VANETs

Vehicular Ad hoc NETworks

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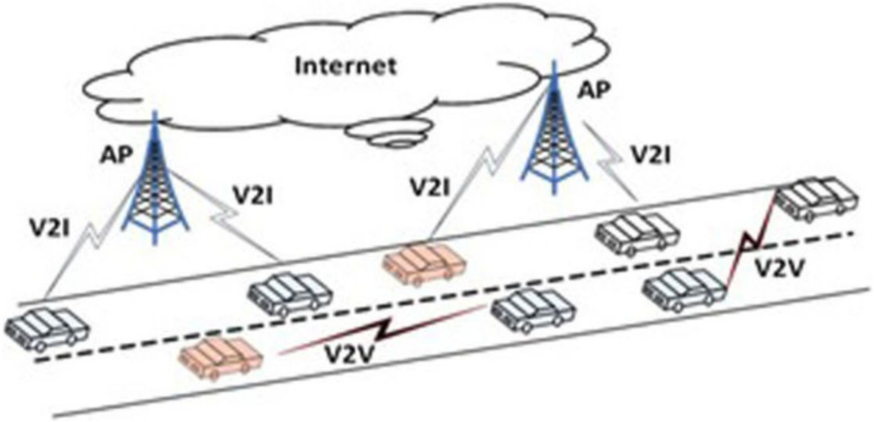
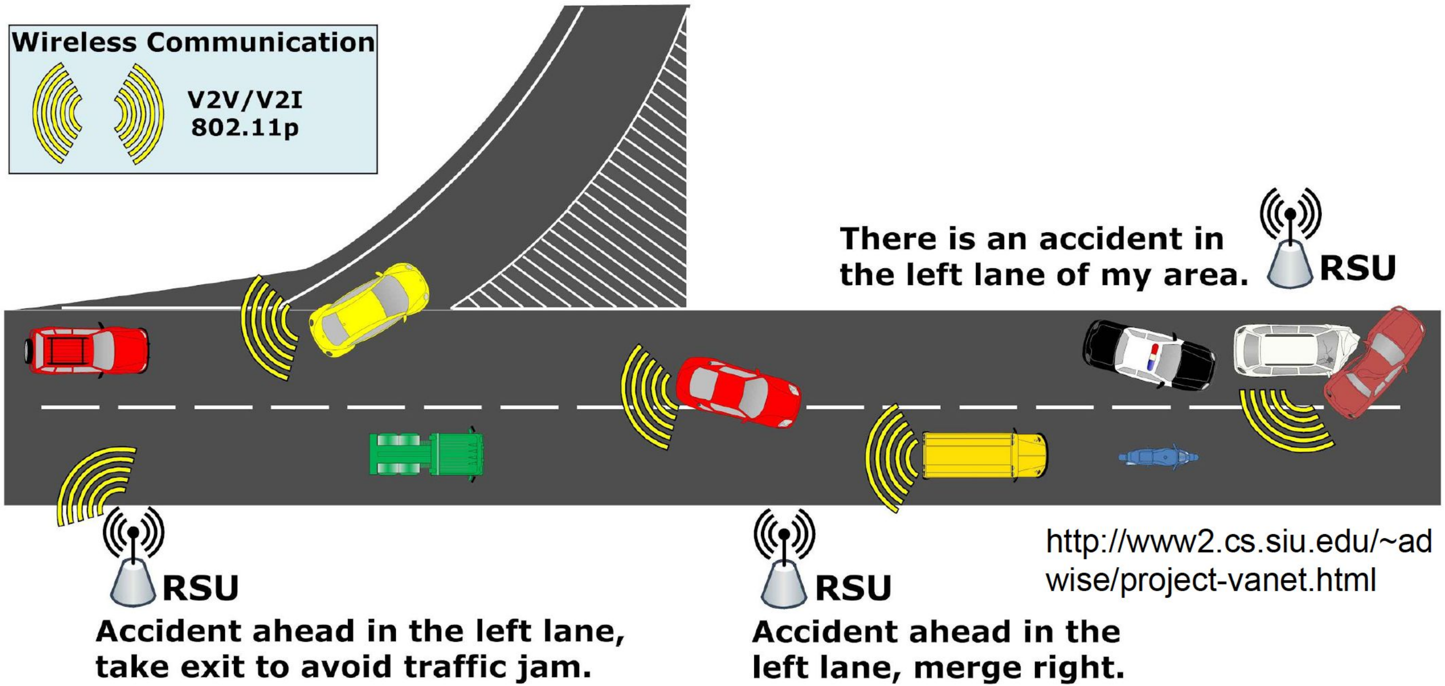
What are Vehicular Networks?

