Physical Carrier Sense in Vehicular Ad-hoc Networks

Razvan Stanica, Emmanuel Chaput, André-Luc Beylot

University of Toulouse
Institut de Recherche en Informatique de Toulouse

IEEE 8th International Conference on Mobile Ad-hoc and Sensor Systems
Valencia - 20 October 2011

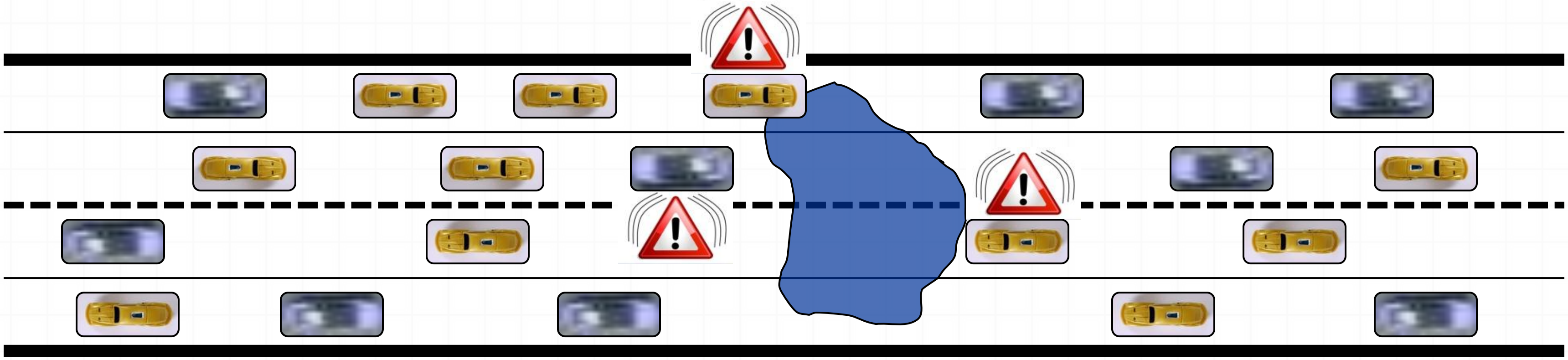
Institut de Recherche en Informatique de Toulouse
CNRS
INPT
UPS
UT1

Université de Toulouse

INP TOULOUSE ENSEEIHT

- Safety Communication in Vehicular Networks
- Particularities of the VANET Control Channel
- The Importance of the Carrier Sense Range
- Adaptive Carrier Sense Threshold

VANET objective: Building an accurate image of the exterior world



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

Safety Applications

- ❑ Intersection Collision Warning
- ❑ Emergency Electronic Brake Lights
- ❑ Approaching Emergency Vehicle
- ❑ Lane Change Assistant
- ❑ Left-Turn Collision Warning

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		

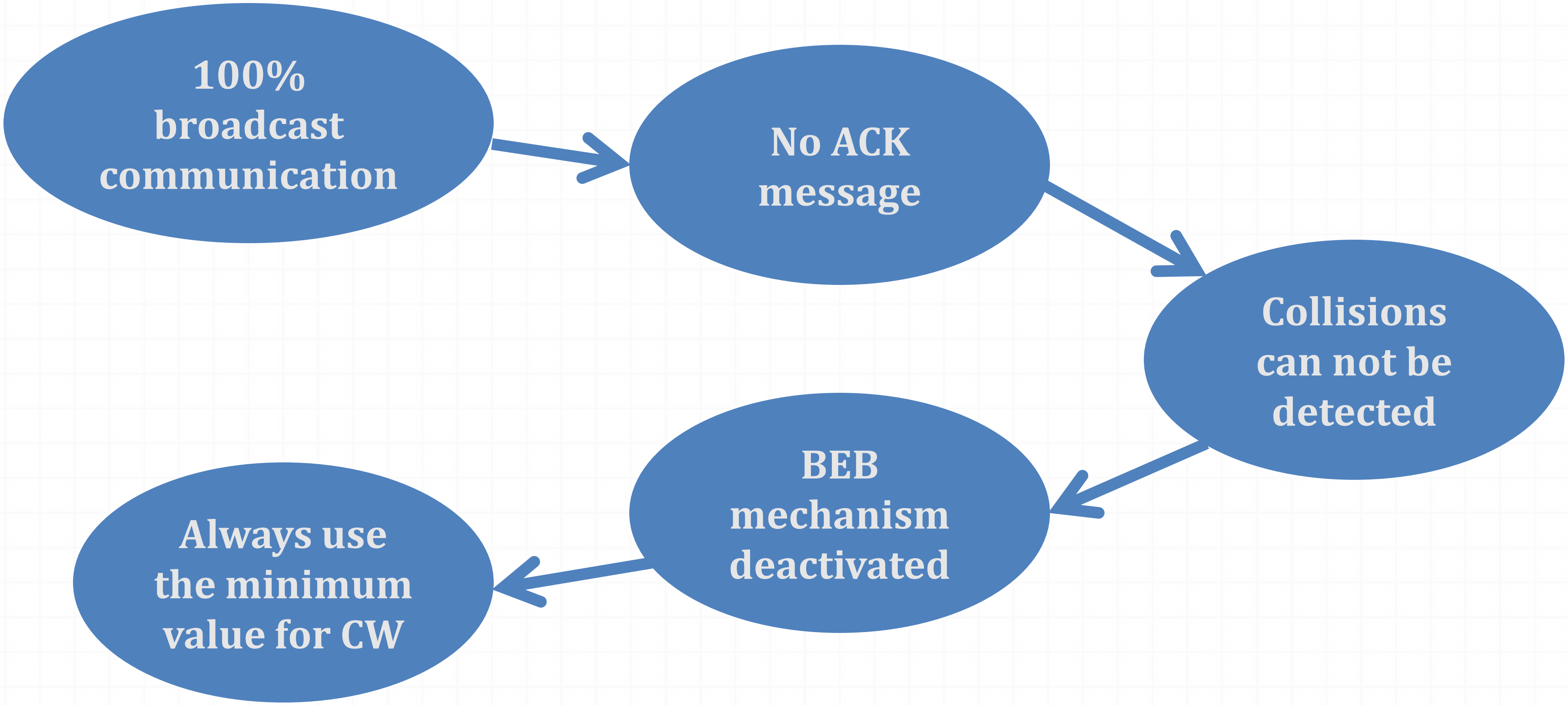
Europe Spectrum Allocation

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

Safety beaconing

- A beacon expires if the next CAM is produced
- No exposed terminals
- Practically no internal contention on the CCH
- MAC delay automatically considered in the expiration probability
- Metric of interest: reception probability

