Connectivity-Aware Routing (CAR) in Vehicular Ad Hoc Network

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Outline

- Introduction
- Related Works
- Connectivity-Aware Routing (CAR)
- Simulation
- Conclusion

Introduction

- To solve the routing problem in Vehicular Ad-hoc Network (VANET).
- Geographic routing protocol
  - Assume every node knows its position, velocity, and direction via GPS.

Related Works

- AODV (Ad-hoc On-demand Distance Vector)
  - A non-geographic routing protocol.
  - Broadcast path request on demand.
- GPSR (Greedy Perimeter Stateless Routing)
  - A geographic routing protocol.
  - Packets are marked with their destinations' locations.
  - Relay nodes make a local greedy routing.

Related Works

- Example of GPSR

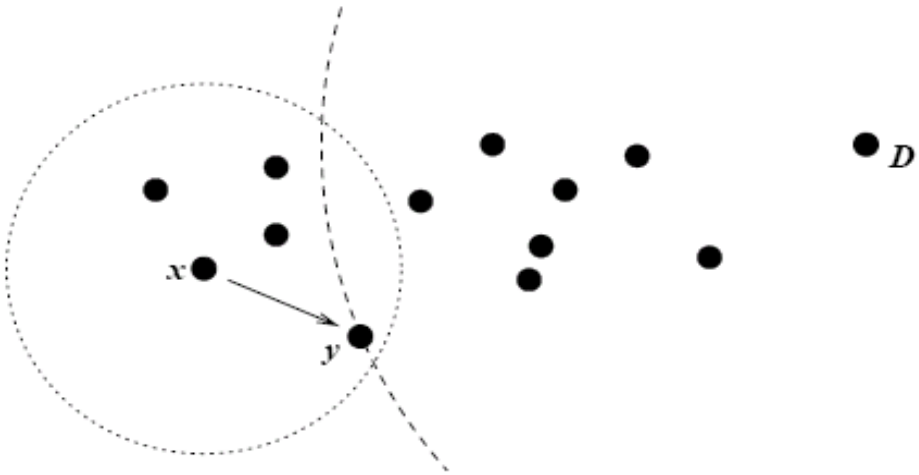


Figure 1: Greedy forwarding example. *y* is *x*'s closest neighbor to *D*.

Related Works

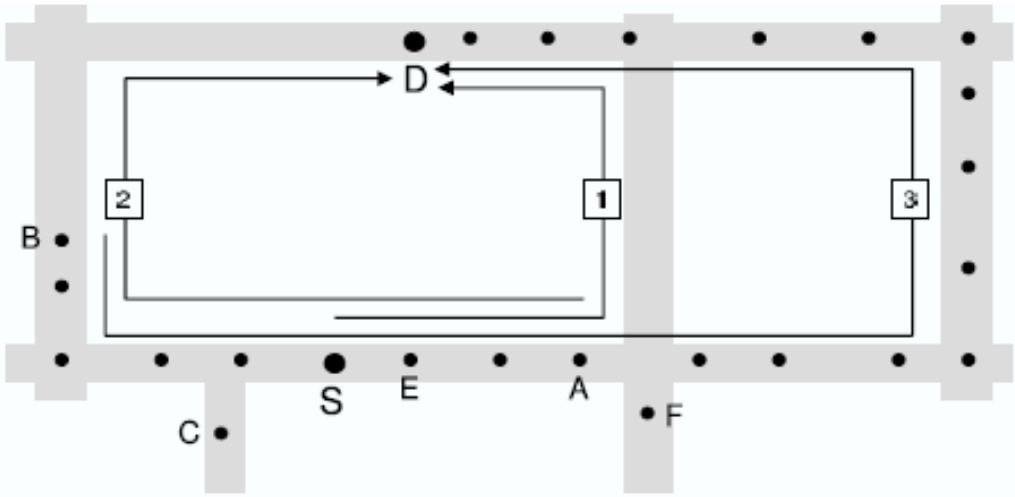


Fig. 1. Find path examples.

Step 1. S → E, E finds he is the closest node to D, no neighbor is closer than E.

Step 2. perimeter mode is activated, E to B is the closest path to D.

Step 3. but this time the path B to D has disappeared, need to find another path.

