours

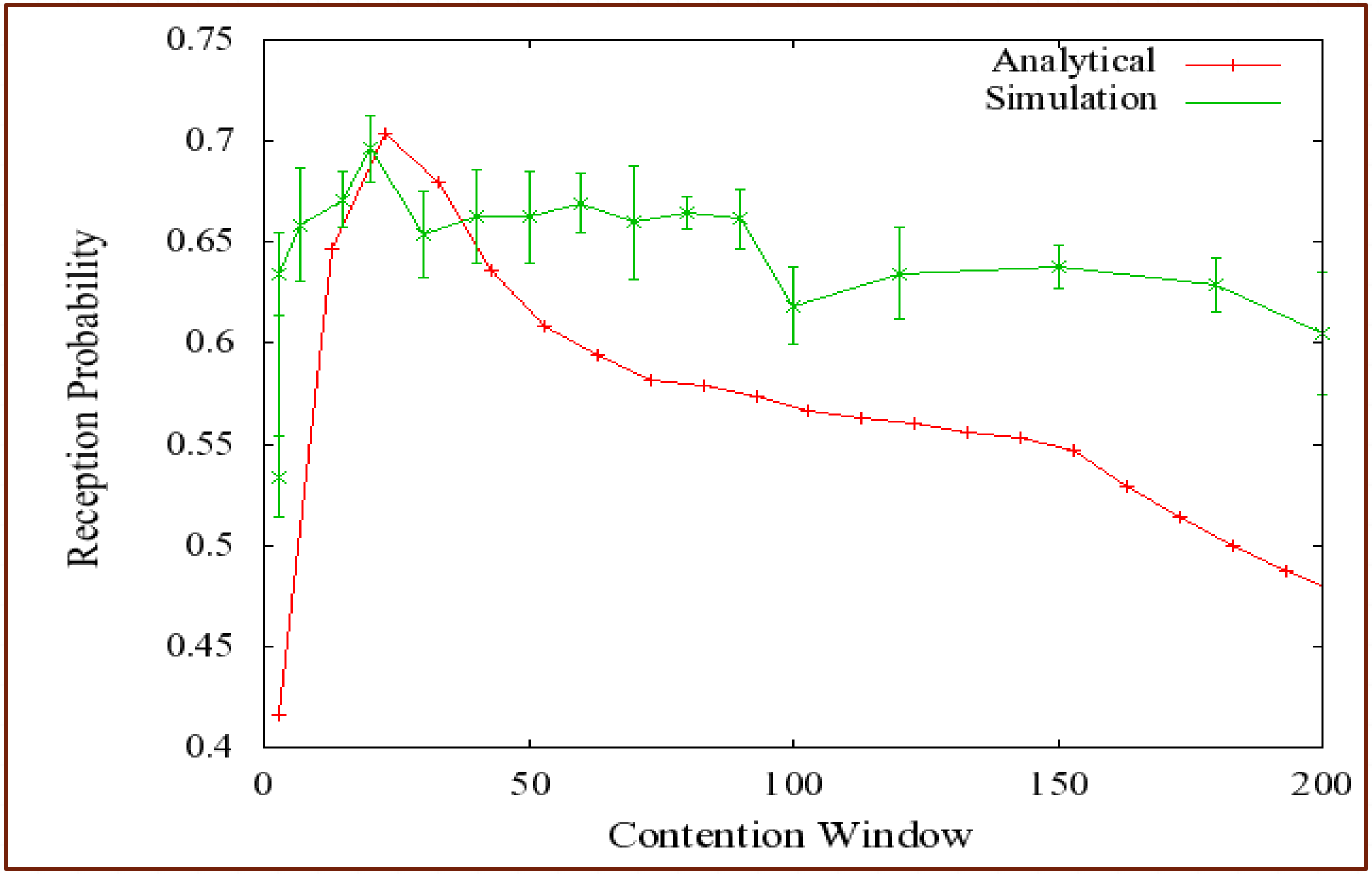
Observations

- ❑ Correct balance between collisions and expirations can bring significant improvements
- ❑ A reduced number of expired messages can benefit the reception ratio
- ❑ The gain obtained from avoided collisions can not cope with the expirations after a certain threshold (optimal CW)
- ❑ The optimal CW decreases with the number of contending stations (the opposite effect as for normal broadcast)

Simulation Study

- JiST/SWANS framework
- Street Random Waypoint mobility model
- Three different real maps from TIGER database
- Medium and high vehicular density

