An Adaptative Broadcast Scheme for VANET Applications in a High Density Context

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Overview

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   - Broadcasting optimization
   - Distance-based broadcasting
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   - Local density evaluation
4. Simulations and results
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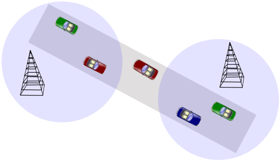
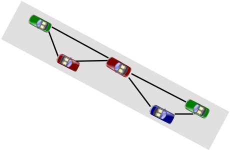
Architectures for inter-vehicular communications

Several architectures exist for inter-vehicular communications.



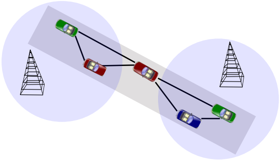
Centralized

V2I



Decentralized

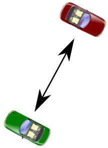
V2V



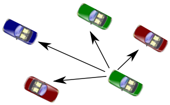
Hybrid

V2X

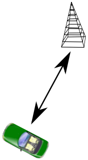
Kind of communication



V2V : Point-to-point



V2V : Broadcast

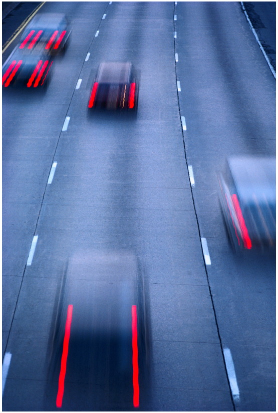


V2I

Applications of inter-vehicular communications

The inter-vehicular communications are used for :

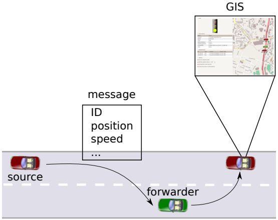
- Safety (Hazard alert)
- Traffic Informations (Compute a path according to current traffic)
- Entertainment (Game, chat, file sharing,...)



Our application

Our application allows to know the informations (position, velocity ...) on neighbor vehicles. Two specific characteristics for this application :

- Multi-hop broadcast : allow to receive informations from vehicle beyond of radio range.
- Messages sent at regulary interval : the informations must be updated with high rate (ideally 2 Hz)



Challenges

To avoid network overload, we can limit :

- The duplication of the forwarded message.
- The frequency of messages sent.
- The broadcasting zone.

To consider this, we propose several policies :

- Favor local informations.
- Adapt the broadcast zone according to the vehicular density.

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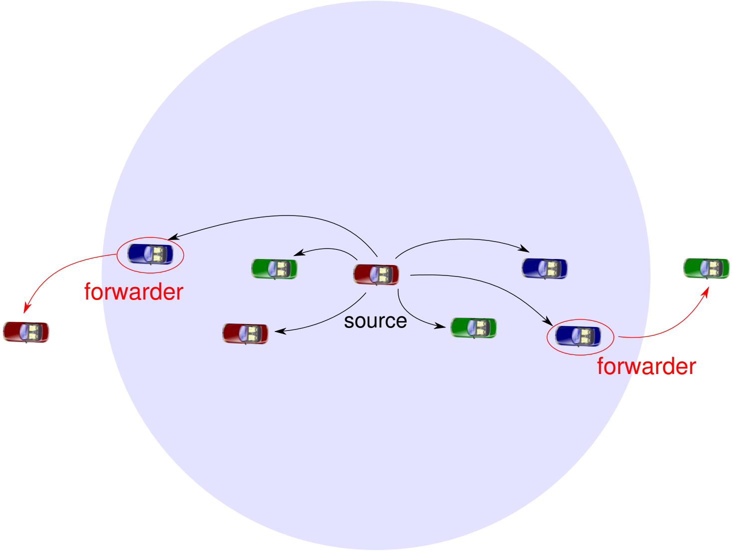
Basic protocol

The vehicles are equipped with geolocalisation system (GPS) and wireless communication system (Wi-Fi).

- Each vehicle send a message at regulary interval containing its informations (ID, position, velocity, ...).
- The receiver processes the message and adds the informations on the vehicle in a table.
- Then, it forwards the message to its neighbors.

Problem : many duplication of forwarded message.

