Performance Analysis of Optimized VANET Protocols in Real World Tests

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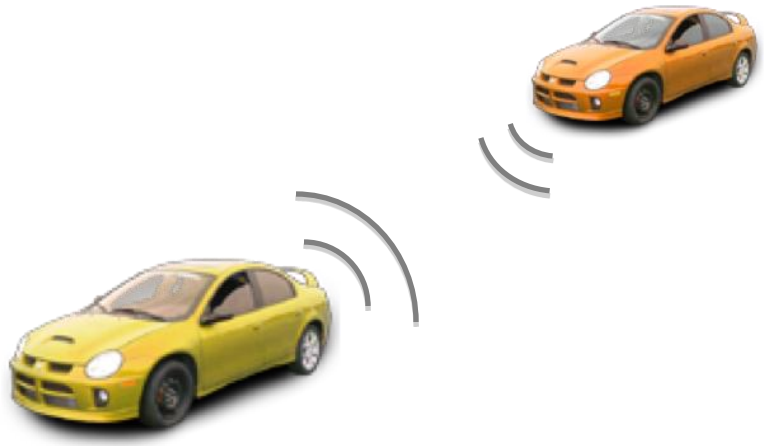
Outline

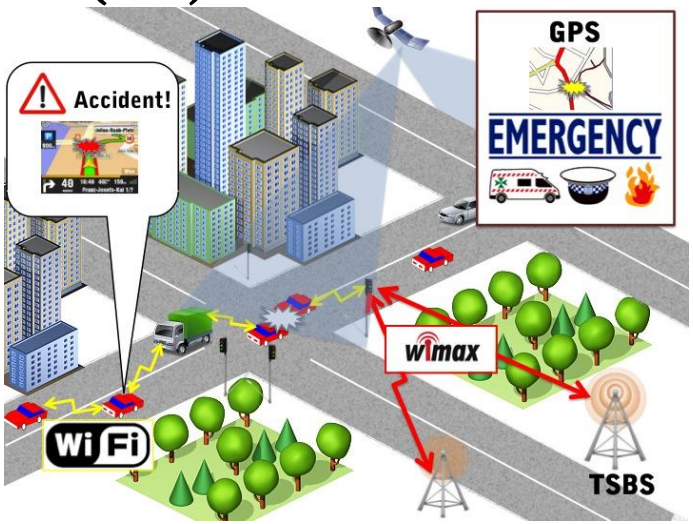


1. Introduction and Motivation. VANETs and ITS

➢**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:

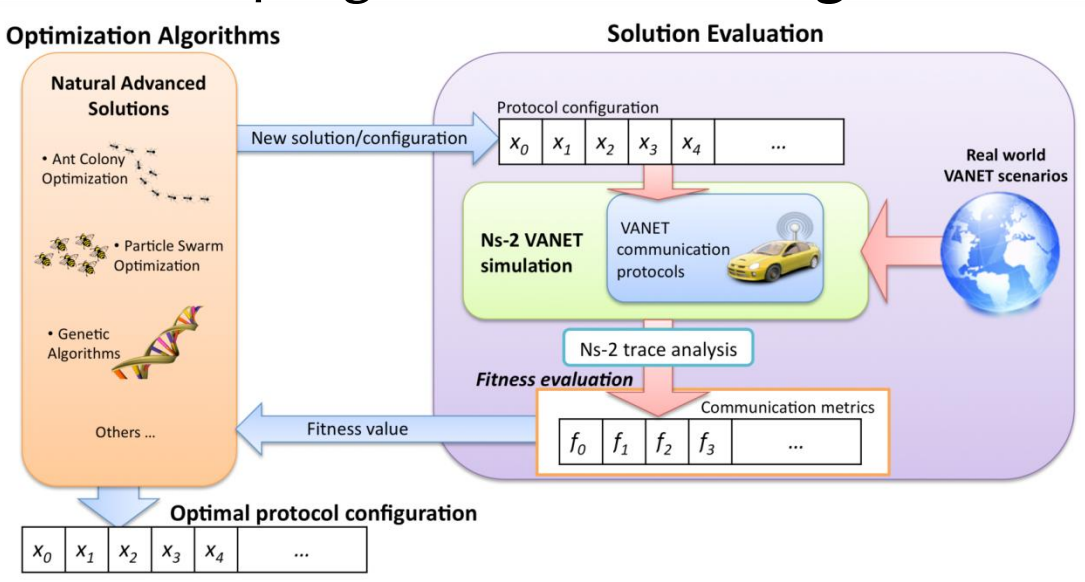
- WAVE: IEEE 802.11p and IEEE 1609

1. Introduction and Motivation. VANET Optimization

➢It is crucial to provide with an **efficient configuration** of the communication protocols to offer the **best quality-of-service** (**QoS**)

