Optimizing OLSR in VANETs with DE: A Comprehensive Study

Design and Analysis of Intelligent Vehicular Networks and Applications
DIVANet'11

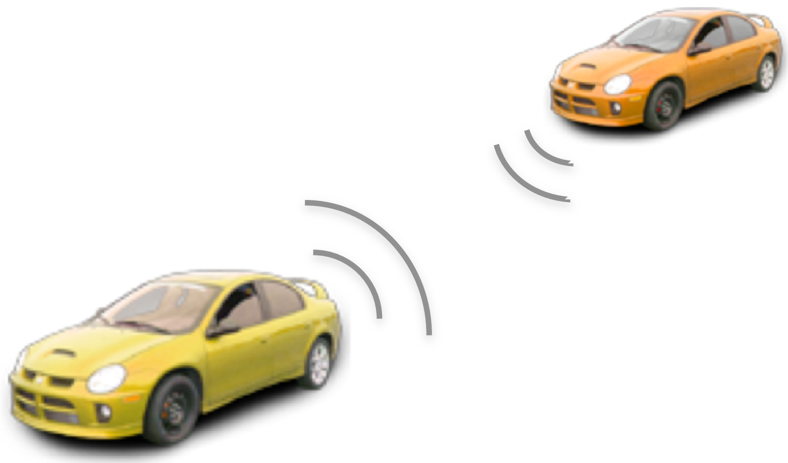
Jamal Toutouh and Enrique Alba
University of Málaga

UNIVERSIDAD DE MÁLAGA

LENGUAJES Y CIENCIAS DE LA COMPUTACIÓN
UNIVERSIDAD DE MÁLAGA

Outline

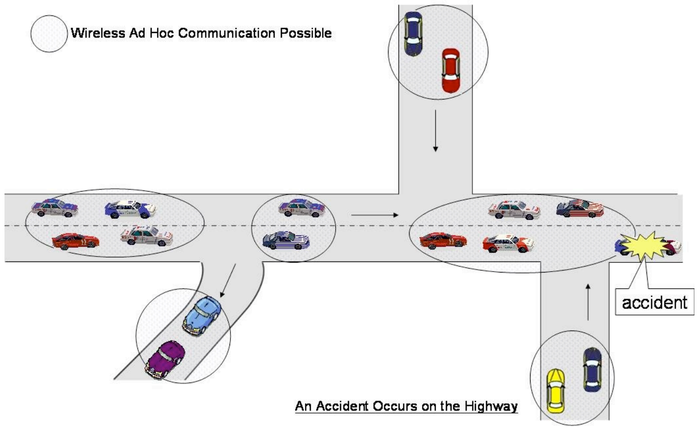
1. Introduction and Motivation
2. Methodology
3. Experimental Results
4. Conclusions and Future Work



1. Introduction and Motivation. Routing in VANET

- **Routing** is a challenging task:
  - High-mobility
  - Presence of obstacles
  - Medium access problems
  - Frequent topology changes
  - Network fragmentations
  - Packet loss

  - There is **no central entity manager**



- It is crucial to provide with **efficient** protocols to offer the **highest reliability** and **lowest delays**

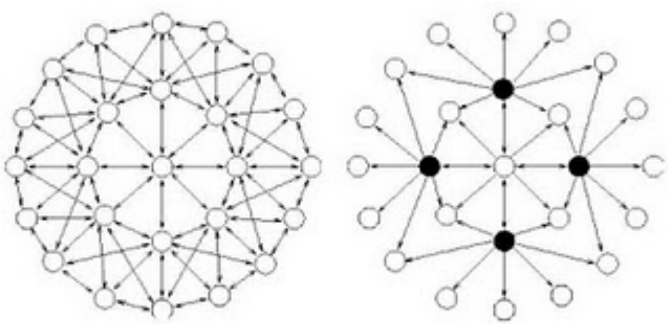
1. Introduction and Motivation. OLSR vs DE-OLSR

- Optimized Link State Routing (**OLSR**) is specifically designed for mobile ad hoc networks with **low bandwidth** and **high mobility**

  - It has been analyzed in VANETs because it offers a **competitive QoS**
    - **end-to-end delay** and **routing path lengths**

