Data Dissemination in Vehicular Ad Hoc Networks

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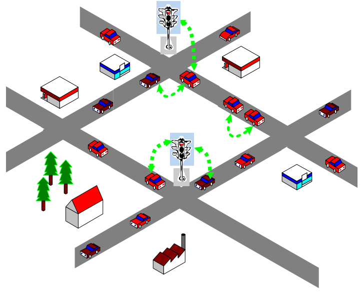
The Big Picture

- Vehicular ad hoc networks - VANET
  - Moving vehicles
  - Stationary sites
    - hotspots, infostations, sensors
- Task
  - Delivery a message from mobile vehicle to the fixed site besides street miles away.
  - Multi-hop forwarding through VANET.



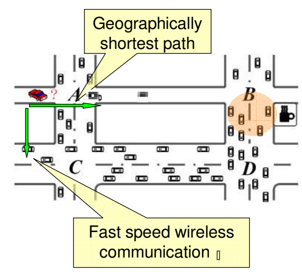
Challenges

- Partitions
  - Large scale sparse networks
  - Uneven vehicle distribution
  - High mobility
- End-to-end connection through multi-hop hard to set up
  - Most current Ad hoc routing protocols implicitly rely on the existence of end-to-end connectivity; otherwise, drop packets.

Vehicle-Assisted Data Delivery (VADD)

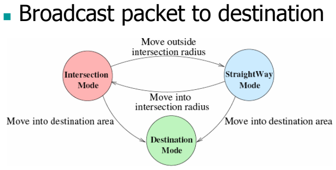
- "Store, carry and forward"
  - Buffer and carry the packet when no routes
  - Forward the packet to the nodes moves into the vicinity which can help packet delivery
  - Possible to deliver the packet without an end-to-end connection
- Use predictable traffic pattern and vehicle mobility to assist data delivery

- Key Issue
  - Select a forwarding path with smallest packet delivery delay
- Guidelines
  - Make the best use of the wireless transmission
  - Forward the packet via high density area
  - Use intersection as an opportunity to switch the forwarding direction and optimize the forwarding path



VADD: Three Modes

- Intersection Mode
  - Optimize the packet forwarding direction
- StraightWay Mode
  - Geographically greedy forwarding towards next target intersection
- Destination Mode
  - Broadcast packet to destination



VADD: Intersection Mode

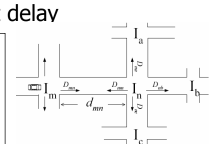
- VADD Model - Which direction to go?
  - Find out the next forwarding direction with ***probabilistically*** the shortest delay

1. Estimate the packet forwarding delay (d_{mn}) between two adjacent intersections based on traffic statistics
2. Use the probabilistic method to estimate the expected delivery delay from current intersection to the destination.

$$D_{mn} = d_{mn} + \sum_{j \in N(n)} (P_{nj} \times D_{nj}) \quad \cdots (1)$$

3. Generate a linear equation system, and solve it by *Gaussian Elimination*

$$P \cdot X = -D \quad \cdots (2)$$

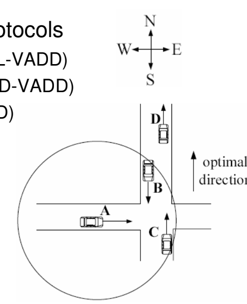


$$P = \begin{bmatrix} P_{11}-1 & P_{12} & \cdots & P_{1n} \\ P_{21} & P_{22}-1 & \cdots & P_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ P_{n1} & P_{n2} & \cdots & P_{nn}-1 \end{bmatrix}$$

$$X = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} \quad \text{and} \quad D = \begin{bmatrix} d_1 \\ d_2 \\ \vdots \\ d_n \end{bmatrix}$$

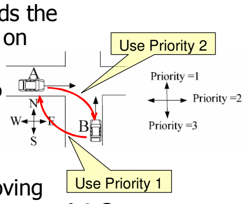
Output: Priority list of the outgoing directions for the packet forwarding

- VADD Protocol - Which carrier to take?
  - Not trivial, need to consider
    - Location
    - Mobility
  - VADD Intersection Protocols
    - Location First VADD (L-VADD)
    - Direction First VADD (D-VADD)
    - Hybrid VADD (H-VADD)



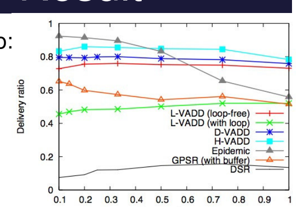
VADD Protocols

- L-VADD
  - Pick the closest carrier towards the preferred direction only based on location, e.g. A→B.
    - Vulnerable to Forwarding Loop
    - Negative on delivery ratio
- D-VADD
  - Only probe those carriers moving towards the preferred direction, e.g. A→C
    - Can be proved no Forwarding Loop
    - Delay may be higher
- H-VADD
  - Hybrid of L-VADD and D-VADD.

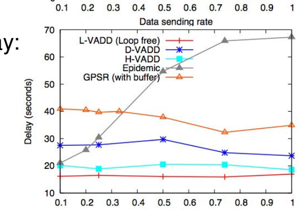


Result

Delivery Ratio:



Delivery Delay:



Conclusion

- Existing routing protocols are not suitable for DTN applications in VANET.
- VADD adopts the idea of "carry and forward", and also explores the predictable vehicle mobility.
- Simulation results shows that the VADD protocols are better suitable for the multi-hop data delivery in VANET.

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