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# Towards a general purpose network layer protocol for VANETs

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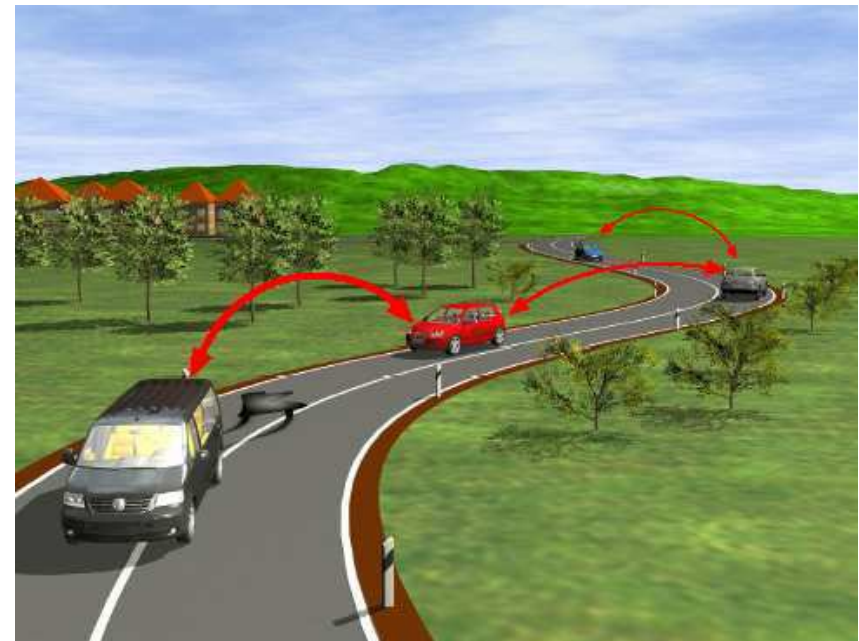
# Outline of this presentation

- VANET networks and applications
- Problematic toward a general purpose network layer protocol
- Research directions
  - Adaptive protocols/solutions
  - Application-specific and message-specific protocol
- Pre-requisites before exploring the research directions



# VANET Networks

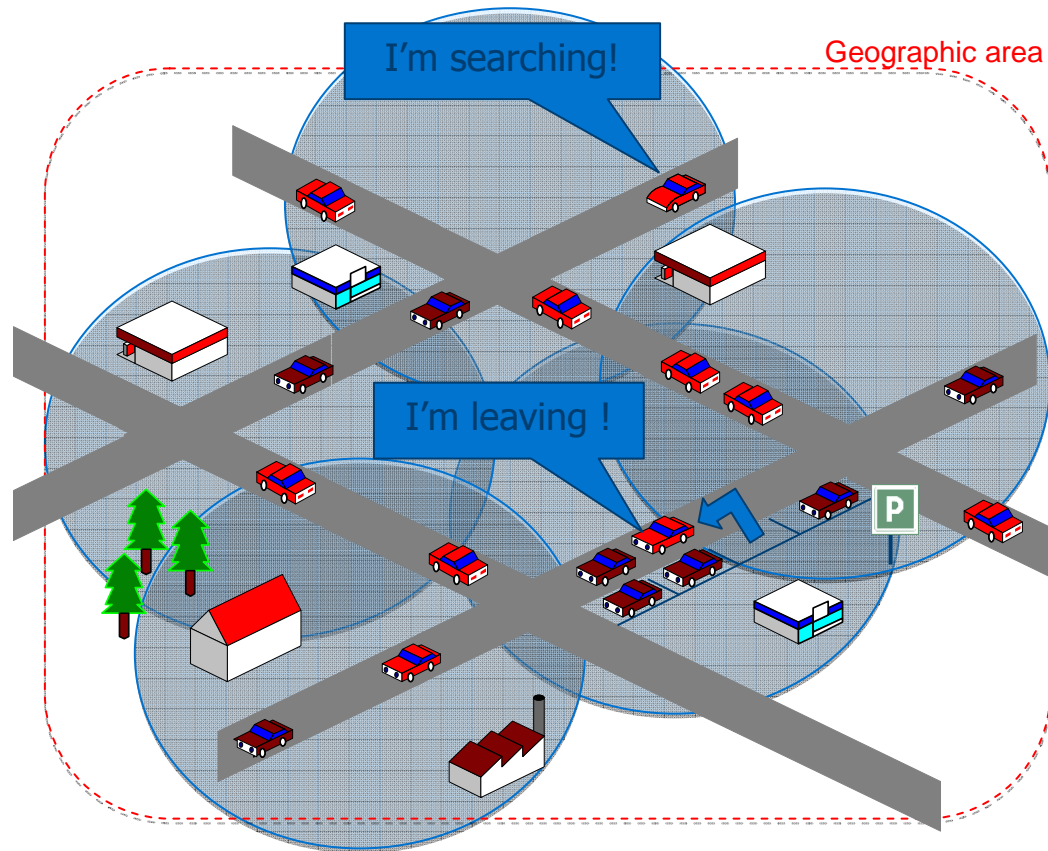
- Vehicle to vehicle communication
  - Exchange information to offers services
  - Possible integration of roadside comm
- Smart vehicles
  - Produce information by Sensors (embedded or not)
  - GPS and Digital Maps
- Use of wireless network technology
  - Future IEEE 802.11p link-layer proposal is tandardize



