Simulation Study on Collective Perception

Gokulnath Thandavarayan, Miguel Sepulcre, Javier Gozalvez

Universidad Miguel Hernandez (Spain)
msepulcre@umh.es

www.transaid.eu
@transaid_h2020
www.linkedin.com/groups/13562830/
www.facebook.com/transaidh2020/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723390

Content

- Objectives
- Simulation set-up
- Simulation results
  - CPM generation
  - Network-based performance metrics
  - Application-based performance metrics
  - Efficiency metrics
- Summary
- Next steps

Objectives

- Deeper understanding of the operation of current CPS
- Evaluating the performance and efficiency of current CPS
- Comparison with periodic message generations
- Identify next steps to evolve current CPS

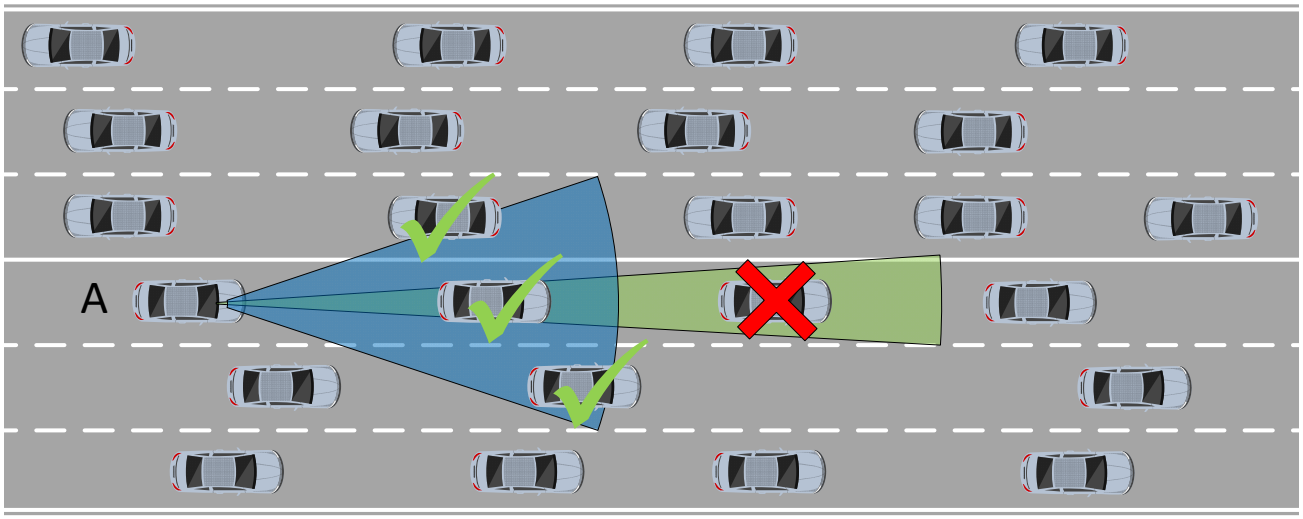
Simulation set-up

- ns3 simulator
  - Future integration into iTETRIS simulation platform.
- CPS implementation:
  - CPM generation rules:
    - Dynamic (DYN): objects included in a CPM every 4m, etc.
    - Periodic (P2): periodic tx of CPM at 2Hz.
    - Periodic (P10): periodic tx of CPM at 10Hz.
  - CPM container sizes calculated offline using the ASN.1
    - Management Container = 121 Bytes.
    - Sensor Container = 35 Bytes per sensor.
    - Perceived Object Container = 35.4 Bytes per object.

