Cohort-Based Construct for Vehicular Cyber-Physical Systems

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Outline

1. Context
2. Problematic
3. System Model
4. Cohort management distributed algorithms
5. Conclusion and future work

Context

- This work is conducted as a part of my Ph. D thesis, where we aim to develop an *Intelligent Vehicular Environment* based on distributed and deterministic solutions, with the purpose to improve road user *safety*.

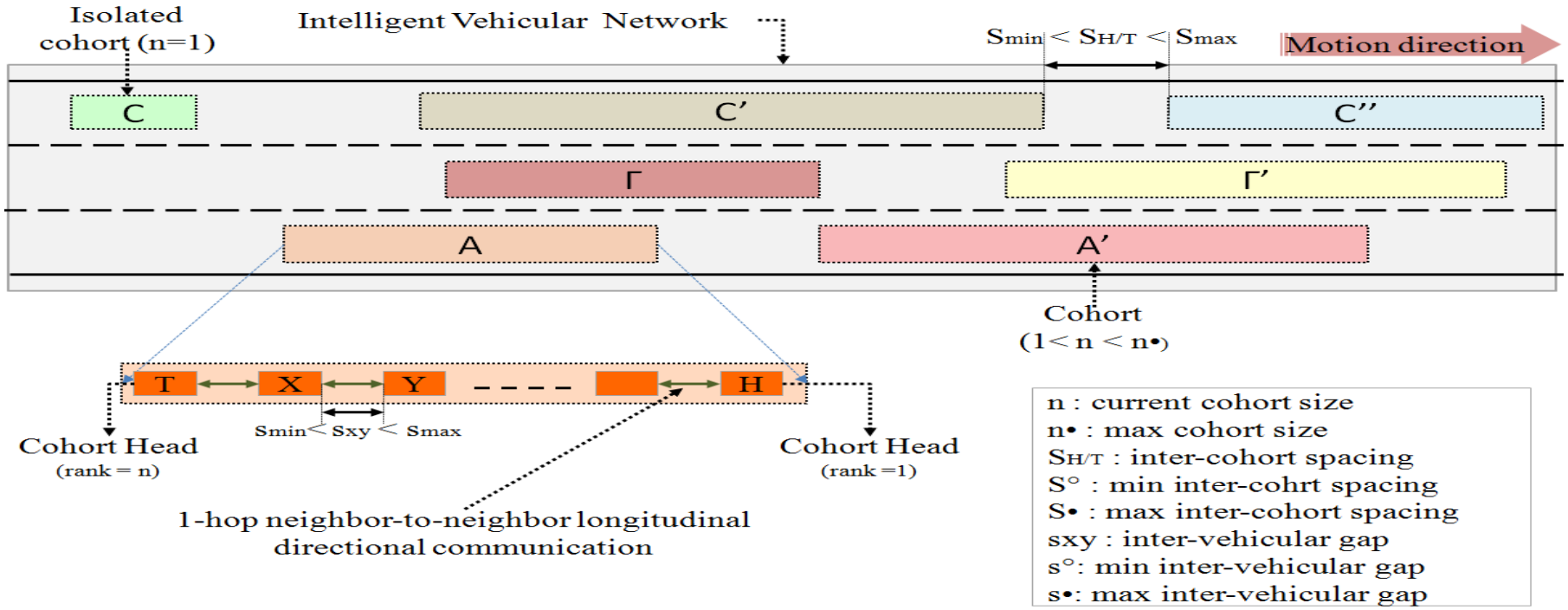
Problematic

- Random topology with unbounded-size
- Timeliness issues
- Reliability issues
- Connectivity issues

Proposed Solutions: System model

❑ Cohort

- Fully-distributed, linear and size-bounded cyber-physical cluster of consecutive vehicles



