Context-Driven Disruption Tolerant Networking for Vehicle Applications

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Context-Driven Disruption Tolerant Networking for Vehicle Applications

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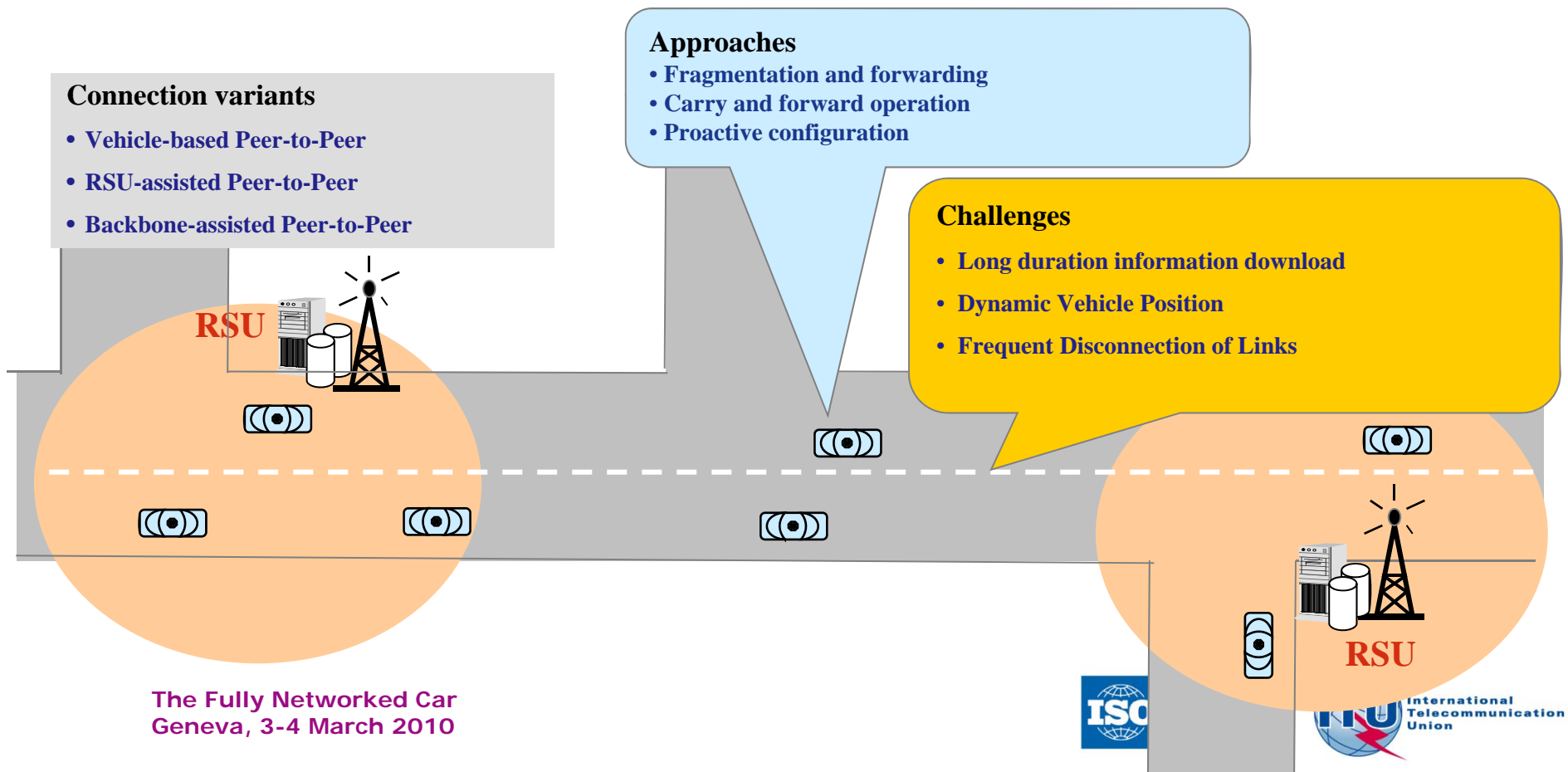[1]Telcordia Technologies
[2]Toyota InfoTechnology Center