- Ad hoc networks between vehicles that allow for communication
- Average single-hop communication range of around 500m (shorter w/o LOS)
- Utilize multi-hop communication methods for longer communication
- Vehicle-to-Vehicle and Vehicle-to-Infrastructure communication



Why do we need this?



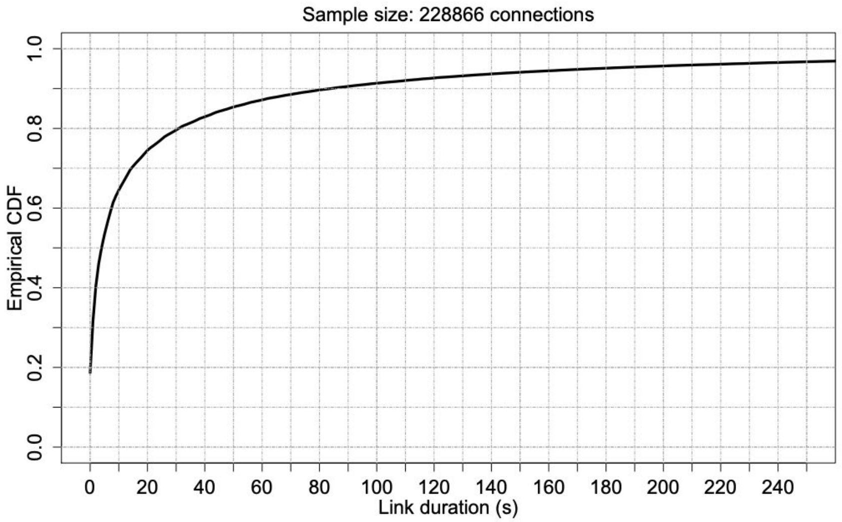
Challenges

- Dynamic topology
  - Vehicular nodes moving at high speeds
- Uneven distribution of nodes
  - Due to city/street topology and traffic
- Spatial heterogeneity
  - Connectivity is not uniform across space
- Security
  - Nodes can join and access network freely

} Packet Loss

Routing Requirements

- Need to react quickly to topological changes
    - Links have short-lifespan due to the high mobility of vehicular networks
- Low control overhead
    - Limit network flooding during communications
    - Increases scalability
- Choosing reliable next-hop
    - Link instability makes this challenging
    - Greedy routing can pick poor links



Topological v Geographic Routing

Topological

- Use link information within the network to send packets (proactive or reactive)
- Topological protocols can't react fast enough for topological changes
- Need to know the topology of the network
- Not suitable for vehicular contexts

Geographic

- Packets are forwarded to nodes that are progressively closer to destination
- Geographic forwarding is less vulnerable to topology changes caused by node movement

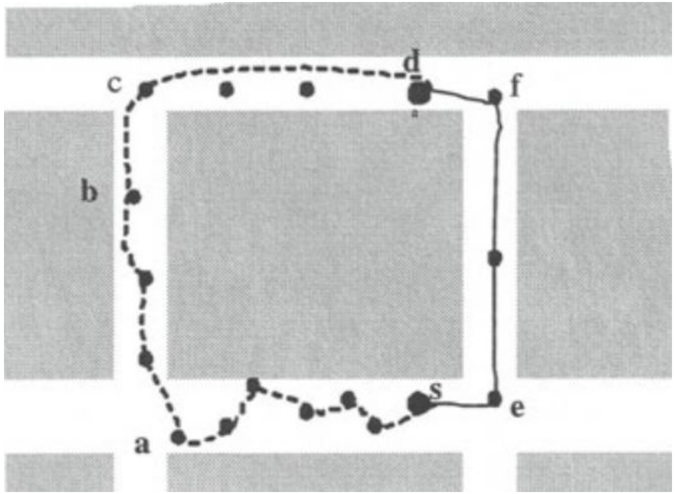
Basic Geographic Protocols

GPSR - Greedy Perimeter Stateless Routing

- Greedily forwards to node closest to destination
- Can encounter local maximum
  - When node is closer to destination than all nearby nodes
  - Use perimeter mode with right hand rule to overcome
  - Very expensive in city environments

GSR - Geographic Source Routing

- Utilizes city map data to calculate route
- Uses dijkstra's to calculate shortest path using map data
- Forwards greedily along path
- Able to take advantage of known topology