Simulation set-up

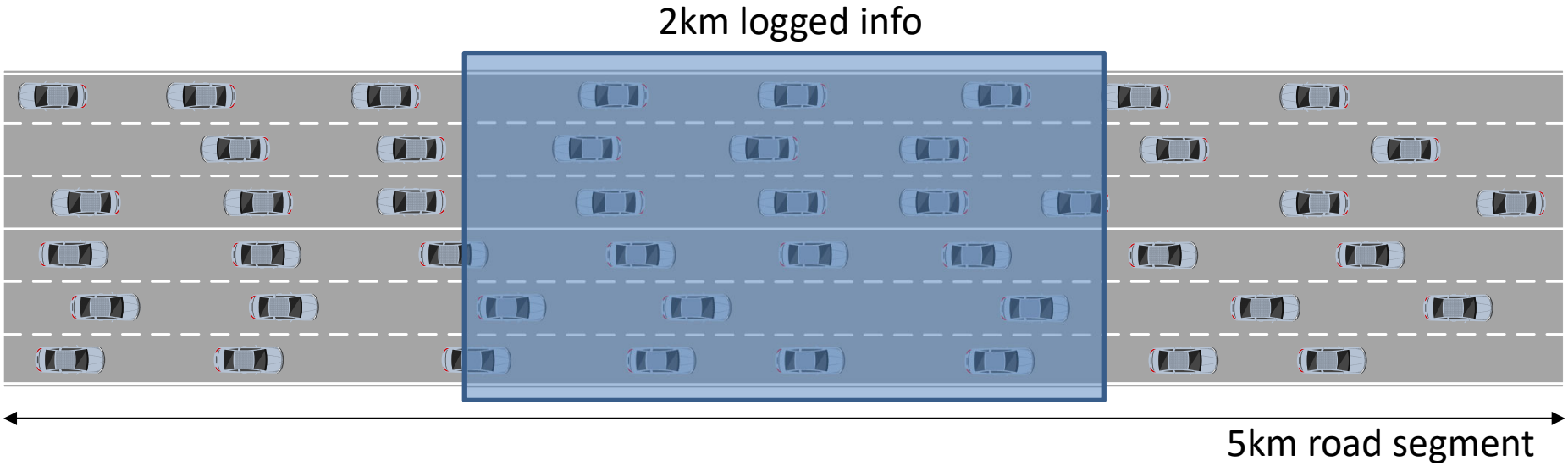
- Onboard sensors:
  - 65m range and ±40 degrees.
  - 150m range and ±5 degrees.

Only vehicles in Line of Sight can be detected



Simulation set-up

- Traffic parameters:
  - 5km road segment with 6 lanes (2 driving directions)



  - High traffic density: 120 vehicles/km
    - Speeds per lane: 70km/h, 66km/h and 59km/h
  - Low traffic density: 60 vehicles/km
    - Speeds per lane: 140km/h, 132km/h and 118km/h

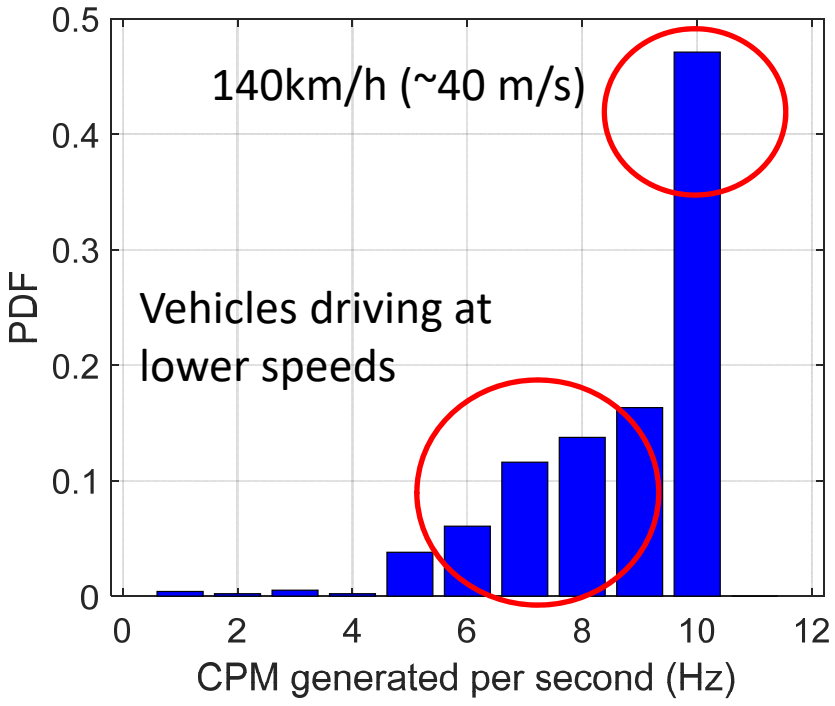
Simulation set-up

- Communication parameters:
  - Transmission power: 24dBm
  - Antenna gain (tx and rx): 1dBi
  - Channel bandwidth/carrier freq.: 10MHz / 5.9GHz
  - Noise figure: 9dB
  - Energy detection threshold: -85dBm
  - Data rate: 6Mbps (QPSK ½)
  - Propagation model: Winner+B1 (pathloss and shadowing)