March 3-4, 2010

Background and Motivation for DTN

o Dissemination of information among vehicles and RSUs with frequent connectivity disruptions

o Current approaches adapted from P2P content delivery networks

Approaches
- Fragmentation and forwarding
- Carry and forward operation
- Proactive configuration

Connection variants
- Vehicle-based Peer-to-Peer
- RSU-assisted Peer-to-Peer
- Backbone-assisted Peer-to-Peer

Challenges
- Long duration information download
- Dynamic Vehicle Position
- Frequent Disconnection of Links

RSU

RSU

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ISO

International Telecommunication Union
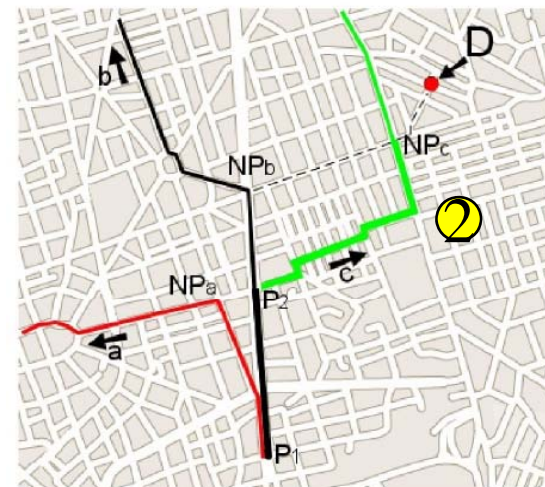
Some Related Work
Geographical Opportunistic Routing for Vehicular Networks
(GeOps)

o Approach

- Exploits geographic information from vehicle navigation system to deliver message to particular location.
  - Given the destination location, the sending vehicle (carrier) compute the nearest point on its route to the destination.
  - Based on nearest point it will calculate the minimum estimated delivery time to the destination by using navigation system.

Each vehicle will compute the minimum estimated delivery time based on its route. And vehicle C will have minimum estimated delivery time and choose to be carrier of message. ①

Vehicle C will choose another carrier to transmit the message to the destination. ②