Step 4. Finally the rest of packets S to D will forward as
S → E → path2 → B → path3 →D

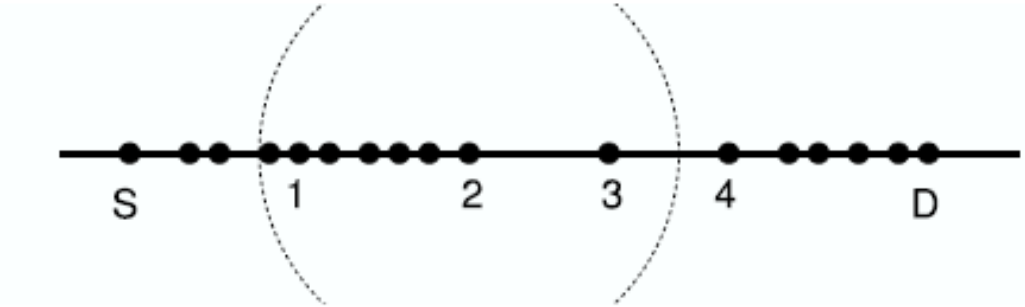
Connectivity-Aware Routing (CAR)

The CAR protocol consists of:

1. Path discovery.
2. Data packet forwarding along the found path.
3. Path maintenance with the help of guards.
4. Error recovery.

Neighbor tables and adaptive beaconing

- Adaptive beaconing
  - The HELLO beacon includes location, moving direction and speed.
  - The beaconing interval is 0.5s * number of neighbors.



Destination location discovery

- A path discovery packet consists of "PD id", destination, previous forwarder's coordinate/velocity vector, travel time, connectivity, anchor.
- Source initiates a PGB (Preferred Group Broadcasting) path discovery request.

PGB

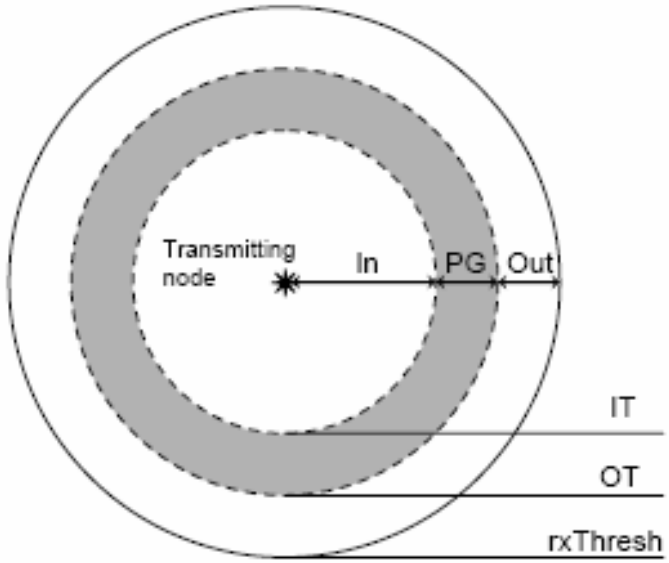
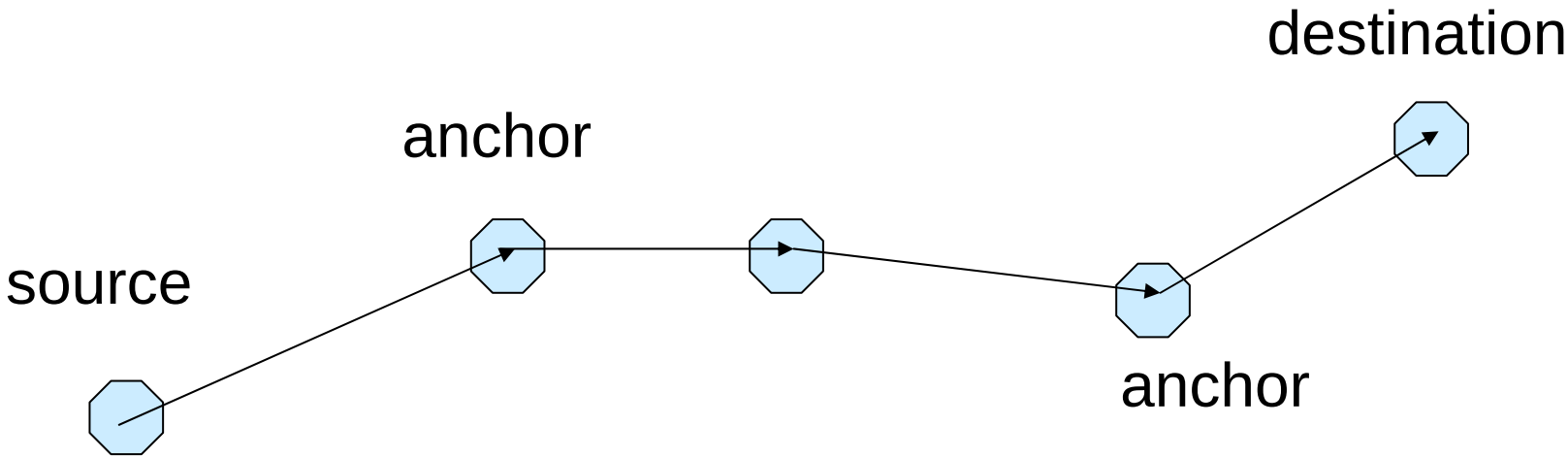


Figure 4: Node groups in Preferred Group Broadcasting.