All vehicles do not need to forward the messages



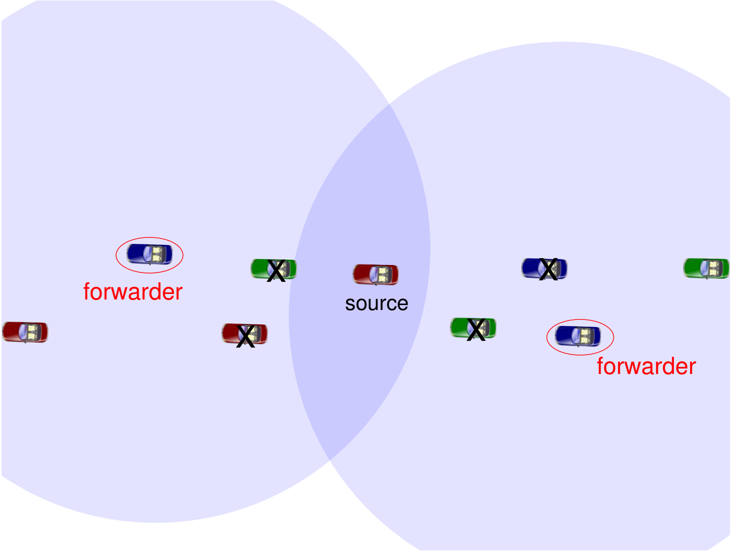
Distance-based broadcasting

The famous technique CBF (Contention Based Forwarding) [FWK+03] is based on the contention delay :

- Each receiver waits during a delay inversely proportional from the distance of the previous forwarder: $T = t_{max} * (1 - \frac{d}{R})$
- The farthest vehicle of previous forwarder forwards the message first.
- The other vehicles in waiting state, cancel the forwarding

Consequence : The only farthest vehicle forwards the message.

Cancel forwarding



Other broadcast schemes

- Hybrid method [HF09] between random-based and distance-based :

$$T_{upper} = \begin{cases} t_{max} * (1 - \frac{d}{R}) & \text{where } d > d_{th} \\ t_{max} & \text{where } d \leq d_{th} \end{cases}$$

$$T_{lower} = \begin{cases} 0 & \text{where } d > d_{th} \\ t_{max} * (1 - \frac{d_{th}}{R}) & \text{where } d \leq d_{th} \end{cases}$$

$$T = random(T_{lower}, T_{upper})$$

  Where d_{th} is the *distance threshold* constant.

- Estimate the local density of vehicles to adjust the power transmission [MML09] .
- Congestion control is proposed in [YLZV04], the message sending rate varies over time.

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Energy E_n of a message

We add a new value in messages instead of the TTL value. We call this value energy.

Definition

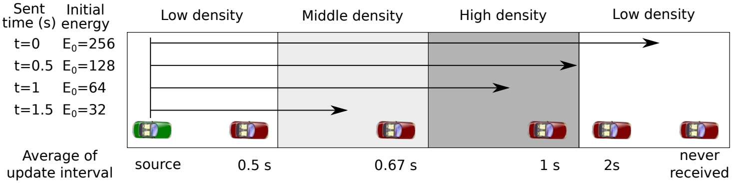
- On message reception, the energy value decreases by node weight : $E_{n+1} = E_n - W$.
- The forwarding condition depends of the local density of vehicles : $E_n > \alpha N_R$.

- E_n : the energy at n-th hops,
- W : the node weight,
- N_R : the number of vehicles in R range,
- α : the penalty factor.

Initial energy E_0

Vehicular information is broadcasted at regular interval.

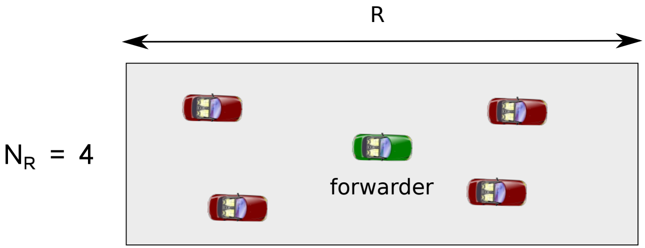
- We would favor the nearest vehicular information.
- We propose to set different E_0.



Local density N_R evaluation

We need to compute the number of vehicles N_R in R range.

- Each message contains the position of the sender.
- The vehicle computes the distance d from the initial sender.
- N_R is the number of vehicles with $d < R$.



Plan

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Simulation with Opnet and SUMO

To evaluate the scalability of protocols with hundreds of vehicles, simulations are needed.

- We use the Opnet network simulator [opn11].
- We have implemented our broadcasting protocol above the 802.11 MAC layer.
- SUMO (Simulation of Urban MObility) [sum11, KGKB11] is used with Opnet to simulate the vehicular mobility.