- N2N directional communication based on *deterministic MAC layer protocol*

Proposed Solutions: System model

❑ Highway lane changing maneuver

- Assumptions:
  - The entire IVN is divided into many cohorts of variable size.
  - Each cohort is formed by n < n● of nodes moving in the same direction at a similar velocity.
  - Cohort's members' cooperation is ensured by directional N2N communication.
  - Periodic control messages exchange, essential for cohort management and local member data update
  - Each vehicle X is able to perform a lane changing maneuver ,

Proposed Solutions: System model

❑ Highway lane changing maneuver

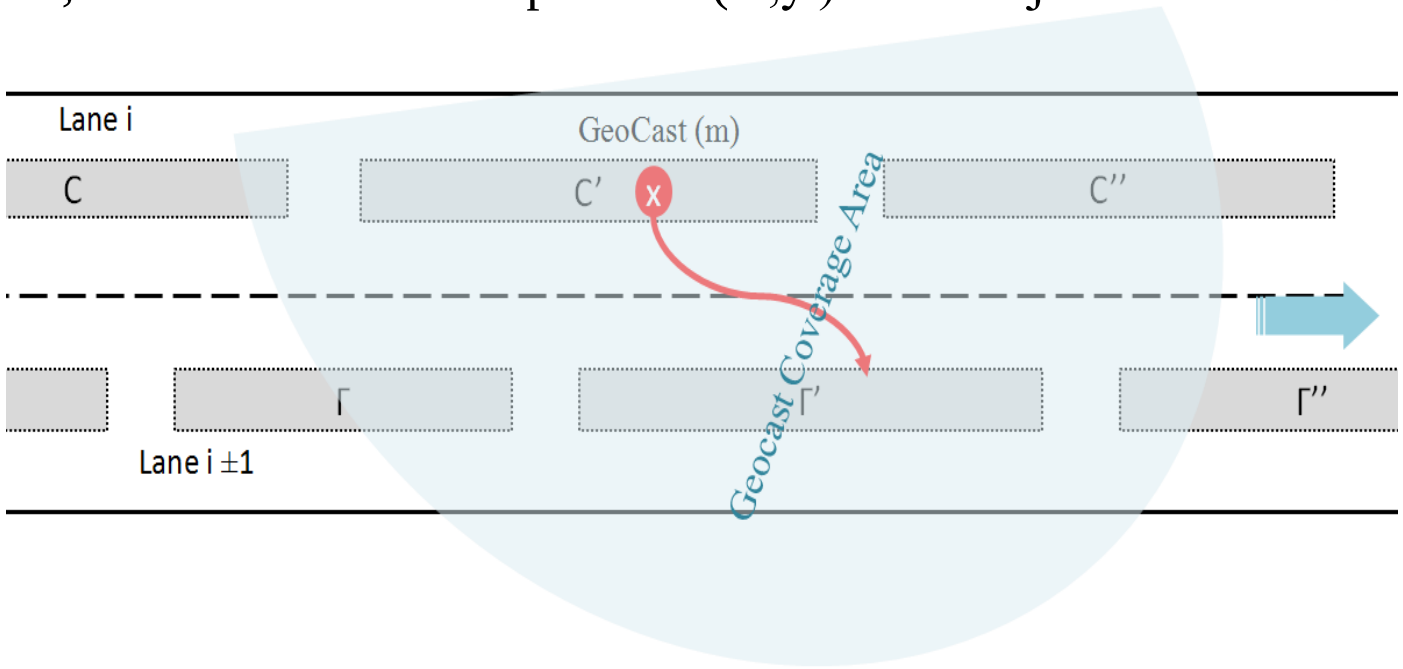
- By leaving its current cohort the vehicle X has to :
  - Create its own cohort
  - Join a pre-existing cohort, with respect :
    - The upper size of the cohort should not be exceeded
    - The available space must respect the constraint of safe inter and intra cohort spacing

Cohort Management Distributed Algorithms

❑ Highway lane changing maneuver

➢ at time τ ,X has the coordinates (x,y) and moving with at the velocity on the lane i.