Destination location discovery

- If two velocity vectors' angle > 18° , anchor is set.
  - Anchor contains coordinates and velocity vector of current node and previous node.

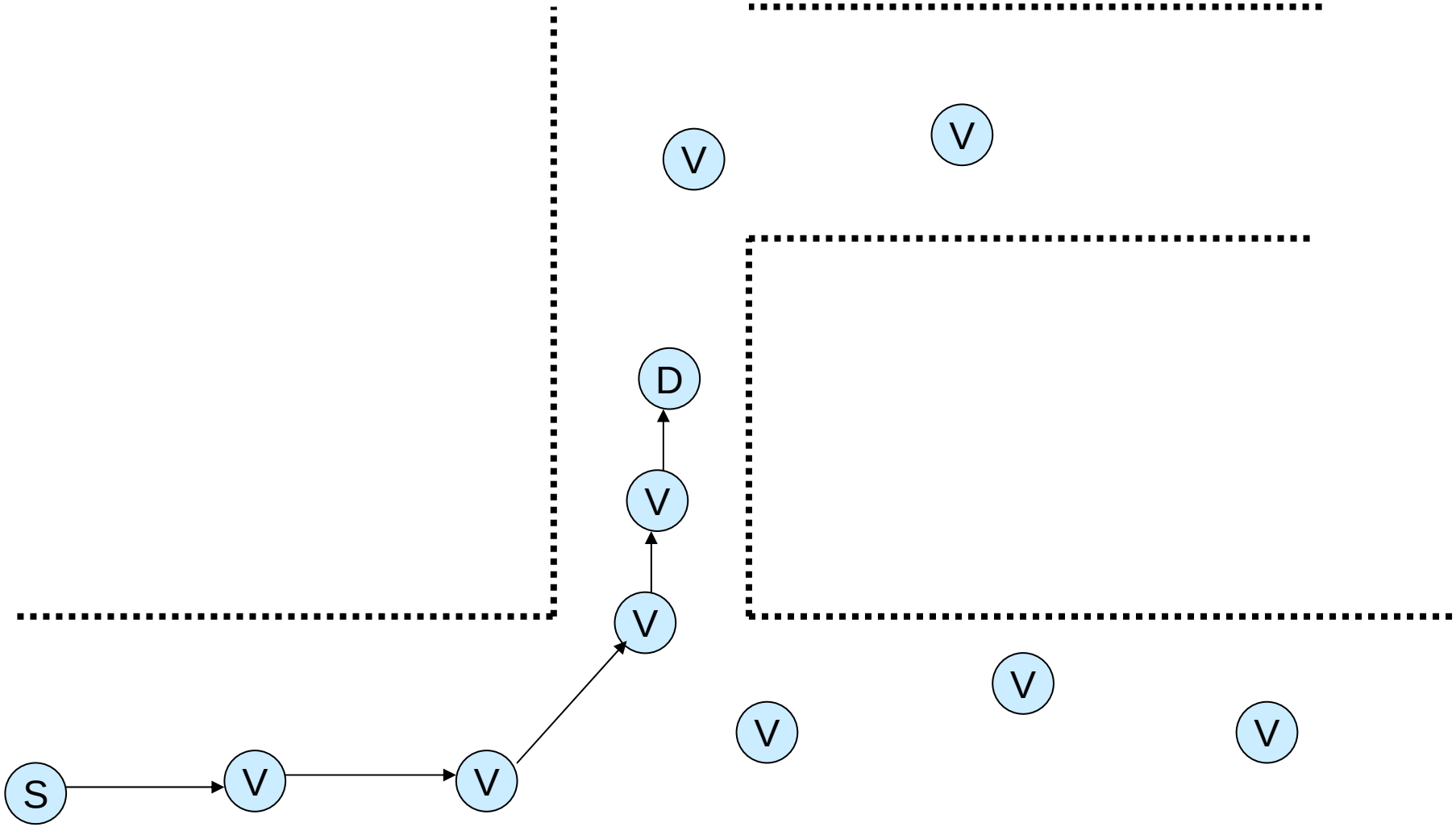


Greedy forwarding over the anchored path

- A neighbor that is closer to the next anchor point is chosen, instead of destination.
- Each forwarding node relays to anchor if the distance is less than half coverage.
  - To avoid multiple attempts to gradually get closer to the next anchor point.

