Congestion Control in CSMA-based Vehicular Networks: Do Not Forget the Carrier Sensing

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IRIT Institut de Recherche en Informatique de Toulouse
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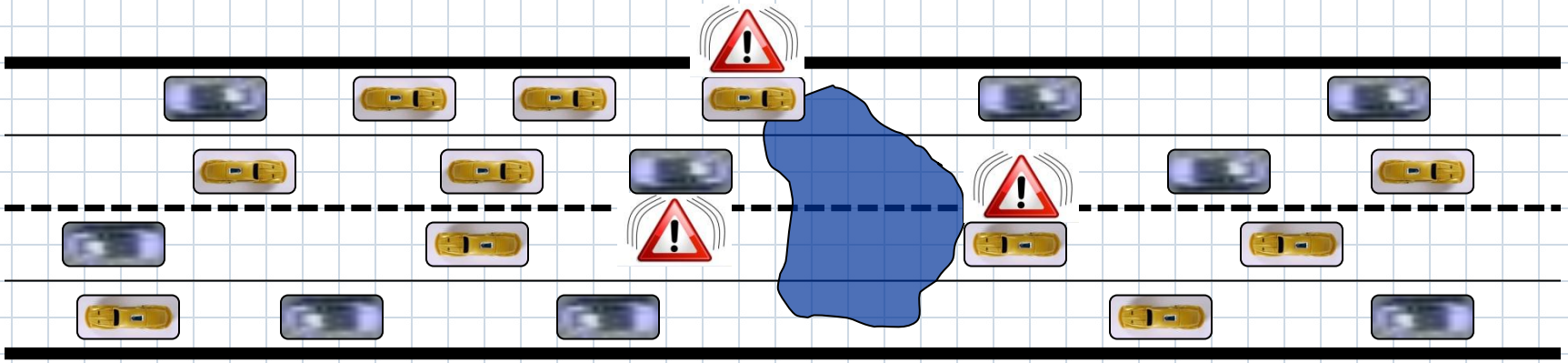
- Safety Communications in Vehicular Networks
- Types of Losses for Vehicular Beacons
- Safety Range CSMA
- Protocol Evaluation
- Conclusion & Future Work