➢ At the time τ+ε, X wants to be at the position (x′,y′) on an adjacent lanei±1.



➢ Three use cases are highlighted within this work

Cohort Management Distributed Algorithms

❑ Middle Cohort Insertion

- **Phase 1** : looking for eligible vehicles
- **Phase 2** : *agreement phase*, selecting actors
- **Phase 3** : informing the requestor about the decision

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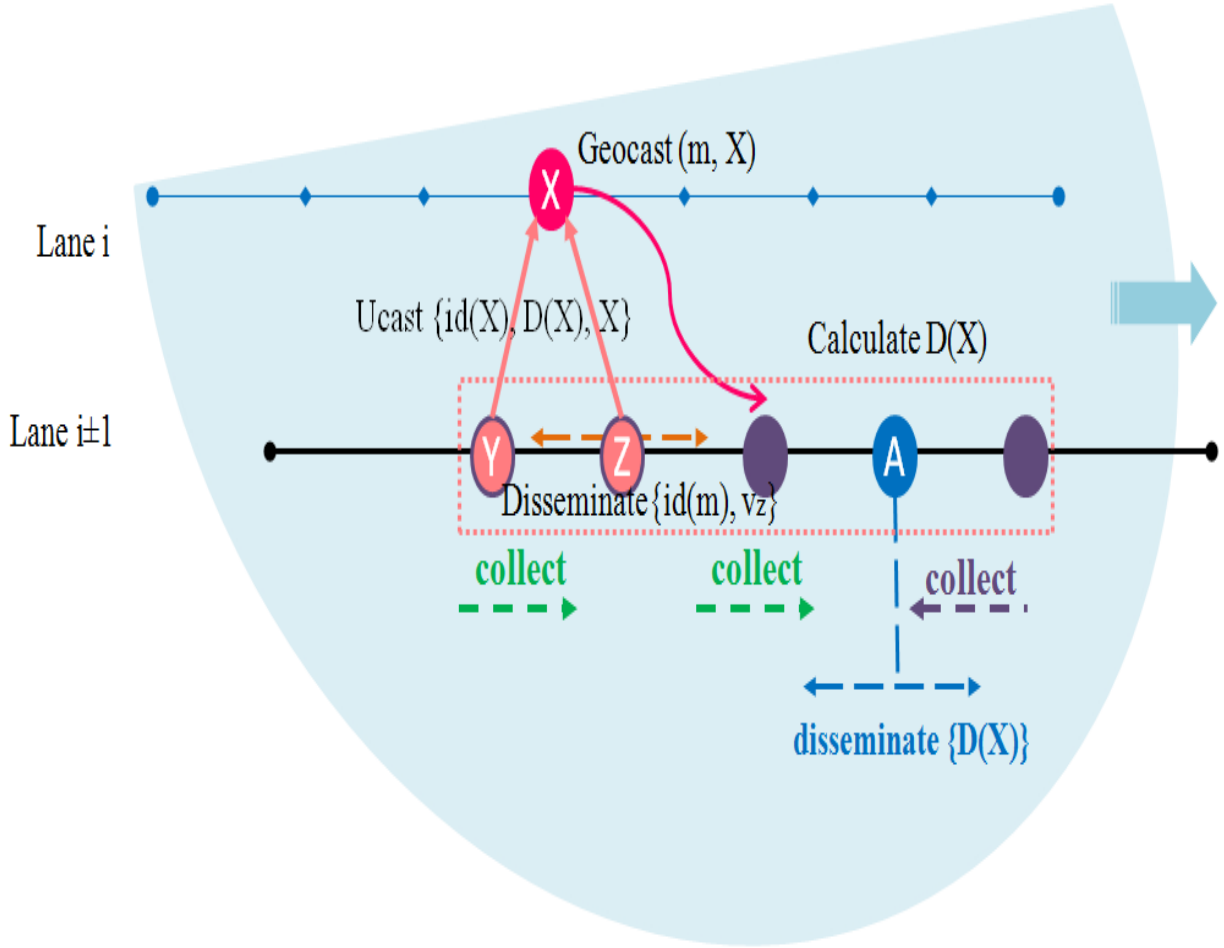
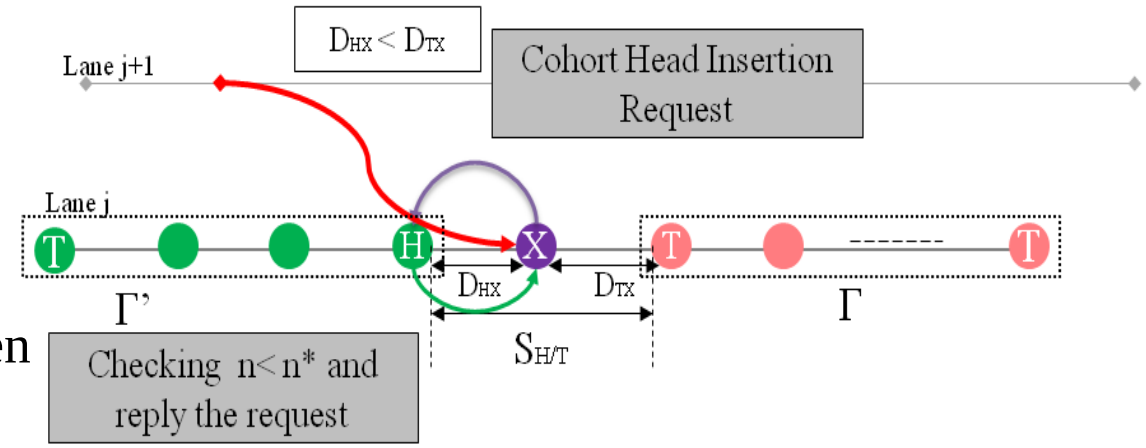