Broacasted schemes evaluated

We compared seven broacast schemes :

- Flooding : all vehicles are forwarders.
- Simple Distance-based Protocol (SDP) : contention according to the distance from the previous forwarder,
- Random : random contention,
- Threshold : hybrid SDP/Random,
- Our proposal with SDP, Random and Threshold.

Metrics

We used different metrics :

- Number of discovered neighbors (n.d.n.),
- Delivery delay,
- Time between information update.

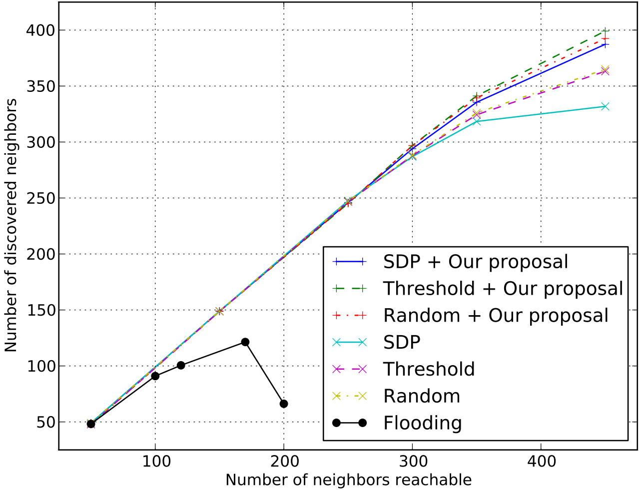
We applied some variations on :

- The total number of neighbors in the network
- The Penalty (α)

Simulation parameters

Simulation length	10 s
Length of road	10 km
Number of lanes	3
Number of vehicles	50 to 450
MAC layer	IEEE 802.11b
Radio range (R)	550 m
Bitrate	11 Mbit/s
Message length	544 bits
Message sending interval	500 ms
Maximal contention time t_{max}	100 ms
Distance threshold d_{th}	170 m
Maximum initial energy E_{0max}	256
Minimum initial energy E_{0min}	32

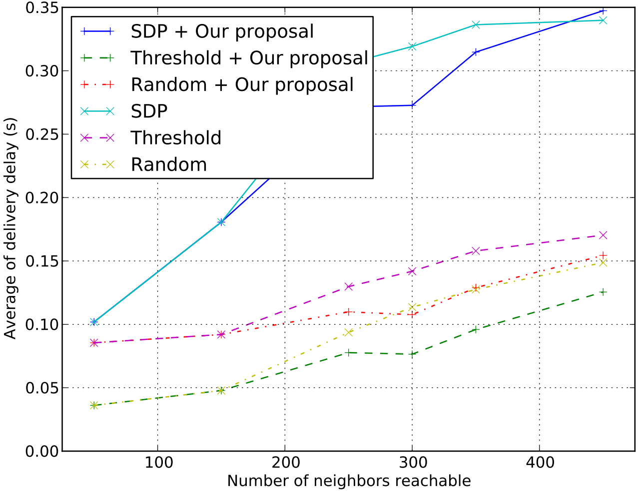
Neighbor discovery vs number of reachable vehicles



- The max. n.d.n. with flooding protocol is low.
- SDP improves considerably the n.d.n.
- The random-based protocols allow us to limit the duplication of message.
- Our proposal allow an increase of the n.d.n.

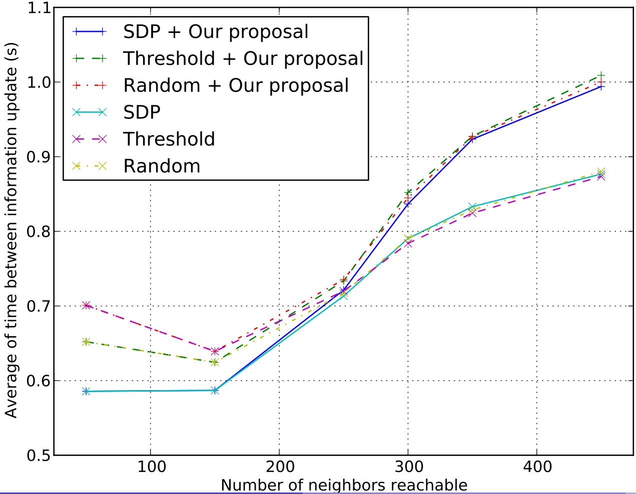
Penalty : 1.0

Average of message delivery delay depending of the number of reachable vehicles



- The threshold + our proposal is the best in terms of delay.
- Our improvement has no impact on message delivery delay.

Average of information update interval vs the number of reachable vehicles



- In a trade-off, the update interval of vehicle information is less.