VANET objective: Building an accurate image of the exterior world



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

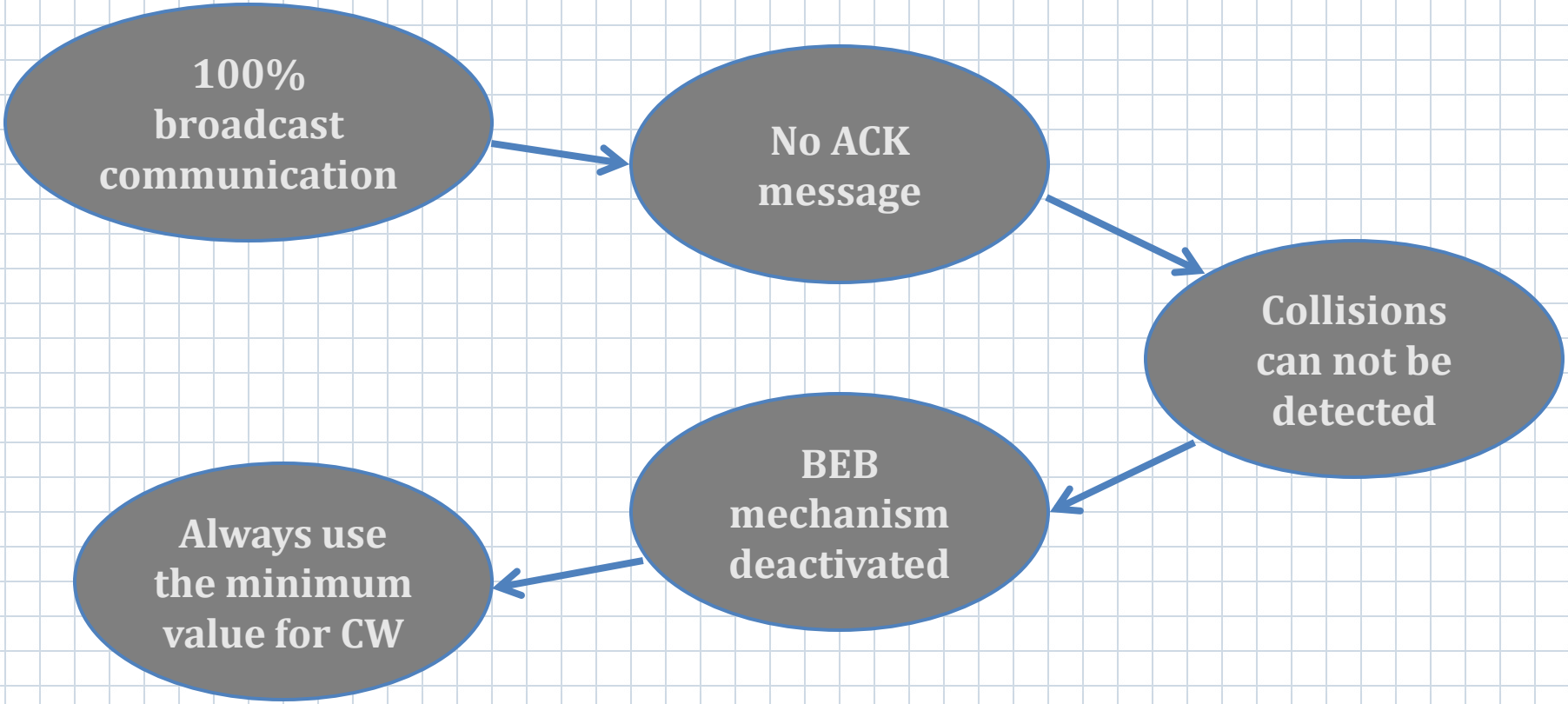
Safety Messages

- Cooperative Awareness Message (CAM)
  - Periodic
  - Position, speed, direction, steering angle ...
  - ETSI TS 102 868
- Decentralised Environmental Notification (DEN)
  - Special events
  - Hazard location, type, dissemination area ...
  - ETSI TS 102 869

Safety beaconing

- Broadcast mode – no exposed terminals
- A beacon expires if the next CAM is produced
- Practically no internal contention on the CCH
- MAC delay automatically considered in the expiration probability
- Metrics of interest: reception probability, number of undetected neighbours

IEEE 802.11p on the CCH



Congestion Control

- Beaconing Frequency
- Data Rate
- Transmission Power
- Contention Window

Congestion Control

- Beaconing Frequency – problems in some scenarios (left turn assistant)
- Data Rate – questioned by field tests
- Transmission Power – included in SR-CSMA
- Contention Window – included in SR-CSMA

Why are safety messages lost?

- ❑ Propagation Problems
- ❑ Expired Beacons
- ❑ Collisions
  - Synchronized Transmissions
  - Hidden Nodes

