Local Density Estimation for Contention Window Adaptation in Vehicular Networks

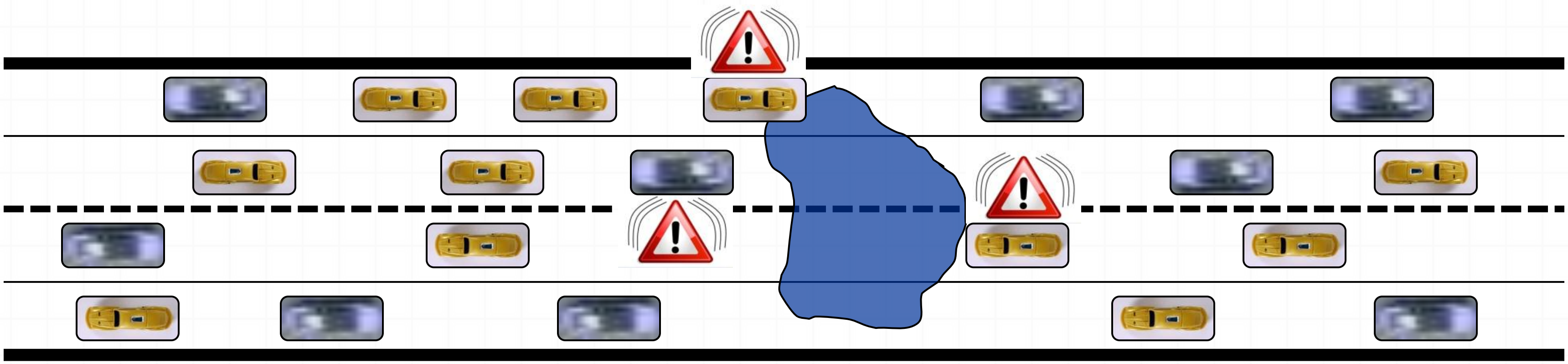
Razvan Stanica, Emmanuel Chaput, André-Luc Beylot

University of Toulouse
Institut de Recherche en Informatique de Toulouse

22nd Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications
Toronto - 12 September 2011

- Safety Communications in Vehicular Networks
- Minimum Contention Window on the VANET Control Channel
- Solutions for Local Density Estimation
- Comparative Results for Adaptive CW Mechanisms

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

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

- 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~~

Bianchi et al. (1996):

- $CW_{min} = N\sqrt{(2T_t)}$
- $T_{idle} = T_{col}$

Bianchi et al. (1996): → **Saturated complete networks**

- $CW_{min} = N\sqrt{(2T_t)}$
  - N → **WLAN size ~ 10 nodes**
- $T_{idle} = T_{col}$
  - T_{col} → **RTS/CTS handshake**

Beacon Based

- Extends the Bianchi relationship
- Uses received beacons to estimate density
- $CW = \lambda N$
- Lost beacons can impact the result

Collided Packets

- Uses sequence numbers to estimate PER
- If PER < PER_{min} – increase CW
- If PER > PER_{max} – decrease CW
- Compatibility problem with privacy framework based on pseudonyms

Idle Time

- Estimate T_{col} using the number of lost messages
- If $T_{col} > \alpha T_{idle}$ – increase CW
- If $T_{idle} > \alpha T_{col}$ – decrease CW
- Compatibility problem with privacy framework based on pseudonyms

Stop Time

- Based on relationships from traffic flow theory
- Measure the time a vehicle is stopped
- $CW = (T_{stop} / T_{update})(CW_{max} - CW_{min}) + CW_{min}$
- A vehicle could stop for other reasons, unrelated to the traffic state

