EE299 Project Course

Vehicular Ad Hoc Networks (VANET)

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# Routing in Sparse Vehicular Ad Hoc Wireless Networks

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## Describe Problem

From the Abstract statement: Study of disconnected network phenomena and its network characteristics. Average time taken to propagate a packet to disconnected nodes (i.e., the re-healing time ). For safety applications need something better than Dynamic Source Routing (DSR) and Ad Hoc On-Demand Distance Vector Routing (AODV) which have long re-healing times.

Introduction:

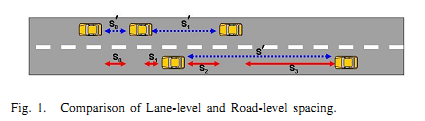
* Problem with VANET is wireless links and strengths constantly changing. Example: Bumper to bumper highway traffic has highly dense networks, night time and rural area experience network fragmentation.
* Focusing on “disconnected network” situation which deserves more attention.
* Three questions straight from the paper:
  + Is the network disconnection problem a severe problem prohibiting vehicles from successfully delivering safety messages to other vehicles?
  + What are the key characteristics of the network disconnection in VANETs and how do they affect the network performance?
  + How can we solve or mitigate this disconnected VANET problem?
* Will show that network fragmentation is a real issue, but will show some solutions (“store-carry-forward” mechanism)
* Look at some traffic models (inter-arrival time and inter-vehicle spacing between roads and vehicles) from I-80 freeway on June 27, 2006.
* Stats: Inter-vehicle spacing is exponential distribution when effective traffic volume is less than 1000 veh/hr. Even with 100% market penetration, network disconnection is 35% during night but well connected network during rush hour. Small market penetration then network disconnection is a problem during rush hour too.
* Characteristics to analyze:
  + Probability of disconnection from another vehicle
  + Cluster size
  + Cluster lengths
  + Intra- and inter-cluster spacing
* Show how re-healing time affects safety applications based on how well connected a network is.
* Key Contributions of this study:
  + Observed that inter-arrival time and inter-vehicle spacing can be approximated by exponential distributions. Validates network fragmentation conjecture about VANETs.
  + Quantify metric of re-healing time, quantifying average delay needed to deliver messages between disconnected vehicles.
  + Potential Solution: “store-carry-forward” for disconnected VANETs. Use Monte Carlo simulations. Use store-carry-forward with broadcast mechanisms in disconnected VANET then the average re-healing time is on the order of a few to several seconds.

II: Related Work

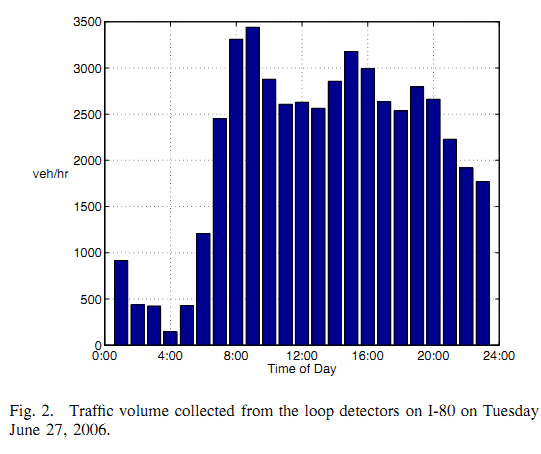
* The data is collected in real-world setting
* Most existing models not mathematically tractable.
  + Random Way Point (RWP) mobile nodes randomly select destinations with a randomly chosen velocity. Doesn’t capture all characteristics of true traffic.
  + Reference Point Group Mobility (RPGM) emulates grouping behavior of battlefield scenarios.
  + Freeway/Manhattan model captured impact of geographic restriction (ie road) on vehicular mobility
  + Simplified car-following model is used to restrict vehicular movements on a road at lane-level defined by real map data.
* Most models are over simplified with assumptions necessary to make the analysis tractable which results in models that fail to adequately represent the extreme complexity of the real-world mobility patterns.
* Emphasis on fact that VANETs are prone to network fragmentation due to uneven nature of vehicle traffic and market penetration.
* Delay Tolerant Networks (DTN) is synergistic with the problem formulation of disconnected VANETs.
* DTN framework proposed to analyze and interconnect challenged networks where end-to-end routes between mobile nodes may not exist:
  + Wildlife tracking sensor networks
  + Inter-planetary networks
  + Military ad hoc networks
* Requires asynchronous message forwarding paradigm based on **“store-carry-forward”** concept to achieve interoperability among different challenged networks.
* Some models that fall into DTN framework
  + DataMules: mobile messengers which promote the network connectivity in a sensor network by providing access between the virtual backbone and sensor nodes
  + Epidemic Routing: relies on mobile nodes to exchange they data they possess whenever they encounter new neighbors
  + Role-based multicast approach: proposed to achieve maximum reach ability in a sparsely connected or fragmented network by using the store-carry-forward mechanism
  + Single-copy and Multi-copy “Spray and Wait” are shown to be efficient alternatives for message delivery
* **Focus on network fragmentation scenarios of VANETs with realistic vehicular mobility models. Main objective in this paper is to establish comprehensive analytical framework for understanding the fundamental characteristics of disconnected VANETs in addition to studying the feasibility of the store-carry-forward approach.**
* Developed analytical framework which can be used to derive several network characteristics and key routing performance metrics such as per-hop delay (re-healing time) in sparsely connected VANETs