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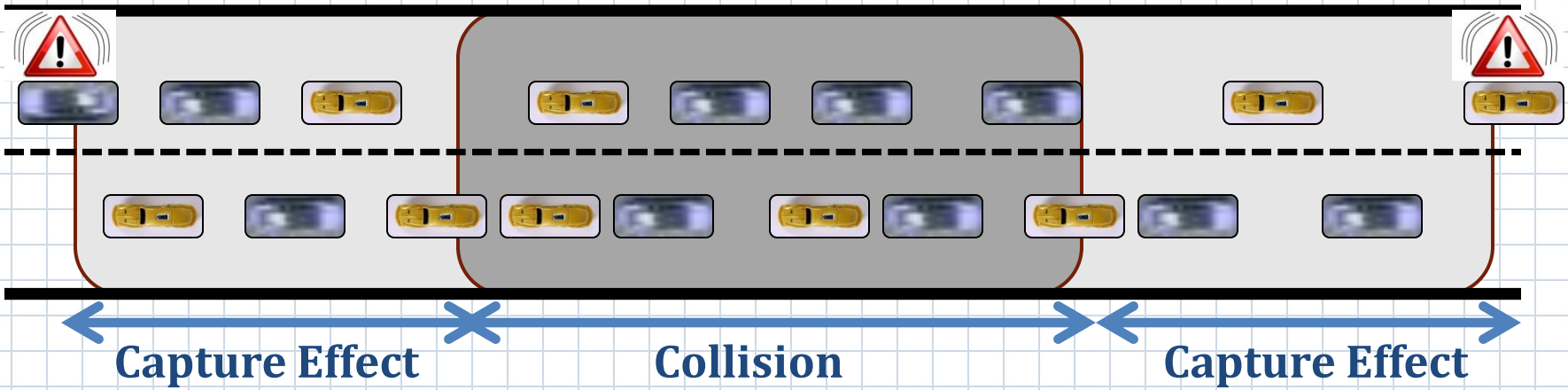
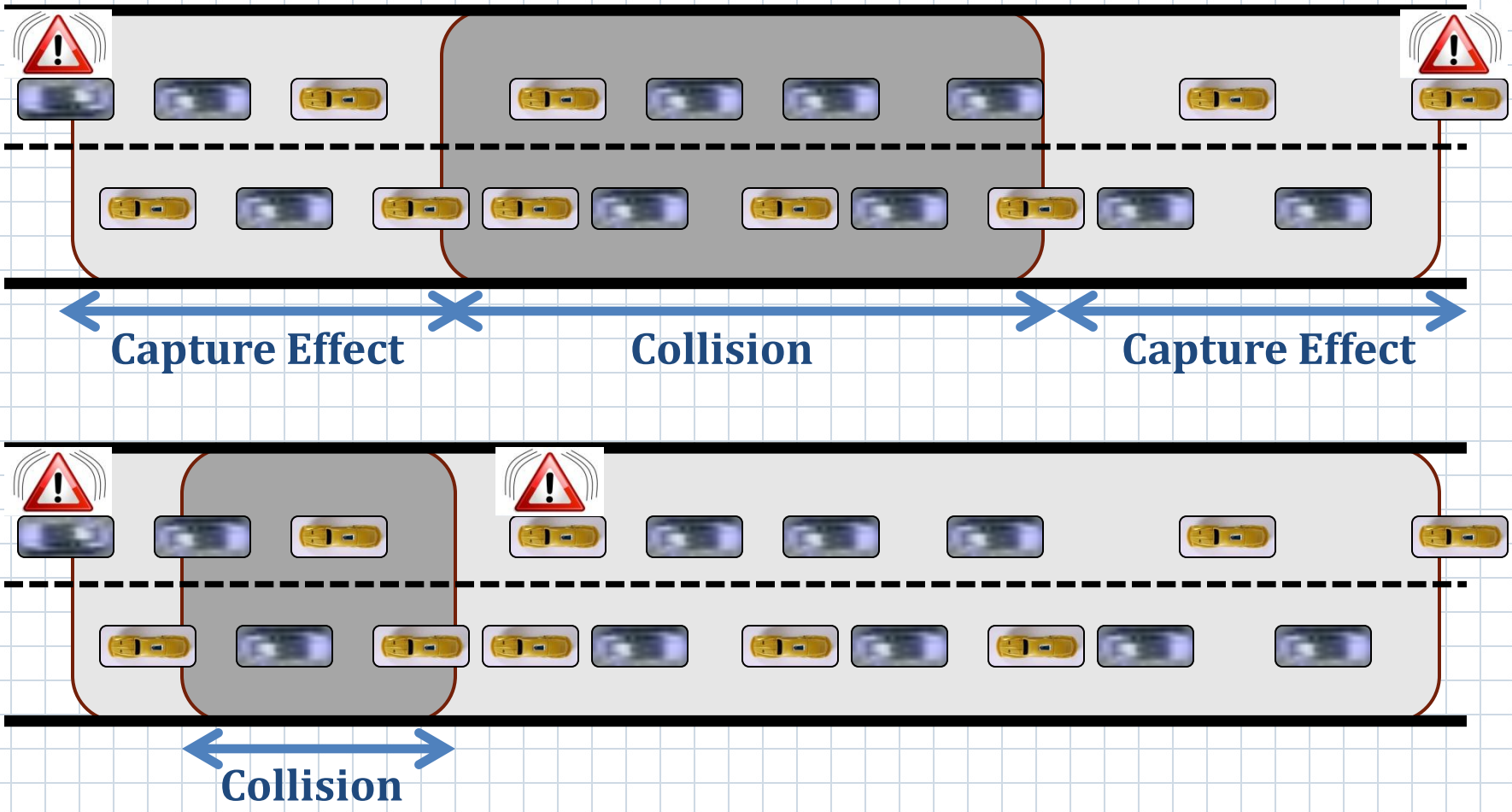

Capture Effect
Collision
Capture Effect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Safety Range CSMA

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

Safety Range CSMA

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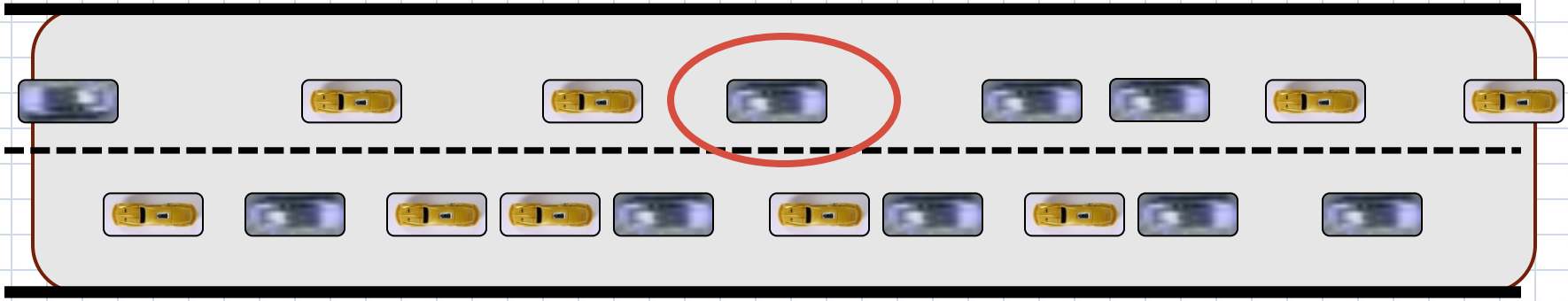
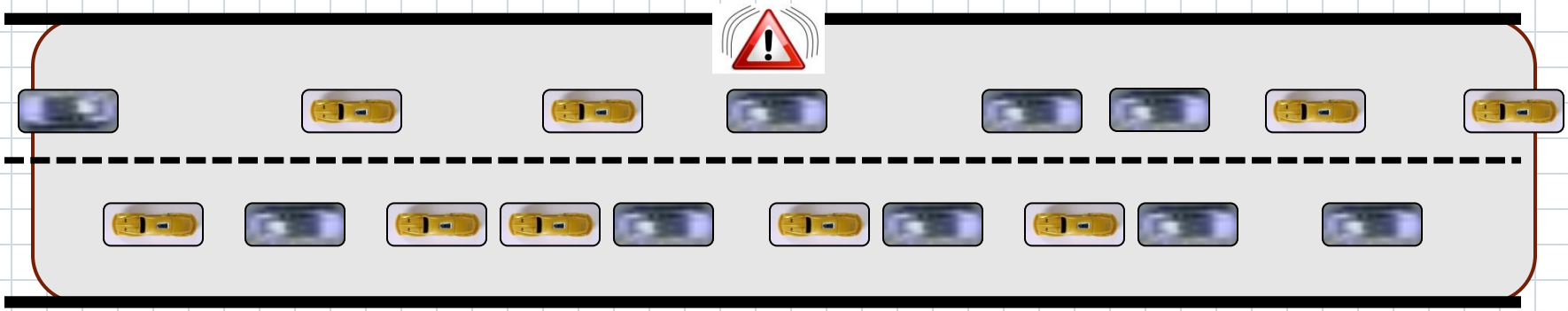
Collisions can not be avoided under high node density