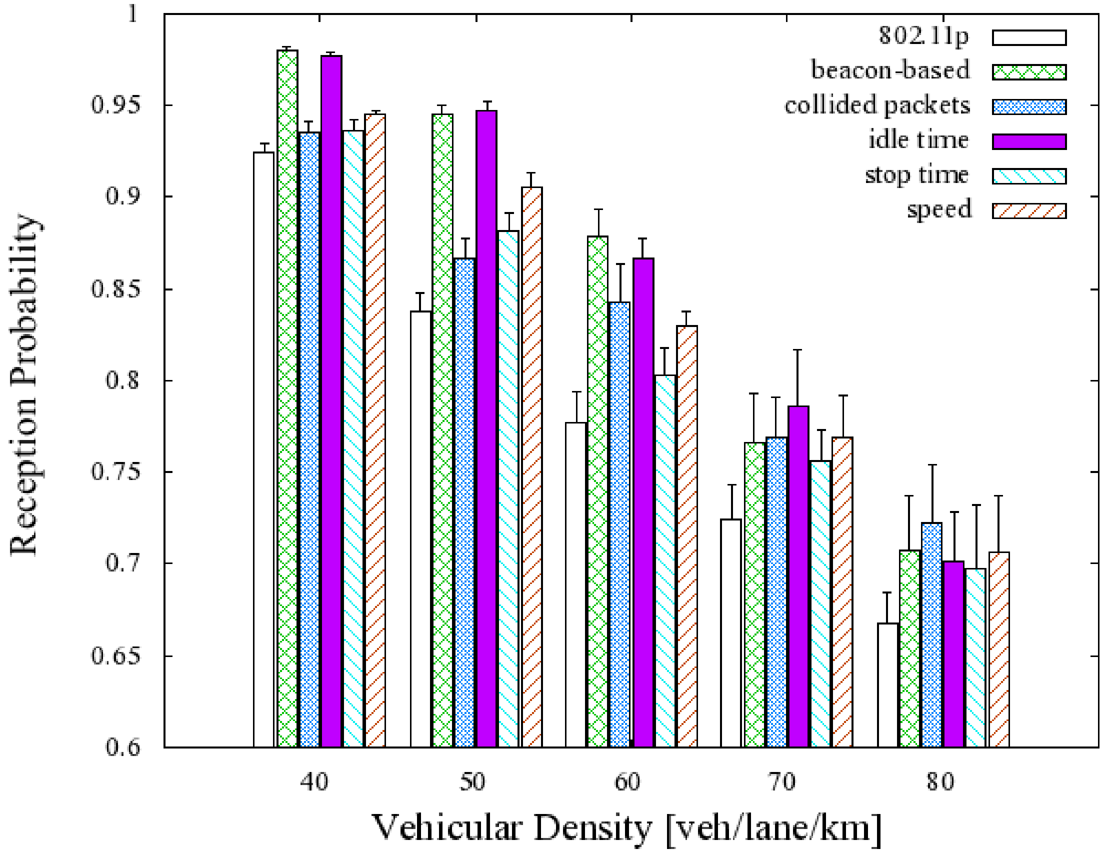
Speed Based

- Using speed information can be useful in intermediate states
- Measure vehicular jerk (the derivative of the acceleration)
- $CW = (|jerk| / speed / D_{max})(CW_{max} - CW_{min}) + CW_{min}$
- Jerk is not currently measured by vehicles

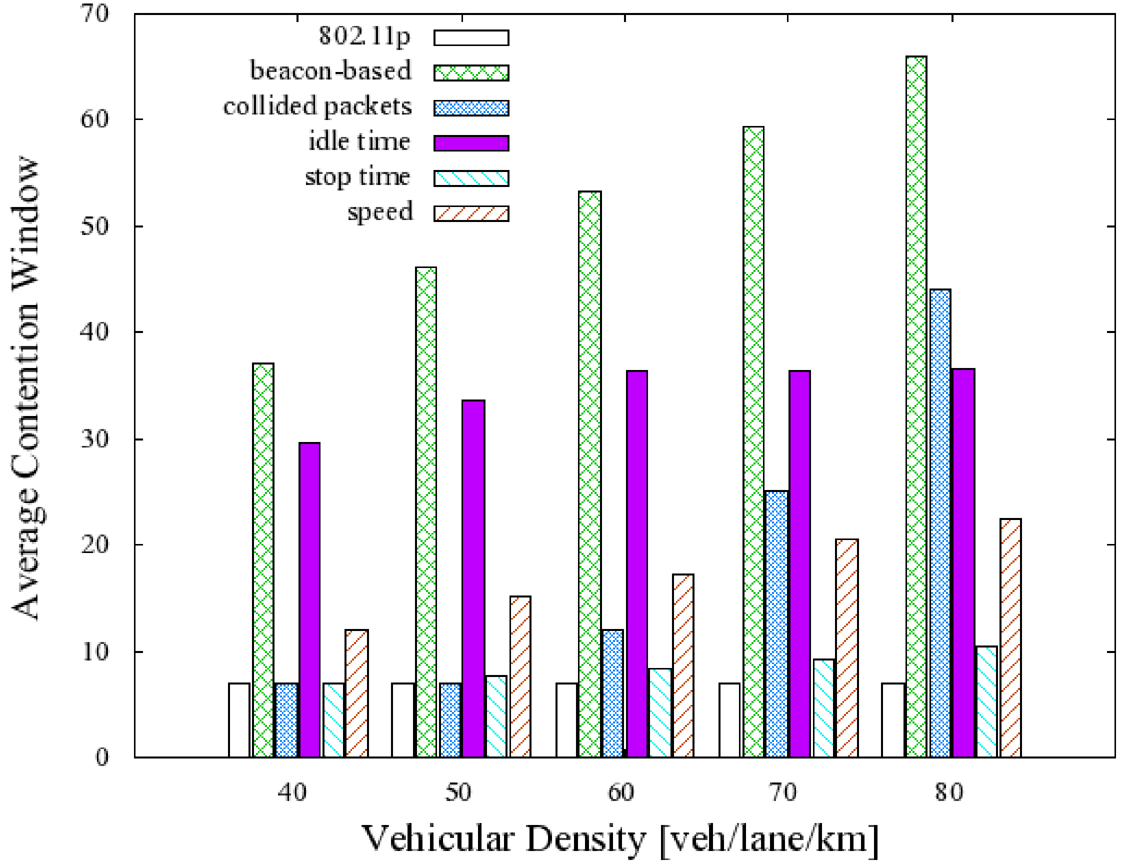
Simulation Study

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

Beaconing Reception Probability at less than 200m from the Sender



Average Contention Window for the different Mechanisms



Observations

- ❑ All the mechanism show an important improvement over the current version of the standard
- ❑ The same results can be obtained using different strategies
- ❑ Solutions based on traffic flow theory are efficient when the vehicular density increases
- ❑ These heuristics are quite simple and they could be straightforwardly integrated in the standard

Conclusion

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

- The contention window of the back-off mechanism is a very important parameter for MAC layer congestion control

- This work compares the performance of five adaptive mechanisms specially conceived for VANETs

Local Density Estimation for Contention Window Adaptation in Vehicular Networks

Razvan Stanica, Emmanuel Chaput, André-Luc Beylot

University of Toulouse
Institut de Recherche en Informatique de Toulouse

22nd Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications
Toronto - 12 September 2011

Institut de Recherche en Informatique de Toulouse CNRS INPT UPS UT1

Université de Toulouse

INP TOULOUSE ENSEEIHT