University College, London 2008

Some Related Work

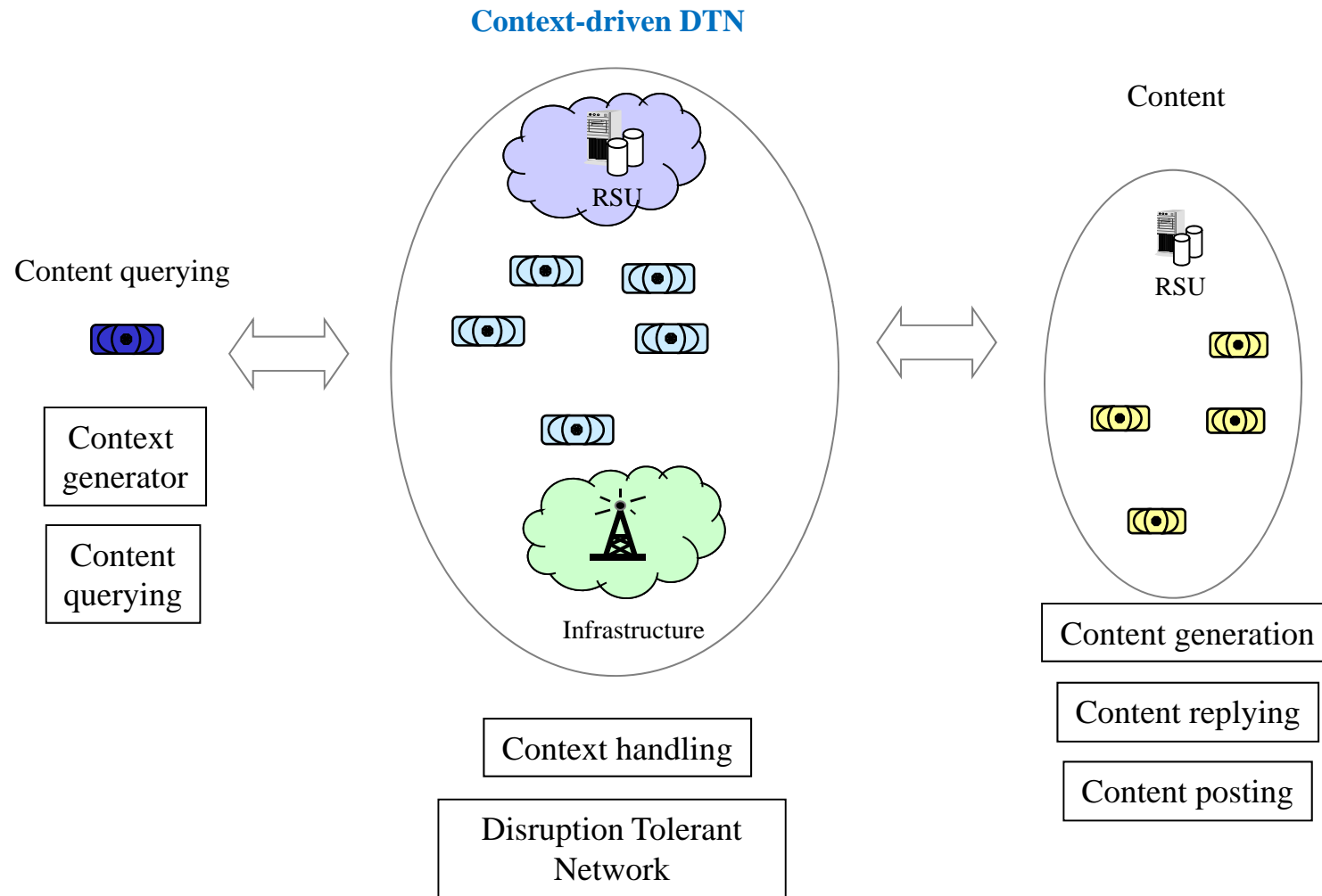|	DTN Protocol	Destination	Applications
GeOpps	Choose forwarding that will take message close to destination based on navigation system.	Fixed single point	Not specified
GeoDTN+Nav	Use Geo-graphic routing and switch to DTN mode when network partitions are detected Determine delivery quality metric based on navigation system to choose best neighbor	Fixed single point	Same as above
VADD	Use predictable vehicle mobility to choose best carry-and-forward neighbor.	Fixed single point	Not specified (Packet routing)
Context-driven DTN	Use context information to optimize and disseminate content	Mobile multiple points	Driving assistance

o Context-driven DTN (C-DTN):

- Networking protocol operations driven by context
  - In contrast to a generic mobile backbone to achieve end-to-end networking via multi-hop dissemination