The New Access Method

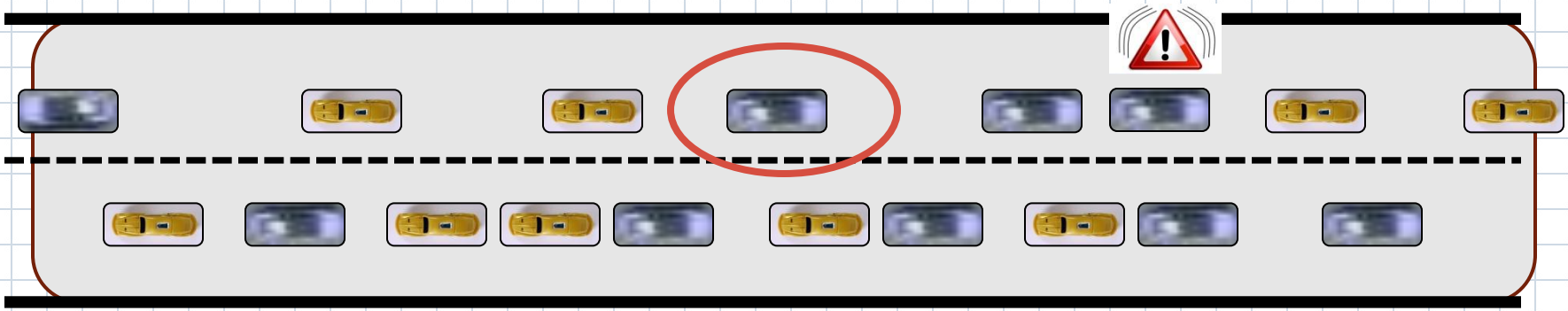


The New Access Method



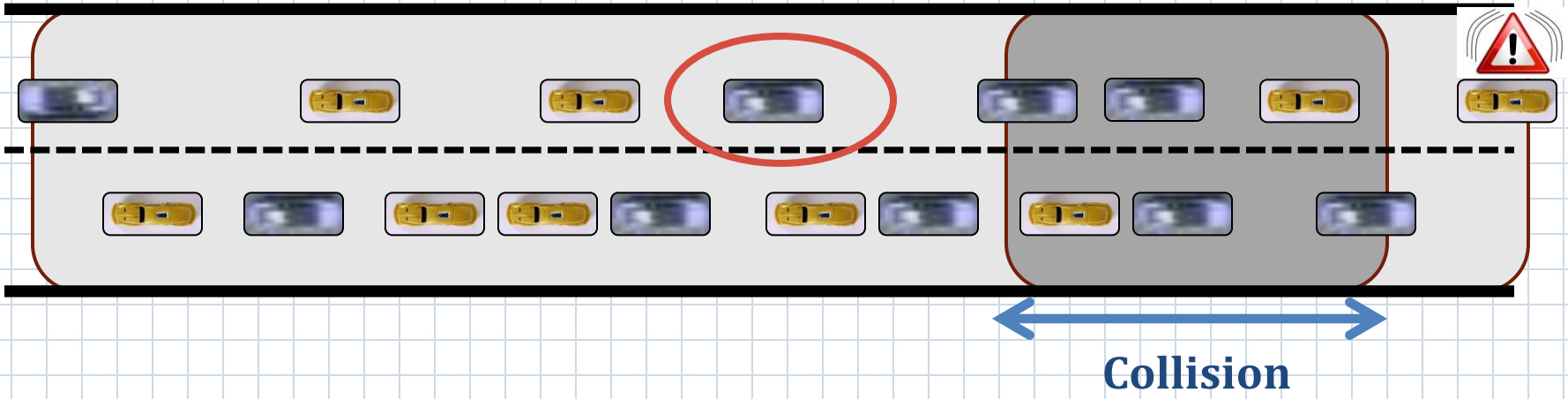
- Idle channel – transmit (IEEE 802.11 approach)