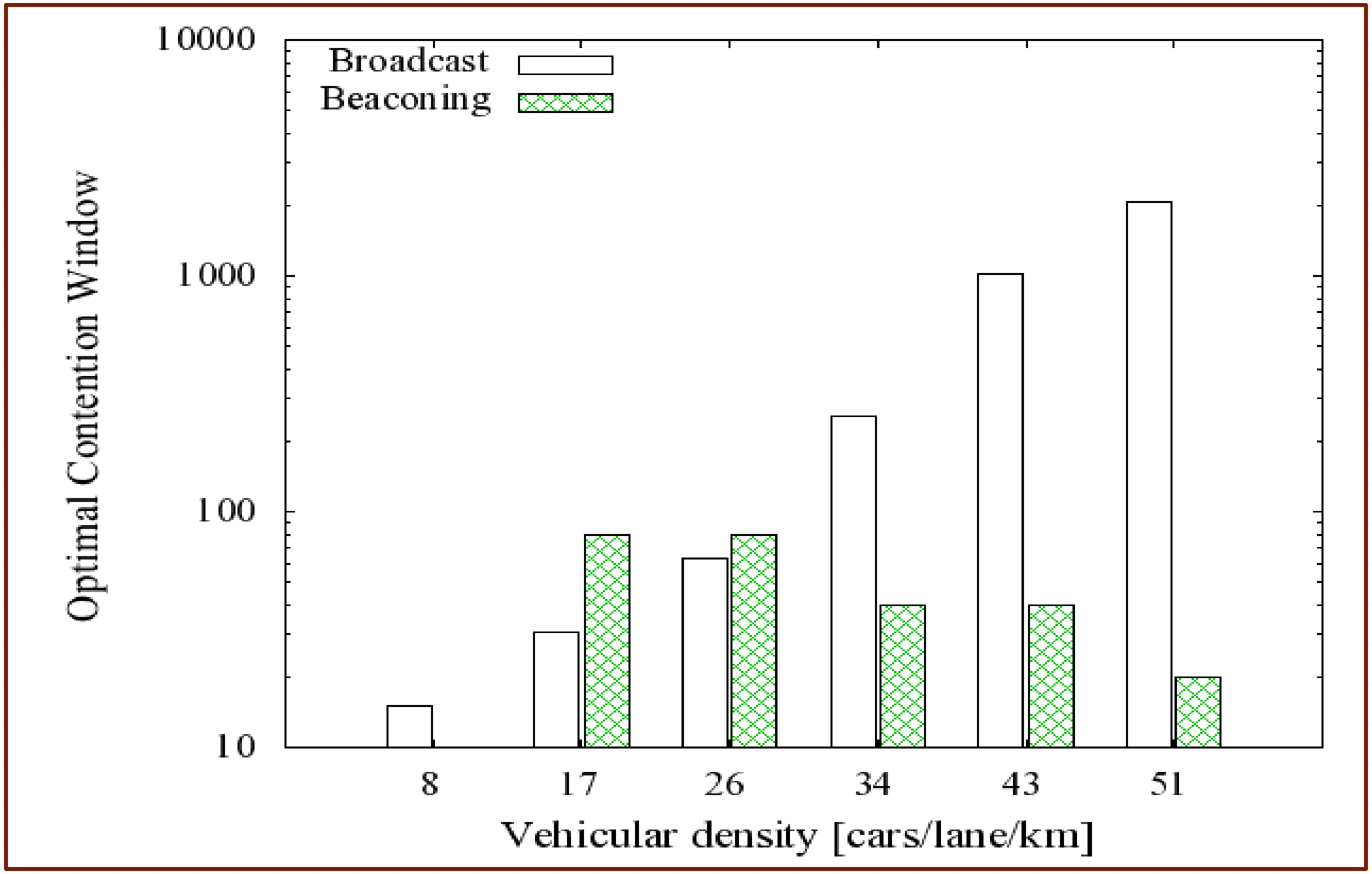
Simulation vs. Analytical (51 veh/lane/km)



Observations

- ❑ Not a perfect match, but similar trend
- ❑ Differences are produced by the assumptions made in the analytical model
- ❑ The value of the optimal CW is correctly predicted in the analytical model
- ❑ Despite quantitative inaccuracies, the analytical framework is a powerful tool in an initial design phase

Confirmation: Evolution of the optimal CW



Confirmation: Evolution of the optimal CW

- Broadcast: Directly proportional with the number of contending stations, as predicted by Bianchi

- Beaconing: Slow decrease when the number of contenders increases, as predicted by our model

Conclusion

- The properties of the CCH need to be taken into account when studying V2V communication

- We propose an analytical framework much closer to reality than the previous work

- The influence of the minimum CW value is studied using this analytical model

- Realistic simulations confirm the observations made analytically, showing a totally different behaviour for beaconing when compared with normal broadcast

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