Overview of Additional Protocols

Protocol	Category	Requirements
A-STAR	Anchor-based	Traffic and map info
TrafRoute	Landmark-based	Connected infrastructure Map info
DAZL	Density-based	None

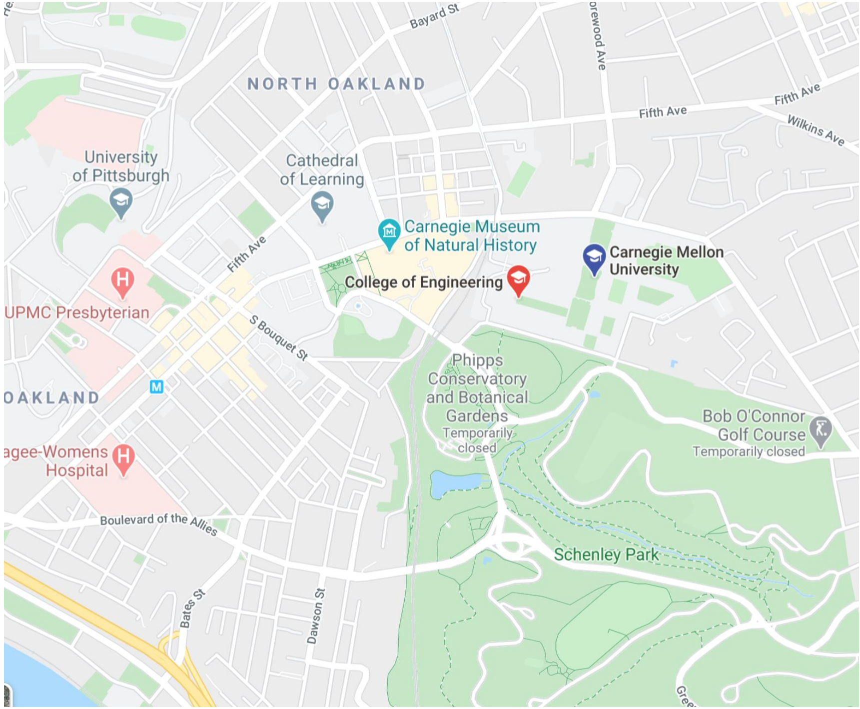
A-STAR

- **Anchor-based Street and Traffic Aware Routing**

- **Anchor-based:** Source node includes a list of anchors through which packets must pass
  - Anchors are fixed geographic points

- **Traffic Aware:** Utilizes existing traffic/congestion data during route planning

- Traffic data can be static (bus routes), or dynamic (congestion data)



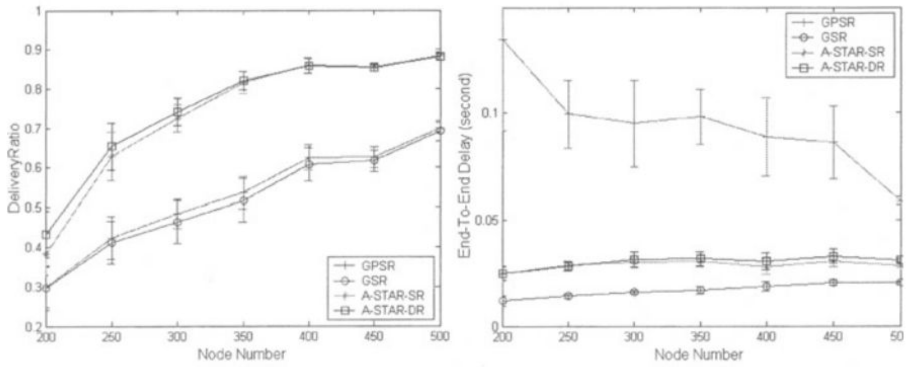
A-STAR

- Uses Dijkstra's least-weight path algorithm to compute anchor path
  - Takes into account map and traffic data

- If a packet reaches a local maximum along path, recompute anchor points and temporarily block off current location
  - Map updates sent to other nodes
  - Better than traditional "right hand rule" methods

Results & Analysis

- 40% more packets delivered with A-STAR compared to GSR
- Longer end-to-end delay than GSR
- A-Star has the best performance because it can select paths with higher connectivity
- A-Star's new local recovery strategy is more suitable for city environments than GSR's greedy approach or GPSR's perimeter mode



