Power Efficient Vehicular Ad Hoc Networks

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Outline

Vehicular Ad Hoc Networks (VANETs)

- Adaptation of mobile ad-hoc networks
- Vehicle to vehicle and vehicle to infrastructure communications
- Promote safety and connectivity on the highway

VANET Protocols

- Topology – Forwarding using link information
- Position – Routing by physical location
- Cluster – Small groups communicate via a head node
- Geocast – Flood data to nodes in a specific region of space
- Traditional – multicast and broadcast techniques adapted to VANETs

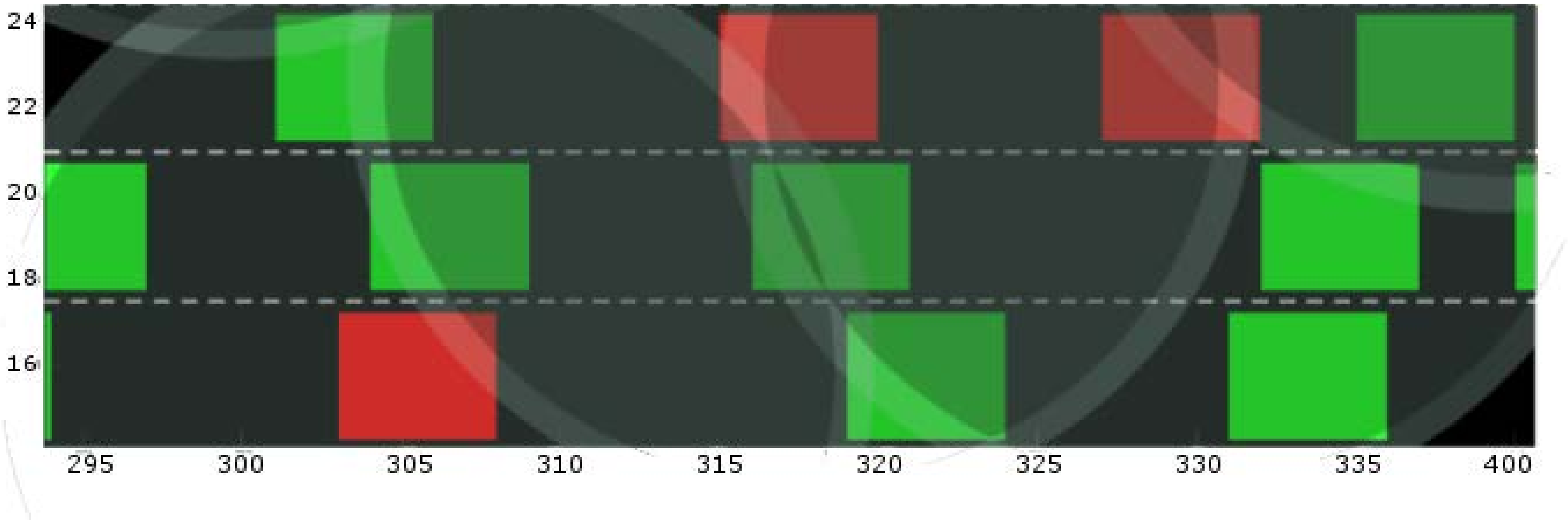
Motivation for a New Approach

- Need for beyond the horizon data
- Most current techniques rely on:
  - Relatively high power, broadband communication
  - Complicated routing protocols

The Proposed Approach

- Deliver kinematic data down road for processing
- Topology and routing protocol based on:
  - Dimensional reduction
  - Clustering
  - Line of sight connections
- Link length prediction algorithm
- Predictive link maintenance algorithm