IEEE 802.11p on the CCH



Congestion Control

- ❑ **Reduce Beaconing Frequency**

Congestion Control

- ❑ Reduce Beaconing Frequency
- ❑ Increase Data Rate

Congestion Control

- ❑ Reduce Beaconing Frequency
- ❑ Increase Data Rate
- ❑ Control Transmission Power

Congestion Control

- ❑ Reduce Beaconing Frequency
- ❑ Increase Data Rate
- ❑ Control Transmission Power
- ❑ Modify Back-off Mechanism

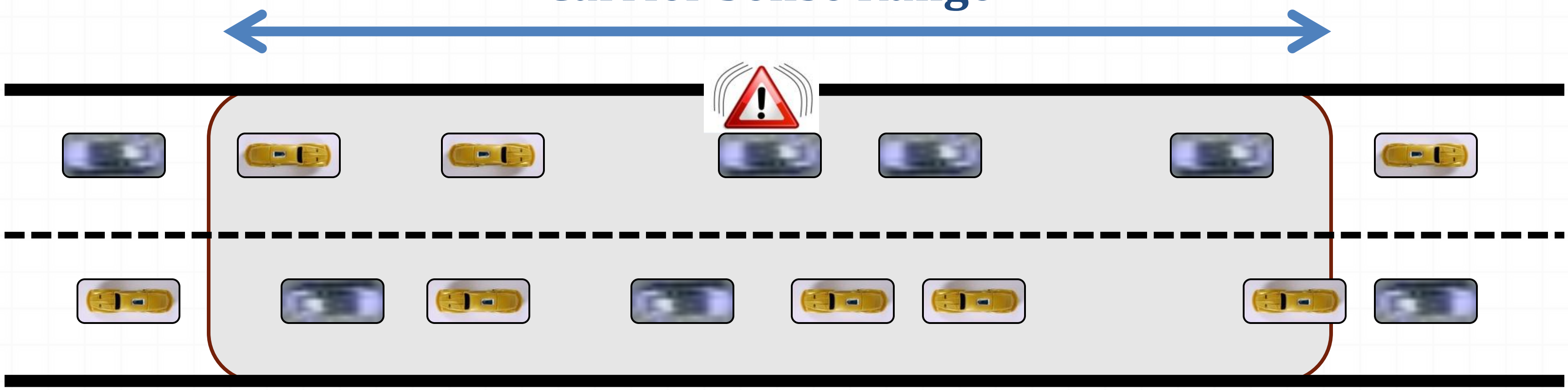
Congestion Control

- ❑ Reduce Beaconing Frequency
- ❑ Increase Data Rate
- ❑ Control Transmission Power
- ❑ Modify Back-off Mechanism
- ❑ Adapt Carrier Sensing

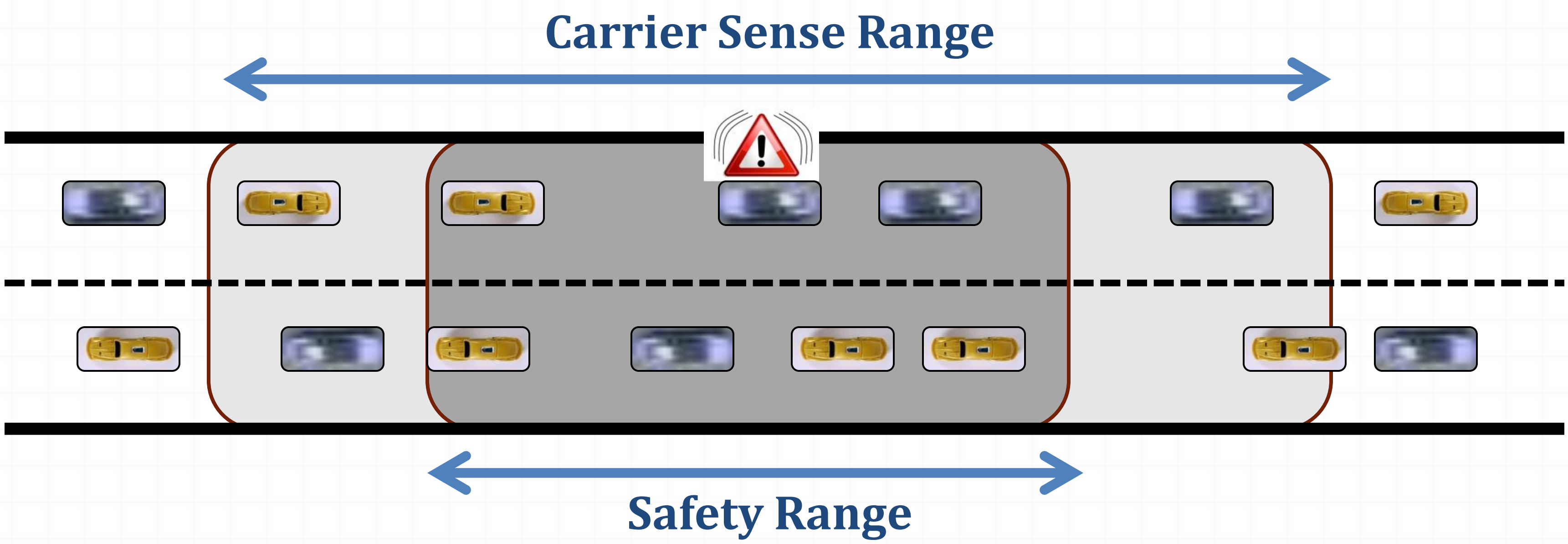
Carrier Sense in IEEE 802.11

- MAC Layer – Network Allocation Vector
  - based on the RTS/CTS handshake
  - unusable on the broadcast CCH
- PLCP Layer – Clear Channel Assignment
  - header detection
  - energy detection

