Green OLSR in VANETs with Differential Evolution

Green and Efficient Energy Applicationsof Genetic and Evolutionary Computation
-**GreenGEC 2012**-

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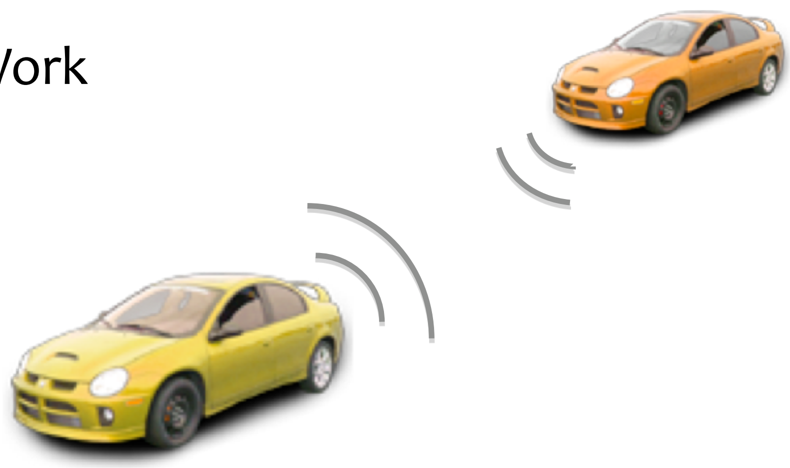
Outline

1. Introduction
2. Energy-Efficient OLSR
3. Experimental Results
4. Conclusions and Future Work

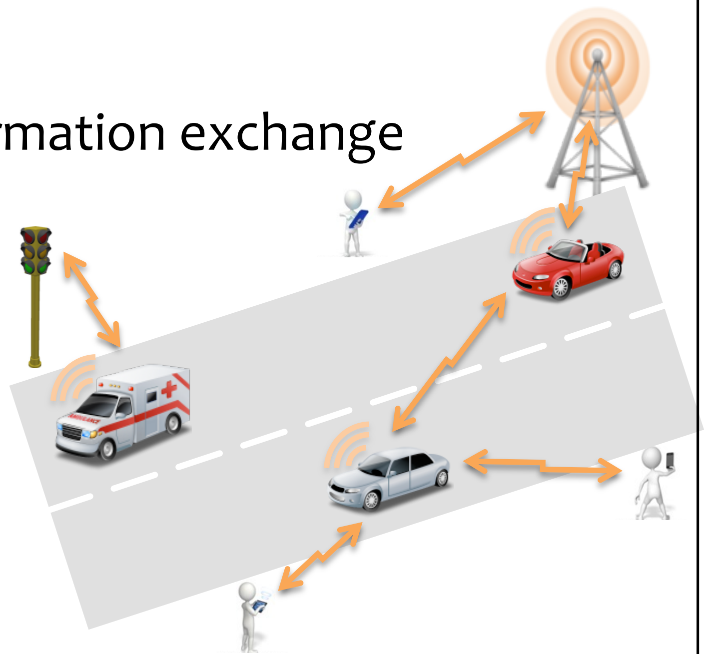


1. Introduction. VANETs and Energy Issues

➢**VANETs** are self-configuring wireless ad hoc networks.
Nodes are **vehicles**, **pedestrian** equipped with personal devices, **sensors**, and elements of **roadside**,

➢Deployed to enable up-to-minute road traffic information exchange

- Transport Efficiency
- Safety



➢VANETs involve devices fed with **limited power sources.** Power-aware network architectures and protocols are highly desirable

➢The **routing protocol** affects the **nodes power consumption**:

- The **protocol operation** → amount of energy used to compute the routing paths
- The **computed routing paths** → the terminals power consumption when forwarding packets

1. Introduction. Contribution

- We study the application of **Differential Evolution (DE)** to compute **power-aware routing protocol configurations**
  - The optimization process is guided by evaluating tentative solutions (protocol parameterizations) by means of **ns-2 VANET simulations**

- We suggest **new energy-efficient protocol parameterization** that reduces the power consumption with no significant loss in QoS

- We validate the results by an exhaustive analysis of the performance in realistic VANET simulations taken the metropolitan area of Málaga (Spain) as main scenario

