GPSR-TARS

Congestion Aware Geographically Targeted Remote Surveillance for VANETs

A. D. Walker M. Radenkovic[1]

[1]School of Computer Science
University of Nottingham, UK

International Conference on Selected Topics in Mobile and Wireless Networking, May 2017
(Slides adapted for G54ACN)

University of Nottingham
UK | CHINA | MALAYSIA

Overview for Today

- **NOT ASSESSED!**
- For interest only
- Work from last year
- Time for questions
- ONE

University of Nottingham
UK | CHINA | MALAYSIA

- Vehicular Ad-Hoc Networks
- Vehicles plus communication
- V2V
- V2I
- Sharing information
  - Emergency
  - Convenience
  - Pleasure

University of Nottingham
UK | CHINA | MALAYSIA

- IEEE 802.11p Wireless Access for Vehicular Environment (WAVE)[1]
- Multi-hop communication
- Range of 300m
- Network layer

[1] Jiang and Delgrossi, "IEEE 802.11p: Towards an International Standard for Wireless Access in Vehicular Environments".

- Highly mobile
- Wide speed range of nodes
- Routing complications
  - Direction of travel
  - 3D topology
- Plus everything else!

University of Nottingham
UK | CHINA | MALAYSIA

- Lax resource constraints
- Predictable
- Acceleration/deceleration
- Direction changes
- Maps
- Social

University of Nottingham
UK | CHINA | MALAYSIA

Assumed Vehicular Equipment

- Computer
  - Processing
  - Storage
- Cameras
  - Dashboard, road focused (dashcams)
  - Passenger/driver facing
    - Buses
    - Taxis
    - Trams
- Global Positioning System (GPS)
- Communications
  - Wi-Fi

University of Nottingham
UK | CHINA | MALAYSIA

Background

- Dashcams are becoming ubiquitous
  - 60% of cars in South Korea are fitted with dashcams[2]
- Existing infrastructure static/disconnected
- Introduce surveillance to challenging environments
- War zones
- Disasters

[2] Park et al., "Motives and Concerns of Dashcam Video Sharing".

University of Nottingham
UK | CHINA | MALAYSIA

Related Work

- V3 (2005)
- LIAITHON (2012)
- REACT-DIS (2012)
- REDEC (2014)
- VoV (2014)
- HIVE (2014)
- QORE & QUALITE (2015)
- VIRTUS (2015)
- QoRA (2016)

University of Nottingham
UK | CHINA | MALAYSIA

Refined Aim

Within a fully V2V network, for multiple remote nodes (e.g. police cars, ambulances) to get the maximum number of possible live video streams from a target region whilst they are en-route to the incident.

University of Nottingham
UK | CHINA | MALAYSIA

Key Considerations

- Streamed multimedia is **highly** demanding
- Packet loss
- Delay
- Congestion
- Coordination

University of Nottingham
UK | CHINA | MALAYSIA

Greedy Perimeter Stateless Routing[3]

Location based greedy forwarding algorithm with a fall-back to perimeter based routing if this fails.

- Requires a coordinate system
- Proactive (table-driven)
- Beaconing
- Next best hop
- Low overhead
- Robust message delivery

[3] Karp and Kung, "GPSR: Greedy Perimeter Stateless Routing for Wireless Networks".

University of Nottingham
UK | CHINA | MALAYSIA

E-GPSR

Enhanced GPSR[4]

Congestion mitigation extension which seeks to avoid overloading nodes.

- Monitor and share buffer capacity
- Avoid over-loading neighbours

[4] Hu et al., "An enhanced GPSR routing protocol based on the buffer length of nodes for the congestion problem in VANETs".

University of Nottingham
UK | CHINA | MALAYSIA

Enhanced GPSR[5]

Uses velocity and direction to improve selection of next best hop.

- Speed and vector added to beacon
- Drastic improvements in VANETs
  - Highway
  - Urban
- Reduced delay and increased delivery

[5] Bouras, Kapoulas, and Tsanai, "A GPSR Enhancement Mechanism for Routing in VANETs".

University of Nottingham
UK | CHINA | MALAYSIA

Targeted Remote Surveillance (TARS) Module

Overview

Aim

To provide multiple, moving vehicles with remote, on-demand access to location based, mobile video streams.

