



# Redundancy Mitigation in Cooperative Perception for Connected and Automated Vehicles

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- Automated vehicles make use of multiple sensors for perception
  - Sensors limitations degrade perception capabilities
- Collective perception can complement and expand sensing capabilities
  - V2X exchange of sensor information: position, speed and size of detected objects
- Challenge: multiple vehicles can detect and report the same object
  - Reception of redundant information
- Proposal: mechanism to reduce object redundancy
  - Takes into account if nearby vehicles have transmitted each object

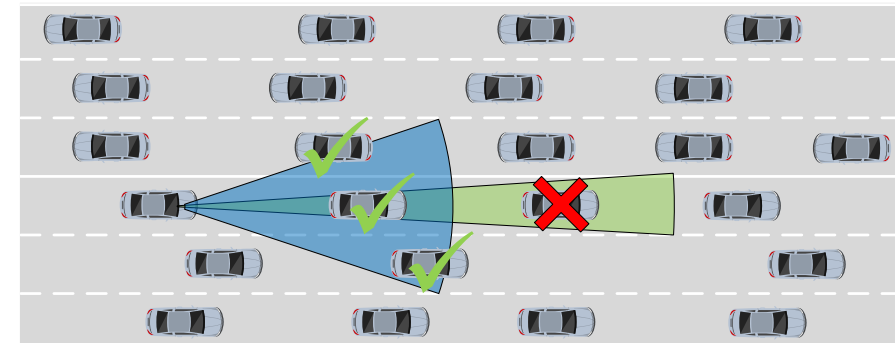
Included in ETSI TR  
103 562 about  
Collective Perception

- Based on continuous tx of CPM (Collective Perception Messages)
  - CPMs include information about detected objects and onboard sensors
  - Checks every  $T$  which detected object must be included in a new CPM
- Objects are included in a CPM considering the last tx CPM:
  - Included if position changed more than 4m since the last tx CPM
  - Included if speed changed more than 0.5m/s since the last tx CPM
- Does not take into account that multiple vehicles could detect the same object
  - A vehicle receives info about the same object if multiple vehicles detect it
  - Redundant information reduces system's scalability and efficiency

- An object is not included in a CPM if it has been recently tx by neighbour vehicle
  - Takes into account received CPMs to include or not each object in a new CPM
- Objects are included in a CPM considering the last rx CPM:
  - Included if position changed more than  $X$ m since the last rx CPM (max  $X=4$ m)
  - Included if speed changed more than  $X$ m/s since the last rx CPM (max  $X=0.5$ m/s)
- Reduces redundancy because objects are transmitted less often
  - Objects moving at higher speeds are included more often
  - Objects regularly included in a CPM by any of the vehicles detecting it
- Evaluation:  $X=1$ m and  $X=4$ m