Path maintenance

- If an end node (source or destination) changes position or direction, standing guard will be activated to maintain the path.
  - Standing guard is tied to a geographical area, rather than a specific node.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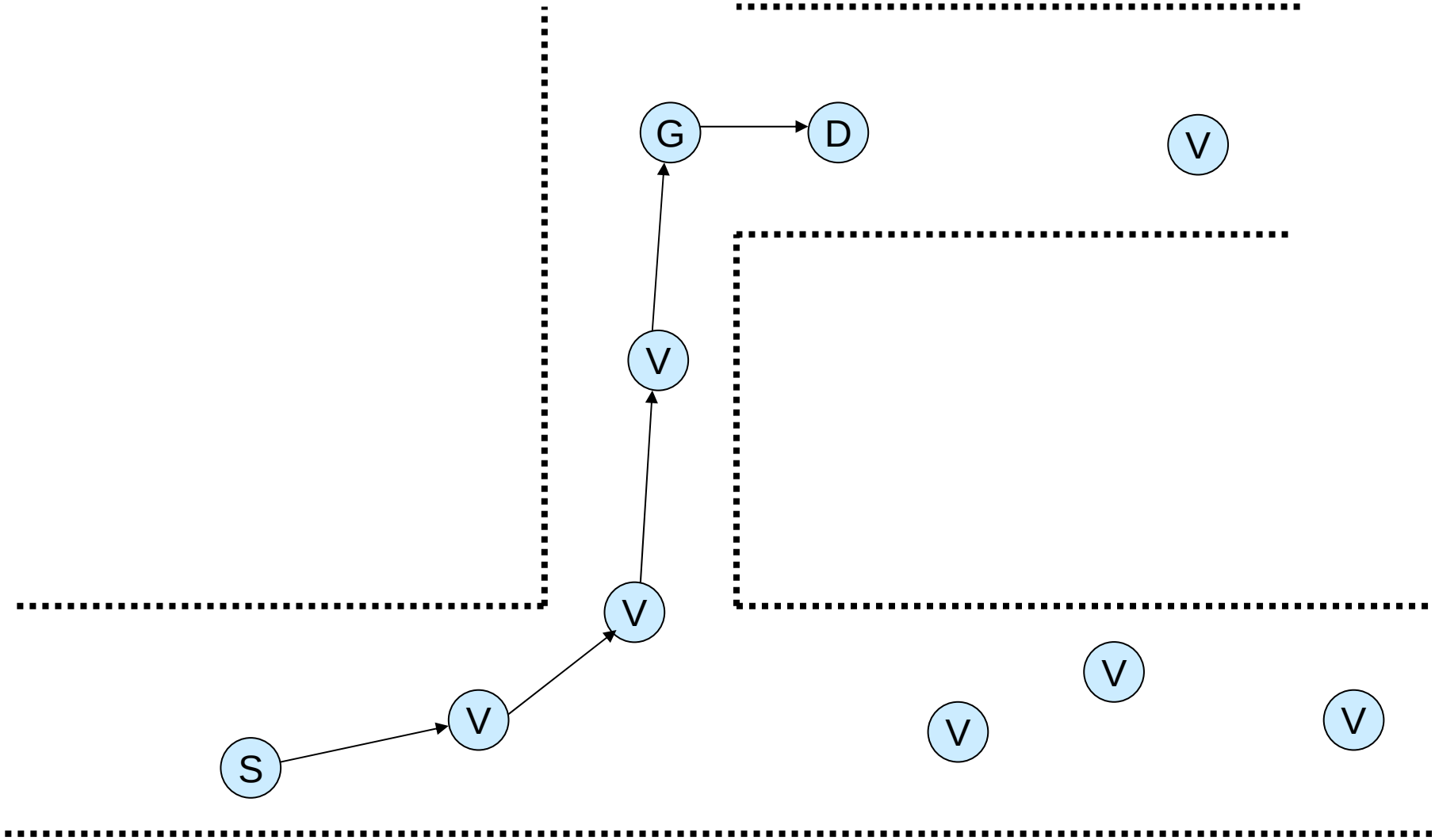
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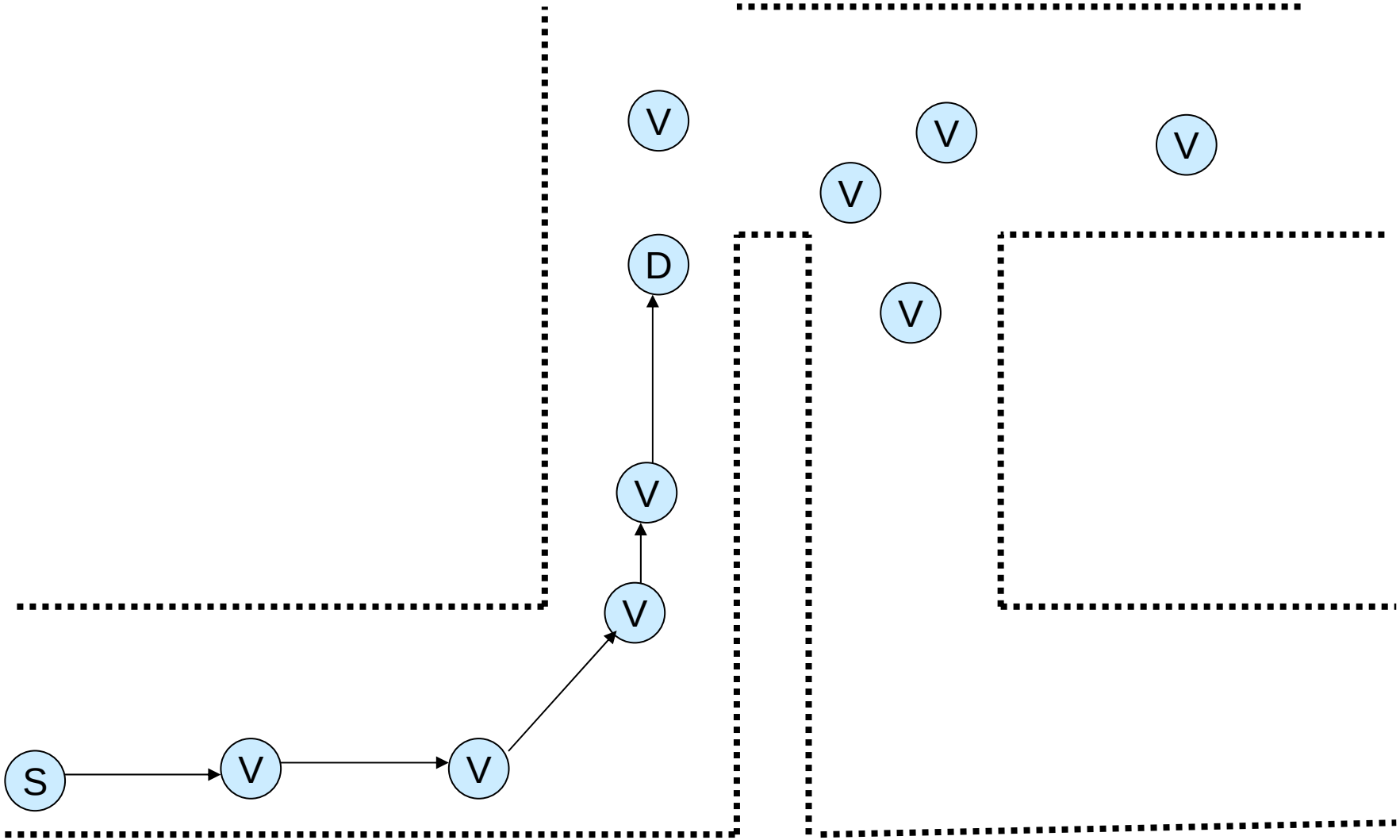
Path maintenance