- High-mobility
- Presence of obstacles
- Congestion
- Frequent topology changes
- Network fragmentations
- Packet loss

➢Automatic optimization tool coupling **Metaheuristic algorithms** and **VANET simulation**



1. Introduction and Motivation. VANET Evaluation

➢Currently, the evaluation of the VANET's protocols and applications is carried out by means of **simulations**

➢The simulation presents the following important **advantages** over **outdoor experiments:**

- **easier** and **cheaper**
- **simplier to analyze** in a distributed and complex environment
- possibility of **reproduction of all kinds of situations** where they must act

➢It presents the following **drawbacks:**

- the **accuracy** **of the simulated results versus the real ones**

1. Introduction and Motivation. Motivation

➢**CARLAB** is a general initiative for the **evaluation of VANETs** that includes simulations (**indoor CARLAB**) and real world experiments (**outdoor CARLAB**)

➢Using **outdoor CARLAB** experiments we wanted to confirm the performance improvements when **optimized protocols** are used, **validating** the results previously obtained by means of **indoor CARLAB**

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

CARLINK: Wireless Traffic Service Platform for Linking Cars [2006-2008]
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DIRICOM

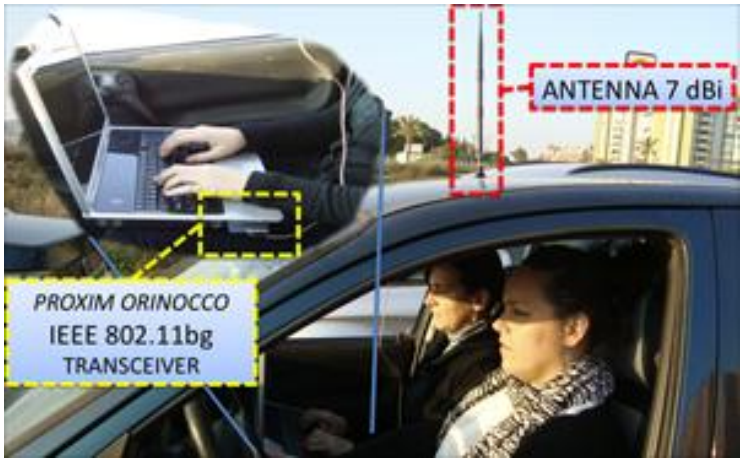
CARLINK

2. Outdoor CARLAB Overview. VANET Scenario Definition

- Two cars moving through some selected roads in a **urban area** from the downtown of **Málaga** (Spain)