Topology



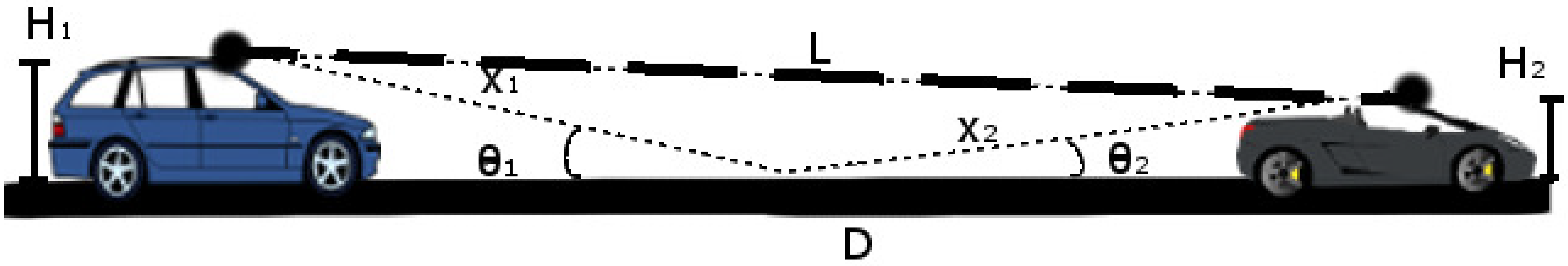
- Dimensional reduction
- Zone of relevance
- Clustering

Link Distance Prediction

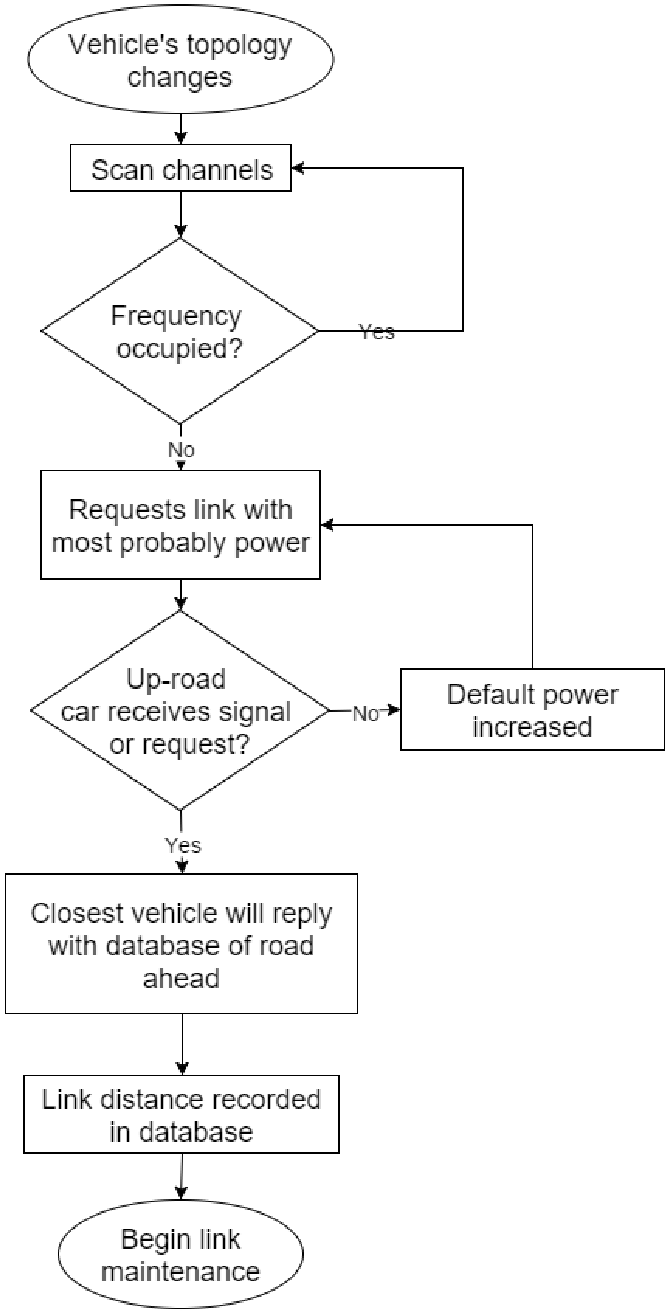
- Universal Transverse Mercator projection
- Track link distances over time
- Two predictive methods:
  - Gaussian analysis
  - Fuzzy logic