The New Access Method



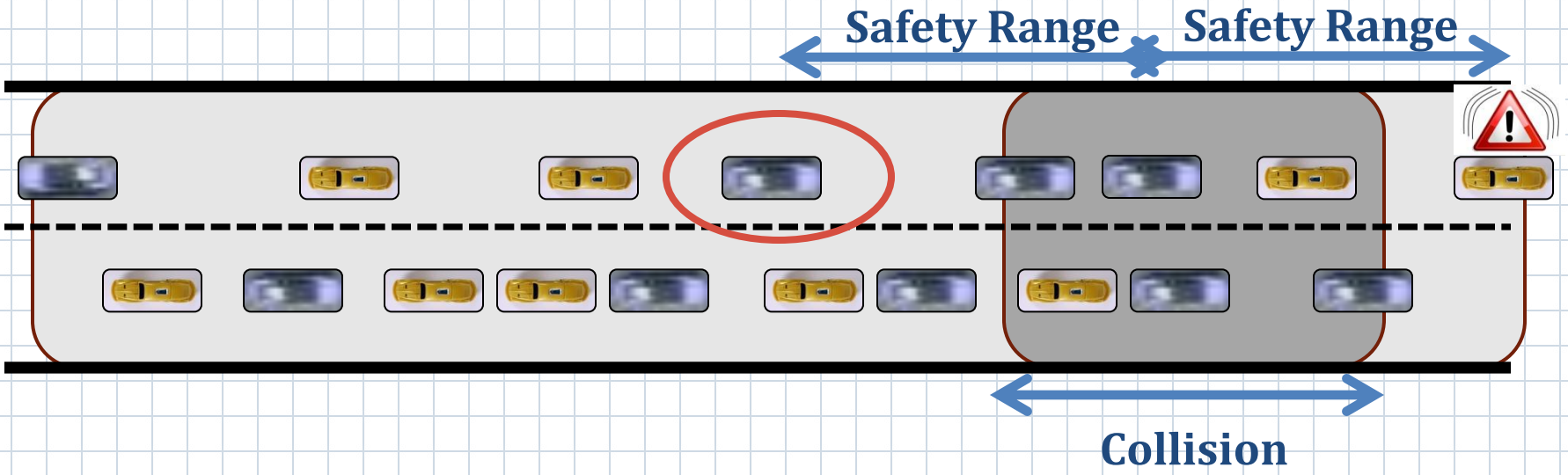
- Another transmission detected – estimate the position of the transmitter
- Cross layer approach (PLCP – MAC)

The New Access Method



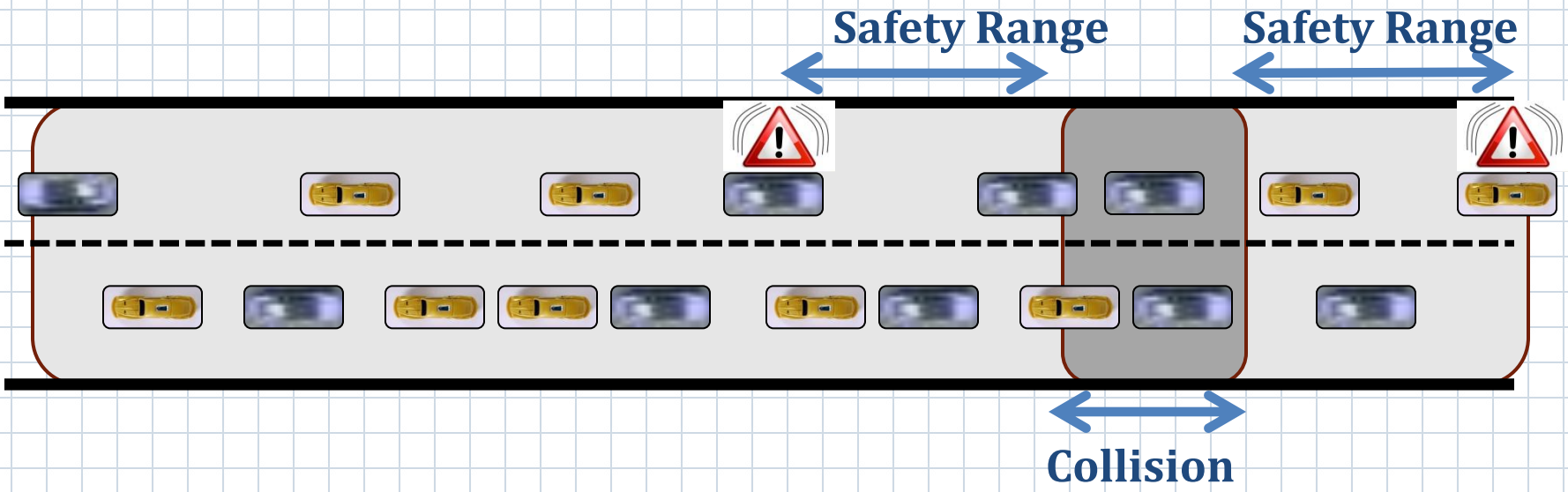
- Estimate if a collision could be solved by the capture effect inside the two safety ranges