- The average distance between nodes was 77 m

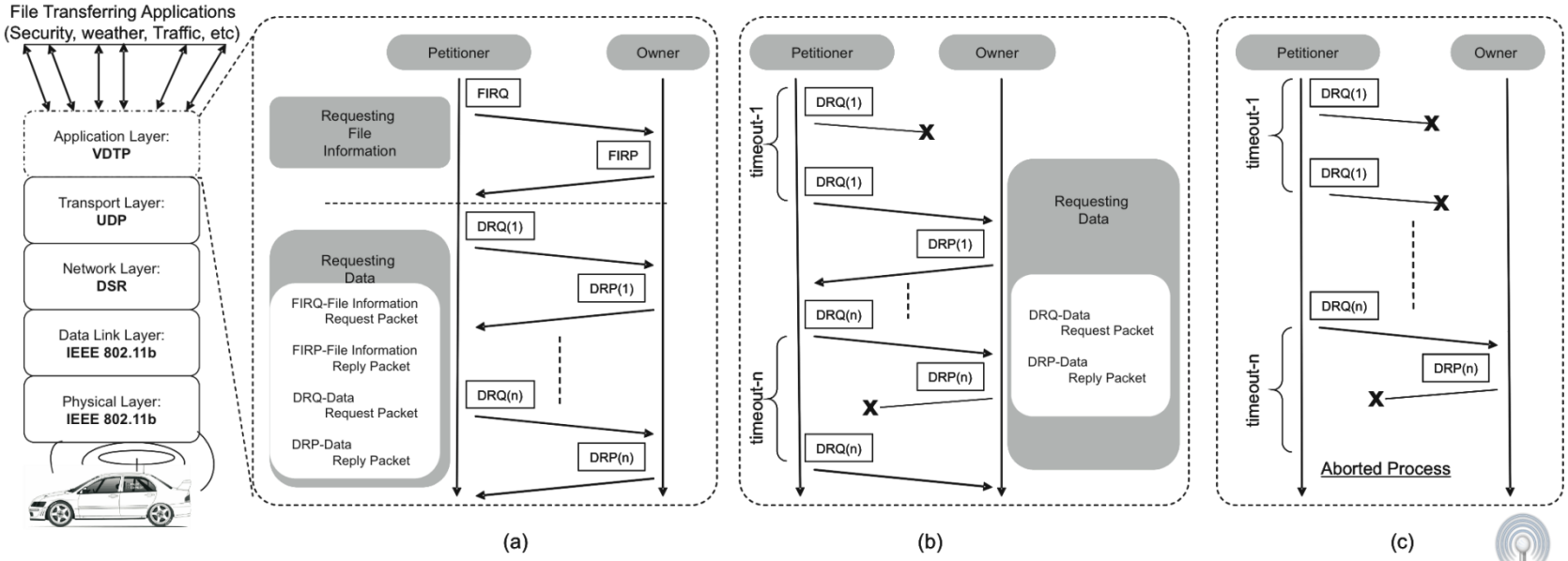
- Vehicles carried a notebook equipped with a PROXIM ORiNOCO PCMCIA (IEEE 802.11bg) WiFi transceiver



Parameter	Value
Propagation model	Two Ray Ground
Carrier frequency	2.4 Ghz
Channel bandwidth	5.5 Mbps
MAC Protocol	IEEE 802.11b
Routing Protocol	DSR
Transport Protocol	UDP
Application Protocol	**VDTP**

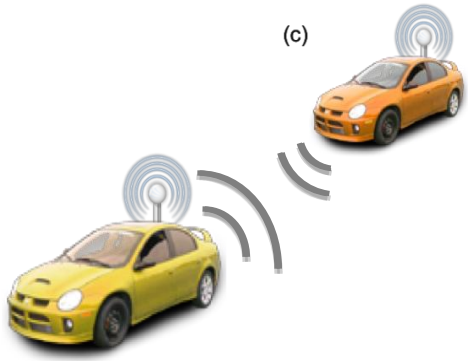
2. Outdoor CARLAB Overview. VDTP Protocol

➢**Vehicular Data Transfer Protocol** (**VDTP**) is an application layer protocol that allows end-to-end file transfer in VANETs