- If end node changes direction against the direction of communication, traveling guard will be activated.
  - A traveling guard contains velocity vector, position and radius.
  - A traveling guard runs as end node's old direction and speed, and reroute the packets to the destination.
  - End node will send a notification to source.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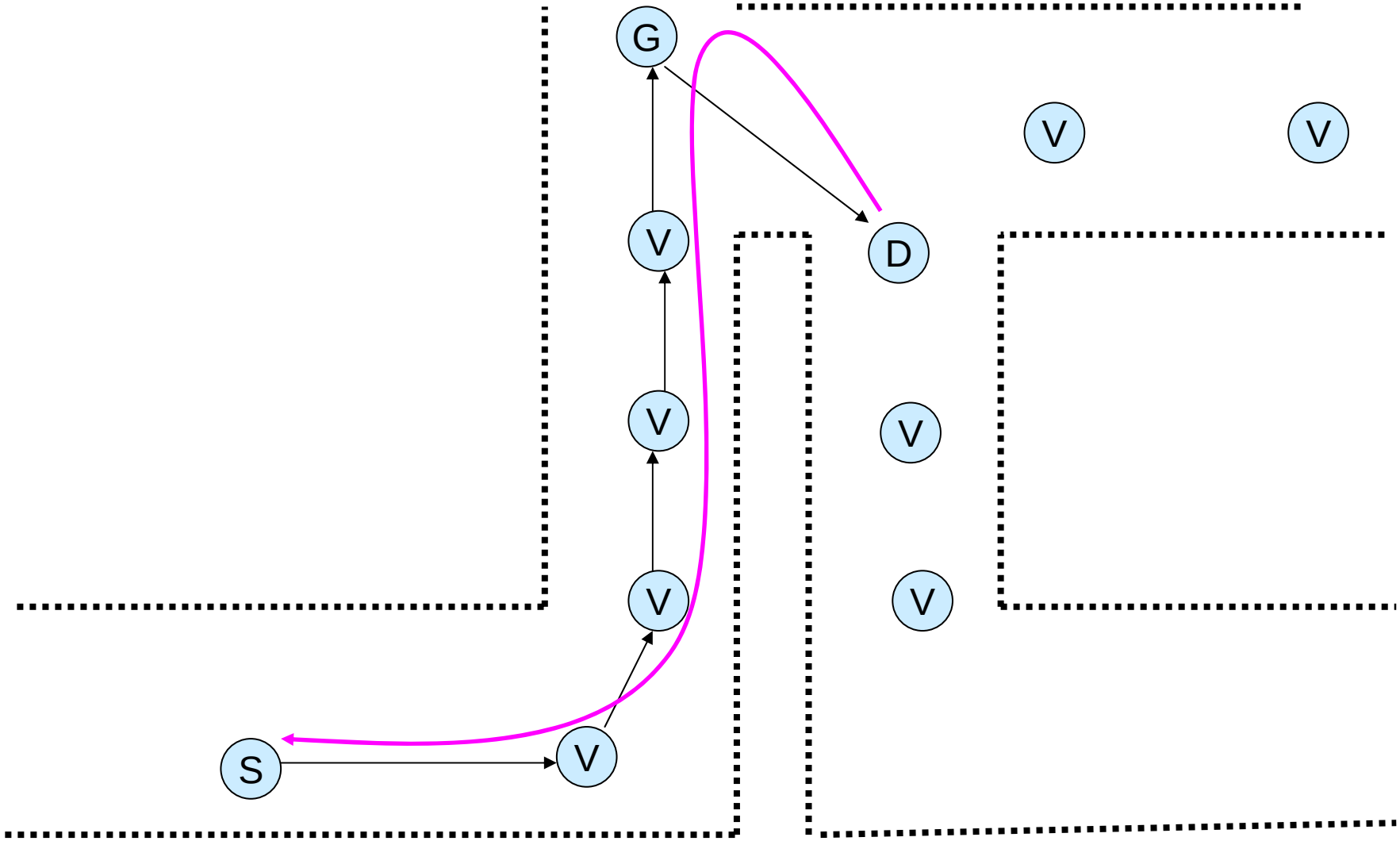
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Routing error recovery