Design Approach of Context-driven DTN (C-DTN)
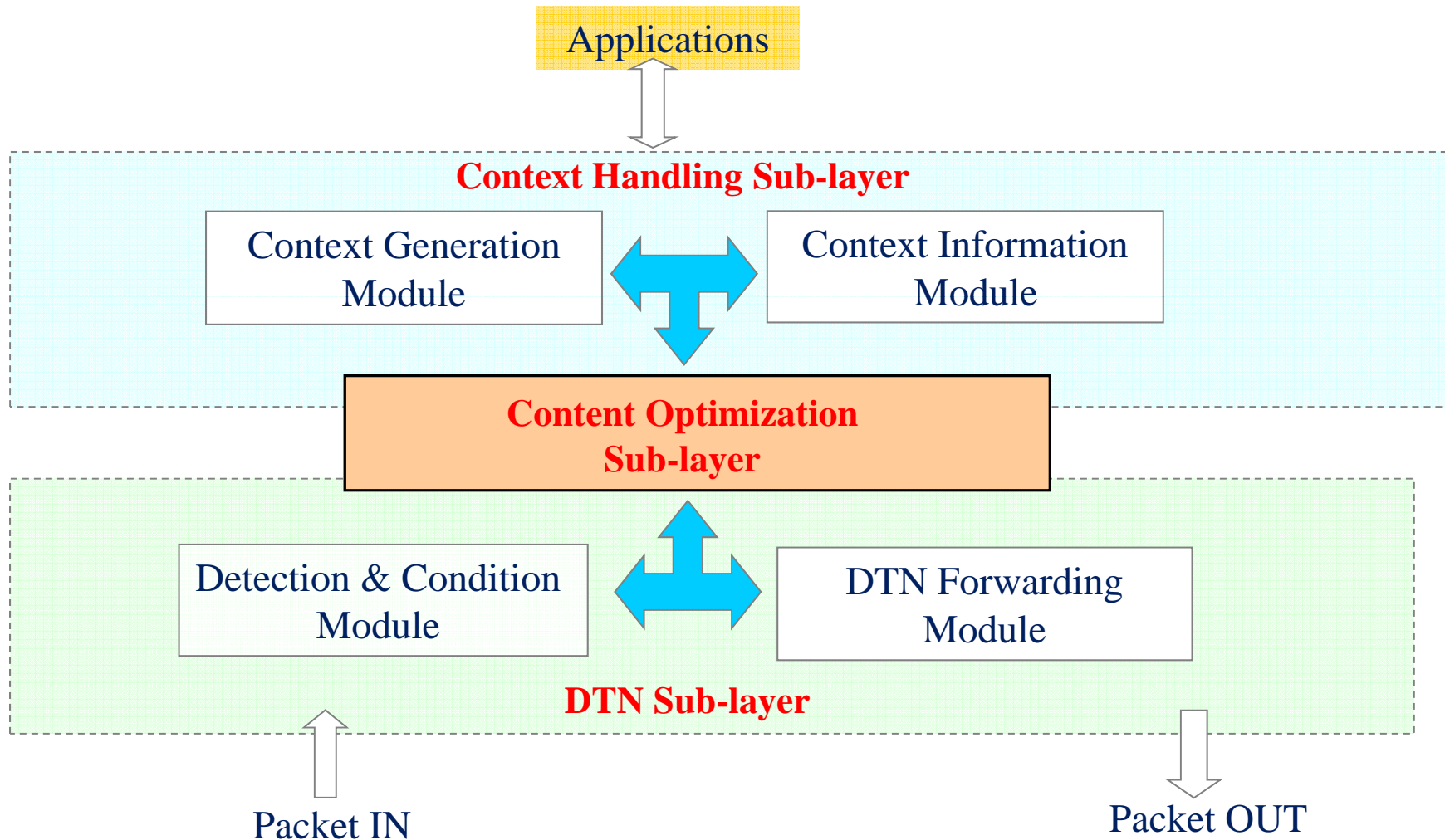## Context Identification

o Focus on individual vehicle application sessions and requirements

o Leverage context to develop technology for disruption tolerant network.

o Context consists of

- Temporal scope
  — Content expiration, (Packet expiration)
- Spatial scope
  — Content position, direction, trajectory, area (region of interest, posting area)
- Driving Attributes
  — Vehicle information including trajectory (driving plan)
    o Used for estimation of future locations
  — Communication pattern
    o End-to-end, end-to-multiple ends, end-to-region, etc.
  — Etc.

