On the Delay to Reliably Detect Channel Availability in Cooperative Vehicular Environments

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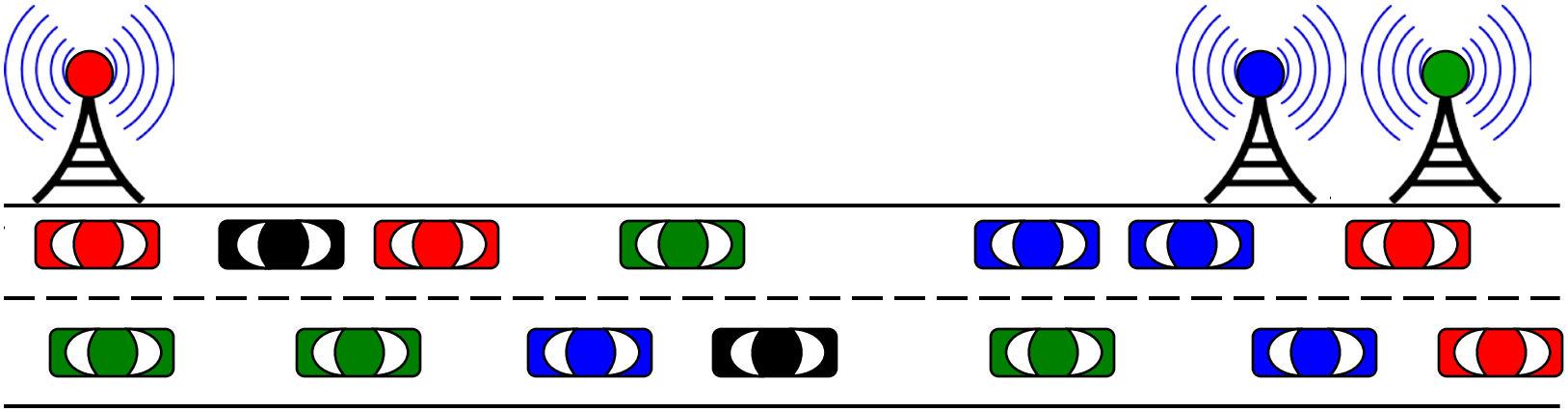
Overview

- Motivation
- System overview
- Single sensor performance
- Cooperative sensing performance
  - AWGN only
  - Vehicular environment

Why sensing in vehicular networks?

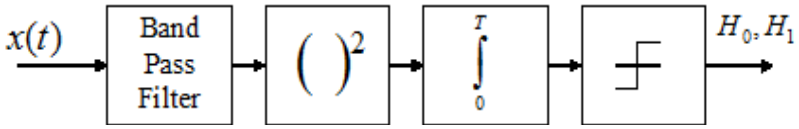
- In licensed band:
  - To help deal with network congestion
  - To help ensure meeting QoS requirements
- In unlicensed band:
  - To enable usage of bands like TV white space

Sensing for dealing with congestion and QoS

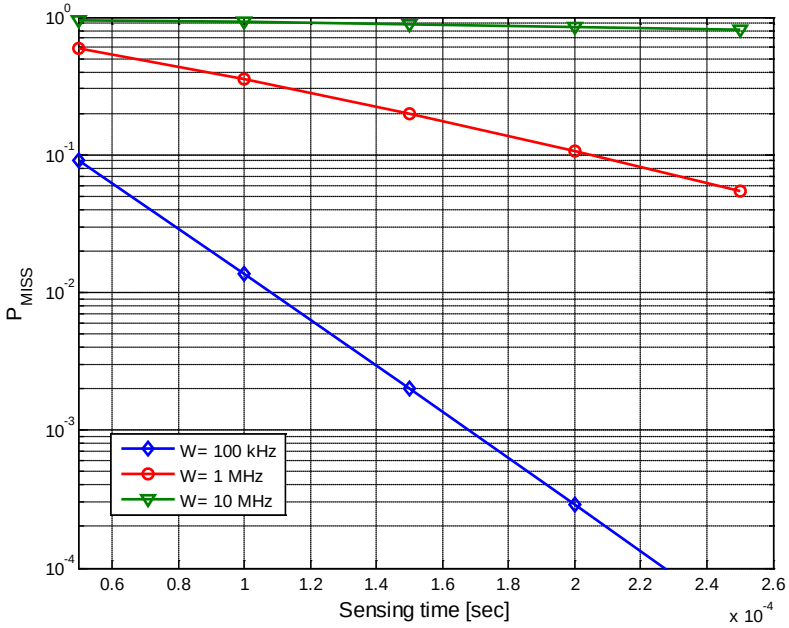


- Increased number of users and applications may cause congestion even with coordination/CSMA/CA
- Users aware of free spectrum may move to other band(s)