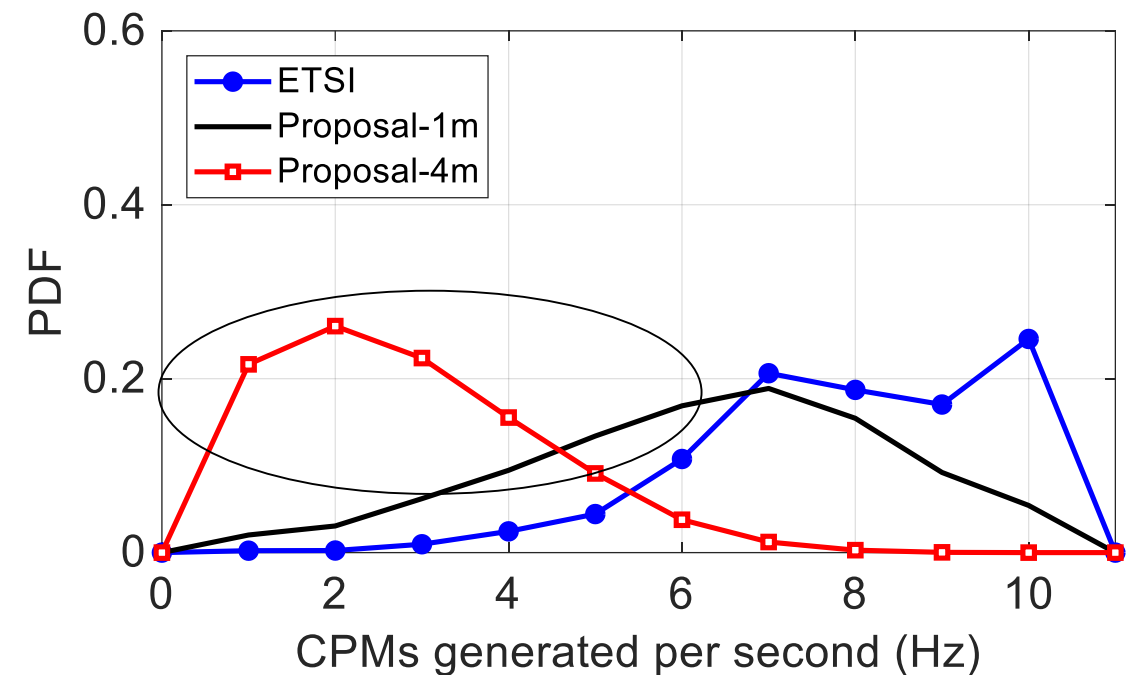
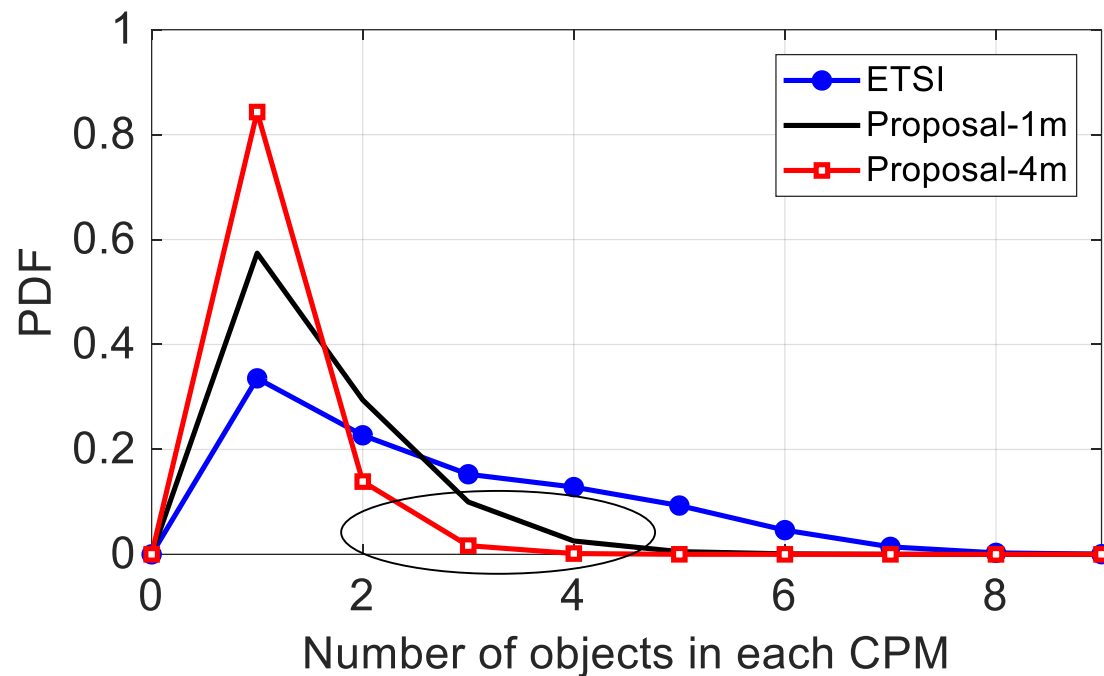
- Simulation tools: ns3 + SUMO
- Traffic parameters:
  - Highway scenario: 6 lanes
  - Traffic density: 120 vehicles/km
  - Speed: 70km/h-59km/h
- Onboard sensors:
  - 65m range and  $\pm 40$  degrees
  - 150m range and  $\pm 5$  degrees