Context-driven DTN

Content

Content querying

RSU

RSU

Context generator

Content querying

Infrastructure

Content generation

Content replying

Content posting

Context handling

Disruption Tolerant Network

Logical Stack Components of C-DTN

Applications

Context Handling Sub-layer

Context Generation Module

Context Information Module

Content Optimization Sub-layer

Detection & Condition Module

DTN Forwarding Module

DTN Sub-layer

Packet IN

Packet OUT

Evaluation Scenarios
Overview

o Scenario # 1

o Content Source: static single node

o Content Recipients: static intersections

o Effect of variation in vehicle density and mobility on performance

o Scenario # 2

o Content Source: multiple intersections

o Content Recipient: mobile vehicles

o Effect of variation in vehicle density and destination mobility on performance

Sender

D Destination locations

Carrying vehicle

Receiving Vehicle
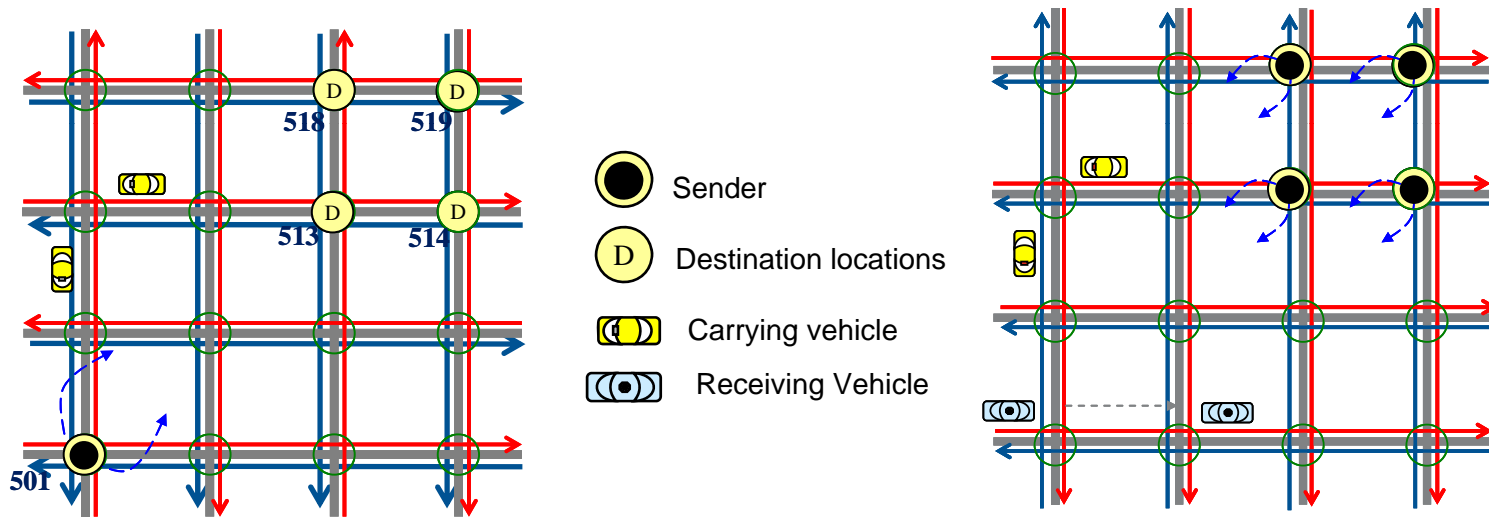
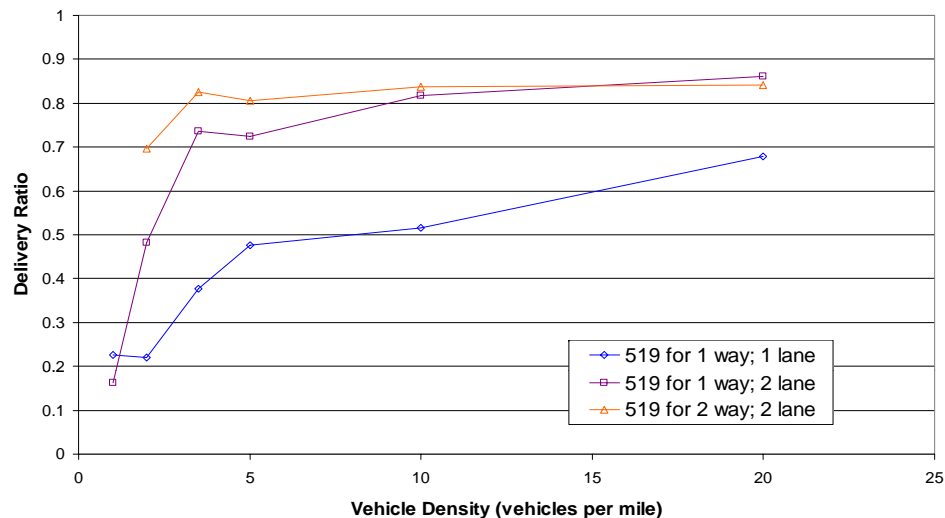| Application Parameter	Value
Cumulative Packet Rate	1300 B pkts @ 1 packet/sec
Radio Range	100m
Duration of simulation	600 seconds
Speed distribution	Uniform [24-96] Kmph