Single Sensor Performance

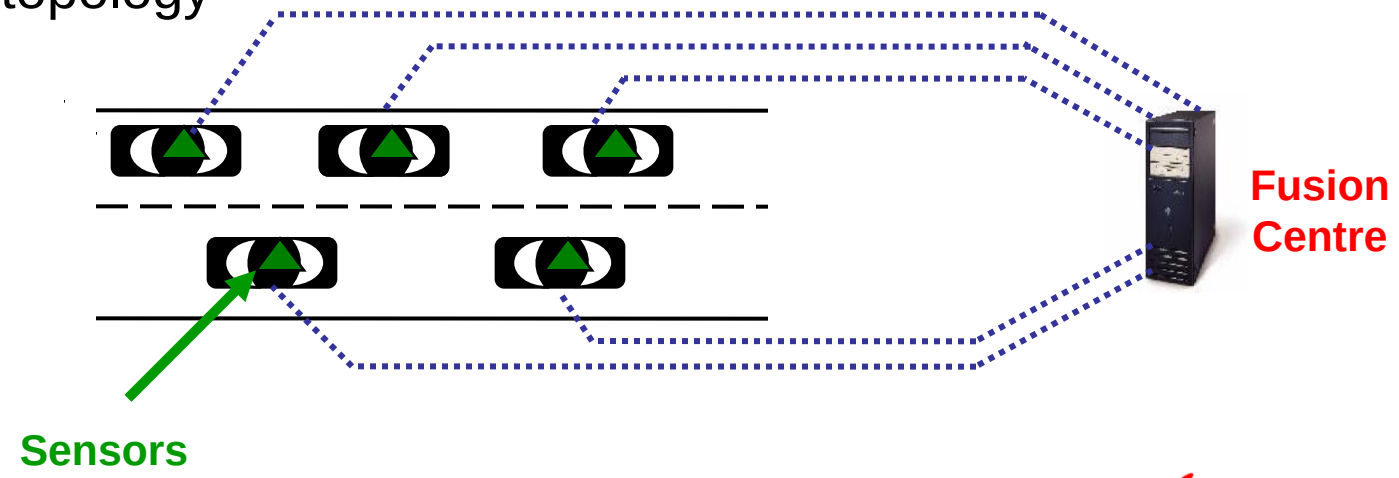


- Energy detector
- Performance depends on:
  - Received signal level
  - Observation time
  - Observed bandwidth
  - Ability to accurately determine noise level



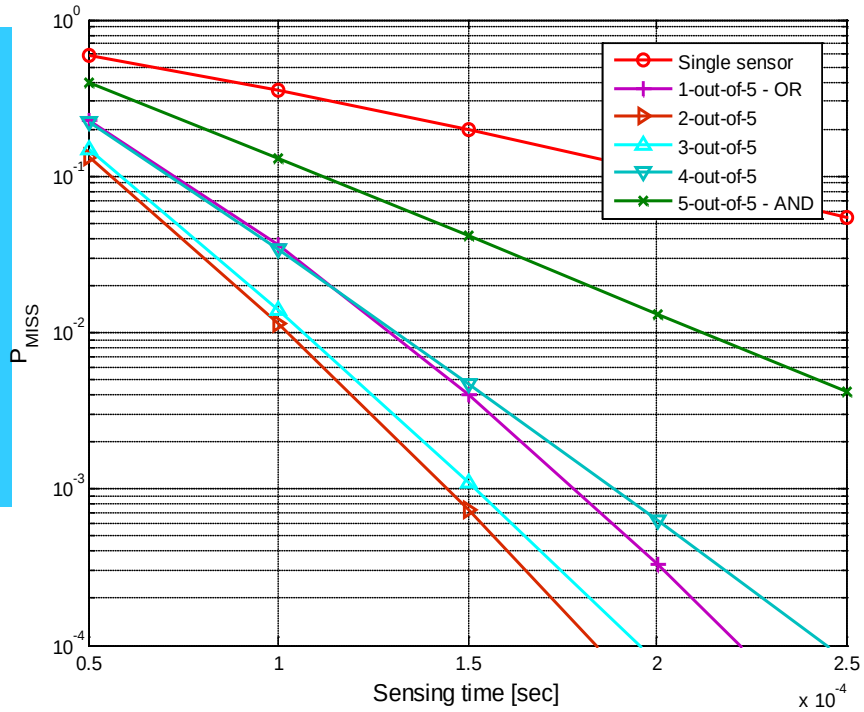
Cooperative Sensing

- Hard fusion – sensors deliver sensing decisions – logical K-out-of-M fusion
- Soft fusion – sensors deliver measured value – Equal gain combining (EGC)
- Performance depends on:
  - Selected fusion technique
  - Sensor topology