Still working on routing/dissemination solutions!!!!

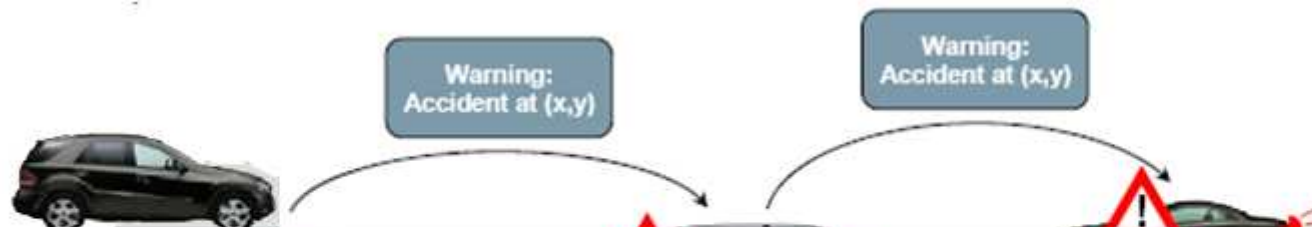
# VANET application examples

- Parking spot locator app



# VANET application examples

- Emergency break announcement



And much more applications examples!

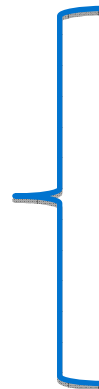
- **Different communication needs**



# There is a problem...

- Much of VANET network layer proposals in literature
  - Application specific
  - Optimize for one app but bad performance in others

Use of different  
communication solutions



Unicast routing  
Dissemination  
Information aggregation  
Carry and forward

# There is a problem...

- How to choose the network protocol that will be installed in vehicle?
  - Vast application possibilities → User acceptance
  - Few app support → technology fail