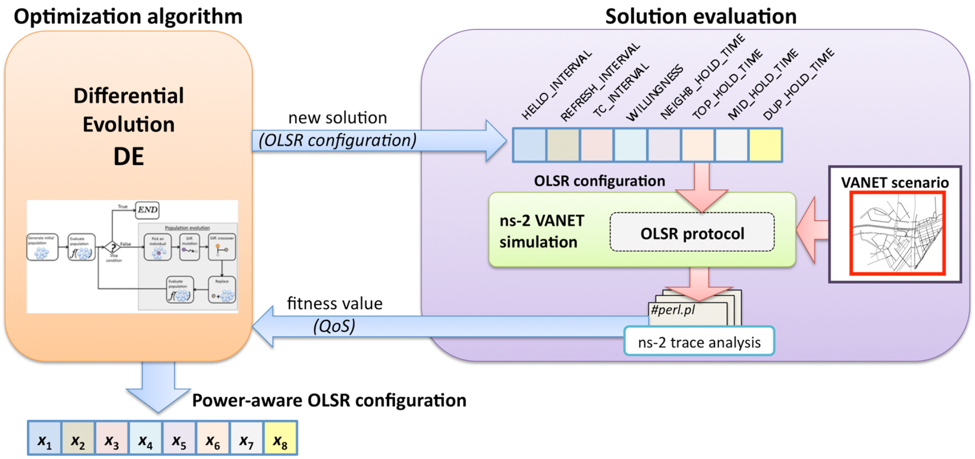
  - Excessive load: **Overhearing problem** in large and dense networks

  - Its performance is regulated by a set of **configuration parameters**



1. Introduction and Motivation. OLSR vs DE-OLSR

- **DE-OLSR** is an **efficiently** and **automatically tuned** version of OLSR
  - **Off-line optimization** strategy based on **DE** and **Ns-2**
  - Optimizing QoS:
    - ↑ **PDR** (Packet Delivery Ratio)
    - ↓ **E2ED** (End-to-End Delay)
    - ↓ **NRL** (Normalized Routing Load)



1. Introduction and Motivation. OLSR vs DE-OLSR

- **DE-OLSR** is an **efficiently** and **automatically tuned** version of OLSR
  - Off-line optimization strategy based on **DE** and **Ns-2**
  - Optimizing QoS: **PDR, NRL,** and **E2ED**

  - **Initial experiments: DE-OLSR outperforms OLSR** in terms of QoS

OLSR configuration		***PDR***	***NRL***	***E2ED***
Gómez et al.	#1	90.00%	1170.02 kbps	1197.25 ms
	#2	90.00%	554.75 kbps	1208.91 ms
	#3	66.00%	208.84 kbps	2435.22 ms
RFC 3626		80.00%	328.42 kbps	1347.22 ms
DE-OLSR		**94.00%**	**68.34 kbps**	**8.36 ms**

  - But, is it a **fair comparison**?

1. Introduction and Motivation. OLSR vs DE-OLSR

➢VANETs are **dynamic networks** and results are **scenario related**

➢A **comprehensive study** is necessary to compare VANET protocols

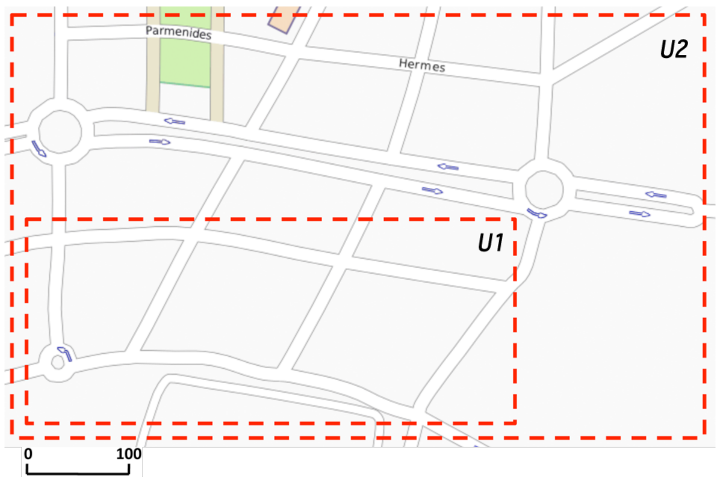
➢The use of a **set of VANET scenarios** (different situations) and **statistical tools** is recommended

OLSR configuration		***PDR***	***NRL***	***E2ED***
Gómez et al.	#1	90.00%	1170.02 kbps	1197.25 ms
	#2	90.00%	554.75 kbps	1208.91 ms
	#3	66.00%	208.84 kbps	2435.22 ms
RFC 3626		80.00%	328.42 kbps	1347.22 ms
DE-OLSR		**94.00%**	**68.34 kbps**	**8.36 ms**