- Error may occur due to:
  - A temporary gap between two vehicles or raised interference.
  - Long-term disconnection.
  - A packet arrives the estimated position but can not find the destination.

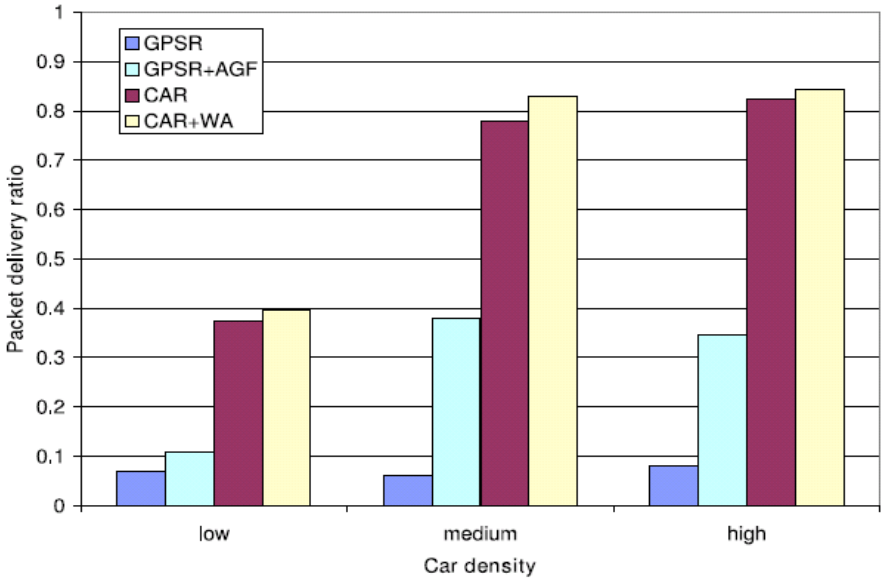
Routing error recovery

- Solution:
  - Timeout algorithm with active waiting cycle
    - Tell other nodes there is a disconnection, and buffer the packets
    - Try to detect next-hop node
  - Walk-around error recovery
    - If the timeout algorithm is fail, the node will report to the source and starts a local destination location discovery process.
    - No matter the destination discovery succeed or not, the result will be reported to the source.