Scenario Evaluation of C-DTN
Packet Delivery Ratio and Average Delay

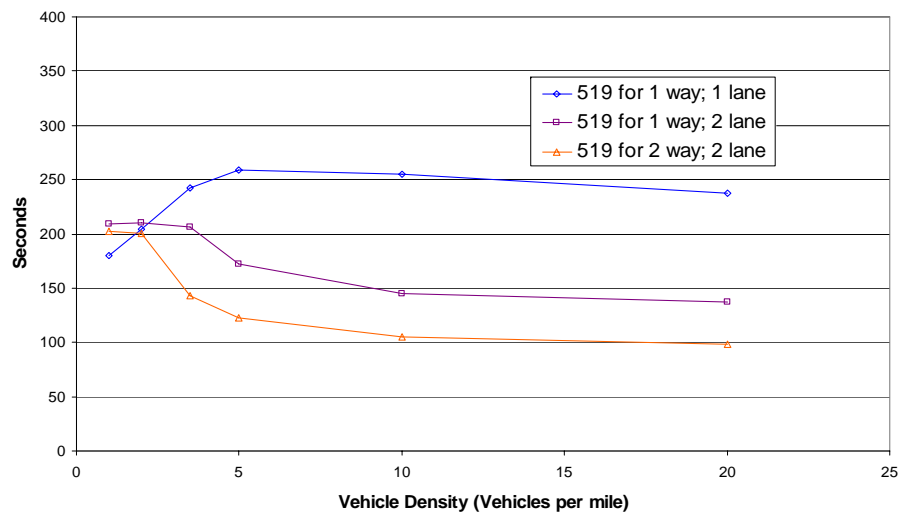**Scenario 1 PDR for #519**
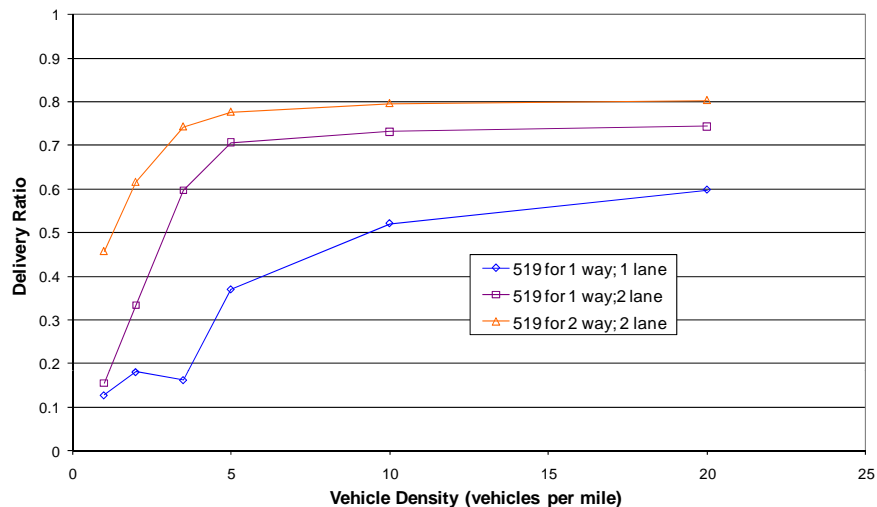
- Comparison for PDR at #519 (farthest from source)

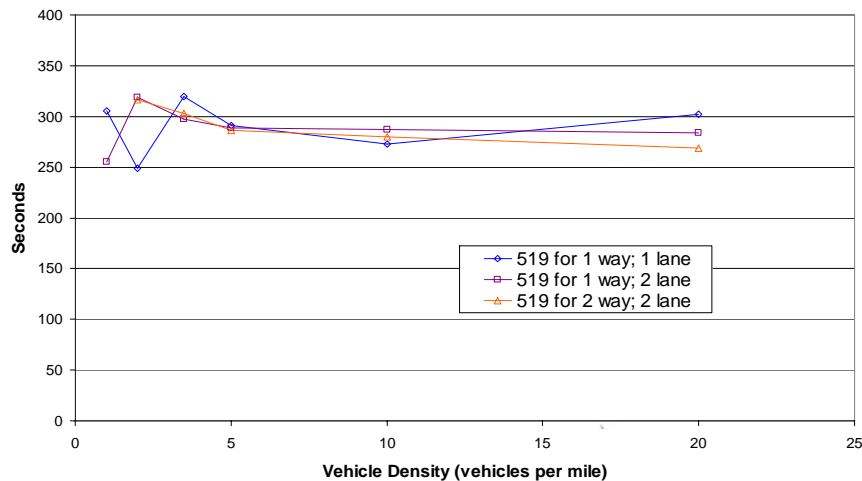**Scenario 2 PDR from Source 519**

- Comparison of PDR at mobile vehicle 1 from source #519

Scenario 1 Delay for #519

- Comparison for delay at #519 (farthest from source)