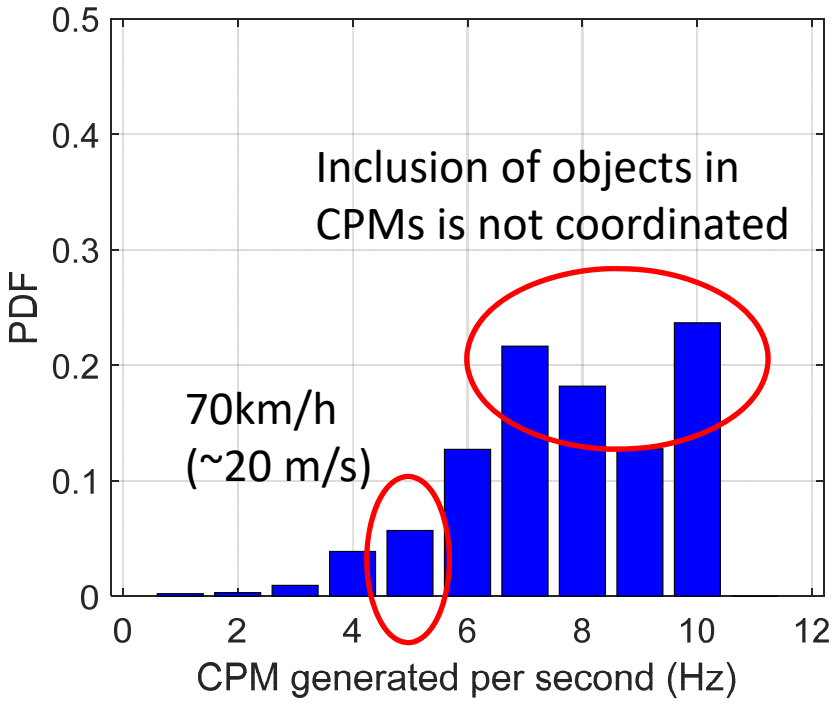
- Simulation parameters:
  - Simulation time: 50s
  - Seeds: 5

CPM generation

- Number of CPM tx per sec depends on speed and density.
  - Low traffic density (high speed): most vehicles tx 10Hz.
  - High traffic density (low speed): tx between 4 and 10Hz.