(a)Packet Delivery Ratio (b) End-to-End Delay

TrafRoute

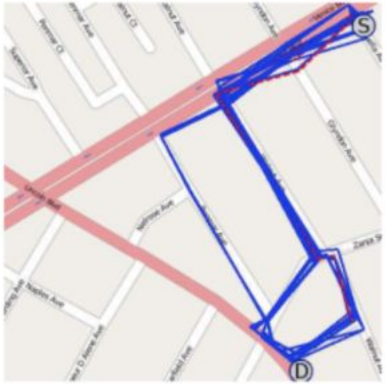
- Creates routes that pass through **Forwarding Points**
  - Predefined anchor regions
  - Selected to ensure quality links

- When forwarding, vehicles in radius of Forwarding Points self-elect to forward
  - Multiple forwarders can improve robustness

- Doesn’t suffer from local maxima due to Forwarding Points

(a) GPSR — Scenario A

(b) GPSR — Scenario B

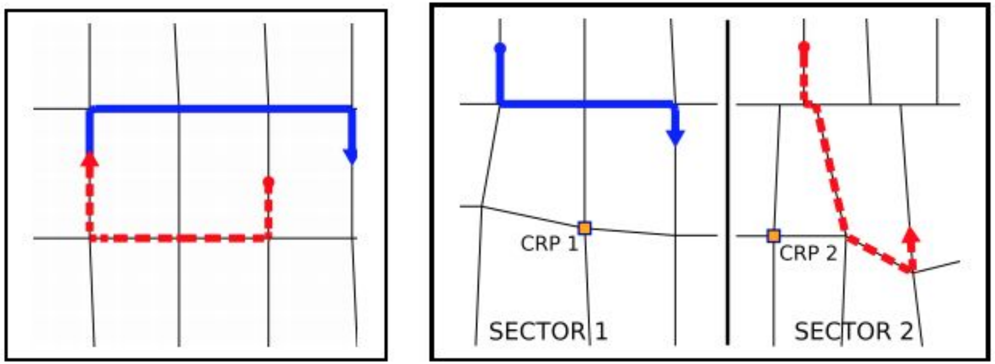


(c) TrafRoute — Scenario A

(d) TrafRoute — Scenario B

TrafRoute - long transmissions?

- Divide space into small sectors. Each sector has a Central Relay Point (CRP): roadside units that register with all vehicles in sector
  - Within each sector use multi-hop communication
  - Between sectors CRPs will communicate and broadcast to designated destination



TrafRoute - Routes

Two Phases: Discovery and Maintenance

Discovery

- Source requests route and floods sector to find path
- If CRP sees that dest is outside of sector, then it relays to appropriate CRP
  - All CRP's have tables of registered vehicles in each sector

Maintenance

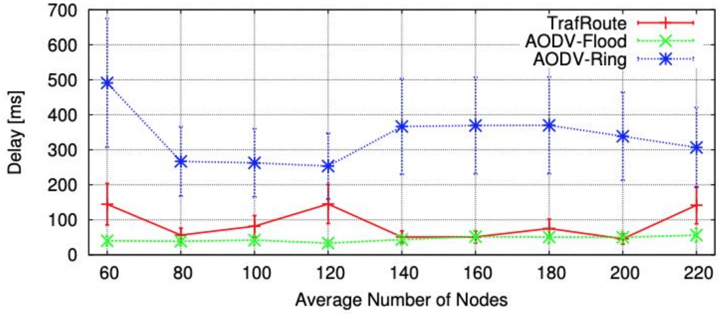
- If route is deemed invalid, new route is discovered
  - Faster to rediscover route than patch

Results

- Generates more direct routes than GPSR due to predefined FPs and no maxima

- Discovers routes faster than AODV

- Much faster and more reliable long-distance (inter sector) communication



Our Analysis

Pros:

- Built to ensure coverage
- Avoids local maximum
- Fast long-distance communication

Cons:

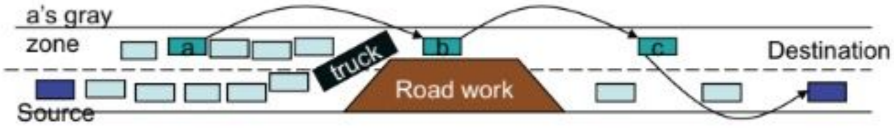
- Requires additional infrastructure
- Flooding from route discovery and maintenance

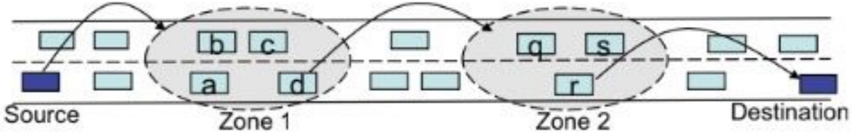
DAZL

- Density-Aware Zone-Based Forwarding

- **Key Idea:** Single links are transient and unreliable. Leverage multiple links to ensure forwarding is successful.