The New Access Method



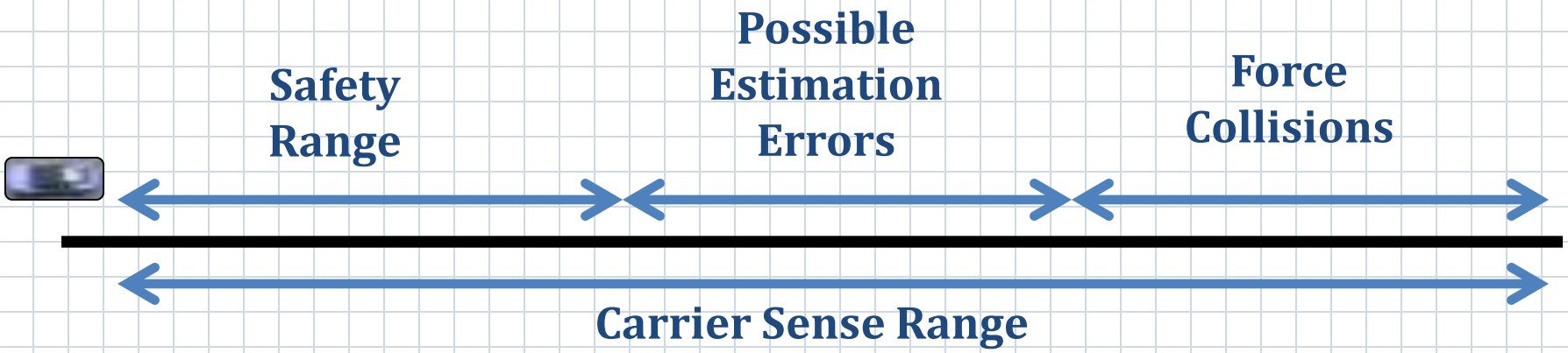
- One of the two safety zones is not safe, regardless of the used transmission power – back-off (IEEE 802.11 approach)

The New Access Method



- The safety zones are safe – transmit (using the highest transmission power that keeps them safe)

If you can't beat them, use them



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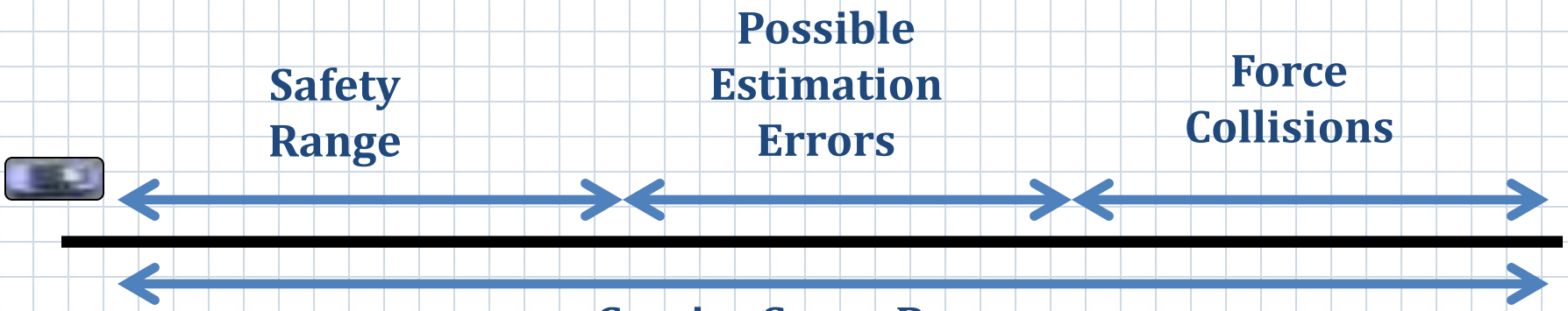
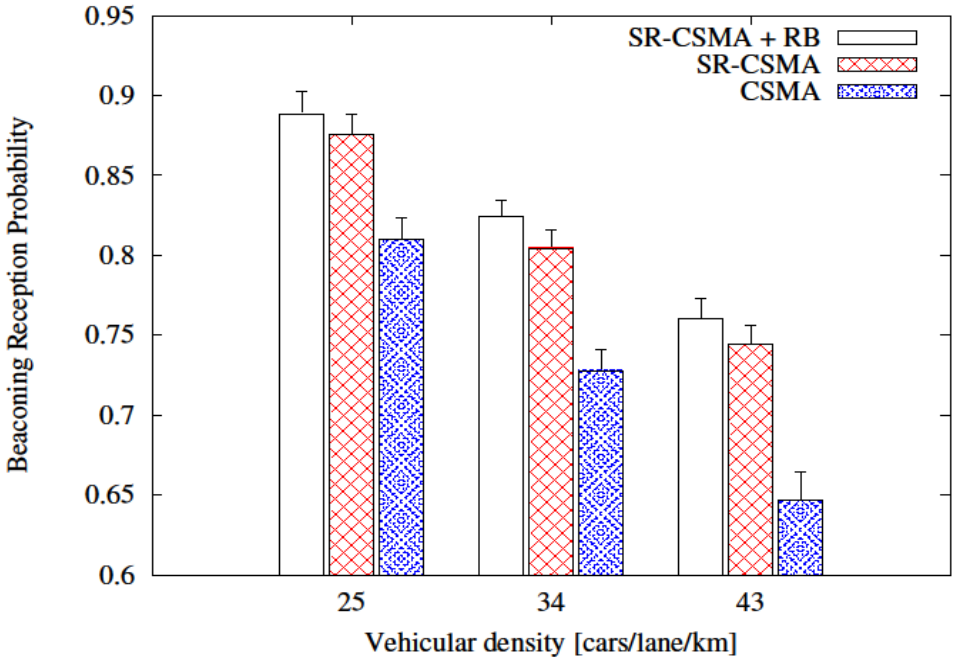