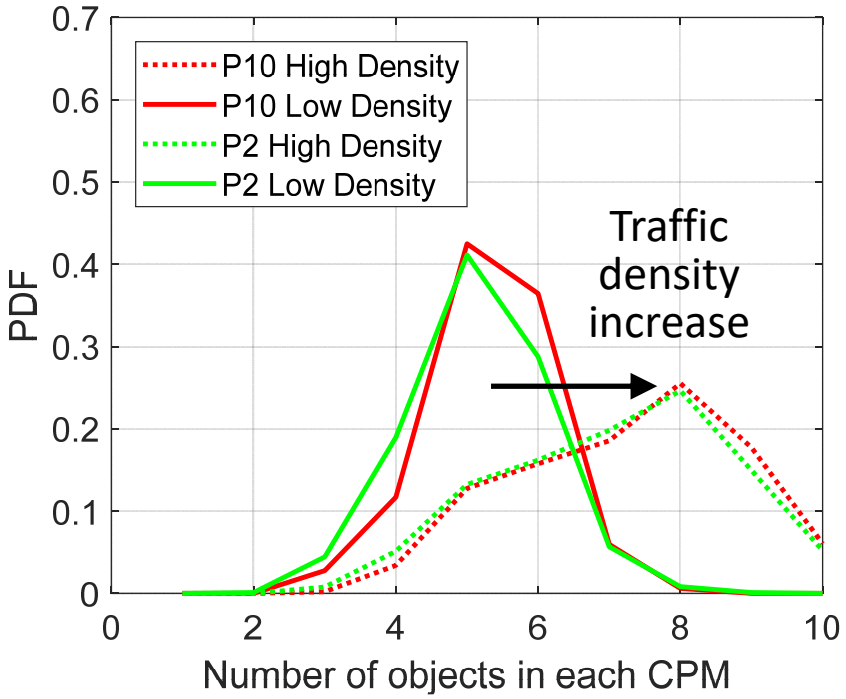
Low traffic density

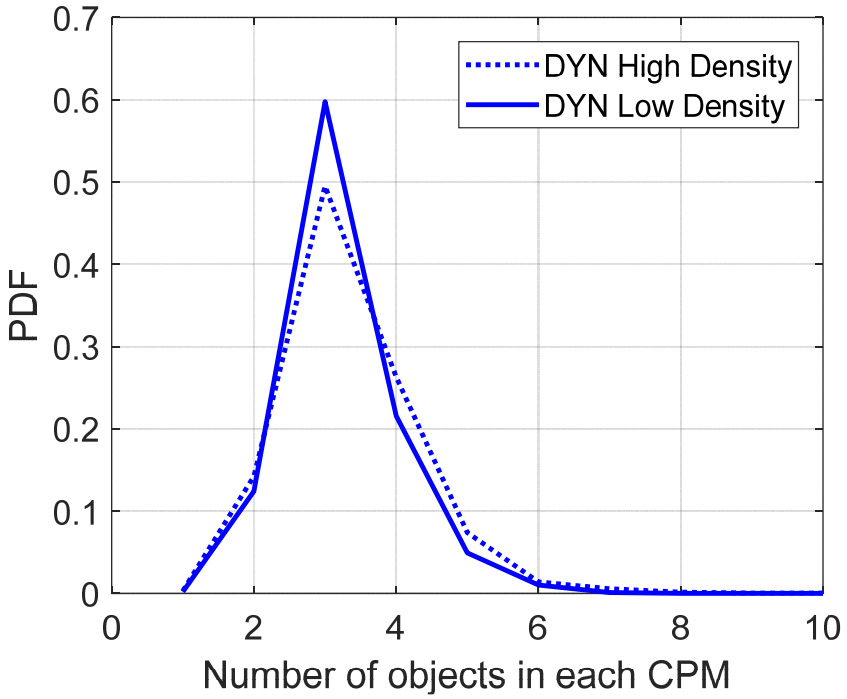


High traffic density

CPM generation

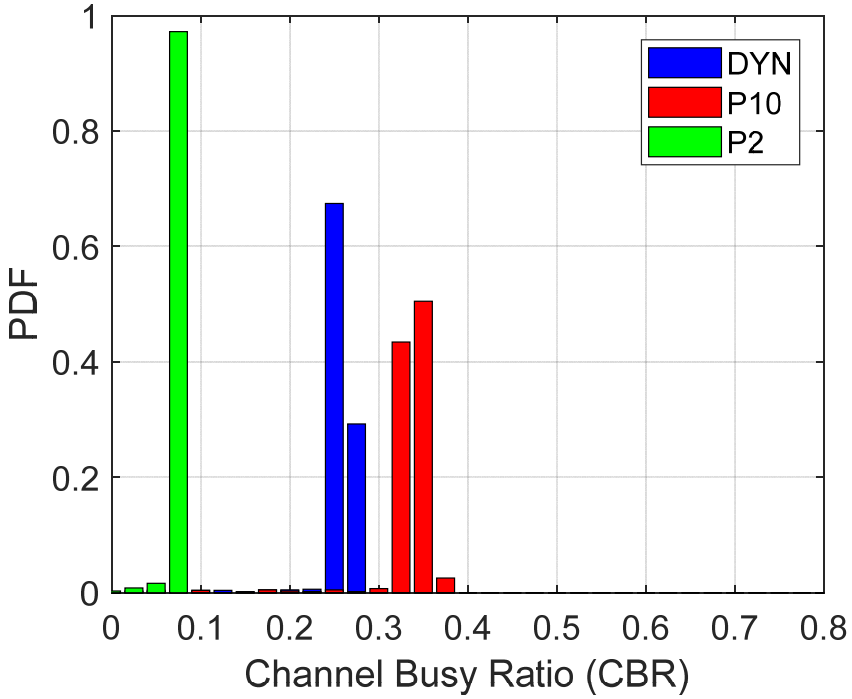
- Number of objects transmitted in each CPM
  - P2 and P10: higher objects/CPM for higher densities.
  - DYN: traffic density does not affect number of objects/CPM.
    - DYN: higher density implies lower speed ⇨ tx less updates.