2. Methodology. VANET Scenarios

- Two different real areas (**U1** and **U2**) from Málaga (Spain) - **SUMO**

  - Three road traffic densities
  - Six different network workloads (CBR rates):
    - *low rates*: 33, 66, and 100 kbps
    - *high rates*: 333, 666, and 1000 kbps



Scenario	Area Size	# Vehicles	CBR sources
U1	120,000 m^2	**L**= 10 **M**=15 **H**=20	**5** **8** **10**
U2	240,000 m^2	**L**=20 **M**=30 **H**=40	**10** **15** **20**

36 urban scenarios

2. Methodology. Urban VANET Analysis

- We analyzed the experiments from **three different points of view:**
  - **Geographical area size**
    - *U1:* 120,000 m^2
    - *U2:* 240,000 m^2
  - **Road traffic density**
    - *low density (L):* 1/12,000 (veh/m^2)
    - *medium density (M):* 1/8,000 (veh/m^2)
    - *high density (H):* 1/6,000 (veh/m^2)
  - **Network load**
    - *low rates*: 33, 66, and 100 kbps
    - *high rates*: 333, 666, and 1000 kbps
- Four different metrics:
  - **PDR** (Packet Delivery Ratio)
  - **E2ED** (End-to-End Delay)
  - **NRL** (Normalized Routing Load)
  - **RPL** (Routing Path Length)
- Comparison in terms of **average results** and statistical tests (**Wilcoxon signed rank**)

Wilcoxon signed-rank test:
▲ Statistical difference
△ Not statistical difference

3. Experimental Analysis. Geographical Area Sizes

- Both protocols are degraded to the size of the area

- **PDR: similar behaviour,** both versions delivered more than **67**%
- **NRL:** **DE-OLSR outperforms** OLSR by **45**% (U2) and **72**% (U1)
- **RPL:** **OLSR** generates statistically **shorter routing paths**
- **E2ED:** **DE-OLSR** requires **shorter times**

Wilcoxon signed-rank test:
▲ Statistical difference
△ Not statistical difference

		DE-OLSR				OLSR			
		PDR	*NRL*	*RPL*	*E2ED*	*PDR*	*NRL*	*RPL*	*E2ED*
scenario size	**U1**	69.81	**▲0.11**	1.66	**△143**	**▲70.90**	0.19	**▲1.41**	202
	U2	**△68.12**	**▲0.12**	1.45	**▲284**	67.65	0.17	**▲1.26**	370

3. Experimental Analysis. Network Workload

- Both protocols perform worsen as data traffic increases

- **PDR**: Low rates DE-OLSR outperform OLSR (5%), but high rates is the reverse (without statistical difference)
- **NRL**: **OLSR** generates almost **twice the load** of DE-OLSR
- **RPL**: **OLSR** computes **significantly shorter paths** (between 16% and 31%)
- **E2ED**: **DE-OLSR** sent packets require **statistically shorter times**

		DE-OLSR				OLSR			
		PDR	*NRL*	*RPL*	*E2ED*	*PDR*	*NRL*	*RPL*	*E2ED*
CBR rates	**low**	△**90.72**	▲**0.17**	1.66	▲**18**	85.73	0.28	▲**1.27**	269
	high	47.20	▲**0.04**	1.63	▲409	△**52.68**	0.08	▲**1.40**	**303**

3. Experimental Analysis. Road traffic density

- **PDR:** **DE-OLSR** provides the **best PDR** in **Low** traffic densities, and **OLSR in Medium**. **Worst** performance in **High** densities
- **NRL:** **OLSR** increases its routing (**211%**) but **DE-OLSR** is **more scalable** (**39%**)
- **RPL:** In Low density **similar performance,** in the other **OLSR** use **shorter** paths
- **E2ED:** **DE-OLSR outperform** significantly OLSR,
  Low density -> **highest E2ED** because **highest mobility**

		DE-OLSR				OLSR			
		PDR	*NRL*	*RPL*	*E2ED*	*PDR*	*NRL*	*RPL*	*E2ED*
traffic density	**L**	△**81.54**	△0.10	1.28	△**359**	73.55	**0.09**	△**1.26**	429
	M	71.24	▲**0.10**	1.37	▲**87**	▲**77.05**	0.17	▲**1.11**	102
	H	54.11	▲**0.13**	2.03	▲**196**	△**57.02**	0.28	▲**1.63**	326