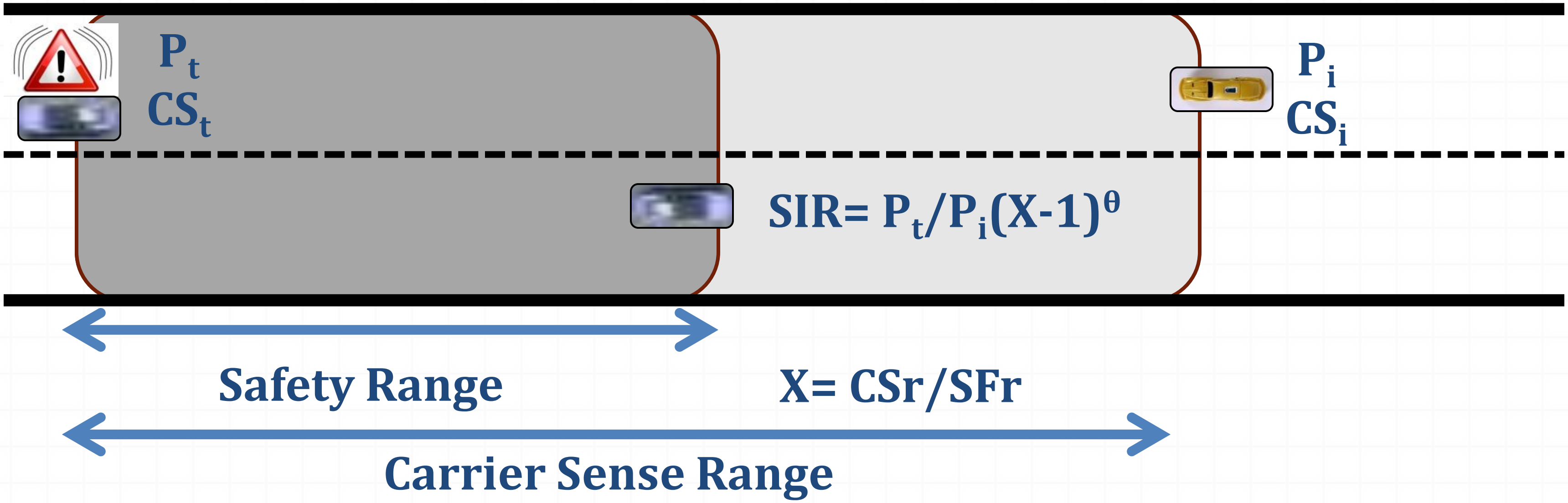
Carrier Sense Range



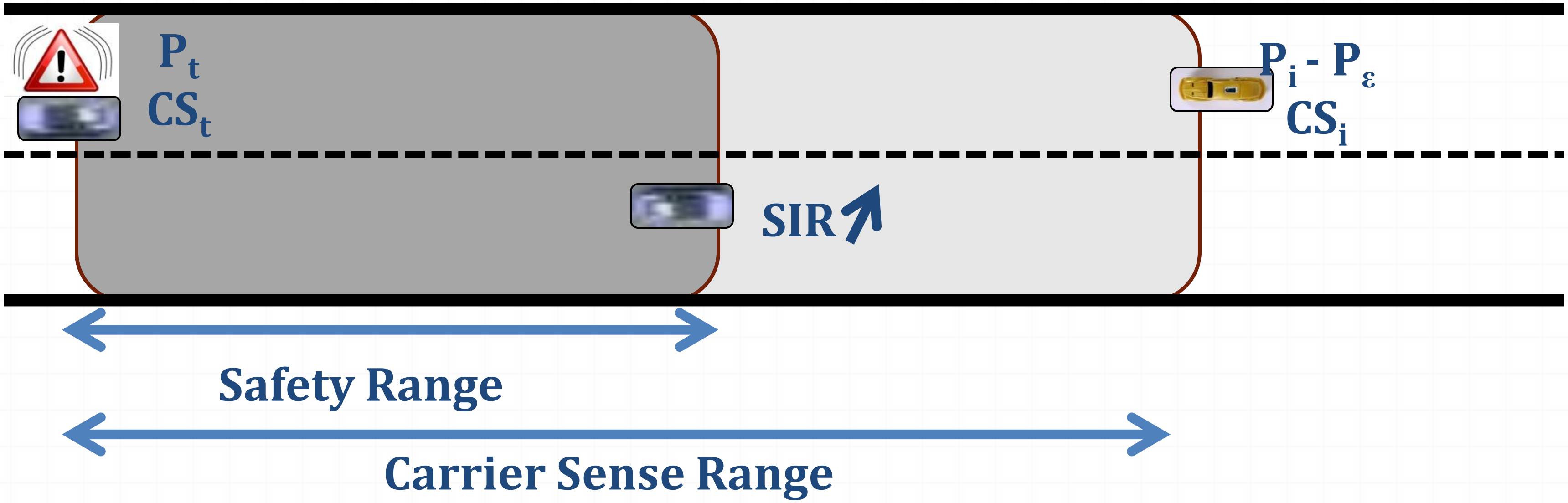
Safety V2V | Control Channel | Carrier Sense Range | Adaptive CS