University of Nottingham
UK | CHINA | MALAYSIA

- Query Mechanism
- Clustering Algorithm
- Dynamic Congestion Response

University of Nottingham
UK | CHINA | MALAYSIA

Security

- Assume an existing public key infrastructure (PKI)
- Mounted tamper-proof key-store
- Authorised surveillance nodes
- Vehicles uniquely identifiable
- Encrypted streams means no data redundancy

University of Nottingham
UK | CHINA | MALAYSIA

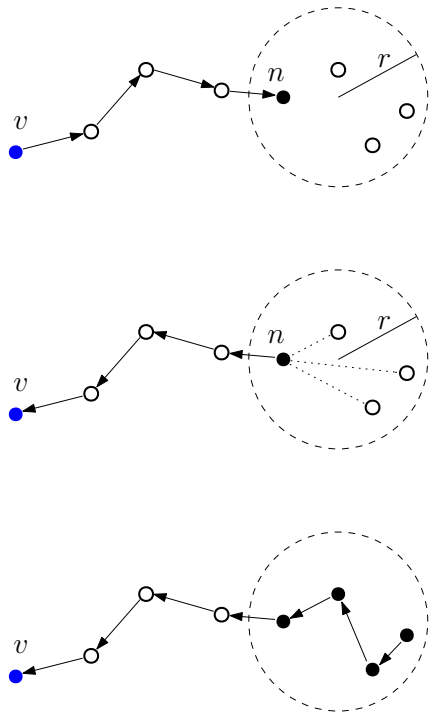
- Add support for region forwarding per CCN
- SREQ: Surveillance Request
  - Desired Location
  - Expiry Time
  - Requesting Node(s)
- Duplicate suppression
- Loop free
- Forwarded to target region

Zone (x, y)	Expiry	$d_0 \ldots d_n$

University of Nottingham
UK | CHINA | MALAYSIA

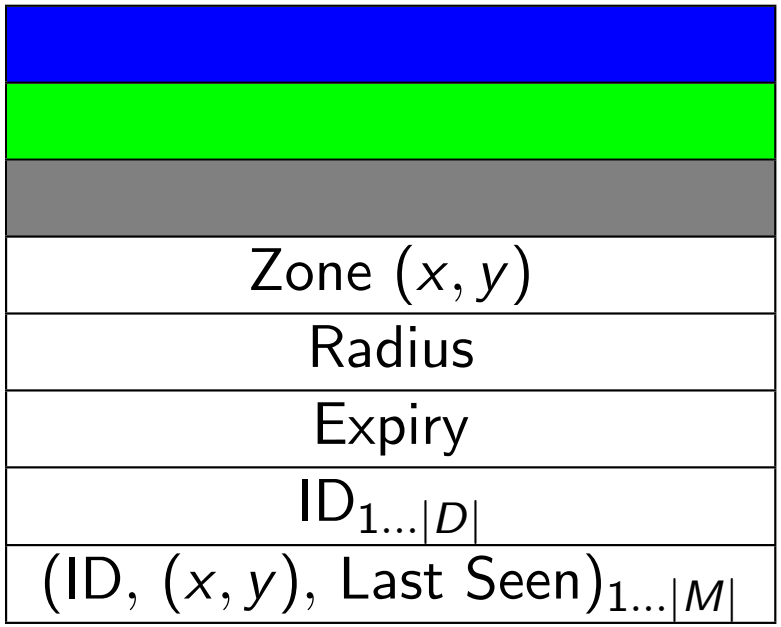
Cluster Formation

- Node(s) in region receive(s) SREQ
- Cluster initialised through HELLO+
- Initial radius estimated from region density
- Streaming begins, propagated to destination node(s)



Intra-Cluster Communication
HELLO+

- Augment GPSR beacons
- Increase frequency
- Nodes independent
- Monitor state
- Trivial membership status changes



University of Nottingham
UK | CHINA | MALAYSIA

$$r_i = r_{i-1} - \frac{\alpha \cdot r_{i-1} \cdot |V(G)|}{\max\limits_{v \in V} \epsilon(v)^{\beta}} \tag{1}$$

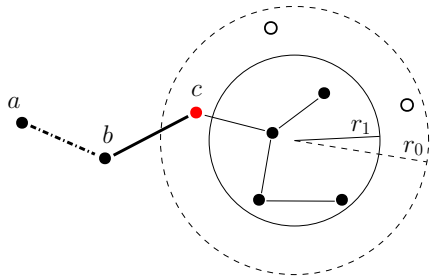
- Absence of congestion
- Increase size slowly based on density
- δ and γ dynamically determined
- Supports competing cluster heads
- Calculation of ϵ via e.g. Vincenty[6].

[6] Vincenty, "DIRECT AND INVERSE SOLUTIONS OF GEODESICS ON THE ELLIPSOID WITH APPLICATION OF NESTED EQUATIONS".

