CAR 2 CAR Roadmap

Precise Positioning Service for future C-ITS Applications

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Irfan Khan, Gia-Minh Hoang, Jérôme Härri, **Rethinking Cooperative Awareness for Future V2X Safety-Critical Applications**, IEEE Vehicular Networking Conference (VNC), Turin, 2017.

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CAR 2 CAR COMMUNICATION CONSORTIUM

Cooperative Awareness

- Method: *Exchange position (GPS), vehicle info and dynamics inside Cooperative Awareness Messages (CAMs)*
- Components of Awareness:
  - **Range:** Percentage of neighbors detected within ideal communication range
  - **Freshness:** How recent are the neighbors position information
  - **Precision:** How precise is the knowledge of neighbors' position
- Limitations of CAM based awareness:
  - CAMs Transmit rate (awareness refresh rate) limited to 10 Hz
  - Recent EU projects (HIGHTS, TIMON) found GPS accuracy is **too low** and **unreliable**

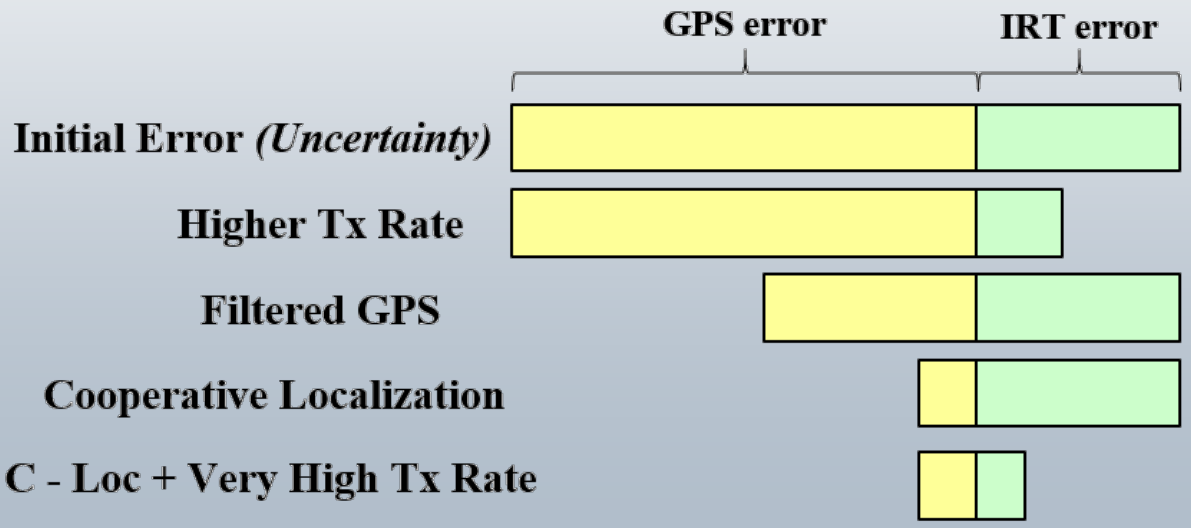
Need high precision awareness strategies **for DAY 2 V2X applications**

Awareness Error

- Sources of Awareness Error (Uncertainty)
  - **Inter Reception Time (IRT):** uncertainty of neighbor's position in between two receptions.
    Ex: 2 meter for 10 Hz CAM, 20m/s speed (72km/h)
  - **Localization error:** GPS error 2 – 10 meter (depending on scenario, satellite visibility)
- Mitigation Techniques:

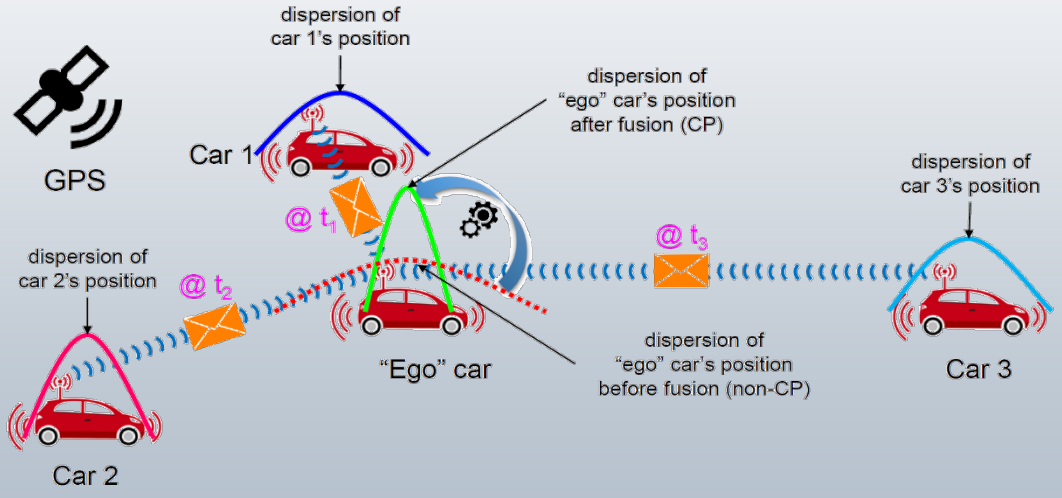
Traditional approach =>

Our approach =>



Cooperative Localization (C-Loc)