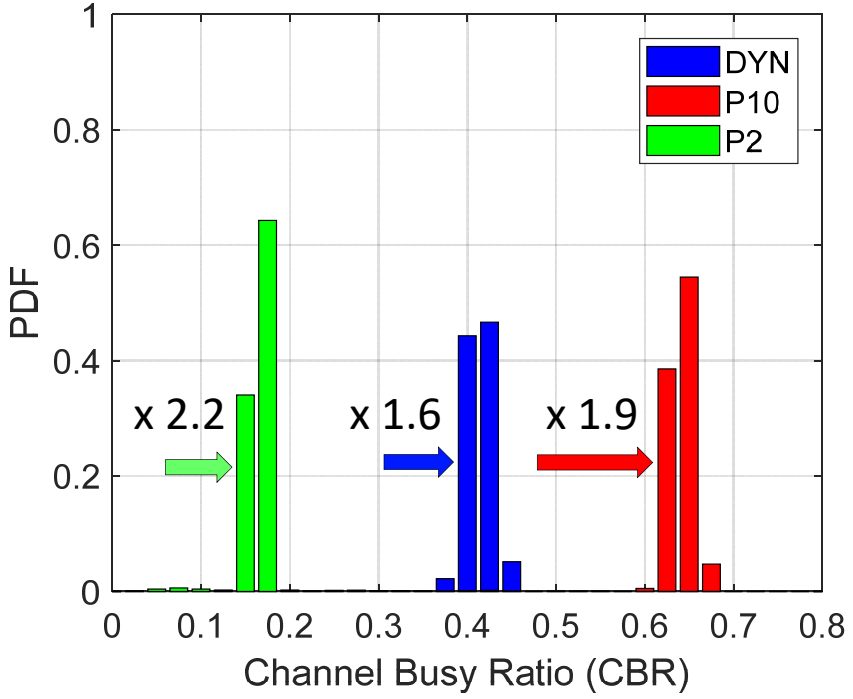


Network-based performance metrics: CBR

- CBR: percentage of time that the channel is busy
  - P10 generates the highest load and P2 the lowest one.
  - Traffic density inrease: higher channel load.
    - Smallest relative increase for DYN due to lower speeds.