2. Energy-Efficient OLSR. Problem Definition

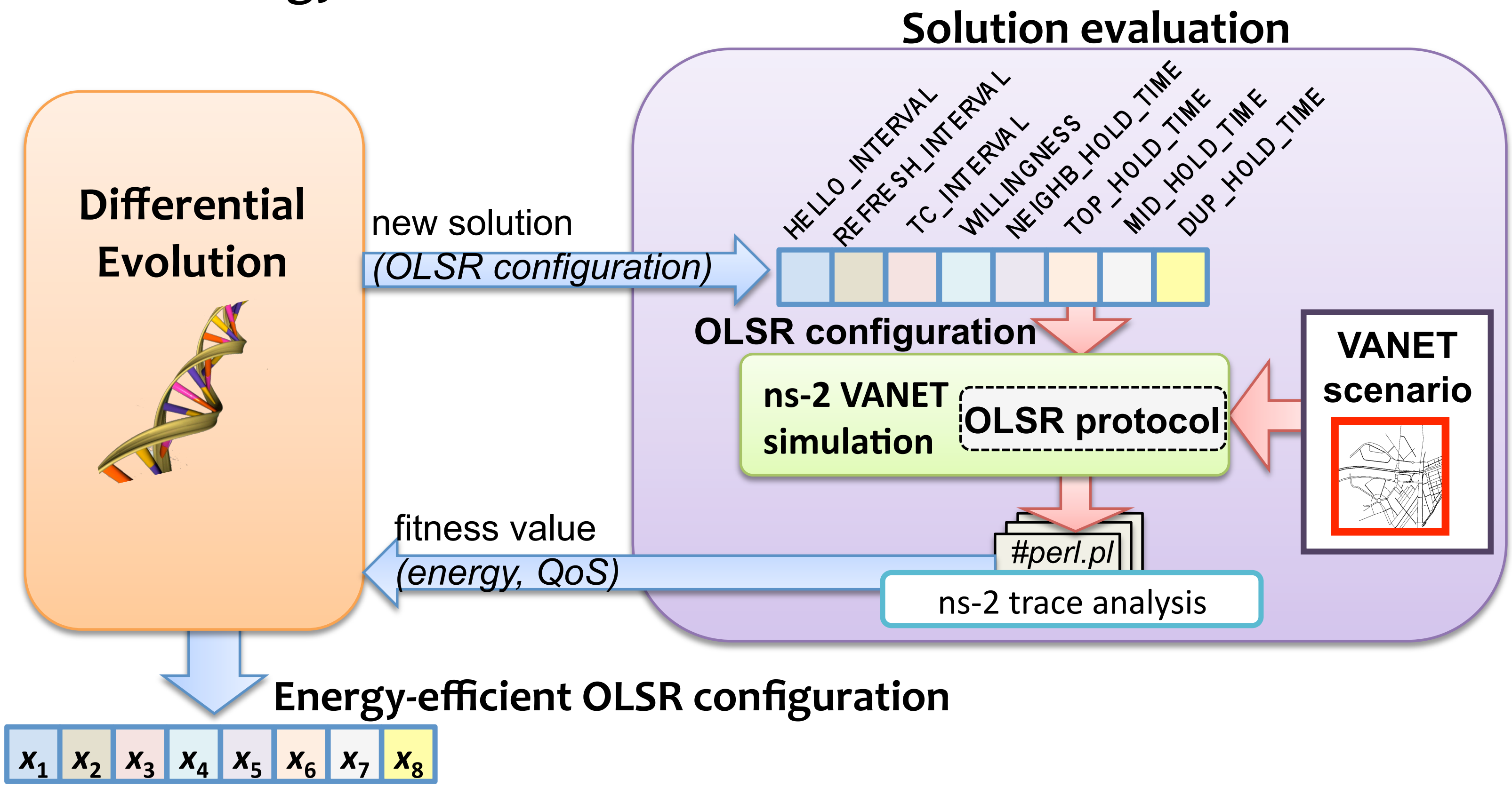
- OLSR is a **proactive** routing protocol for mobile ad hoc networks
- OLSR generates significant routing workload that produces **network congestion** and **excessive energy consumption** problems
- Finding the best OLSR configurations to enable **green communications** in VANETs is the main subject of this work
- An excessive energy consumption reduction can lead to protocol **malfunction**
  - QoS restriction → Maximum allowed **PDR degradation 15%** (over the standard)

parameter	RFC 3626 value	type	range
HELLO_INTERVAL	2.0 s	real	[2.0, 15.0]
REFRESH_INTERVAL	2.0 s	real	[2.0, 15.0]
TC_INTERVAL	5.0 s	real	[4.0, 35.0]
WILLINGNESS	3	integer	[0, 7]
NEIGHB_HOLD_TIME	6.0 s	real	[5.5, 45.0]
TOP_HOLD_TIME	15.0 s	real	[10.5, 90.0]
MID_HOLD_TIME	15.0 s	real	[10.5, 90.0]
DUP_HOLD_TIME	30.0 s	real	[10.5, 90.0]