1. Neighbors 1-3 transmit absolute position estimate
2. Ego-vehicle: Fusion
   {Good quality Neighbors' absolute position + Relative position (RSSI) + On board GNSS position }
3. Ego-vehicle: Broadcast improved ego position
4. Neighbors in turn use it to improve own locations



Goal: Precise localization via Fusioning & not exchanging imprecise GPS

A Lightweight Precision Awareness Message (PAM)

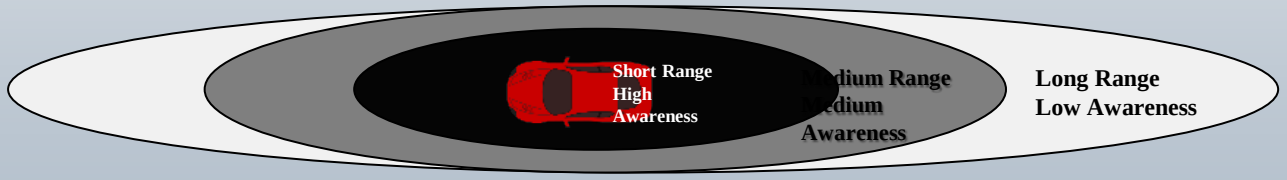
- Goal: Small Message Size for low channel footprint
  - High Tx/refresh rate (100 Hz) for IRT error, same level as C-Loc error
- Content and Size:

Fusioned Position	2 x 4 byte scalar
Covariance Matrix	3 x 4 byte scalar
Timestamp	1 x 8 byte
Headers MAC & PHY	42 byte
Total Packet Size = 70 bytes vs ~ 300 byte CAM	

- No need to transmit:
  - **Speed, Direction, Dynamics:** derived from subsequent messages
  - **Security trailers:** Fusion engine filters fake data as outliers

Cooperative Awareness Control

- Target Channel Load – *limit at 60% Channel Load*
- Target Awareness Density – *Nb of neighbors to reach, @100Hz 60% CL*
  - *Example Channel Footprint: 50 Nodes, 70 bytes, 100Hz, 6Mbps: CL 46.7%*
- Transmit Power Control - *Tx power to reach target Nb of neighbors*



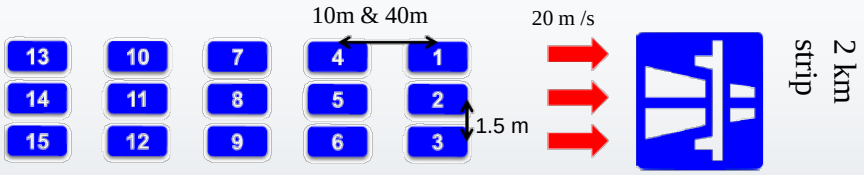
Simulation Parameters

- **Dense Scenario**

  (100 vehicle/lane/km x 6 lanes)

- **Sparse Scenario**

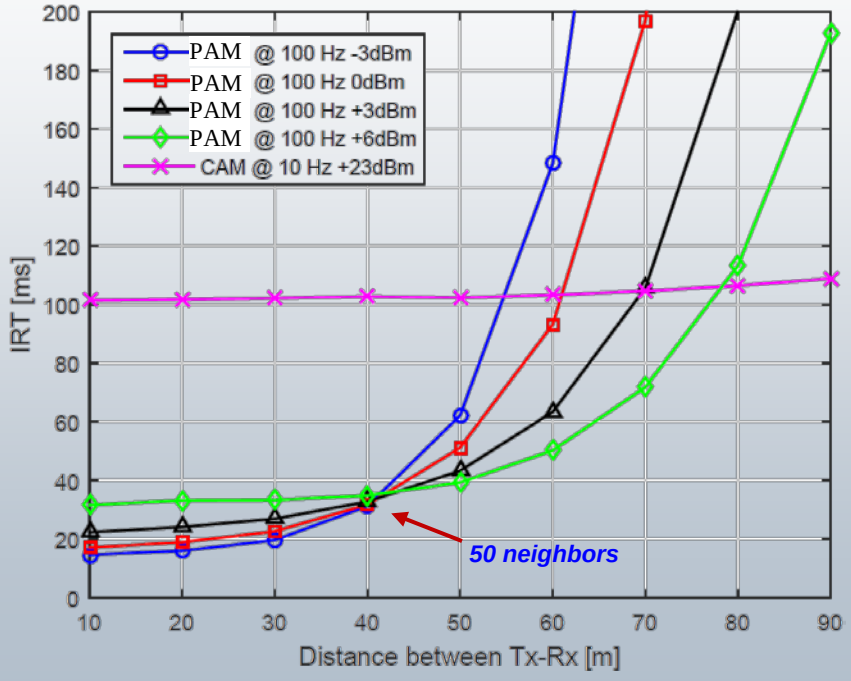
  (40 vehicle/lane/km x 6 lanes)