Neighbor discovery vs the penalty value

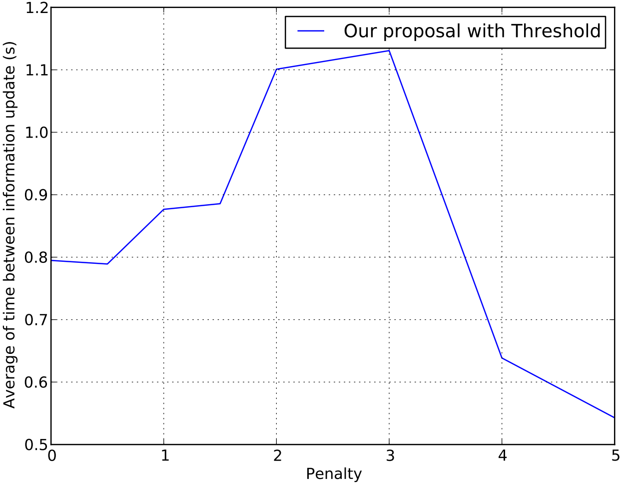
- Between the value 1 and 3 for the penalty,
  the number of discovered neighbors is maximal.

Number of vehicles = 350.

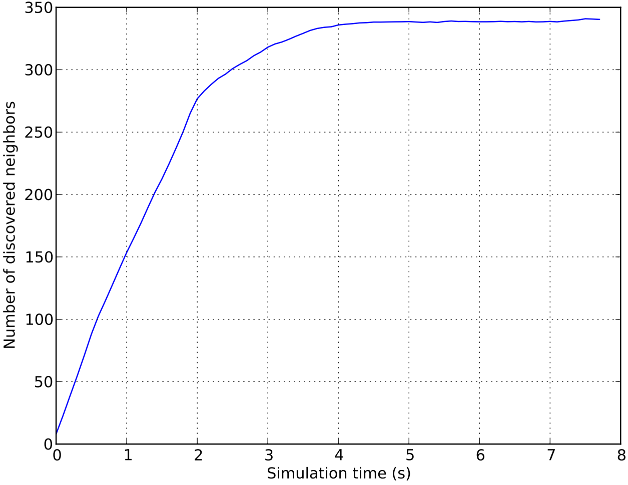
Conclusion

- We have proposed a new broadcast scheme by adding the concept of message energy.
- This scheme favors the information of closest vehicles, limits the number of forwarded messages and the network congestion.
- We have evaluated our proposal with some other existing schemes and we improve the *threshold* scheme proposed recently.
- Our future work will concern the development of a model to compute the *penalty* optimal value and initial energy values and improve neighbor discovery.

Average of information update interval depending to the penalty value.



Number of discovered neighbor over time. The convergence time is about 5 seconds



Message header format

Information type (16)	Hop (8)	Energy (8)
Sequence number (32)		
Lifetime (32)		
Node ID (128)		
Forwarder longitude (32)		
Forwarder latitude (32)		
Forwarder elevation (32)		
Vehicular information (n) ...		

H. Füßler, J. Widmer, M. Käsemann, M. Mauve, and H. Hartenstein.
Contention-based forwarding for mobile ad hoc networks.
Ad Hoc Networks. Elsevier, 1(4):351–369, 2003.

F. Hrizi and F. Filali.
Achieving broadcasting efficiency in v2x networks with a distance-based protocol.
In *Communications and Networking (ComNet), 2009 IEEE*, pages 1–8, Hammamet, Tunisia, 2009.

F. Kaisser, C. Gransart, M. Kassab, and M. Berbineau.
A framework to simulate VANET scenarios with SUMO.
In *OPNETWORK, 2011 OPNET Technologies, Inc*, pages 1–5, Washington, D.C., USA, 2011.

N. Mariyasagayam, H. Menouar, and M. Lenardi.
An adaptive forwarding mechanism for data dissemination in vehicular networks.
In *Vehicular Networking Conference (VNC) 2009 IEEE*, pages 1–5, Tokyo, Japan, 2009.

OPNET Modeler.
http://www.opnet.com/solutions/network_rd/modeler.html, 2011.
[Online; accessed 6-October-2011].

SUMO - Simulation of Urban MObility.
http://sumo.sourceforge.net, 2011.
[Online; accessed 6-October-2011].

Xue Yang, Jie Liu, Feng Zhao, and Nitin H. Vaidya.
A vehicle-to-vehicle communication protocol for cooperative collision warning.
Mobile and Ubiquitous Systems, Annual International Conference on, 0:114–123, 2004.