University of Nottingham
UK | CHINA | MALAYSIA

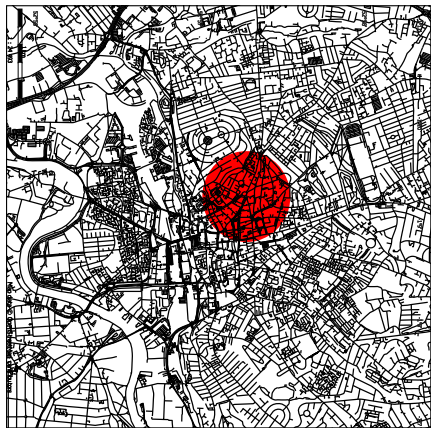
- Detection of congestion along path
- Early propagation of *future* failure
- Scale down region by factor of density
- α and β dynamically determined to promote rapid scaling
- Beacon period before further adjustment

$$r_i = r_{i-1} + \frac{\gamma \cdot r_{i-1} \cdot |V(G)|}{\max_{v \in V} \epsilon(v)^{\delta}} \quad (2)$$



University of Nottingham
UK | CHINA | MALAYSIA

- Simulation of Urban MObility (SUMO)[7]
- Highly realistic traces
- 25km^2 area of Nottingham city centre
- Urban scenario
- 'Typical' daily traffic



[7] Krajzewicz et al., "Recent Development and Applications of SUMO - Simulation of Urban MObility".

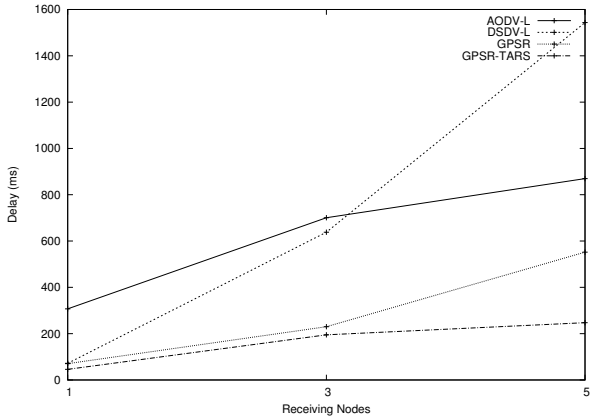
- ns-3[8]
- Compared against existing work (GPSR-TARS, GPSR, AODV-L, DSDV-L)
- Increasing number of requesting nodes
- Delay
- Packet Loss
- Size of region

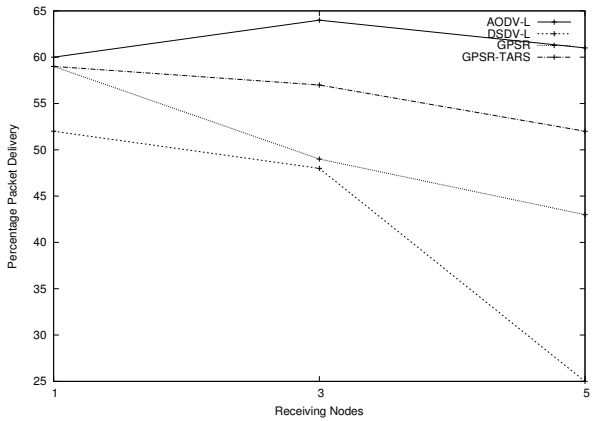
[8] Riley and Henderson, "The ns-3 Network Simulator".

University of Nottingham
UK | CHINA | MALAYSIA

Results

- GPSR & GPSR-TARS identical when $|M|$ is 1
- When $|M| > 1$ TARS provides better recovery
- AODV consistently higher delivery ratio![9]
- $\lessapprox$ 200ms delay for all D
- Successful adaptation to congestion *but* reduced zone size





[9] Bala and Krishna, "Scenario Based Performance Analysis of AODV and GPSR Routing Protocols in a VANET".

University of Nottingham
UK | CHINA | MALAYSIA

Future Work

- Deeper analysis
- Heterogeneous network adaptations
- Consider resource constraints
- Connectivity Aware Routing (CAR)[10]
- Retroactive queries
- Framework
- Prediction based dynamics
- Investigate related proposals[11]

[10] Yang, Lim, and Agrawal, "Connectivity Aware Routing in Vehicular Networks".

[11] Alsaqour et al., "Dynamic Packet Beaconing for GPSR Mobile Ad Hoc Position-based Routing Protocol Using Fuzzy Logic".

University of Nottingham
UK | CHINA | MALAYSIA

Finally

Any Questions?

Reminder

- Lecture tomorrow with Milena
- Think about coursework topic

University of Nottingham
UK | CHINA | MALAYSIA