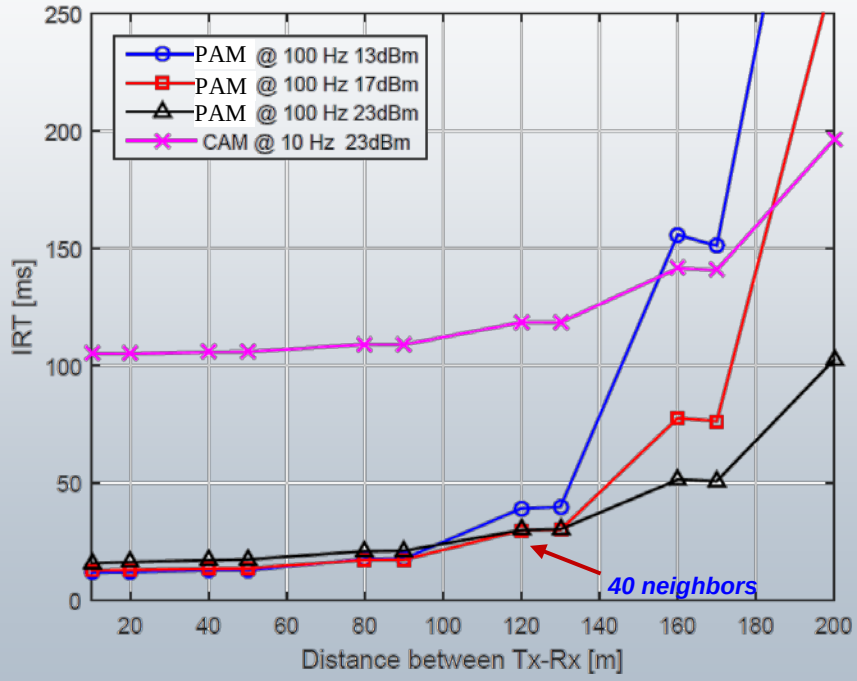
Parameter	Value
Simulator	iTetris – NS 3.20
Transmit Power	-3 dBm to +23 dBm
Transmit Rate	PAM: 100Hz, CAM: 10 Hz
Packet Size	PAM 70 bytes, CAM 300 byte
Mobility	Gauss Markov
Fading	WINNER B1

Communication Performance

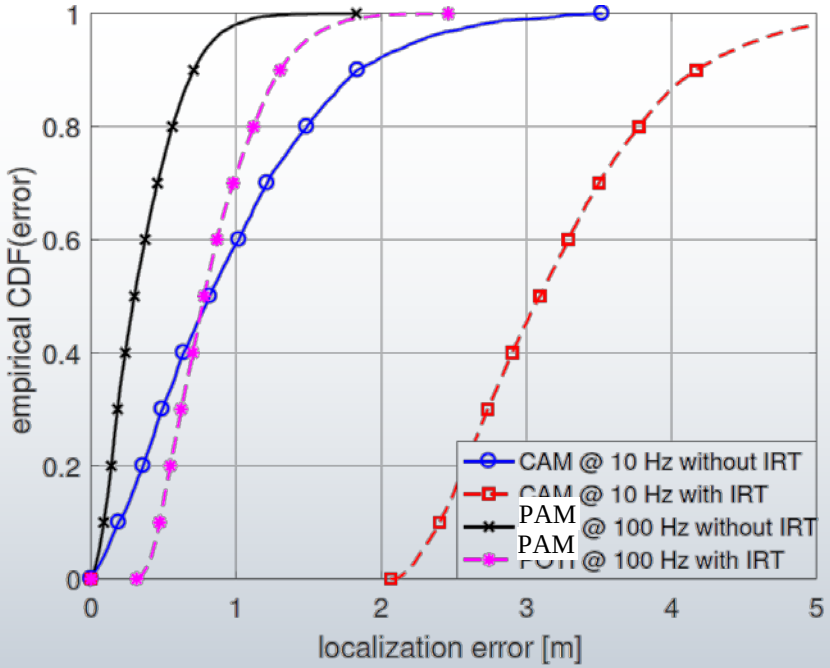
- **Dense Scenario**
  (100 vehicle/lane/km)



- **Sparse Scenario**
  (25 vehicle/lane/km)



Awareness Precision – 100Hz PAM vs 10Hz CAM



- **Median Errors:**
  - 10 Hz CAM (only localization error): 0.82 m
  - 10 Hz CAM (localization error + IRT): 3.1 m
  - 100 Hz PAM (only localization error): 0.3 m
  - 100 Hz PAM (localization error + IRT): 0.78 m

Discussion and Conclusion

- Awareness Precision: location precision & refresh rate
- We propose high precision awareness:
  - Based on Cooperative Localization
  - 15ms IRT to 50 neighbors, Channel load < 60%
  - Awareness precision < 0.8m, 4x wrt CAMs with imprecise GPS
- Next Steps:
  - Reduce packet loss in medium and long range
  - Hybrid CAMs and PAMS: for backward compatibility and performance of mixed distribution