2. Energy-Efficient OLSR. Methodology

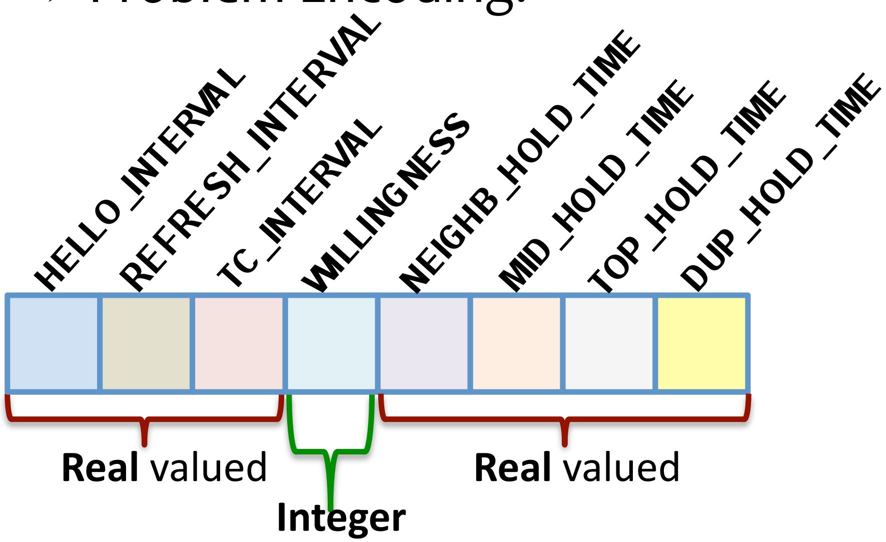
- Automatic optimization tool coupling **Differential Evolution (DE)** and **realistic VANET simulation (ns-2)**

- **Methodology**



2. Energy-Efficient OLSR. Optimization Method Details

➢Problem Encoding:



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➢Fitness Function:

$$F(s) = \Delta + \left(\omega_1 \times \frac{E(s)}{E_{RFC}} + \omega_2 \times \frac{PDR(s)}{PDR_{MAX}}\right)$$

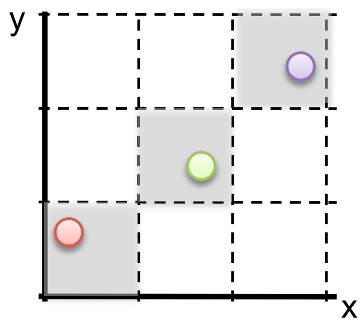
Δ=0.1, ω_1=0.9, and ω_2=-0.1

Penalization model (PDR degradation > 15%)

$$F_P(s) = F(s) + \left((PDR_W - PDR(s)) \times \frac{E(s)}{E_{RFC}}\right)$$

2. Energy-Efficient OLSR. Optimization Method Details

- Initialization:
  - **Spreads uniformly** the population over the search space. It splits the search space into *pop_size* (number of individuals) **diagonal subspaces** and locates each individual in one subspace.



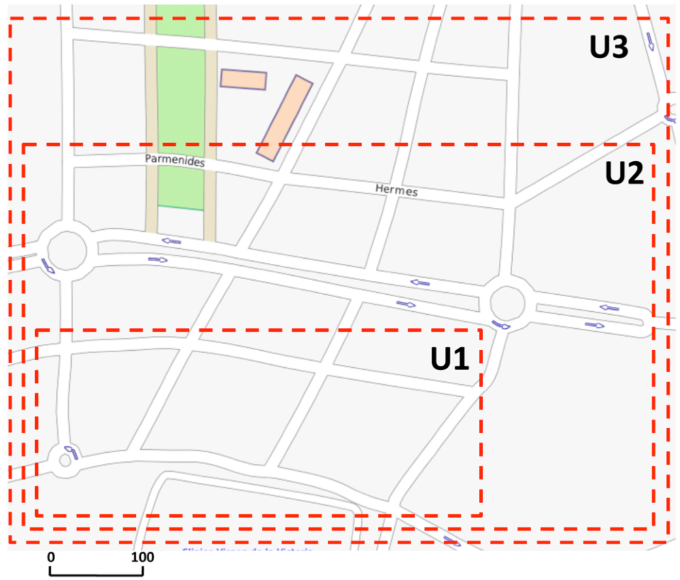
- Offspring generation:

  Differential-crossover and ***Differential-mutation***

3. Experimental Analysis. Experiments Definition

➢VANET scenarios definition (54 scenarios):

Urban area	Area size	Num. nodes
U1	120,000 m^2	10
		15
		20
U2	240,000 m^2	20
		30
		40
U3	360,000 m^2	30
		45
		60



Scenario for the optimization process: **U2, 20 nodes, 66 kbps**

- VANET workload:

  low-rates: 33, 66, and 100 kbps
  high-rates: 333, 666, and 1000 kbps

3. Experimental Analysis. Experiments Definition

- DE was developed by using C++ MALLBA Library:
  - Population size = 8 individuals
  - Number of generations = 125
  - Crossover probability (Cr) = 0.9
  - Mutation factor (μ) = 0.125

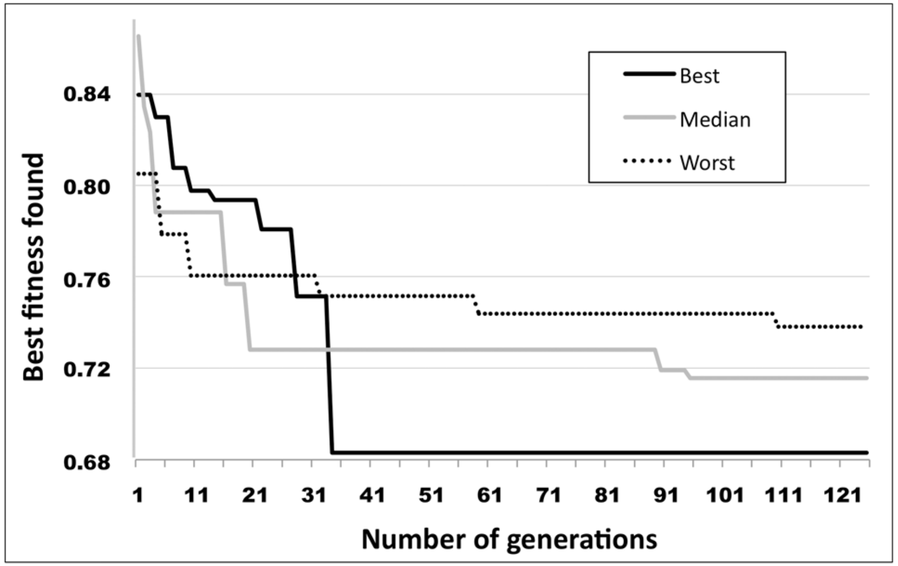
  After performing DE configuration analysis experiments using **U1, 10, 33 kbps** scenario to find the best DE parameterization

- 30 independent runs

3. Experimental Analysis. DE Optimization Results

➢ Optimization performance:

Solution	Fitness value	Energy (J)	PDR (%)
Best (Minimum)	**0.6831**	**6684.71**	77.76
Median	0.7157	7026.93	78.92
Maximum	0.7382	7256.19	79.08
OLSR RFC	n/a	9104.19	**87.12**



>25% energy saving

<10% of PDR degradation

- Mean execution time = 4.6 hours (1.6525E+4 secs)
- Best solution found mean time = 2.8 hours (1.0037E+4 secs)

3. Experimental Analysis. Validation Results

- Comparison: **DE/EE-OLSR**, standard configuration (OLSR-RFC), and QoS optimized OLSR (DE-OLSR)
  - Over 54 VANET scenarios