3. Experimental Analysis. Global Performance Analysis

		DE-OLSR				OLSR			
		PDR	***NRL***	***RPL***	***E2ED***	***PDR***	***NRL***	***RPL***	***E2ED***
average all experimentation		68.97	▲**0.11**	1.56	▲**214**	△**69.20**	0.18	▲**1.34**	286
scenario size	U1	69.81	▲**0.11**	1.66	△**143**	▲**70.90**	0.19	▲**1.41**	202
	U2	△**68.12**	▲**0.12**	1.45	▲**284**	67.65	0.17	▲**1.26**	370
CBR rates	low	△**90.72**	▲**0.17**	1.66	▲**18**	85.73	0.28	▲**1.27**	269
	high	47.20	▲**0.04**	1.63	▲409	△**52.68**	0.08	▲**1.40**	**303**
traffic density	L	△**81.54**	△0.10	1.28	△**359**	73.55	**0.09**	△**1.26**	429
	M	71.24	▲**0.10**	1.37	▲**87**	▲**77.05**	0.17	▲**1.11**	102
	H	54.11	▲**0.13**	2.03	▲**196**	△**57.02**	0.28	**1.63**	326

3. Experimental Analysis. Global Performance Analysis

		DE-OLSR				OLSR			
		PDR	*NRL*	*RPL*	*E2ED*	*PDR*	*NRL*	*RPL*	*E2ED*
average all experimentation		68.97	▲0.11	1.56	▲214	△69.20	0.18	▲1.34	286
scenar size	U1								202
									370
CBR ra									269
									303
traffic densit									429
									102
									326

•There is **no** significantly **difference** between both resulted **PDR**

•**OLSR** computes **shorter** routing **paths**

•**DE-OLSR** generates statistically **lower routing load** and data packets take **shorter times**

4. Conclusions and Future work. Conclusions

➢ In this work, we study the improvements of applying **optimized protocols in VANETs.** Specifically, we compare the two different configurations of the OLSR (standard RFC 3626 and DE-OLSR)

➢ We have defined **36 urban VANET scenarios** and analyzed four metrics (PDR, NRL, RPL, and E2ED) by using **Wilcoxon statistical tests**

4. Conclusions and Future work. Conclusions

- **OLSR** computes **shorter paths** but generating **excessive routing load** (problems of congestion and scalability)

- Using **DE-OLSR** the nodes **economically access** the medium, leaving a larger bandwidth for data packets, requiring **shorter delay times**

- **No** significant differences between their **PDR**

- **DE-OLSR is better-suited for VANETs** since it is **lighter** in terms of resources consumption and able of **larger scalability** than OLSR, offering **close maximum throughput**

4. Conclusions and Future work. Conclusions

- **OLSR** computes **shorter paths** but generating **excessive routing load** (problems of congestion and scalability)

- Using **DE-OLSR** the nodes **economically access** the medium, leaving a larger bandwidth for data packets, requiring **shorter delay times**

- **No** significant differences between their **PDR**

- **DE-OLSR is better-suited for VANETs** since it is **lighter** in terms of resources consumption and able of **larger scalability** than OLSR, offering **close maximum throughput**

4. Conclusions and Future work. Future Work

- ➢Analyzing the application of other optimization techniques in order to obtain protocols of larger efficiency e.g. OLSR for VANETs
- ➢Extending our testbed with new still larger urban areas, highways, and assorted workloads to generate more VANET instances
- ➢Performing outdoor tests (using real vehicles travelling through different kinds of roads) in order to validate the simulation result

Thank you for your attention…

Comments

jamal@lcc.uma.es
www.jamal.es

DIRICOM: Design of Wireless Communication Networks [2008-2012]
`http://diricom.lcc.uma.es`
CARLINK: Wireless Traffic Service Platform for Linking Cars [2006-2008]
`http://carlink.lcc.uma.es`

Thank you for your atention

jamal@lcc.uma.es
www.jamal.es

DIRICOM: Design of Wireless Communication Networks [2008-2012]
`http://diricom.lcc.uma.es`
CARLINK: Wireless Traffic Service Platform for Linking Cars [2006-2008]
`http://carlink.lcc.uma.es`

2. OLSR and DE-OLSR

- **DE-OLSR** is an efficiently and automatically tuned version of OLSR
  - Off-line optimization strategy based on **DE** and **Ns-2**
  - Optimizing QoS: PDR, E2ED, and NRL