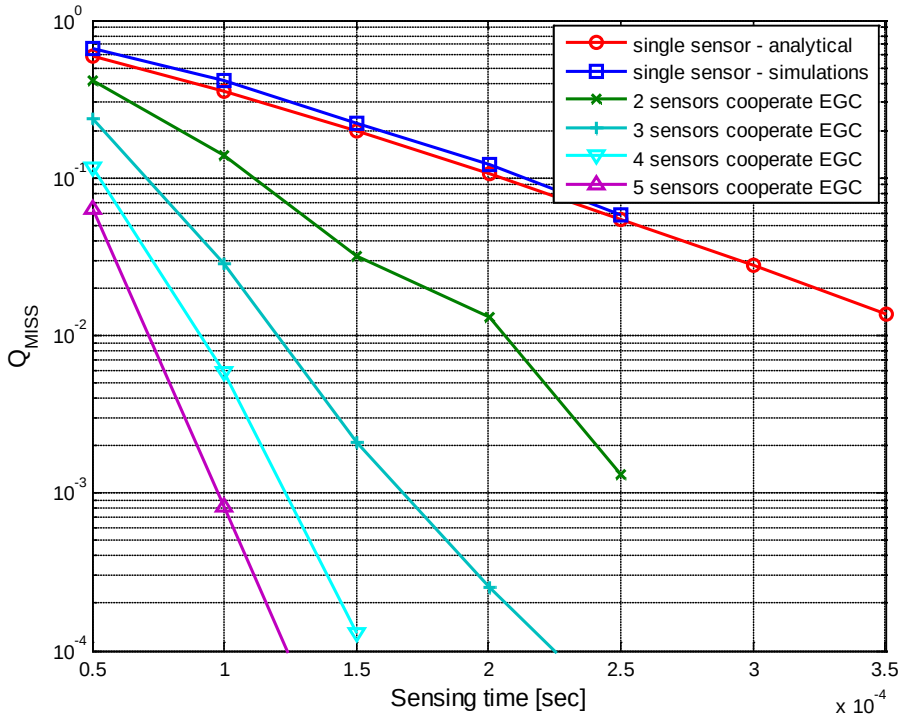


Cooperative sensing in AWGN

- Hard fusion:



- EGC fusion:



Vehicular channel

- Pathloss model [Cheng et al, 2007]:

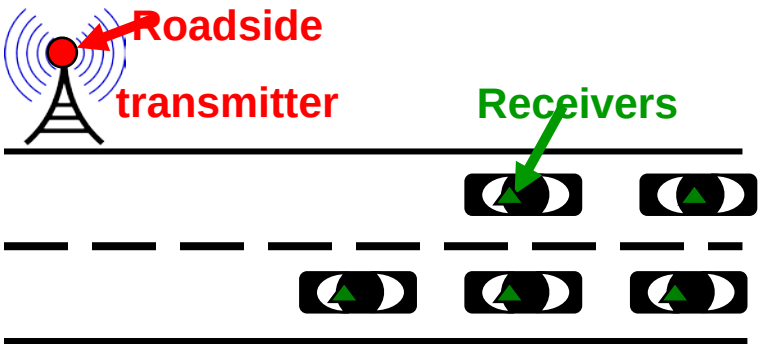
$$P_d = \begin{cases} P(d_0) - 10\gamma_1 log_{10}(\frac{d}{d_0}) + X_{\sigma_1} & if\ d_0 \le d \le d_c \\ P(d_0) - 10\gamma_1 log_{10}(\frac{d_c}{d_0}) - 10\gamma_2 log_{10}(\frac{d}{d_c}) + X_{\sigma_2} & if\ d \ge d_c \end{cases}$$

$d_c = 100m \quad \gamma_1 = 2.1 \quad \sigma_1 = 2.6dB \quad \gamma_2 = 3.8 \quad \sigma_2 = 4.4dB$