Link Formation

- Forward linking, backward listening
- Predict power with two-ray ground reflection model
- Reply using Carrier Sense Multiple Access with Collision Avoidance

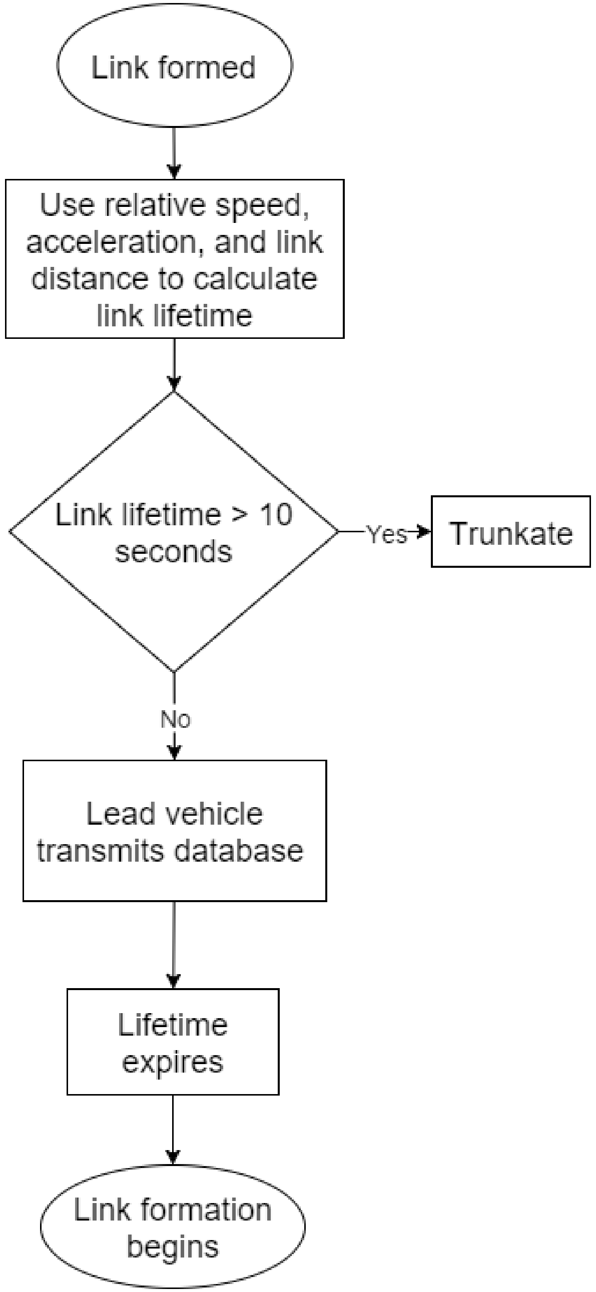


Link Formation



Link Maintenance

- Calculate link lifetime
- Calculate transmit power



Message Format

Latitude	Longitude	3D Acceleration	Speed	Transmission State	Position Accuracy	Heading
Steering Wheel Angle	Yaw Rate	Elevation	Temporary ID	Brake System Status	Timestamp	Vehicle Size

Band Plan

- 75 MHz at 5.9 GHz assigned by the FCC
    - Divided into 7, 10MHz channels
- Proposal: Divide one FCC channel into 6, 1.5 MHz channels