- Average **energy consumed** by each node and the **PDR**

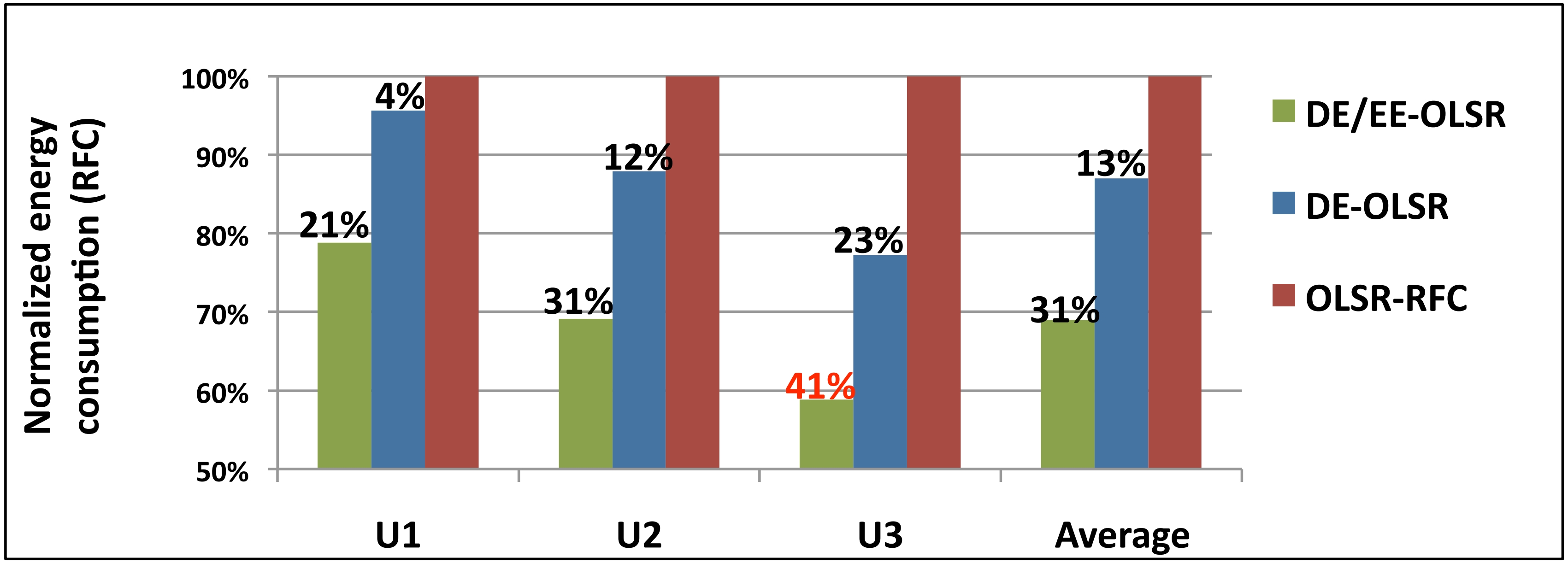
- **Friedman statistical test** is applied to rank the configurations regarding the energy consumption

3. Experimental Analysis. Validation Results

- Energy consumption
  - **DE/EE-OLSR** and DE-OLSR improve RFC
  - The energy savings increase with the size of the VANET
  - **DE/EE-OLSR saves between 21% and 41%** of power consumption comparing to the standard
  - **Friedman** statistical test **ranked DE/EE-OLSR as the configuration with the lowest power consumption** (*p-value << 0.05*)

Energy consumption per node (J)

Config.	U1	U2	U3
DE/EE-OLSR	**703.21**	**598.21**	**516.38**
DE-OLSR	853.47	760.33	678.07
OLSR-RFC	892.59	865.08	877.75



3. Experimental Analysis. Validation Results

➢ PDR results

PDR

Config.	U1	U2	U3
DE/EE-OLSR	66.11%	62.04%	56.62%
DE-OLSR	69.57%	66.30%	**67.70%**
OLSR-RFC	**71.71%**	**71.78%**	64.00%

- The three analyzed configurations delivered **more than 55%** of the data packets
- The PDR metric decreases with the size of the network
- The PDR **degradation** of DE/EE-OLSR is **lower than 9% (<15%)** regarding OLSR RFC. The energy savings **do not cause malfunction**

4. Conclusions and Future Work

- Automatic methodology for computing power-aware OLSR configurations for VANETs, by coupling DE and ns-2 VANET simulator
- Main results:
  - this methodology obtained automatically energy-efficient configurations requiring a mean time of 4.6 hours
  - the best power-aware configuration (DE/EE-OLSR) saved up to 31% of energy, with significant improvements up to 41% in large networks
  - the degradation of PDR is bellow 9%
- Promising methodology for automatic and efficient customization of VANET routing protocols
- Future work:
  - analyze other metaheuristic techniques to explore the search space
  - analyze new fitness functions considering new power-aware and QoS metrics
  - multi-objective optimization techniques to solve this problem since the energy vary in inverse proportion with QoS

Thank you for your attention…

Comments

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