Carrier Sense Range
Safety Range

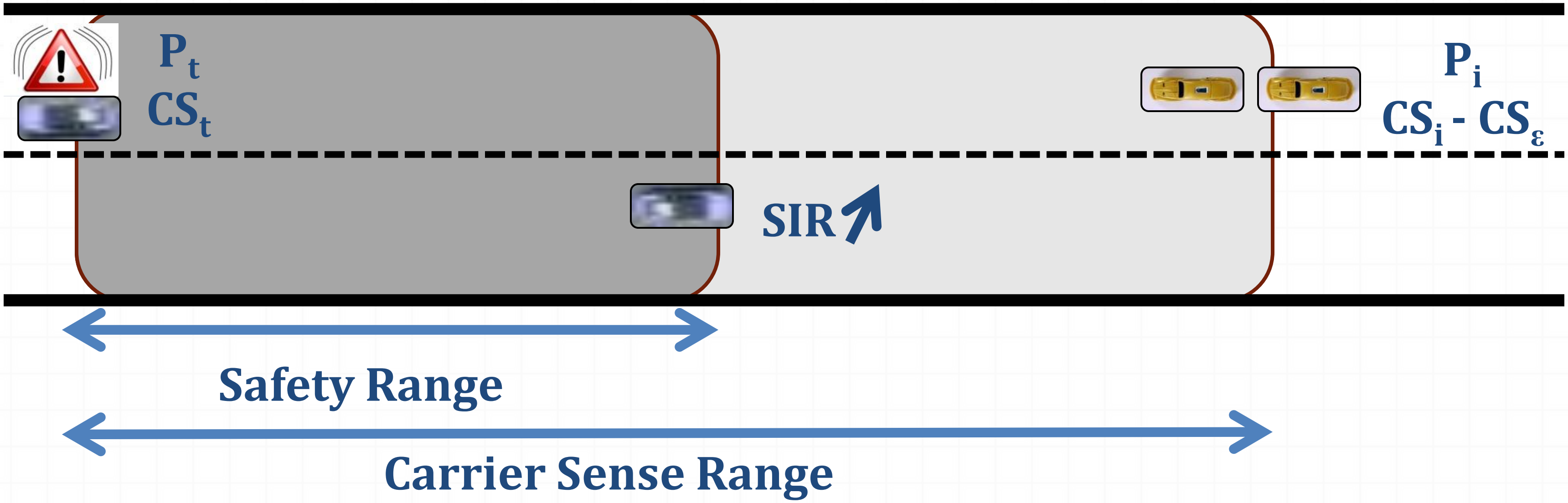
Worst Case Scenario



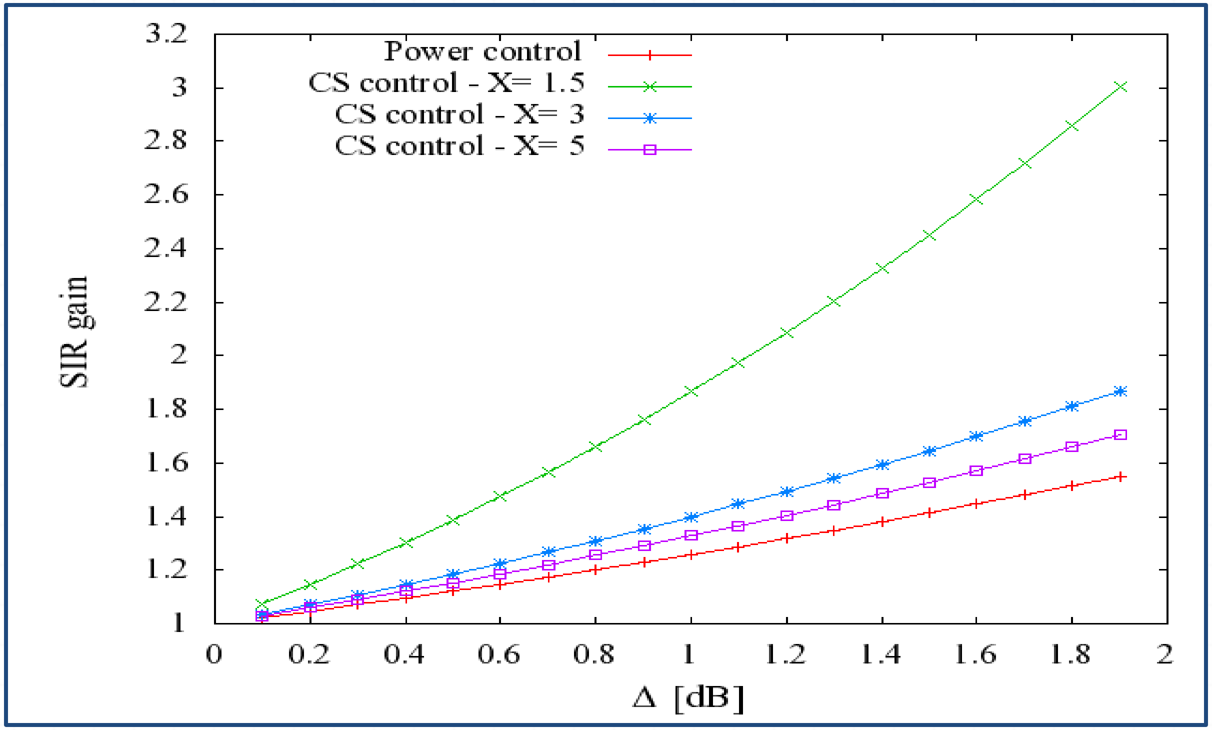
Transmission Power Control



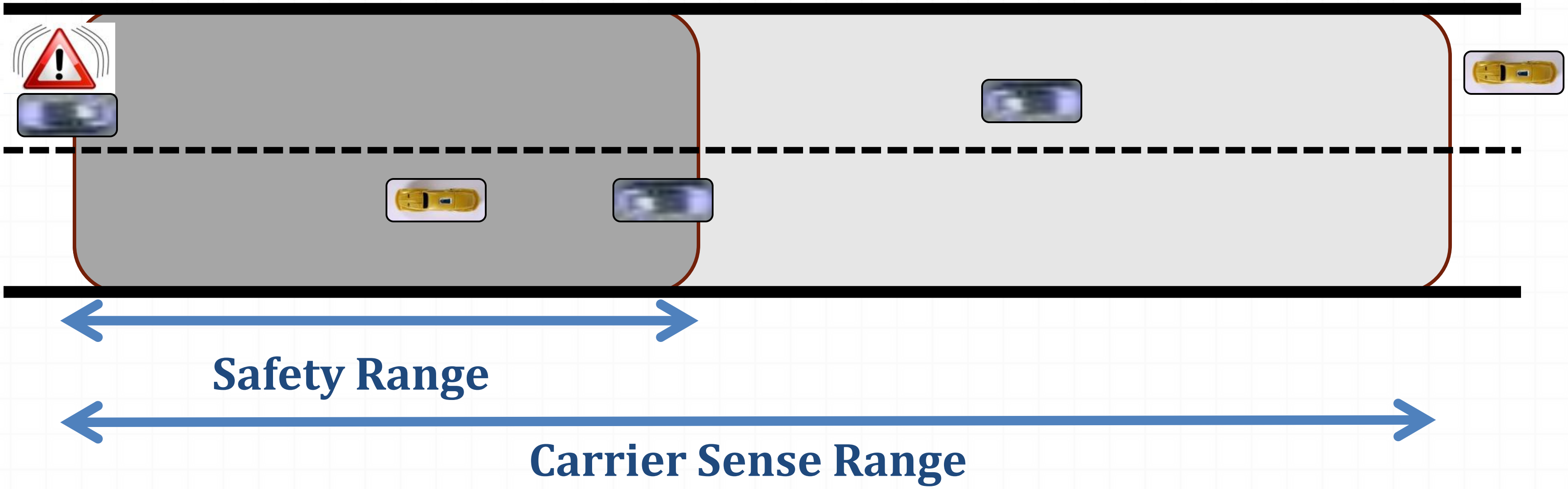
Carrier Sense Threshold Control