Scenario 2 Delay for Source 519

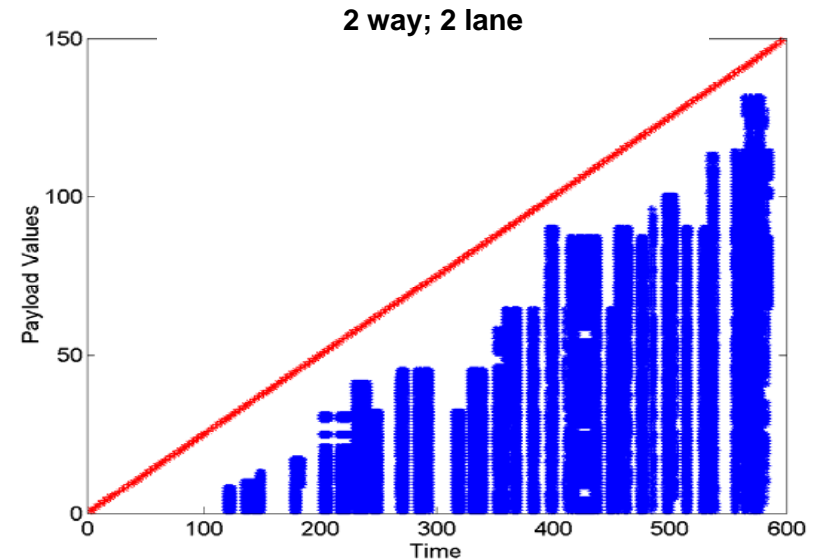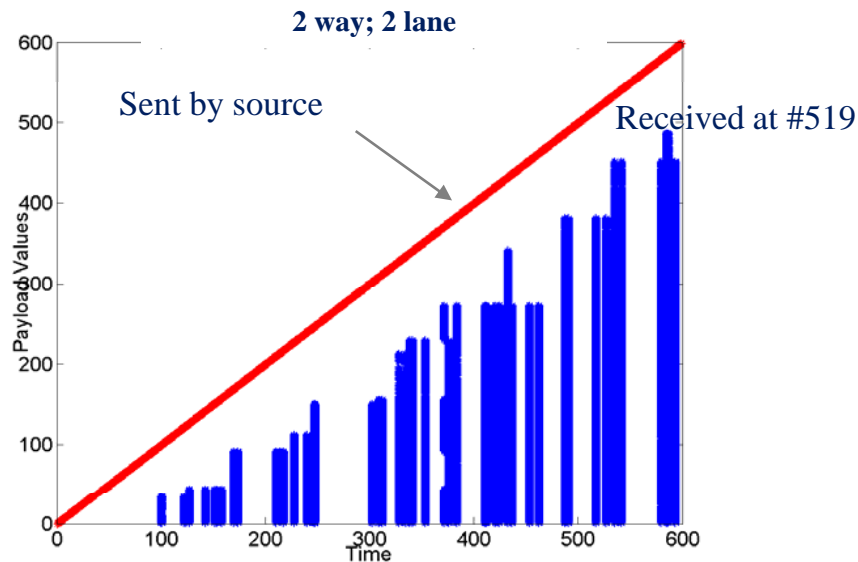
- Comparison of delay at mobile vehicle 1 from source #519

Scenario Evaluation of C-DTN
Freshness

o Vehicle density = 5 vehicles per mile

2 way; 2 lane

Sent by source

Received at #519

2 way; 2 lane

- DTNMP #519 (farthest from source) receives from content source
- Distinct instances of content reception

- Mobile destination receives from farthest content source
- Mobile destination receives content more frequently due to correlated mobility

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Summary

o   Overviewed general DTN approaches

o   Proposed a context-driven DTN (C-DTN) that supports networking in consideration of application context needs

o   Evaluations to validate C-DTN dissemination performance with realistic mobility

- Diversity in mobility pattern generally improves performance
- Under correlated mobility model, DTN dissemination performance depends on a number of factors