- Instead of having a single node forward, have all qualified forwarders line up and send for redundancy





DAZL - The Steps

1. Sender broadcasts with destination coordinates

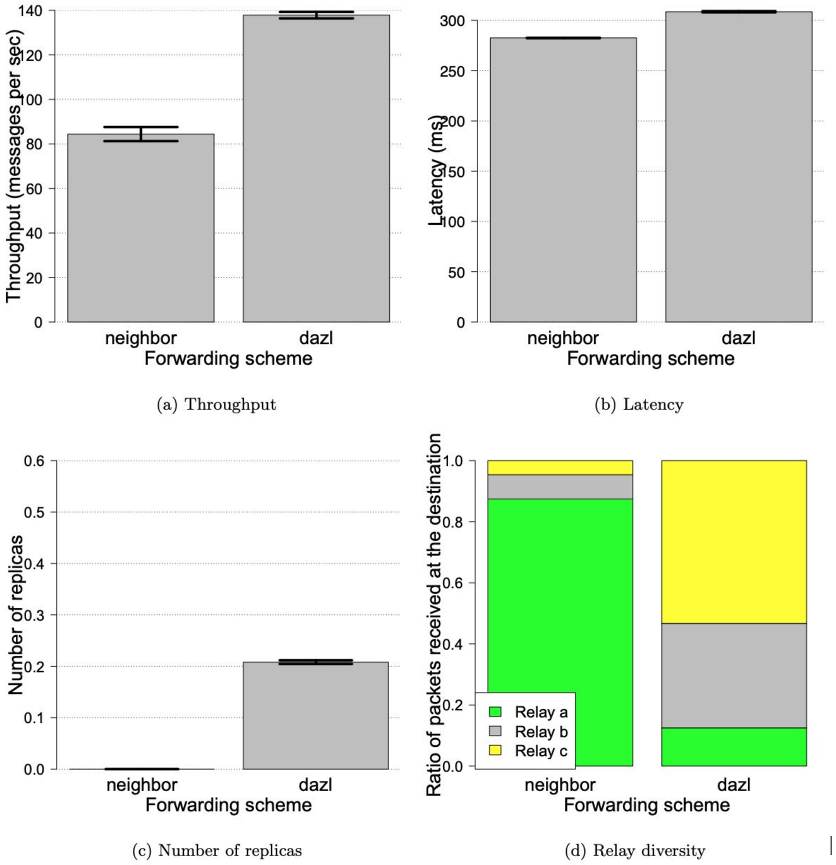
2. All nodes who receive the broadcast determine if they are a good forwarder
    - If they are closer to the destination than the sender or not

3. Candidates rank themselves according to distance from destination

4. Candidates broadcast in rank order with allotted buffers between transmissions, cancel transmission if they hear a successful transmission

DAZL Results

- Increased throughput compared to simple neighbor model
- Slight increase in latency
- Greater route diversity than neighbor protocol



(a) Throughput

(b) Latency

(c) Number of replicas

(d) Relay diversity

Our Analysis

Pros:

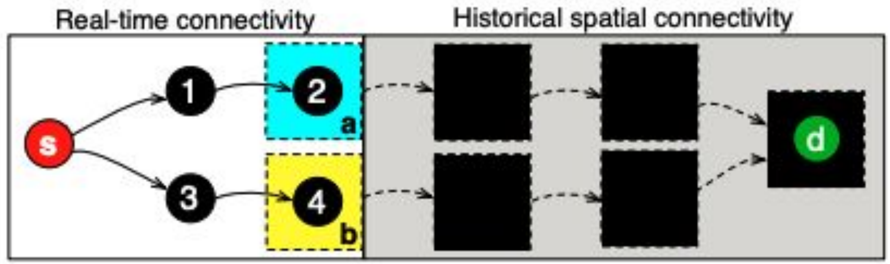
- Entirely distributed and localized
- Built-in redundancy
- Great throughput

Cons:

- Additional overhead from duplicated messages
- Slightly higher latency
- Results are from highly controlled experiment

LASP

- LASP is a geographic unicast multi-hop communication protocol whose goal is to maximize end-to-end delivery probability
- Generalization of DAZL
- Addresses spatial heterogeneity present in vehicular networks
- Historical spatial connectivity is used as a look-ahead to complement local real time information



Questions?

Thank you!

References

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