- ❑ Increased spatial reuse
- ❑ Higher (but manageable) interference
- ❑ More transmission opportunities
- ❑ More collisions at far distances
- ❑ Increased reception probability inside SR

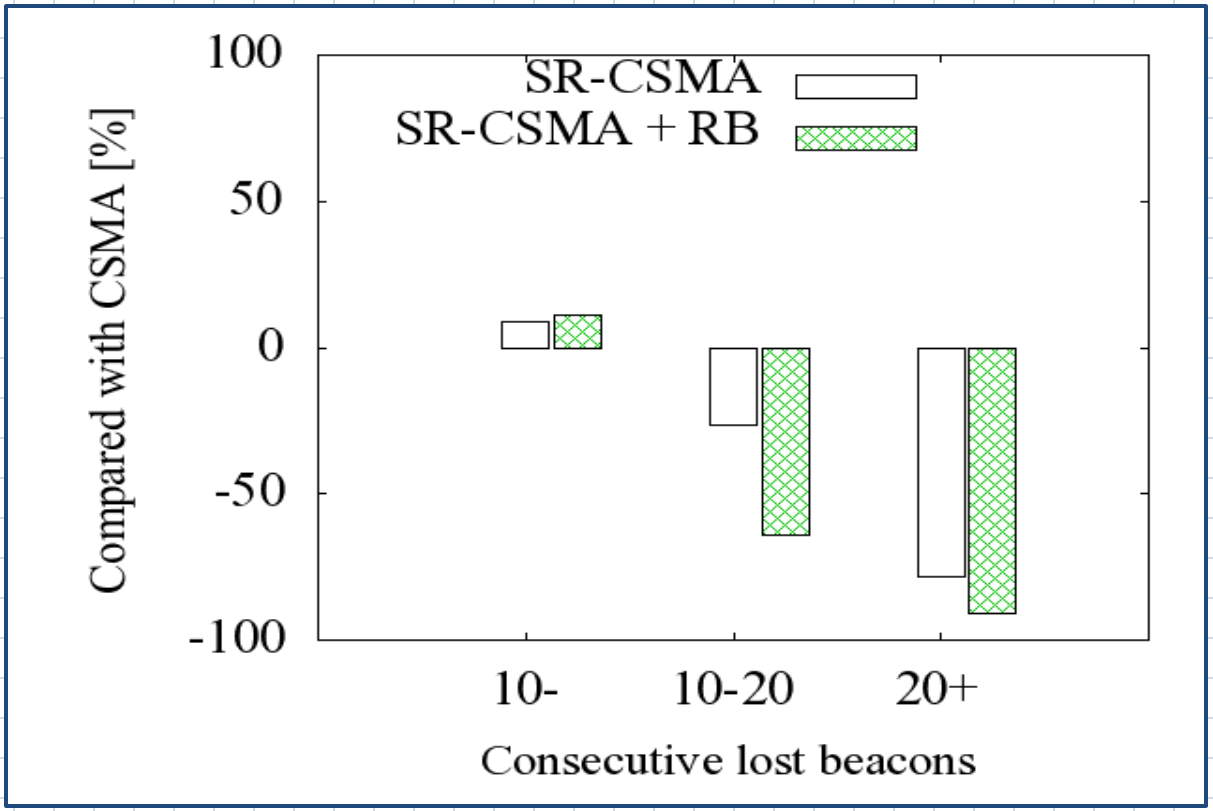
Reverse Back-off Mechanism

- Can not detect collisions
- We can detect expired beacons
- Relatively high initial CW (e.g. 127)
- CW = CW/2 after every expired beacon
- CW goes back to the initial value after N beacons