Simulation Environment

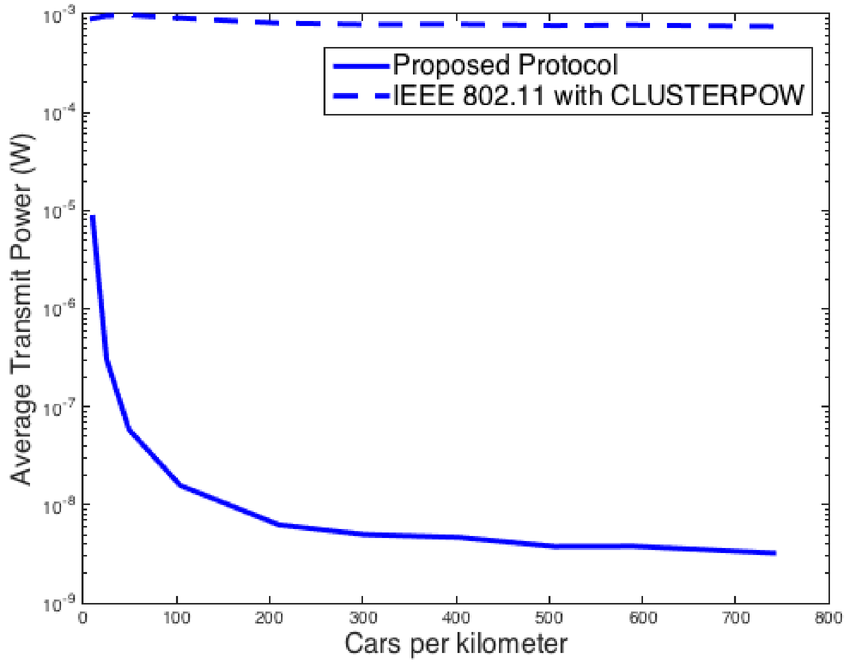
- Two part simulation:
  - Road structure
  - Communications
- Comparison case: IEEE 802.11 VANET specification using CLUSTERPOW power management

Results

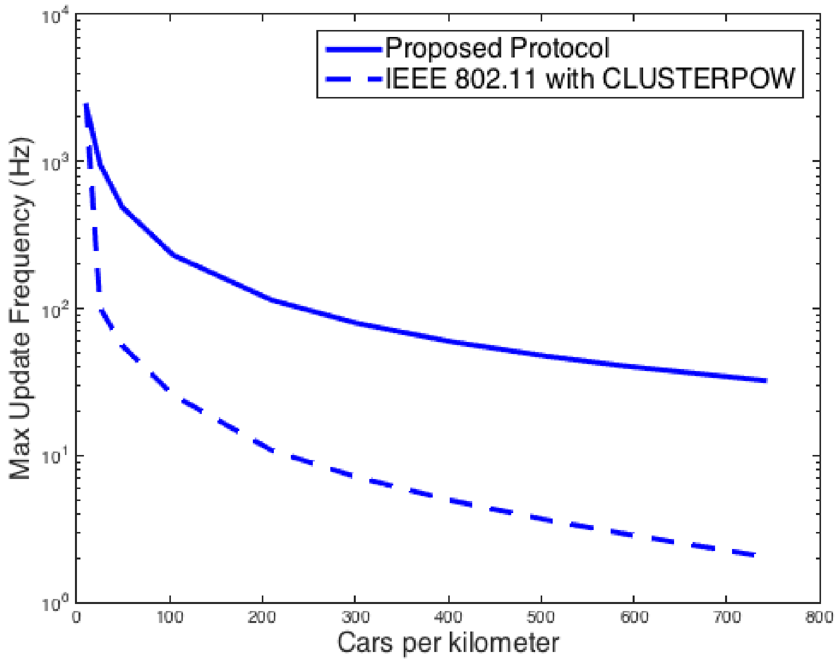
		Proposed Network:		IEEE 802.11:	
Number of Lanes	Number of Simulated Cars	Average Transmit Power (Watts)	Average Max Update Frequency (Hz)	Average Transmit Power (Watts)	Average Max Update Frequency (Hz)
1	10	8.448798e-06	2390.19	9.000000e-04	2390.19
2	25	3.042131e-07	956.074	9.600000e-04	100.639
3	49	5.848702e-08	487.793	9.795918e-04	55.672
4	104	1.577975e-08	229.826	9.134615e-04	25.6525
5	210	6.261866e-09	113.818	8.095238e-04	10.7867
6	302	4.980621e-09	79.1452	7.847682e-04	7.09014
7	403	4.661964e-09	59.3098	7.890819e-04	4.92893
8	506	3.766406e-09	47.2369	7.667984e-04	3.63248
9	590	3.791124e-09	40.5116	7.762712e-04	2.9174
10	741	3.225761e-09	32.2562	7.516869e-04	2.03864

Results

Average Transmit Power per Car Density



Maximum Update Frequency per Car Density



Questions?