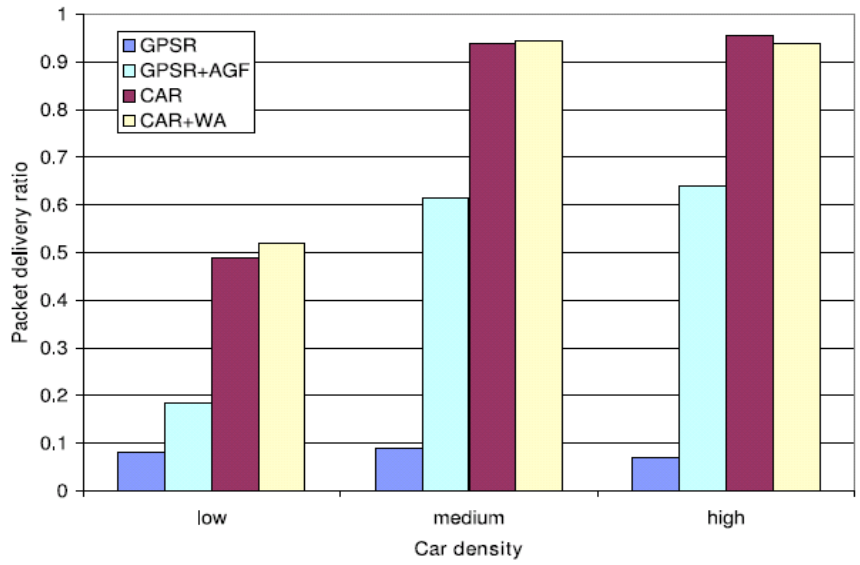
Simulation

- The evaluated protocols are: GPSR, GPSR+AGF (Advanced Greedy Forwarding), CAR, CAR+WA.
- Scenarios: highway and city, with three different densities (low, medium, high).
- Metrics:
  - Packet Delivery Ratio (PDR)
  - Average delay of a data packet
  - Routing overhead