**Add all application specific  
network layer protocols in vehicle?**



# Another problem...

- VANET have very dynamic characteristics

- Node velocity

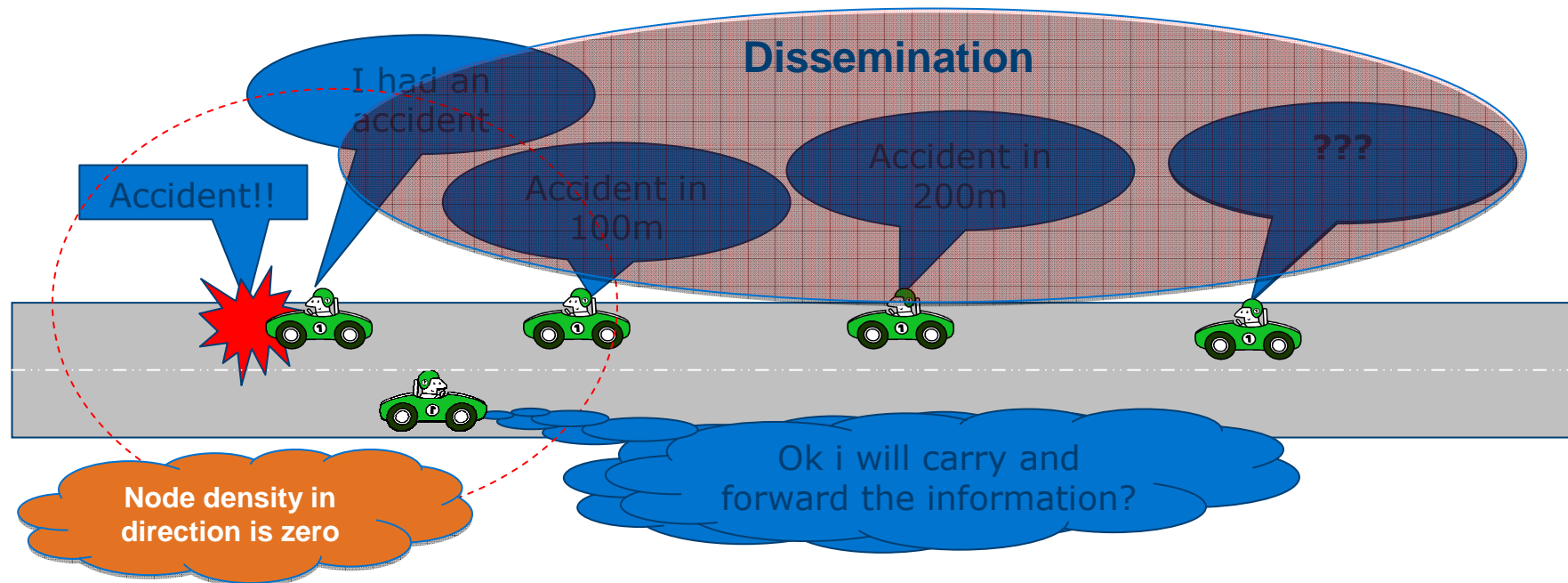
- Movement pattern

More proposals to address these extreme conditions!

- Normal vehicles, authority vehicles
- With GPS, with digital maps system, with sensor
- Roadside units

# Even...

- Network context could change communication solution to be used



# Problematic

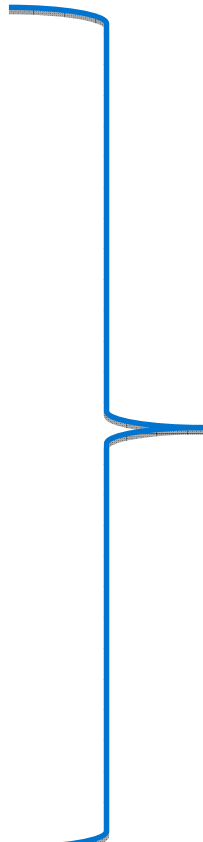


General purpose network layer protocol

**How can we approach this problem?**

# Research directions

- Adaptive protocols/solutions
  - Purpose:
    - Join protocols, reduce number of protocols
    - Performance with variable network conditions
  - Application-specific, message-specific protocol
    - Purpose:
      - Not viable to join very different protocols
      - Interoperability of a set of protocols



Minimal set of protocols

# Adaptive protocols/solutions

- « Hadzig et al. define them as protocols that automatically adjust their behavior to runtime phenomena such as traffic or link characteristics »
- Adaptive solutions already exist in other networks prior VANETs
  - TCP congestion control algorithms → adapt to bottleneck throughput
  - SHARP protocol → adapts between proactive/reactive routing
  - AZRP protocol tunes routing algorithm parameters



<sup>1</sup> Ramasubramanian V., Haas Z., Sireer E., "SHARP: a hybrid adaptive routing protocol for mobile ad hoc networks", Proceedings of the ACM International Symposium on Mobile Ad Hoc Networking and Computing MobiHoc'03, June 2003, p. 303-314.