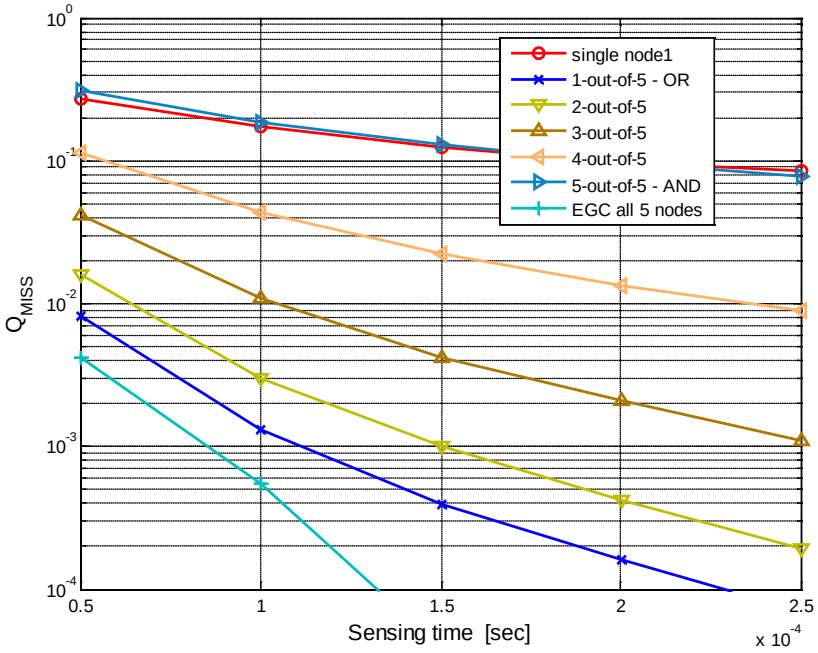
- Nakagami fading parameter dependant on distance

Distance bin [m]	μ
From 0.0 to 5.5	4.07
From 5.5 to 13.9	2.44
From 13.9 to 35.5	3.08
From 35.5 to 90.5	1.52
From 90.5 to 230.7	0.74
From 230.7 to 588.0	0.84

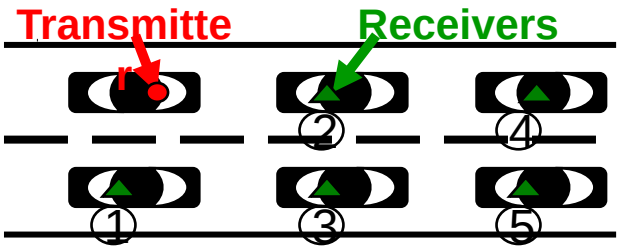
Infrastructure to Vehicle (I2V)



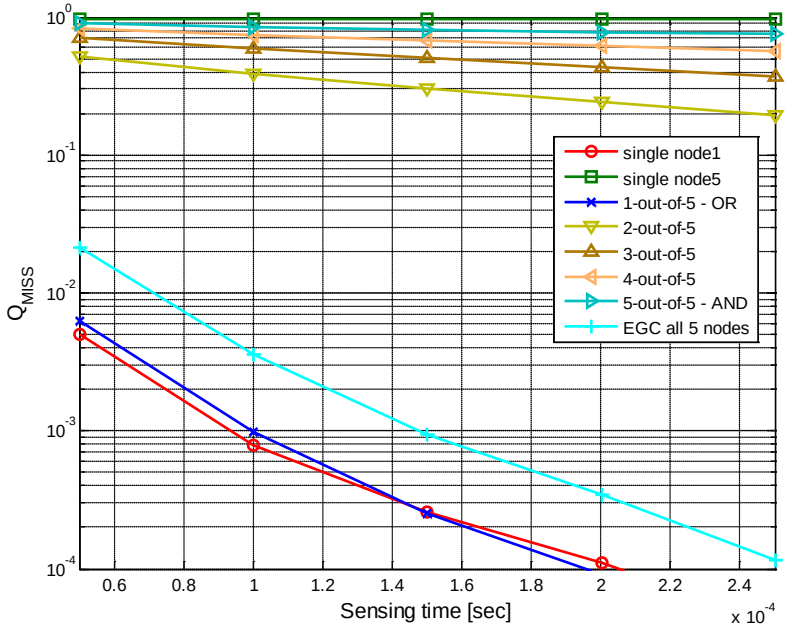
- All sensors have similar average SNR
- Favors EGC



Vehicle to Vehicle (V2V)



- Sensor # 1 with highest average SNR
- Favors OR fusion



Conclusions

- Goal: how to balance need for fast and reliable sensing
- Single sensor:
  - Larger bandwidth sensing introduces more delay
- Cooperative sensing in vehicular scenarios:
  - I2V scenario favors soft decision combining
  - V2V scenario gains the most when the OR hard fusion rule
  - OR rule is good alternative to EGC

Q&A

Thank you!