Comms. parameter	Values
Transmission power	23dBm
Channel bandwidth/carrier freq.	10MHz / 5.9GHz
Energy detection threshold	-85dBm
Data rate	6Mbps (QPSK 1/2)



Only vehicles in Line of Sight can be detected

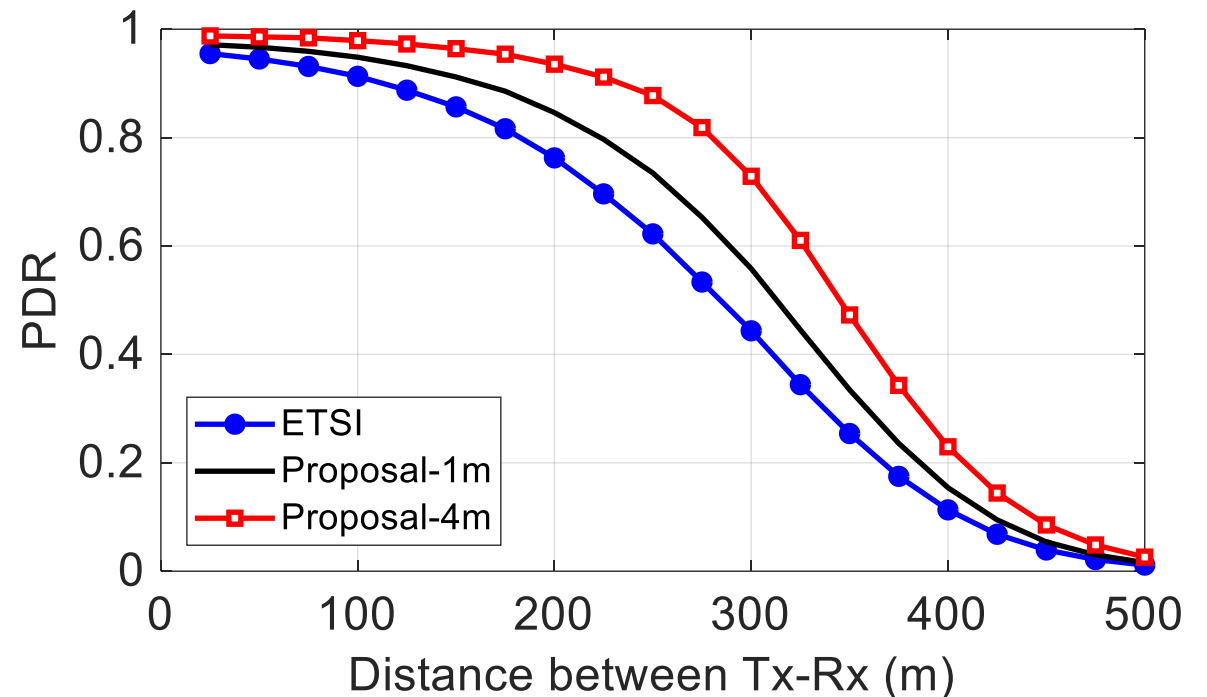
- Reduction of the CPM rate and size
  - Objects included in CPMs only when nearby vehicles have not recently transmitted them
  - Decrease of object transmission rate and message headers