Parameter	OLSR	DE-OLSR
HELLO INTERVAL	2.0 s	3.13 s
REFRESH INTERVAL	2.0 s	3.15 s
TC INTERVAL	5.0 s	45.24 s
WILLINGNESS	3	1
NEIGHB HOLD TIME	6.0 s	3.56 s
TOP HOLD TIME	15.0 s	103.14 s
MID HOLD TIME	15.0 s	141.05 s
DUP HOLD TIME	30.0 s	67.79 s

- **Initial experiments: DE-OLSR outperforms OLSR** in terms of QoS

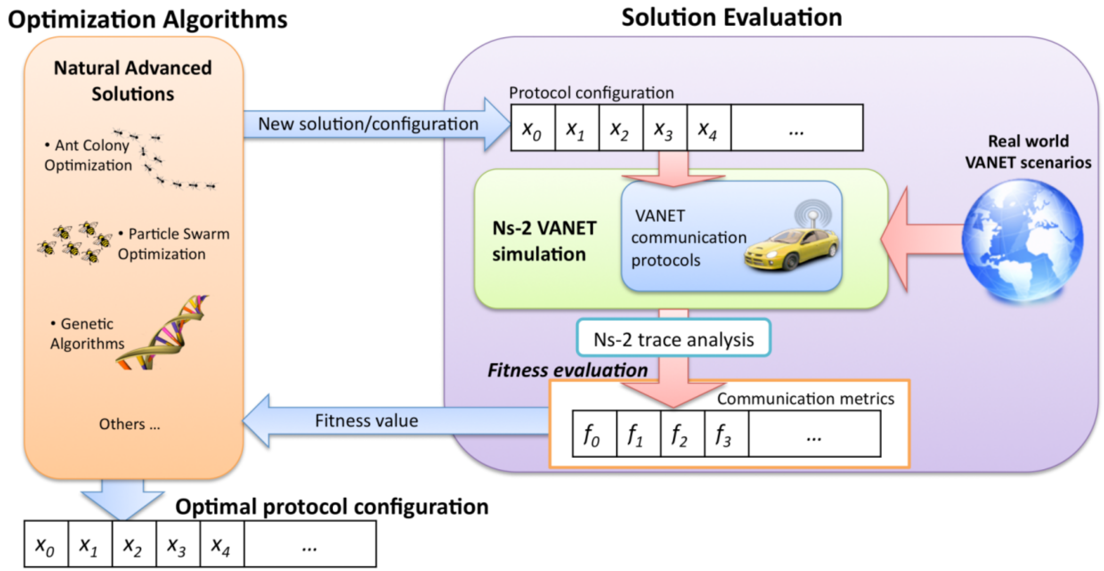
2. Methodology. Network Specifications

- Vehicles were configured with **WAVE** (IEEE 802.11p) standard – **Ns-2**
  - **Nakagami** radio propagation model
  - WAVE standard is completed by using Unex (DCMA-86P2) WiFi transceiver parameters
  - Simulation time: **180 seconds**

Parameter	Value
Propagation model	Nakagami (Urban)
Carrier frequency	5.89 Ghz
Channel bandwidth	6 Mbps
PHY/MAC Protocol	IEEE 802.11p
Routing Protocol	**OLSR or DE-OLSR**
Transport Protocol	UDP
CBR Packet Size	1024 bytes
CBR Data Rate	**33**, **66**, **100**, **333**, **666**, and **1000** kbps
CBR Time	30 s

1. Introduction and Motivation. VANETs Optimization

➢To improve protocols performance we are using an automatic optimization tool coupling **Metaheuristic algorithms** and **VANET simulation**



DIRICOM: Design of Wireless Communication Networks [2008-2012]
http://diricom.lcc.uma.es

CARLINK: Wireless Traffic Service Platform for Linking Cars [2006-2008]
http://carlink.lcc.uma.es

1. Introduction and Motivation. VANETs and ITS

- **Vehicular ad-hoc networks (VANETs)** are emerging new communication and information technologies to integrate **vehicles**, elements of **roadside infrastructure**, **sensors**, and **pedestrian** personal devices (smartphones, PDAs, etc.) by using self-configuring wireless ad-hoc networks.

- Enabling **Intelligent Transportation Systems (ITS)**:
  - Safety
  - Transport Efficiency
  - Multimedia content distribution

- **IEEE 802.11 (WiFi)** based technologies:
  - WAVE: IEEE 802.11p and IEEE 1609