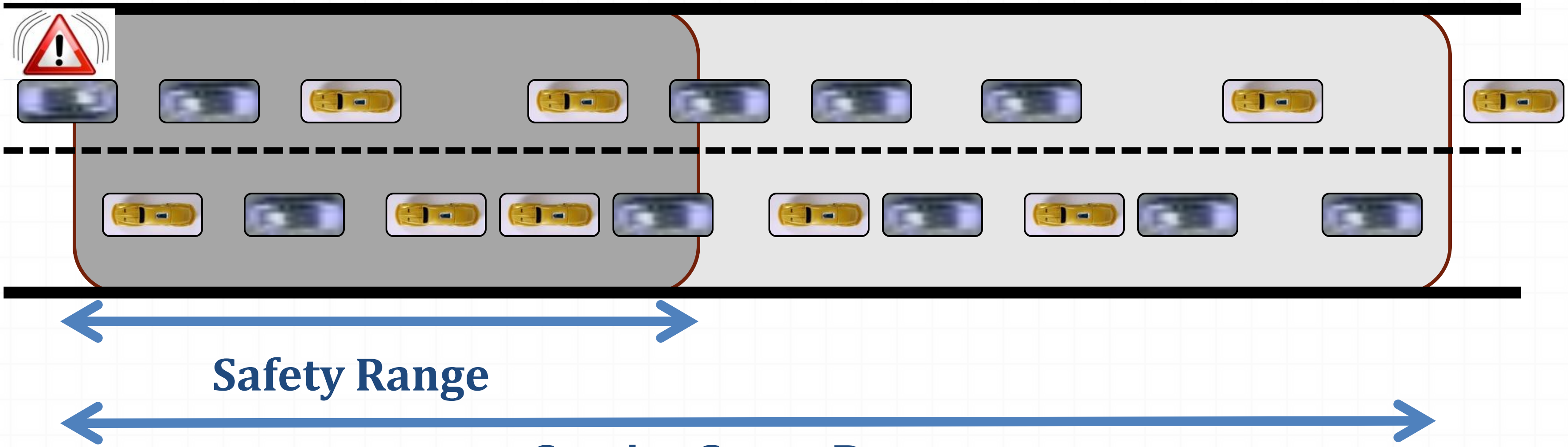
Carrier Sense vs. Transmission Power



Why Not Use the Minimum Carrier Sense Threshold?



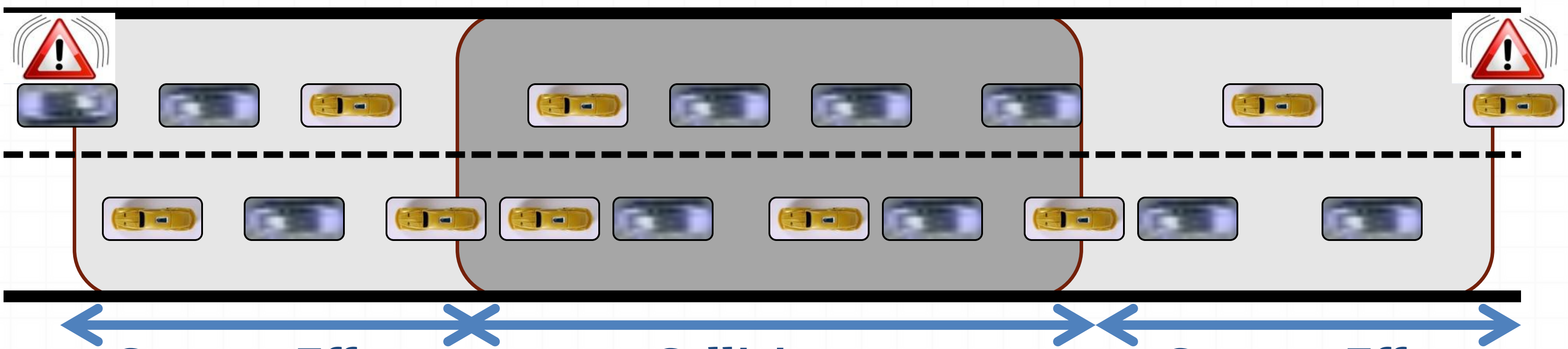
Why Not Use the Minimum Carrier Sense Threshold?