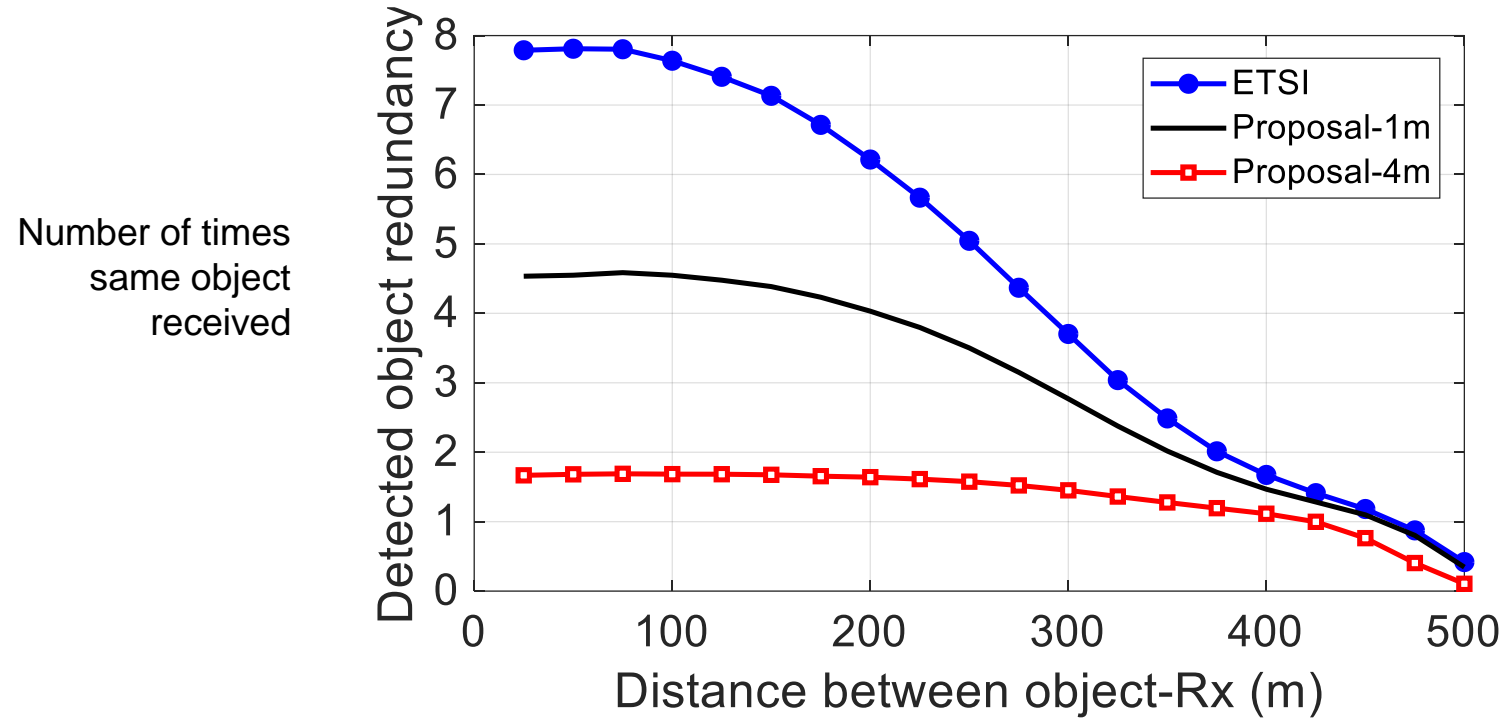
- Improvement of the V2X communications performance
  - Reduction of CBR thanks to the decrease of CPM size and rate
  - Enhancement of Packet Delivery Ratio (PDR) due to lower interference