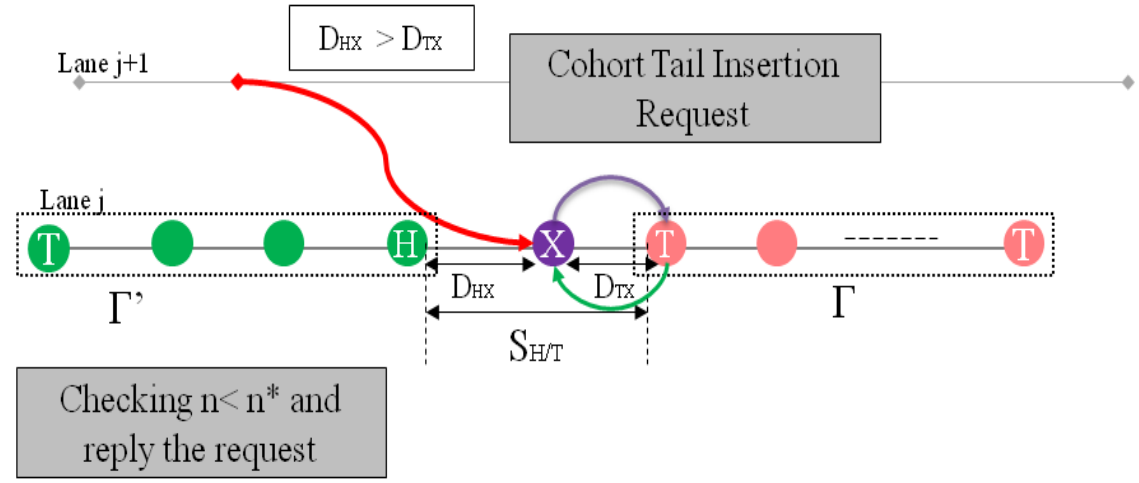
Cohort Management Distributed Algorithms