<sup>2</sup> Giannoulis S., Katsanos C., Koubias S., Papadopoulos G., "A hybrid adaptive routing protocol for ad hoc wireless networks," Proceedings of IEEE International Workshop on Factory Communication Systems WFCS'04, September 2004, p. 287-290.

# Adaptive protocols/solutions

- Some VANET adaptive proposals
  - Adler et al.<sup>1</sup> solution
    - Adapts dissemination area, time, prioritization to send
    - Adaptation based on network and application context
    - Relevance based
  - Cenerario et al.<sup>2</sup> solution for dissemination of safety messages
    - Adaptation based on event/vehicle direction, mobility
    - Encounter probability based

Show promising results  
dealing with various types of events!



<sup>1</sup> Adler C., Information Dissemination in Vehicular Ad Hoc Networks, PhD thesis, University of Munchen, 2006.

<sup>2</sup> Cenerario N., Delot T., Ilarri S., "Dissemination of information in inter-vehicle ad hoc networks", IEEE Intelligent Vehicles Symposium 2008, Eindhoven, the Netherlands, June 2008, p. 763-768..

# Application-specific and message-specific protocol

- Idea from Zhao et al<sup>1</sup>.
- Set of protocols
- Application decide and pick its communication needs
- Useful to work various different protocols running in the same network

Motivation: Not all protocols are viable to merge into one,  
work with a set of protocols



<sup>1</sup> Zhao S., Raychaudhuri D., "Policy-Based Adaptive Routing in Mobile Ad Hoc Wireless Networks", *Processing of the IEEE 2006 Snarnoff Symposium*, Princeton, NJ, March 2006, p. 1-4.

# Application-specific and message-specific protocol

- Applications-specific network layer protocol
  - Static application – app associates to a network layer protocol
    - Table of association app-protocol in each node.
  - Dynamic application – protocol association
    - Difficultly in consensus solution to change association
    - Introduction of new application
    - Possible service discontinuity

app	Net prot
Parking spot	Geobroadcast
Internet access	Unicast

- Message-specific network layer protocol
  - More information centric
  - Messages has field specifying protocol to route itself
  - No consensus needed, easier to change protocol in middle of route
  - Needs to be secured to avoid unauthorized protocol use



# Pre-requisites before exploring the research directions

- Adaptive solutions requires knowledge of problem to adapt
  - What to adapt, how to adapt, how to measure, etc.
  - VANET environment is complex
- Reviews of adaptive solution more manageable if decompose in Metric/Mechanism/Policy concepts
  - Metric: How does it detect that it needs to adapt?  
E.g. node density, vehicle mobility, vehicle position
  - Mechanism: How does the adaptation occurs?  
E.g. dissemination area, sending frequency, change protocol
  - Policy: When to adapt and how much does it need to adapt?  
E.g. encounter probability, relevance,, threshold



# Pre-requisites before exploring the research directions

- Before research direction more research is needed
  - Clearly identify VANET applications trying to support
  - Clearly identify the unique/complementary communication/ network layer strategies useful in VANET applications
  - Schoch et al.<sup>1</sup> Is a great starting point → communication patterns

Comm patterns
Beaconing
Geobroadcast
Unicast routing
Advance Information Dissemination
Information aggregation
Carry and forward



<sup>1</sup> Schoch E., Karg F., Leimüller T., Weber M., “Communication Patterns in VANETs”. IEEE Communications Magazine, vol 46(11), November 2008, p. 119-125.

# Future work

- In-dept review adaptive solutions, policy systems
  - Identify good metrics, mechanism and policies for adaptive solutions in VANETs
- Proposed adaptive solutions towards building a general purpose communication protocol
- Integrate adaptive solutions into the VESPA protocol
  - VESPA uses dissemination of short messages only
  - Extend communications modes of VESPA (unicast, carry and forward, etc)
  - Add in VESPA the possibility to adapt to network conditions



# Questions?

Thanks you for attention

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