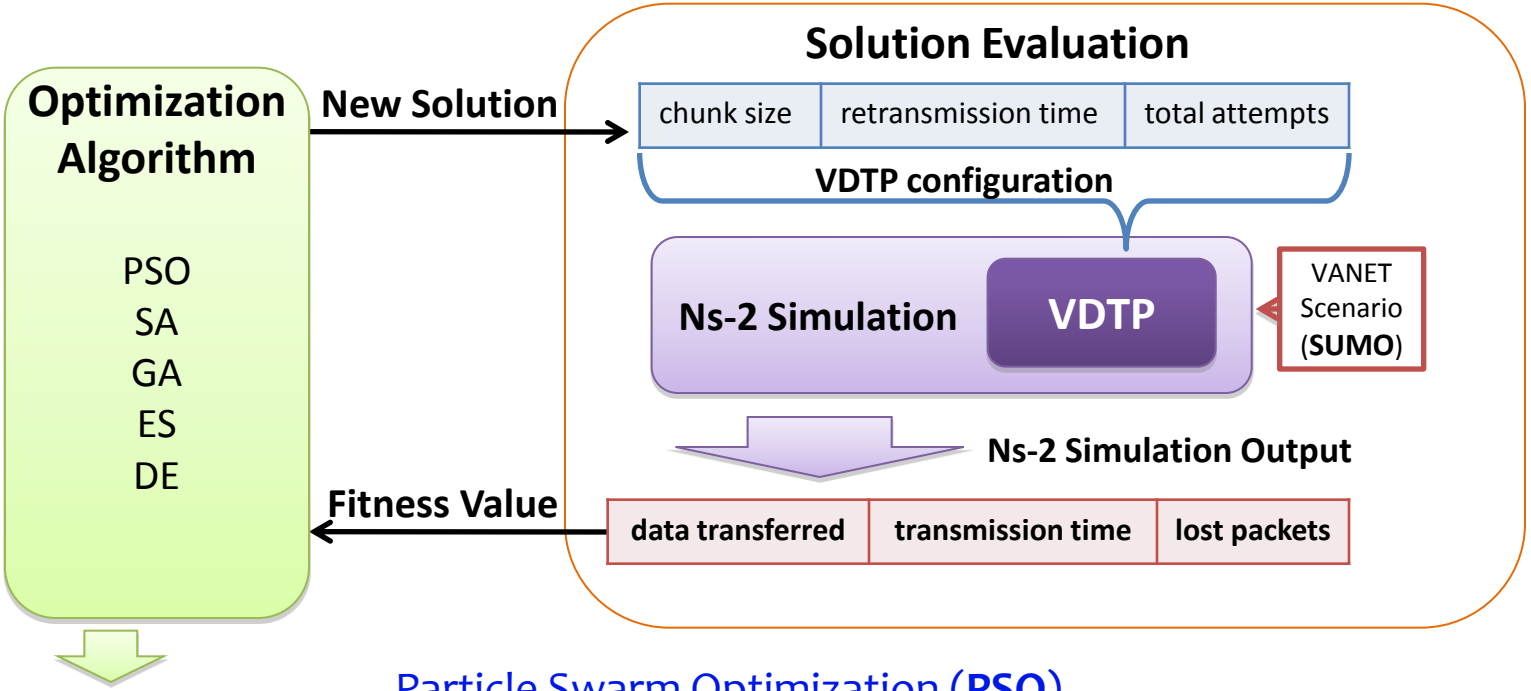
➢Configuration parameters of VDTP:

- PDU or chunk size
- Retransmission time (timeout)
- Max attempts per packet



2. Outdoor CARLAB Overview. Experimental Settings

➢Optimal VDTP configurations:



Particle Swarm Optimization (**PSO**)
Evolutionary Strategy (**ES**)
Differential Evolution (**DE**)
Genetic Algorithms (**GA**)
Simulated Annealing (**SA**)

2. Outdoor CARLAB Overview. Experimental Settings

➢Six different VDTP configurations:

Configuration	*chunk size*	*timeout*	*max. attempts*
PSO	41,358	10.00	3
DE	28,278	6.00	9
ES	23,433	10.00	8
GA	31,196	3.83	9
SA	19,756	6.43	3
EXPERTS	25,600	8.00	8

➢Two different car speeds: ***Urban Low Speed*** (20 to 30 Km/h) and ***Urban High Speed*** (40 to 50 Km/h)

➢Five type of data files: **100 KB, 500 KB, 1 MB, 5 MB,** and **10 MB**

➢**15 file transfers** of each file type (15 x 5 = 75 file transfers)

➢VANET evaluation:
- ***lost packets***
- *transmission time*
- *amount of data* exchanged

→ ***effective transmission data rate (goodput)***

3. Experimental Results. VANET Global Performance

- All files were transferred completely and correctly
  - In spite of transmission problems, the nodes were able to reconnect before the file transfers were refused
- Majority of transfers bandwidth were higher than **600 KB/s**

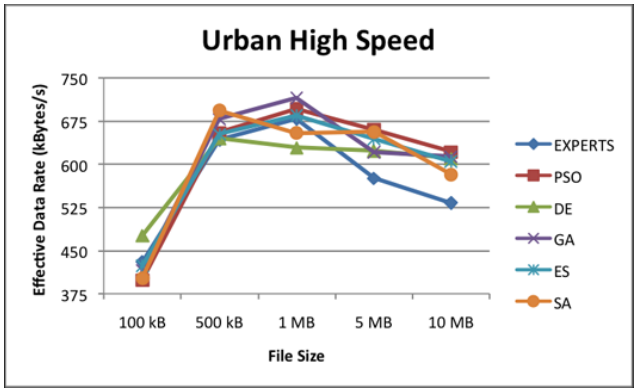
3. Experimental Results. VANET Global Performance