Simulation-Packet Delivery Ratio

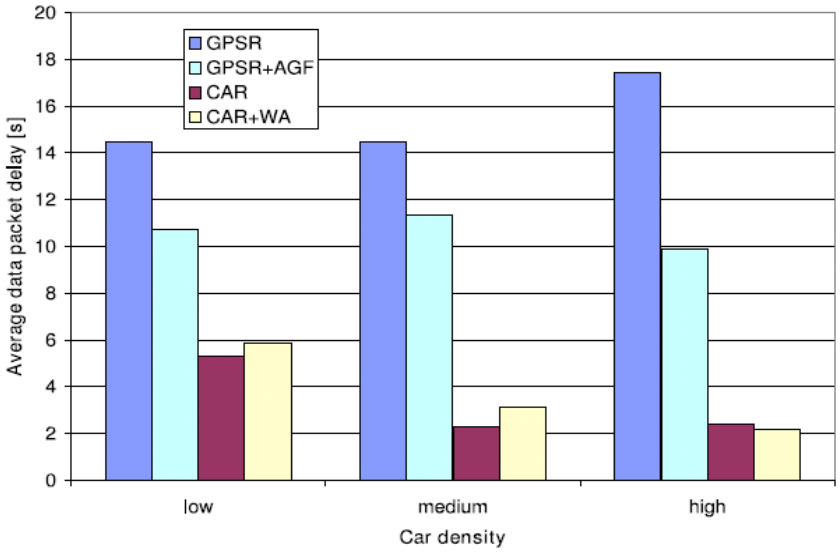


(a) City

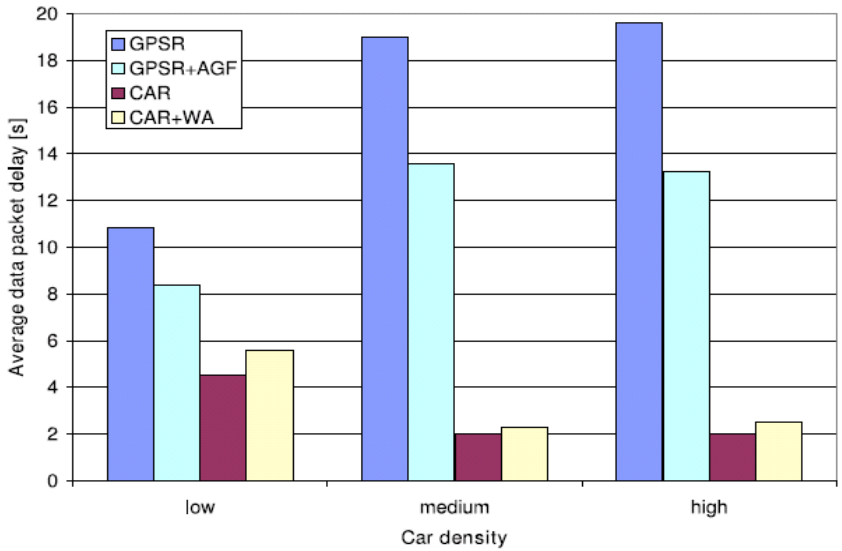


(b) Highway

Simulation-Average data packet delay

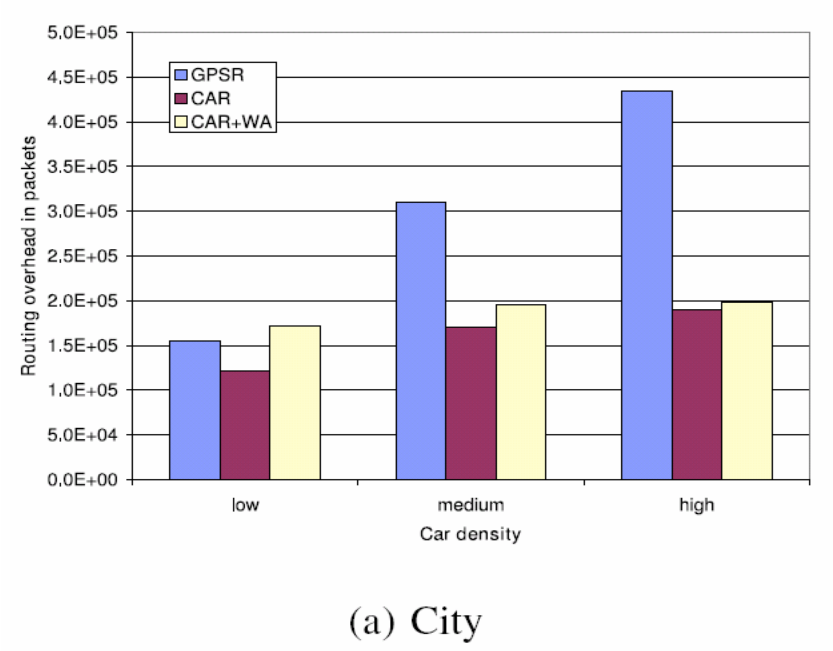


(a) City

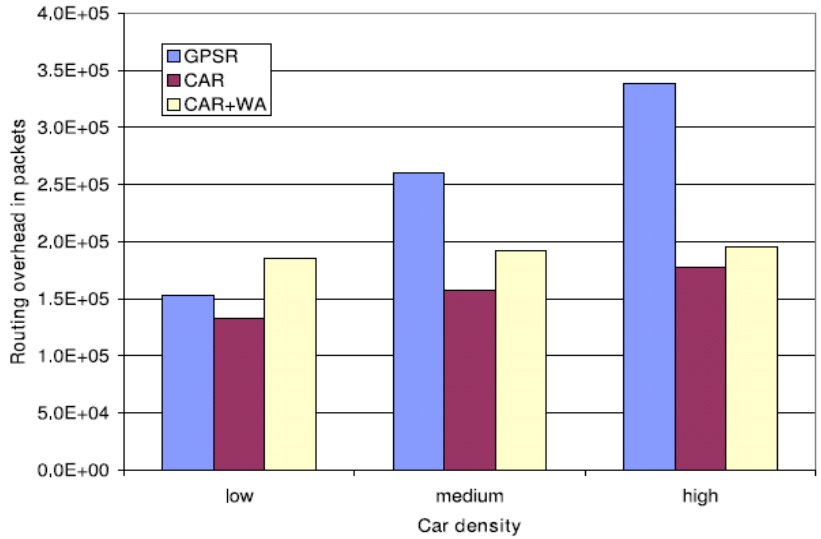


(b) Highway

Simulation-Routing overhead



(a) City



(b) Highway

Conclusion

- Adaptive beaconing
- PGB, AGF, and velocity vectors
- Anchor points
- Path maintenance with guards
- Error recovery
- Higher performance and lower routing overhead than GPSR