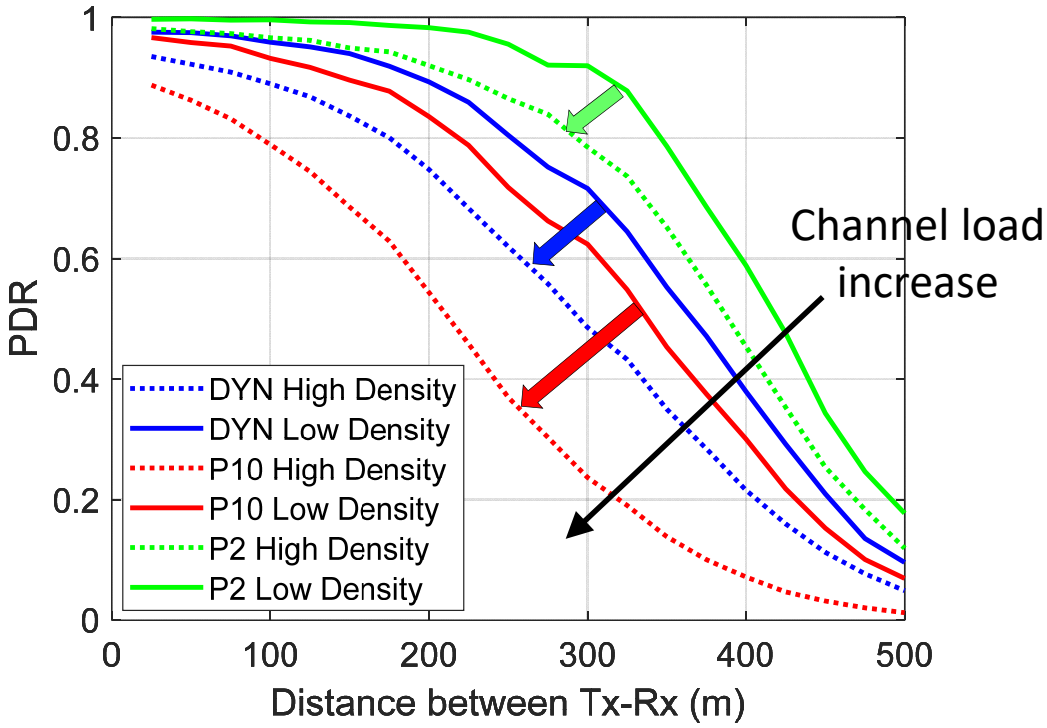
Low traffic density



High traffic density

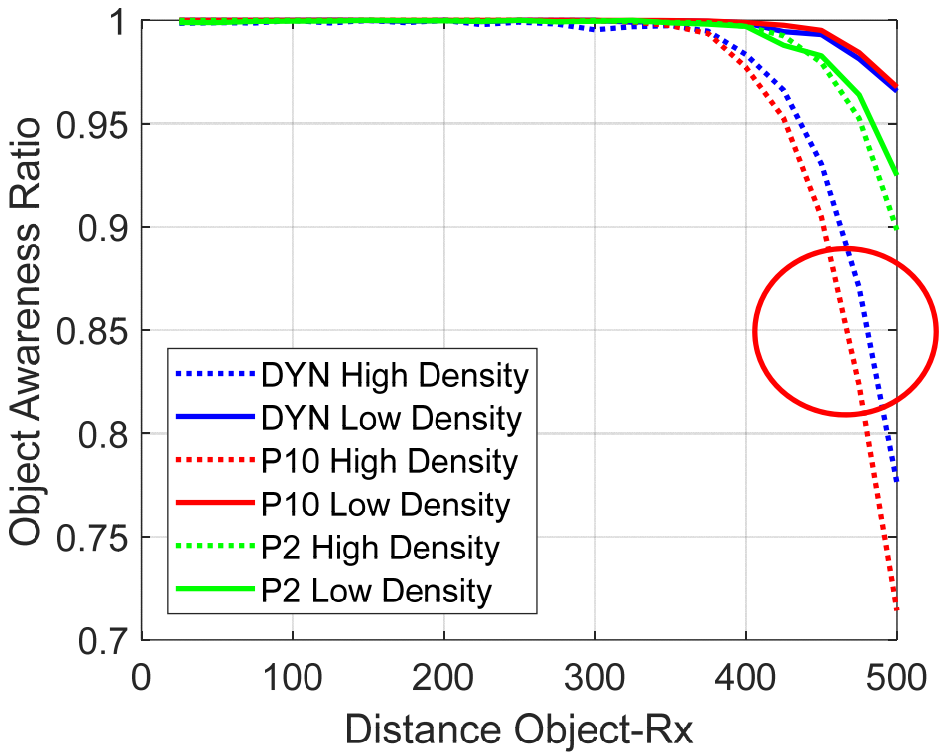
Network-based performance metrics: PDR

- Packet Delivery Ratio: prob of successfully receiving a CPM
  - Propagation and interference reduce the PDR.
  - Higher PDR for approaches with lower channel load.



Application-based performance metrics: OAR

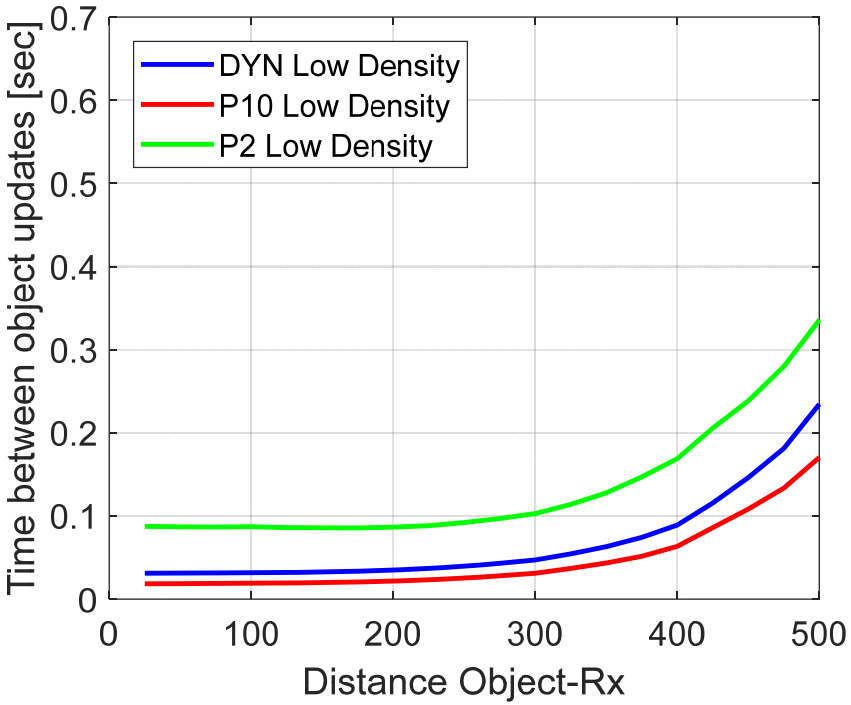
- Object Awareness Ratio: prob of *detecting* an object
  - Very high object awareness ratio for all configurations.
  - Degradation beyond 400m for P10 and DYN (high density).