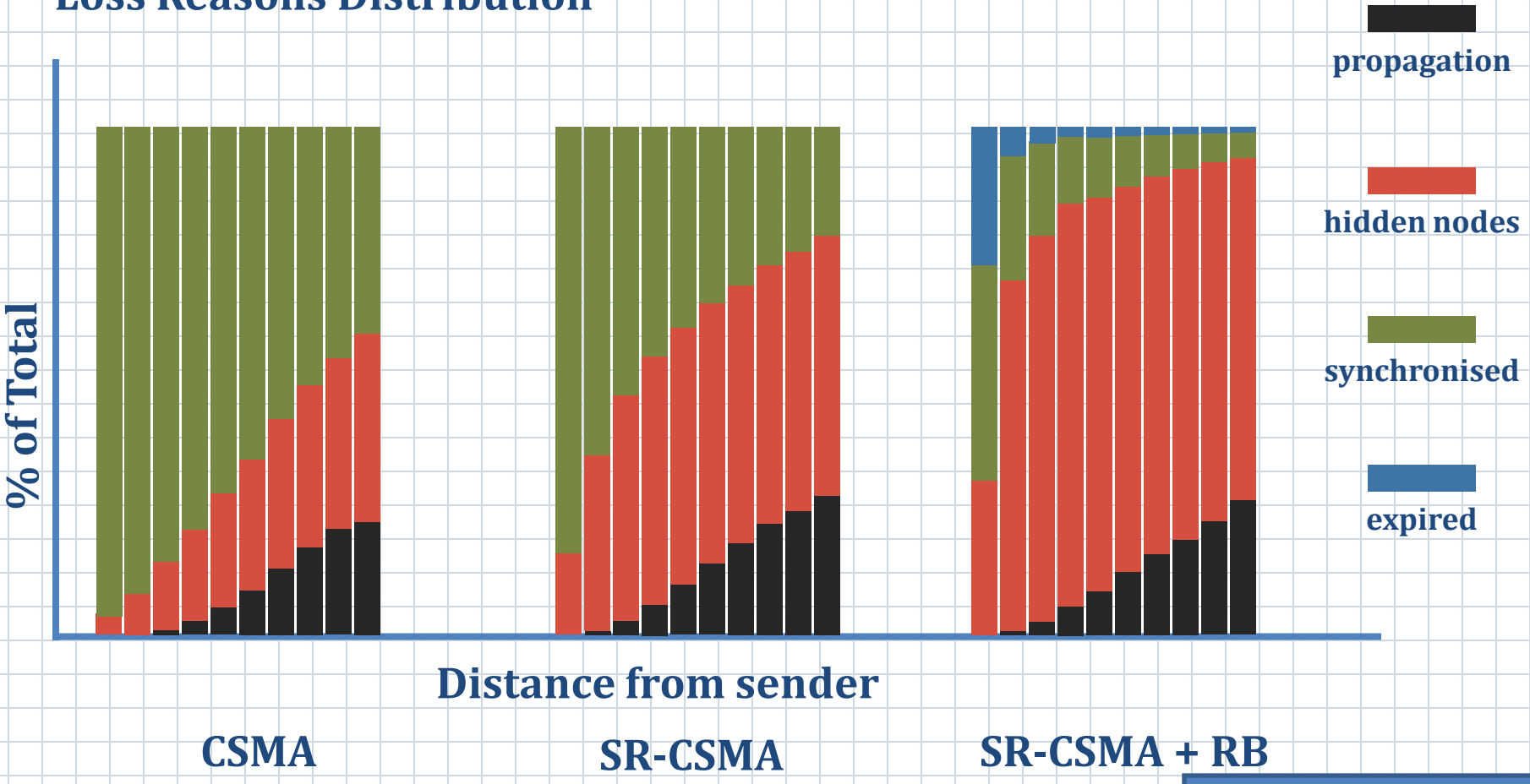
Reception Probability inside the Safety Range



Consecutive Lost Beacons



Loss Reasons Distribution



Conclusion

- The communication range in IEEE 802.11p is too long under high density
- Collisions are unavoidable (the load is larger than 1)
- Collisions with close neighbours have deeper consequences
- Force collisions with vehicles situated farther away to increase spatial reuse

Future Work

- Study of Special Notifications
- Impact of ranging techniques
- Implementation on real hardware

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