❑ Inter-Cohort Insertion

- ➢ After leaving its cohort X is located between cohorts Γ and Γ'
- ➢ X has the freedom to select its future cohort with respect of the cohort size and the available space



a- Inter-cohort Spacing : Cohort Head Insertion



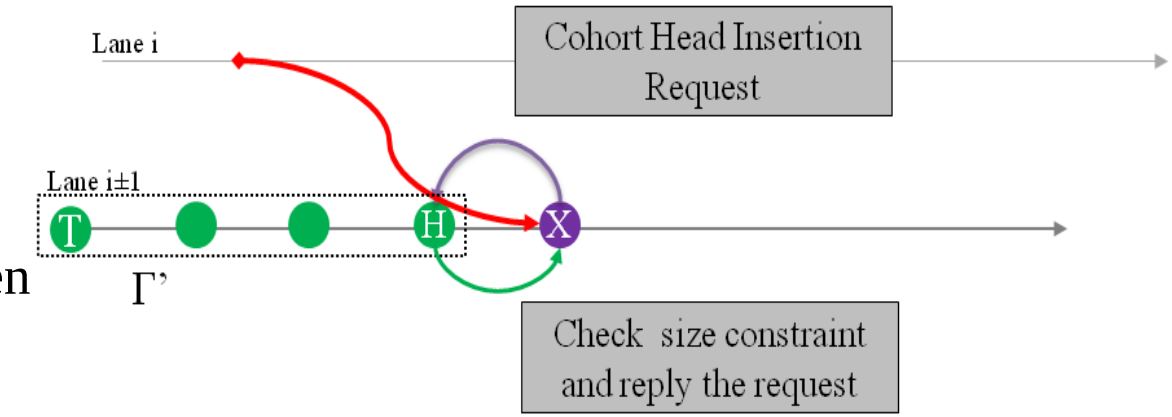
b- Inter-cohort Spacing : Cohort Tail Insertion

Cohort Management Distributed Algorithms

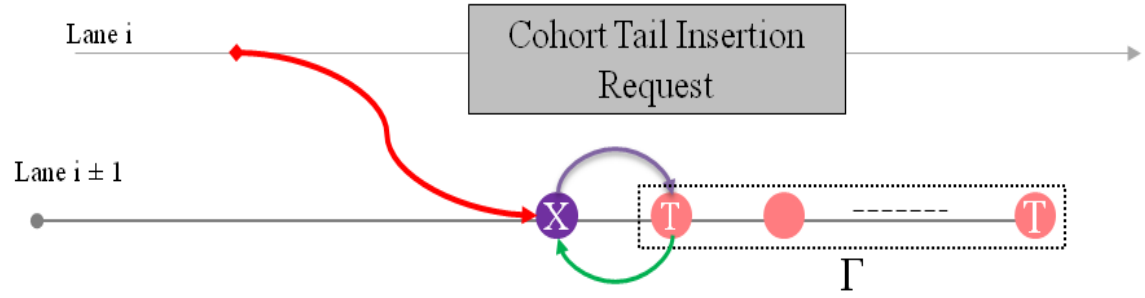
❑ Free Space Insertion

After leaving its cohort X is located in an open space

- ➢ Create new cohort
- ➢ Try to join existing one by deceleration/acceleration maneuver



a- Free-Space : Cohort Head Insertion



b- Free-Space : Cohort Tail Insertion

Conclusion and Future Works

- Breaking down IVN into fully-distributed and bounded-size cohorts, based on deterministic solutions and short range N2N directional communications, would help :

  i. Alleviating the vehicular environment complexity,
  ii. Ensuring road traffic safety and efficiency,
  iii. Minimizing collision and interference in terms of networking side .

Conclusion and Future Works

- Develop distributed and deterministic MAC layer algorithm based on N2N communication

- Develop consensus algorithm adapted to our proposed vehicular environment

Thank you!