Carrier Sense Range
=
Competition for Channel Access

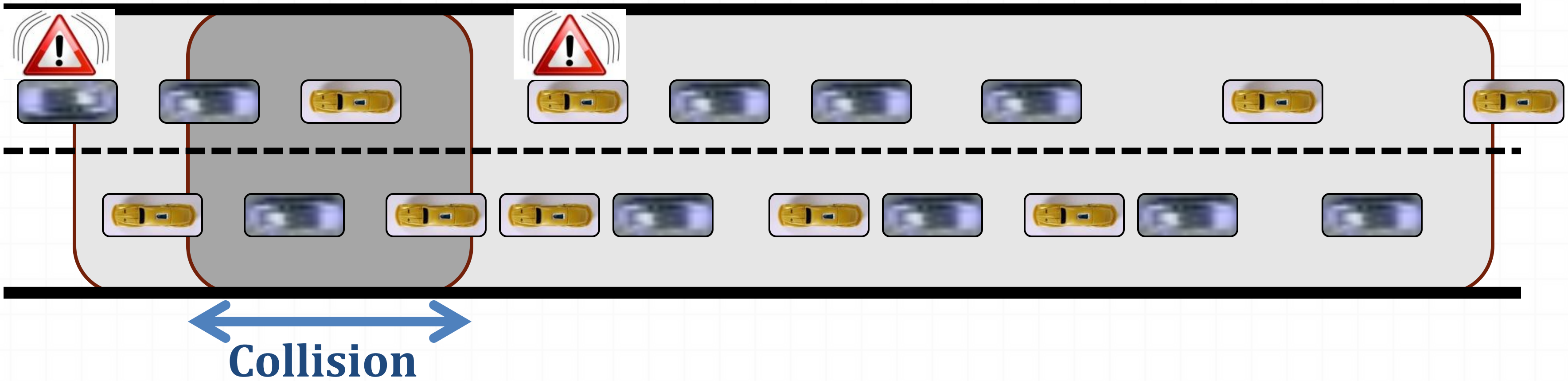
Vehicular Density

- ❑ More neighbours – longer back-off
- ❑ More neighbours – more expired beacons
- ❑ More neighbours – more collisions



Vehicular Density

- More neighbours – longer back-off
- More neighbours – more expired beacons
- More neighbours – more collisions



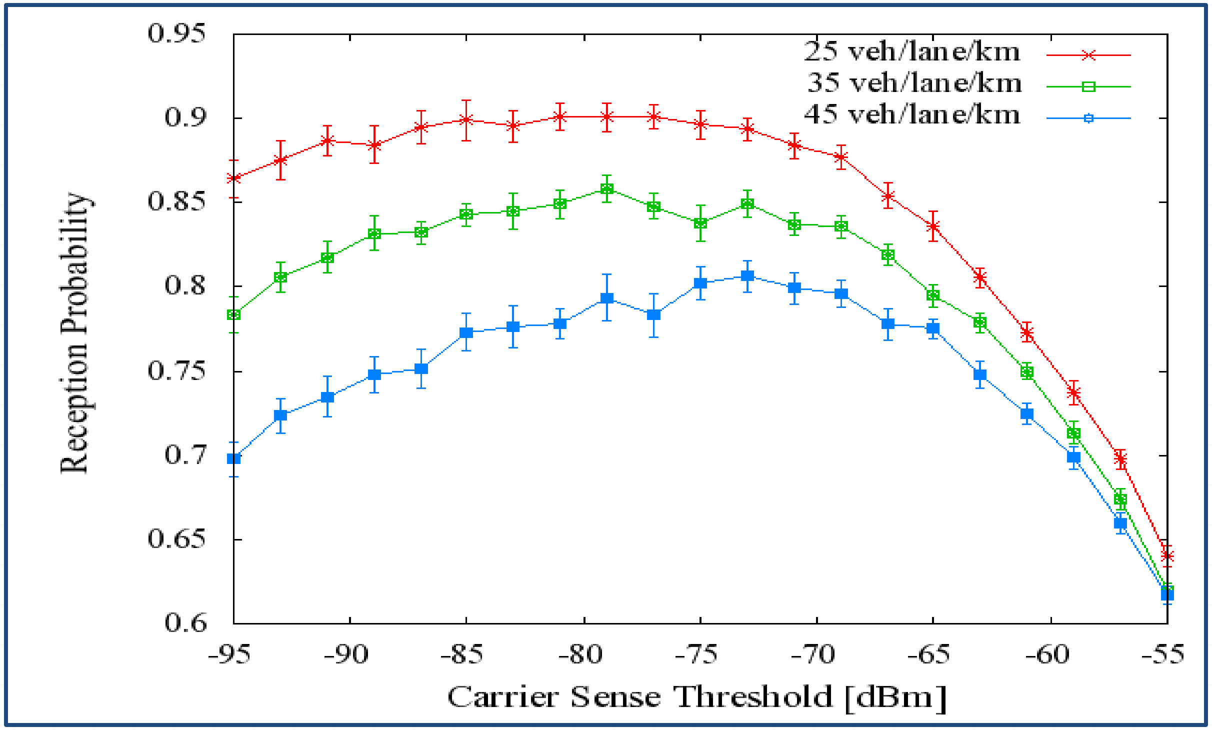
Adaptive Carrier Sense Threshold

- ❑ Low CSt value under low density
- ❑ High CSt value under high density
- ❑ Beacon-based density estimation – λ
- ❑ CSt= f(λ)