Policy	CBR
ETSI	31.8 %
Proposal-1m	23.4 %
Proposal-4m	10.1 %

Channel Busy Ratio

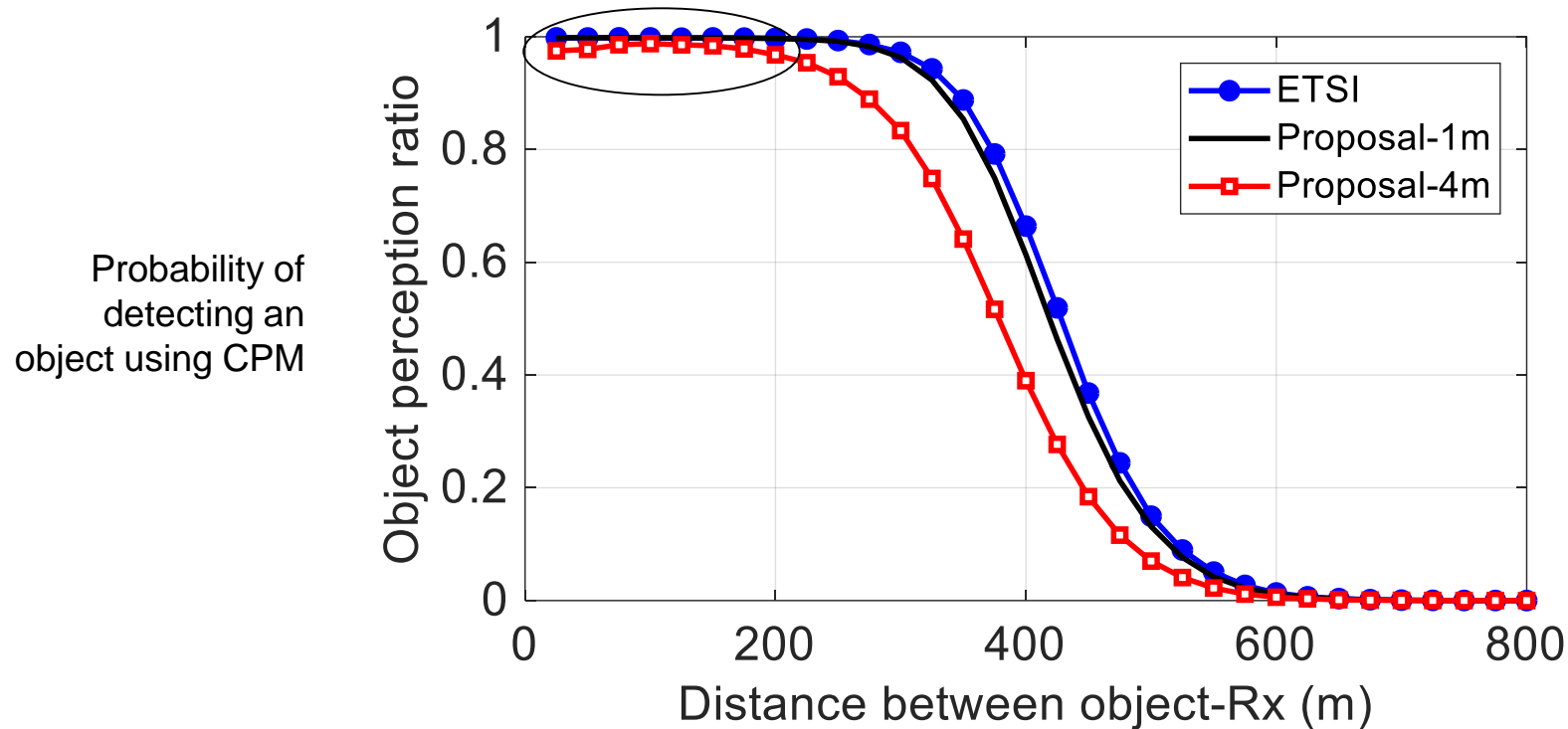


- Reduction of the detected object redundancy
  - Proposal effectively reduces the number of object updates
  - Effective control of transmitted redundant information





- Object perception ratio: trade-off between perception and channel load
  - Proposal-1m achieves similar perception to ETSI while using 26% lower CBR
  - Proposal-4m achieves lower perception, but with 68% less CBR



- Collective perception designed to share sensor information
  - Improves perception capabilities of connected and automated vehicles
- Multiple vehicles detecting the same object: tx the same information
  - Unnecessary redundancy reduces system's capacity
- Proposal based on objects dynamics and received redundant information
  - Reduces redundancy and channel load (30-70% reduction)
  - Maintains high perception for critical distances

# Thank you for your attention



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