Backup Slides

Some Related Work
## GeoDTN+Nav: Hybrid Geographic and DTN Routing with Navigation Assistance

o Approach

- • Start forwarding in greedy forwarding (shortest path) mode and switch to DTN when network is disconnected
  - — Proposed score function to detect the network disconnection.
- • Compute delivery quality metric for each neighbor and choose the best quality node to forward the packet.
  - — Ex. Compute d1, d2 and d3 for 3 neighbors and choose best (d1) node. (below)

Proposed Vehicle Navigation Interface (VNI) for these vehicles.
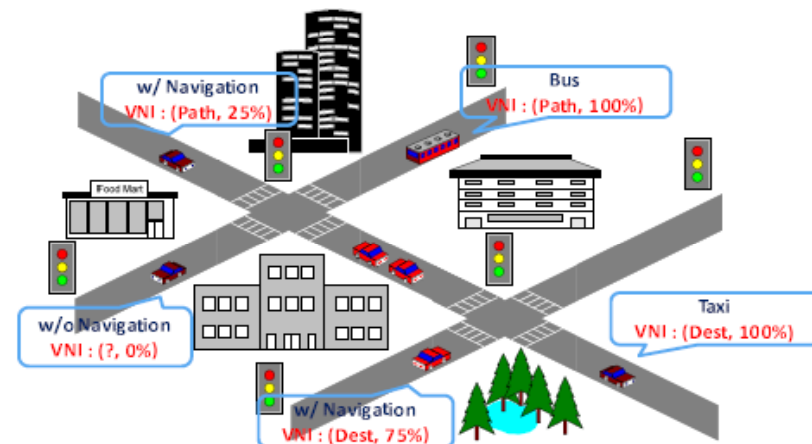
Univ. Of California, Los Angeles, 2008

Some Related Work
Vehicle-Assisted Data Delivery (VADD) Protocol

o Approach

- Estimates packet delivery delay on each roadway.

- Select forwarding direction using a priority list based on probabilistically shortest delay path computed in a centralized manner.

- Source and destination assumed to be in a connected graph

Geographically shortest path (traditional)

Fast speed wireless communication path (VADD)
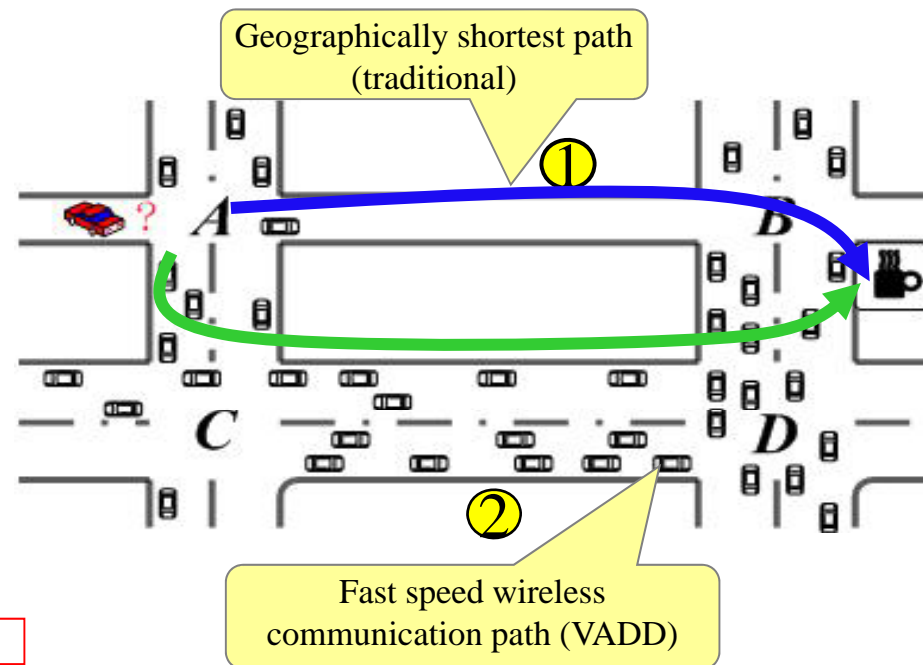
Penn State University, PA, 2005

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