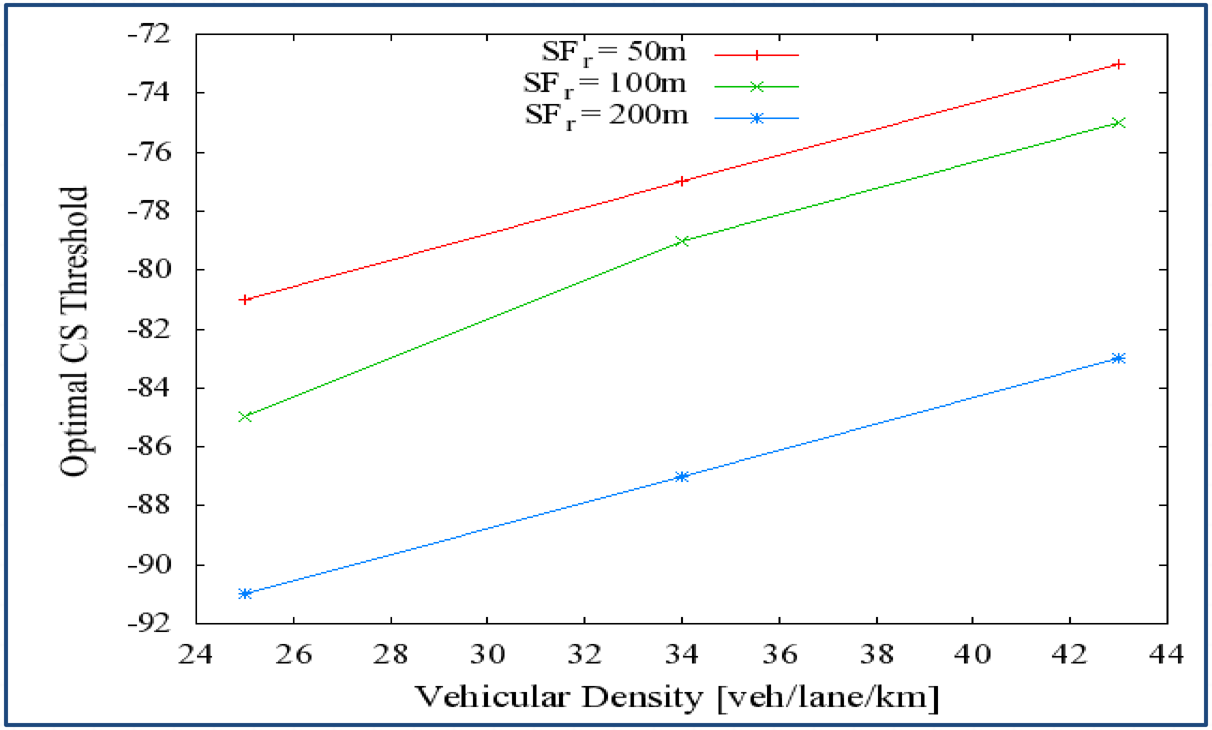
Simulation Study

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

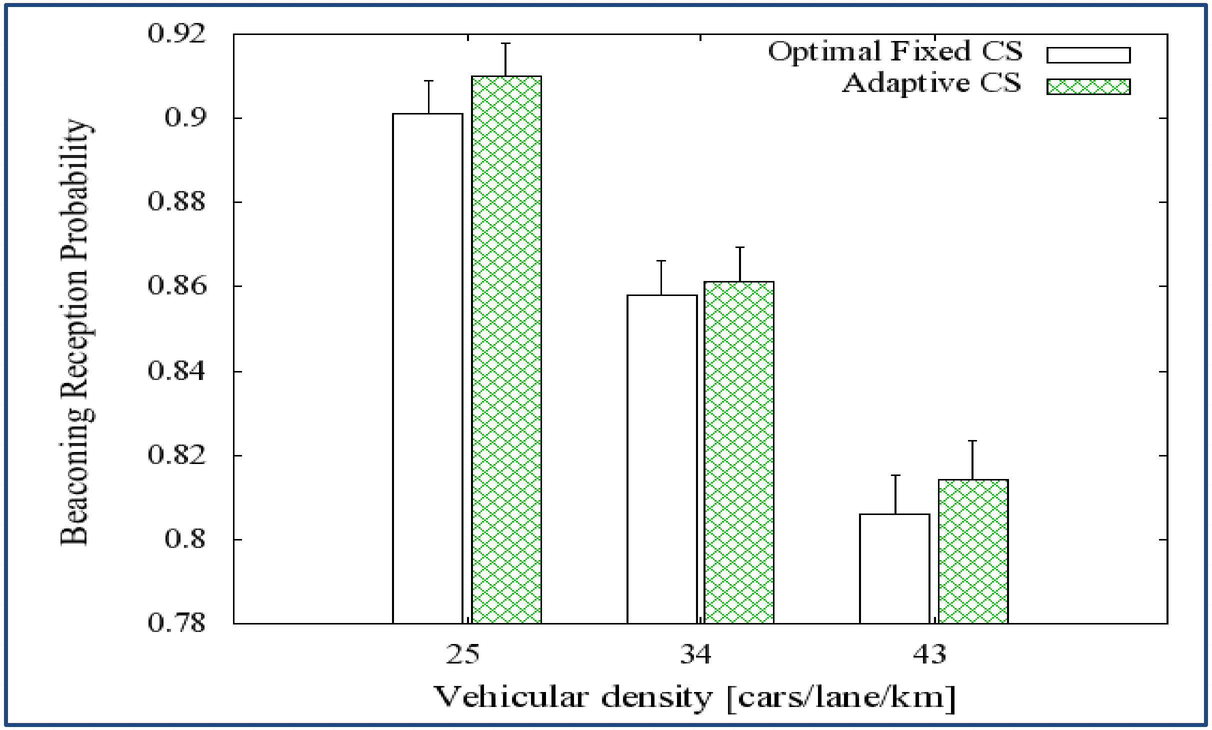
Beaconing Reception Probability for different Densities and CS Thresholds