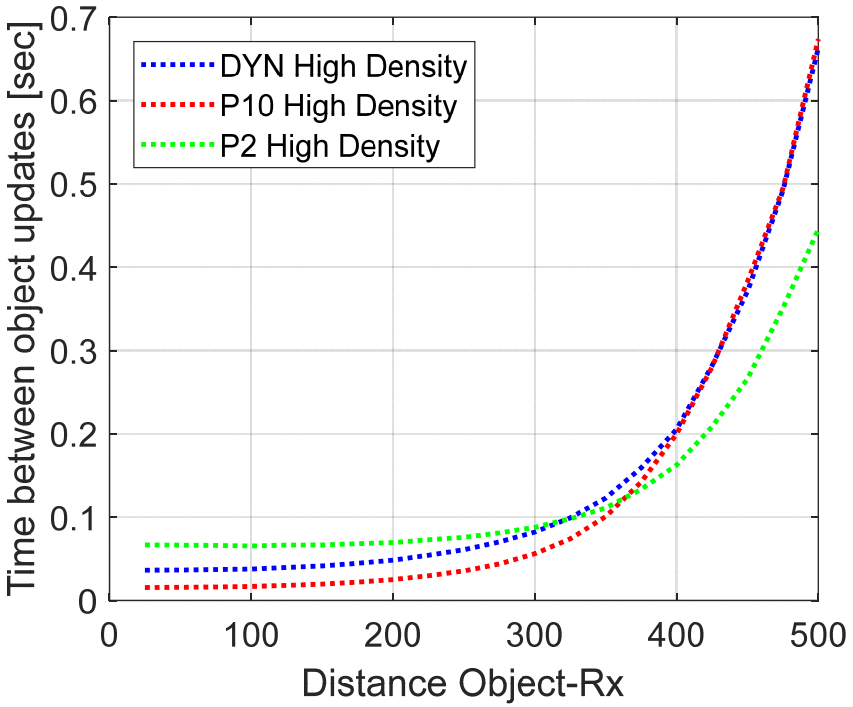
We consider that an object is successfully detected if at least one CPM it is received within a second with info about it.

Application-based performance metrics: TBU

- Time between object updates: average time difference between updates about an object.
  - All: time between object updates below 0.1s up to 300m.
  - DYN can provide updates every 0.04s up to 200m.



