Evaluating DTN Routing Schemes for Application in Vehicular Networks

Suhel Magdum, **Mehul Sharma**, Srikant Manas Kala, Antony Franklin A, and Bheemarjuna Reddy Tamma

> Networked Wireless Systems (NeWS) Lab Dept. of Computer Science and Engineering Indian Institute of Technology Hyderabad, INDIA

Fifth Workshop on Intelligent Transportation Systems (ITS) COMSNETS 2019 11th January 2019

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Introduction

- V2V/V2X is emerging as an efficient solution for achieving road safety and securely transmitting data from one vehicle to other.
- Vehicular Ad-hoc Networks (VANETs) have emerged as a competent solution for achieving seamless connectivity in ITS.



Figure: V2V/V2I communication

Introduction continued..

- Disruptions, strict latency, dynamic network topology, unbounded network size, fast vehicle movement, and environmental conditions.
- Failure of AODV and DSR.
- Technologies like Delay Tolerant Networking (DTN) and AllJoyn can be used to tackle these limitations.
- Performance of DTN routing protocols and AllJoyn in V2V/V2X aspect.
- Static nodes and bundle loss.

Objective

To compare the performance of different DTN routing schemes and investigate the relevance of AllJoyn framework in sparse V2V scenarios.

Contributions

- We compare the performance of AllJoyn framework and Direct Delivery protocol in a single-hop scenario and then draw the attention towards a multi-hop scenario by comparing the routing protocols that use DTN as the underlying paradigm.
- Evaluate the performance by transmitting the files of size 1, 4, and 10 MB from a static sender to a mobile receiver.
- Oeveloped an Android app that implements these routing protocols along with file sharing functionality.

Delay/Disruption Tolerant Networking (DTN) [1]

- Used to provide communication in the most challenging and unstable environments.
- DTN uses Store-Carry-Forward (SCF).
- No establishment of path. Data is incrementally moved and stored throughout the network in hopes that eventually reaches the destination.
- Composed of nodes with bidirectional links. Links may disconnect due to mobility.
- Connectivity issue due to frequent changes in topology, vehicle speed, and unpredictable movement of vehicles.

Direct Delivery

- Consumes minimal resources.
- Overhead is less as it sends only one message at a time.
- Works only for single hop.

Flooding

- Packet delivery is guaranteed.
- Easy to implement and converges fast.
- Bandwidth wastage is more.

Epidemic [2]

- Summary Vectors are exchanged.
- Number of redundant packets is reduced compared to flooding.
- Still suffers from bandwidth wastage.

Probabilistic Routing Protocol using History of Encounters and Transitivity (PRoPHET) [3]

- A higher delivery ratio, less communication overhead.
- delivery predictability.

AllJoyn Framework [4]

- Open source framework designed by Allseen Alliance for automatic discovery and communication between mobile devices.
- Proximity based P2P framework.
- Service advertisement, discovery, bus attachment, and session management.



Figure: Components of AllJoyn Framework

Why AllJoyn??

- Open source
- Allows dynamic configuration of the network.
- Can use C, C++, and Java for developing applications.
- Provides greater security (Simple Authentication and Security Layer (SASL)) by allowing access at the granularity of application-to-application communication.

App to transfer files



Figure: Android app to transfer files

- Nodes are connected by means of hotspot.
- Network Time Protocol (NTP) is used to synchronize the clocks.



Figure: Topology for AllJoyn and Direct Delivery

- The receiver is moved away from the sender with an average speed of 1.4 m/s which is also the average human walking speed, with multiple obstacles in between.
- We are considering the mobility of a single device (the receiver) in our experiment, to emulate sparse and low mobility V2V scenario.

Single-Hop Results



Figure: Transfer Time vs Inter-node distance (1 MB file transfer) Figure: Transfer Time vs Inter-node distance (4 MB file transfer) Figure: Transfer Time vs Inter-node distance (10 MB file transfer)

- Both fail to transmit beyond 70 meters.
- AllJoyn performs better than Direct Delivery up to 50 meters and than its performance starts to deteriorate.
- Induced delay is rather high for V2V.

Multi-Hop Scenario



Figure: Topology for Flooding, Epidemic, and PRoPHET

- Smartphones are referred to as nodes.
- Nodes are kept at a certain height for better connectivity.

Multi-Hop Results



Figure: Transfer Time vs Inter-node distance (1 MB file transfer) Figure: Transfer Time vs Inter-node distance (4 MB file transfer) Figure: Transfer Time vs Inter-node distance (10 MB file transfer)

- Flooding could not transmit beyond 80 meters.
- Epidemic performs better than PRoPHET for 4 MB and 10 MB.
- For 1 MB however, PRoPHET if performing good.
- Comparable till 40 meters.

Multi-Hop Results continued..



Figure: Throughput vs Inter-node distance (1 MB file transfer) Figure: Throughput vs Inter-node distance (4 MB file transfer) Figure: Throughput vs Inter-node distance (10 MB file transfer)

- Receiver's throughput in Mbps.
- Epidemic surpasses all the other protocols and offers maximum throughput.

- This work presented the performance analysis of routing protocols that use DTN and the AllJoyn framework for V2V applications.
- AllJoyn performs good till 40 meters only.
- AllJoyn does not support multi-hoping which is characteristic of V2V scenarios.
- Results demonstrate that Epidemic outperforms all other multi-hop DTN protocols.
- As an extension to this work,
 - We plan to develop a smartphone-based application using cloud and adhoc technologies for real-time collision detection and incident reporting.
 - We will use the Epidemic protocol to share location data to neighbors in real-time.

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Acknowledgement

This work was supported by the project M2Smart: Smart Cities for Emerging Countries based on Sensing, Network and Big Data Analysis of Multimodal Regional Transport System, JST/JICA SATREPS, Japan.