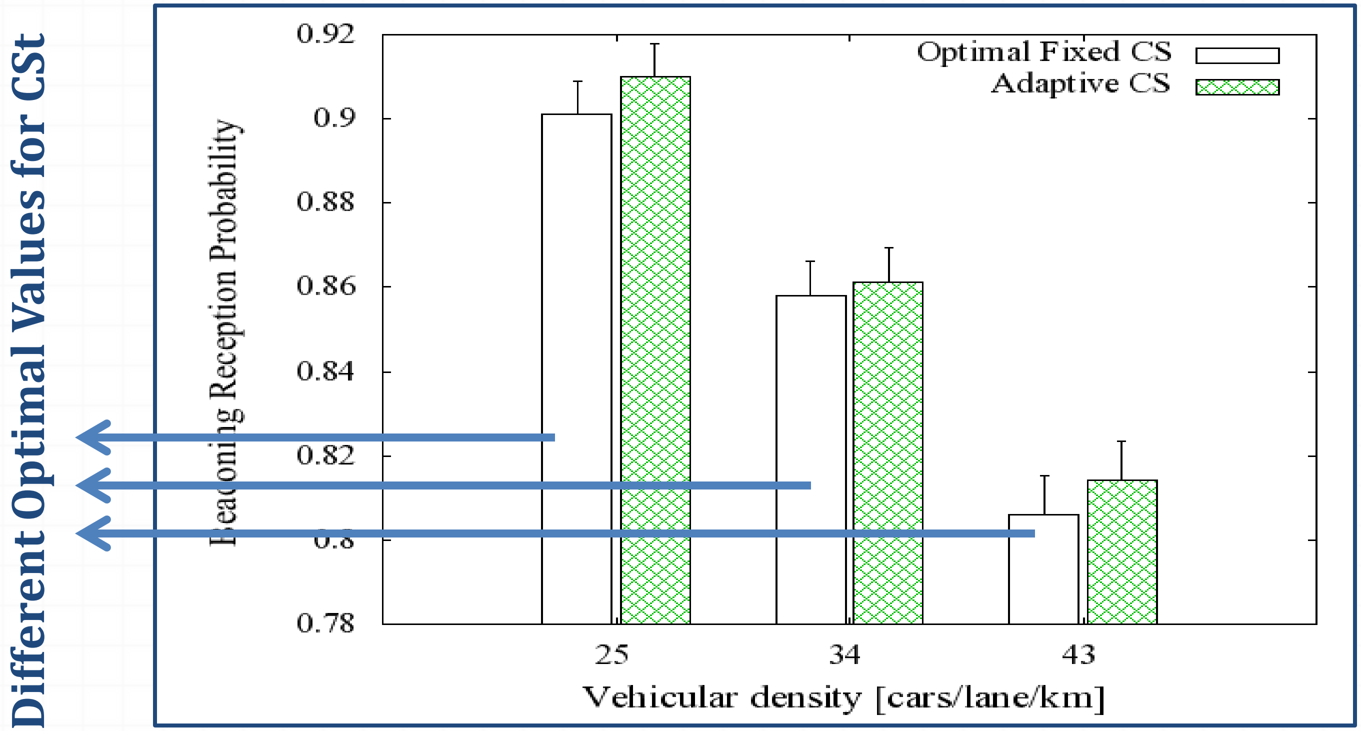
Impact of the Carrier Sense Range



Adaptive vs. Best Fixed CSt



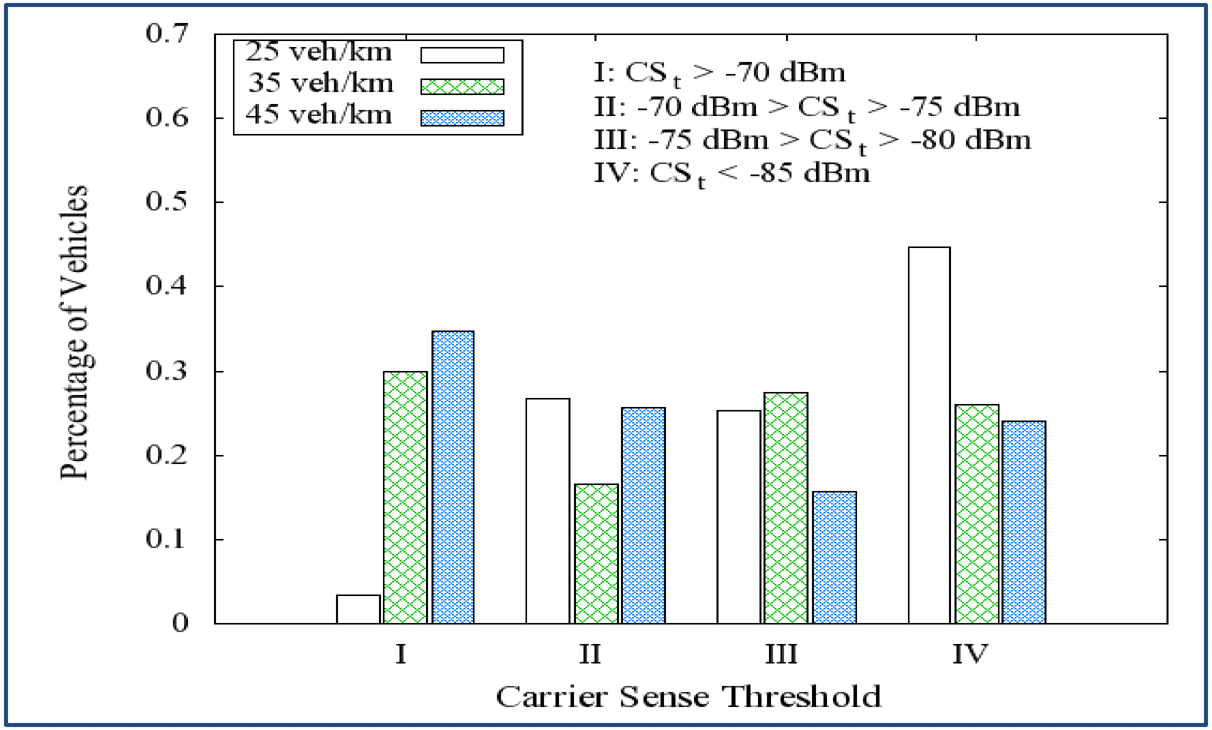
Adaptive vs. Best Fixed CSt



Adaptive vs. Best Fixed CSt

Vehicular Density	Adaptive Mechanism	CSt= -95 dBm	CSt= -85 dBm	CSt= -75 dBm
25 veh/lane/km	91.02%	86.42%	89.88%	88.64%
35 veh/lane/km	86.12%	78.38%	84.27%	81.81%
45 veh/lane/km	81.41%	69.76%	76.32%	80.20%

Distribution of CSt for the Adaptive Mechanism



Conclusion

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

- The carrier sense mechanism represents the basis for CSMA/CA channel access techniques and should receive more attention

- Carrier sense threshold control is more powerful than transmission power control on the VANET CCH

- A simple adaptive mechanism can bring important performance improvement in IEEE 802.11p networks

Physical Carrier Sense in Vehicular Ad-hoc Networks

Razvan Stanica, Emmanuel Chaput, André-Luc Beylot

University of Toulouse
Institut de Recherche en Informatique de Toulouse

IEEE 8th International Conference on Mobile Ad-hoc and Sensor Systems
Valencia - 20 October 2011

Institut de Recherche en Informatique de Toulouse
CNRS
INPT
UPS
UT1

Université de Toulouse

INP TOULOUSE ENSEEIHT