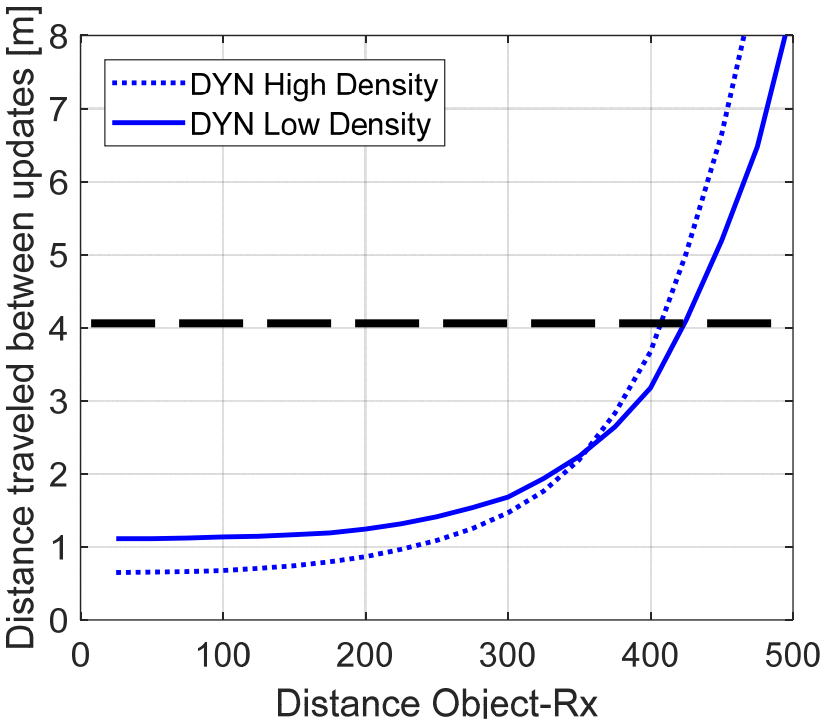
Low traffic density

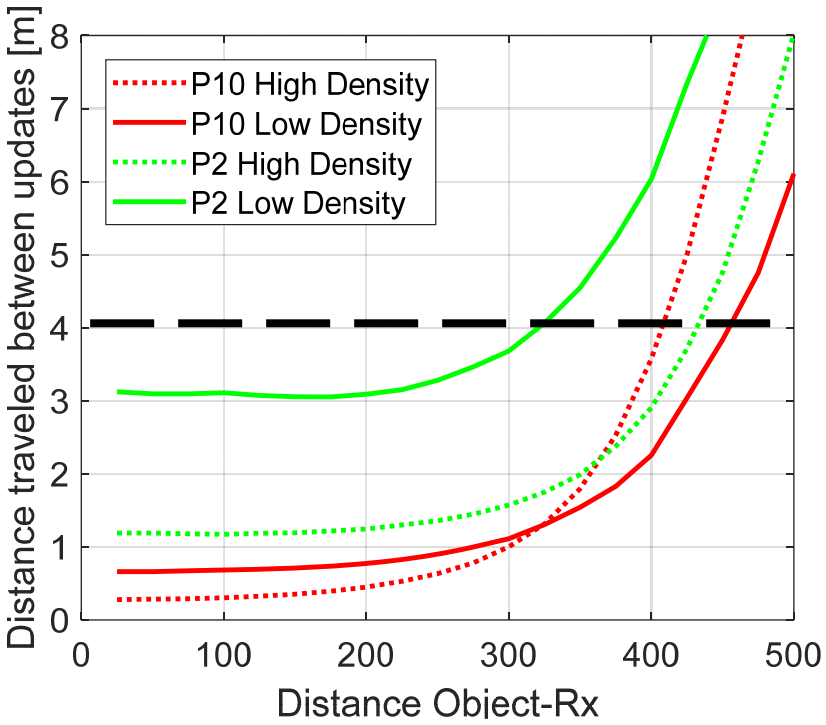


High traffic density

Application-based performance metrics: DT

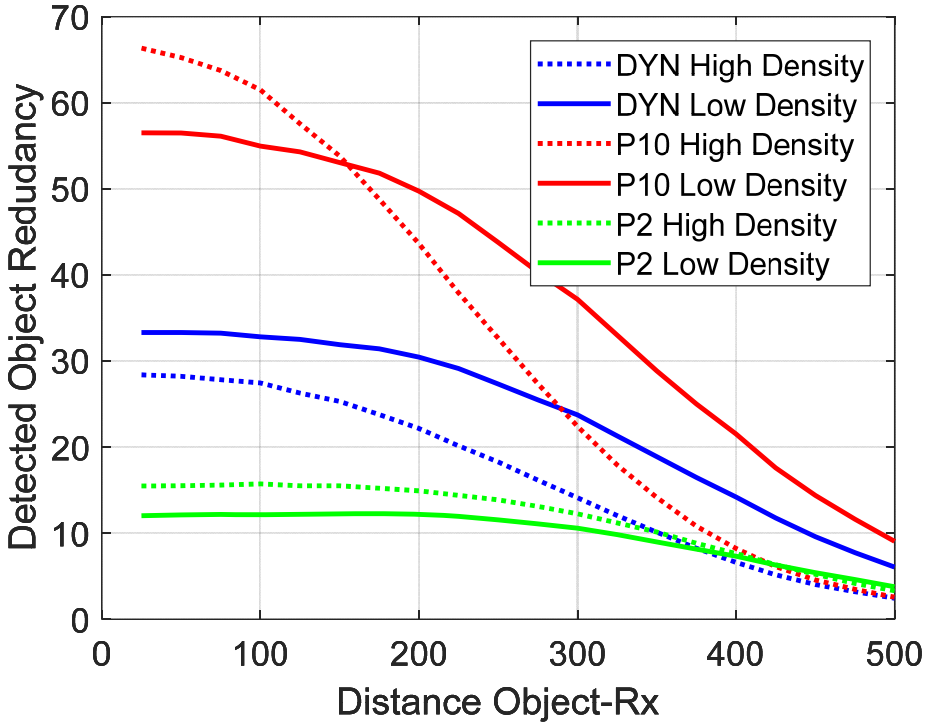
- Distance travelled by an object between updates.
  - DYN: provides updates below 2m for up to 300m.
  - P2: provides updates below 4m for up to 300m.
    - Is 4m the target threshold?





Efficiency metrics: DOR

- Detected Object Redundancy: number of updates about same object received per second.
  - All approaches provide a high number of updates / sec.



Summary

- DYN CPM generation
  - Efficient adaptation of # objects per CPM to traffic density.
  - Improvement of object selection could reduce # CPM rate.

- Application oriented metrics
  - DYN provides very high object awareness ratio.
  - Similar than P2, but P2 consumes lower channel load.

- Efficiency
  - DYN provides object updates every 2m (or 0.04s).
  - DYN provides ~30 object updates per second.

Next steps

- Deeper performance analysis
  - Differentiate packet error types (collision, propagation, etc.).
  - Percentiles 5th/95th and 25th/75th.

- More advanced traffic and sensor simulation
  - Mobility traces (SUMO).
  - 360º sensors.

- Study the effect of other Facilities/Protocols on CPS
  - Other messages (e.g. CAMs).
  - Integration with ETSI DCC.

- Design methods to reduce unnecesary redundancy
  - Too frequent updates might not be needed.

Thank you for your attention!

Gokulnath Thandavarayan, Miguel Sepulcre, Javier Gozalvez

Universidad Miguel Hernandez (Spain)
msepulcre@umh.es

www.transaid.eu
@transaid_h2020
www.linkedin.com/groups/13562830/
www.facebook.com/transaidh2020/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723390