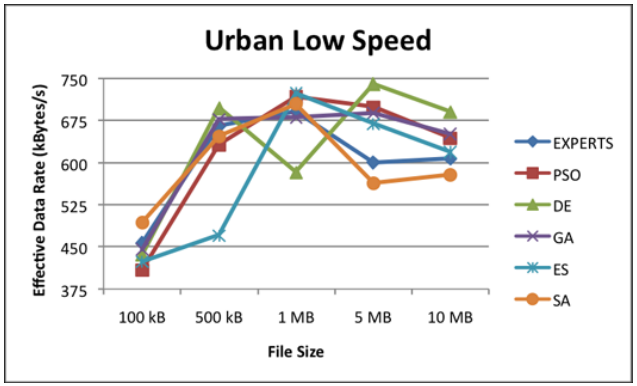
- Influence of the vehicles' speed
  - Communications performed **better when the speeds were lower**
    Urban Low Speed (ULS) lost **0.133** packets per file with a bandwith of **610 KB/s**
    Urban High Speed (UHS) lost **0.153** packets with a bandwith of **598 KB/s**

- Influence of the file size
  - **1 MB files transferred with higher bandwith**
    683 KB/s (ULS) and **676 KB/s** (UHS)
    VDTP was optimized to exchange 1 MB files
  - **100 KB files transfers performed the worst**
    444 KB/s (ULS) and **424 KB/s** (UHS)
    Impact of handshaking process of VDTP is greater for smaller files

3. Experimental Results. VDTP Configuration Comparison

- In order to compare the performance of the six studied protocols we use the ***goodput* metric**





- It is not easy to provide any global conclusion about wich configuration performed the best

- Therefore, we applied **statistical tests** to the distribution of the achieved goodputs

3. Experimental Results. VDTP Configuration Comparison

- **Friendman Ranking** test (*p-value<0.05*) of goodput:
  - Non-parametric test for distribution that violates heteroscedasticity ~~**ANOVA**~~

Urban Low Speed		Urban High Speed		Urban	
Configuration	Rank	Configuration	Rank	Configuration	Rank
PSO	**4.26**	**PSO**	**4.26**	**PSO**	**4.26**
GA	3.95	**SA**	3.62	**ES**	3.60
DE	3.73	**ES**	3.56	**GA**	3.54
ES	3.64	**DE**	3.28	**DE**	3.51
SA	2.74	**EXPERTS**	**3.16**	**SA**	3.18
EXPERTS	**2.68**	**GA**	3.12	**EXPERTS**	**2.92**

- **PSO** is the **best ranked** achieving the best average goodput, **613 KB/s**
- **EXPERTS** is the **worst ranked** obtaining the worst average goodput, **579 KB/s**
- Globally, the **optimized VDTP outperformed** the experts proposed version, **confirming the resutls obtained by means of simulations**

3. Experimental Results. VDTP Configuration Comparison

- In terms of **data loss:**

Urban Low Speed		Urban High Speed		Sum of Lost Data	
Configuration	Data loss	Configuration	Data loss	Configuration	Data loss
ES	**14,060**	**ES**	**16,403**	**ES**	**30,463**
SA	15,804	**DE**	16,967	**DE**	33,933
PSO	16,543	**SA**	19,756	**SA**	35,560
DE	16,967	**EXPERTS**	**20,480**	**EXPERTS**	**38,400**
EXPERTS	**17,920**	**PSO**	24,815	**PSO**	41,358
GA	**28,076**	**GA**	**28,075**	**GA**	**56,152**

- **ES** lost the **lowest** amount of data (**30,462 bytes**)
  - Longest retransmission time (10 s) and second smallest chunk (23,433 bytes)
- **GA** suffered with the **highest** data loss (**56,152**)
  - Shortest retransmission time (3.83 s) and second largest chunk (31,196 bytes)
- **PSO** is the **fifth**, however it presents the best goodput results
- **EXPERTS** configuration is the **forth**

IWCMC 2011
Istanbul, Turkey
5-8 July 2011

4. Conclusions and Future Work

- The **results** obtained performing **outdoor CARLAB experiments** (real VANETs) **confirm** the ones obtained by the **indoor CARLAB experiments** (VANET simulations)
- During our tests, **1 MB files** were exchanged achieving the **highest data rates**
- Globally, **automatically optimized configurations outperformed** the human experts proposed one
- Friedman Rank statistical test ranked **PSO** as the **best one** (goodput)
- **Metaheuristic techniques** seem to be adequate to address the problem of configuring VANET protocols

- **Extending our outdoor CARLAB testbed** by increasing the number of vehicles (multi-hop) and planning new experiments in highway roads

Thank you for your attention…

Comments

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Thank you for your atention

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