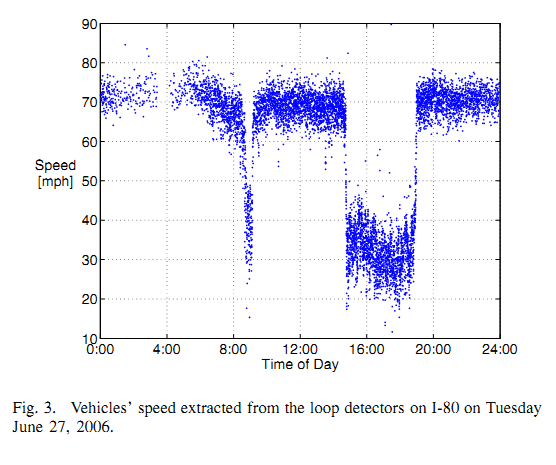
III. Vehicle Traffic Model

* Car following model, single-lane behavior under both free-flow and congested traffic conditions. Assumes drivers maintains safe distance from leading vehicle. Takes into account deceleration factor for braking performance and drivers behavior.
  + Complete mathematical model:
    - S’ headway spacing between rear bumper to rear bumper
    - L effective vehicle length in meters
    - V vehicle sped in meters/second
    - driver reaction time in seconds
    - reciprocal of twice the max average deceleration of a following vehicle (ie approximately 0.075 )
  + and introduced to ensure sufficient spacing so that following vehicle can come to a complete stop if the leading vehicle suddenly brakes.
  + Simplified Model: Good driving assumption, similar braking performance () 🡺
* Limitations of the car following model:
  + Describes headway spacing between 2 adjacent vehicles in same lane (lane level spacing). From network perspective most relevant metric is spacing from leading vehicle to the nearest following vehicle on a multi-lane road (road level spacing), regardless if following vehicle is in same or different lane. Distance to nearest neighbor determines whether wireless link between vehicles exist or not.
  + Car following model appropriate under free flow traffic or heavy traffic scenarios where **driver reaction time** is believed to be a dominant factory.
    - typically small that represents reaction time of driver following a log-normal distribution
    - can be large as 50-100 seconds in light to moderate traffic, **CAN NOT** be interpreted as driver reaction time. In this case, **inter-arrival time** is used to describe vehicle spacing. Represented by exponential distribution (not sure if there is evidence to justify the distribution)
  + Address both limitations by replacing with road-level inter-arrival time . Reduces model to . By focusing on road-level inter-vehicle spacing S, proposed model accounts for rush-hour heavy traffic and captures sparse or intermediate traffic.
    - inter-arrival time of vehicles on any lane from fix observation point
    - is minimum spacing between any two adjacent vehicles



* Incorporate empirical data into traffic model from Berkeley Highway Laboratory (BHL)
  + Shows when network disconnection occurs.
  + How serious the disconnected network problem could be in real traffic situations.





IV: Road-Level Traffic Model: Empirical Study

## Solution

## Analysis

## Performance Results

## Discuss Results

## Suggestion