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A semi-deterministic channel model for VANETs simulations

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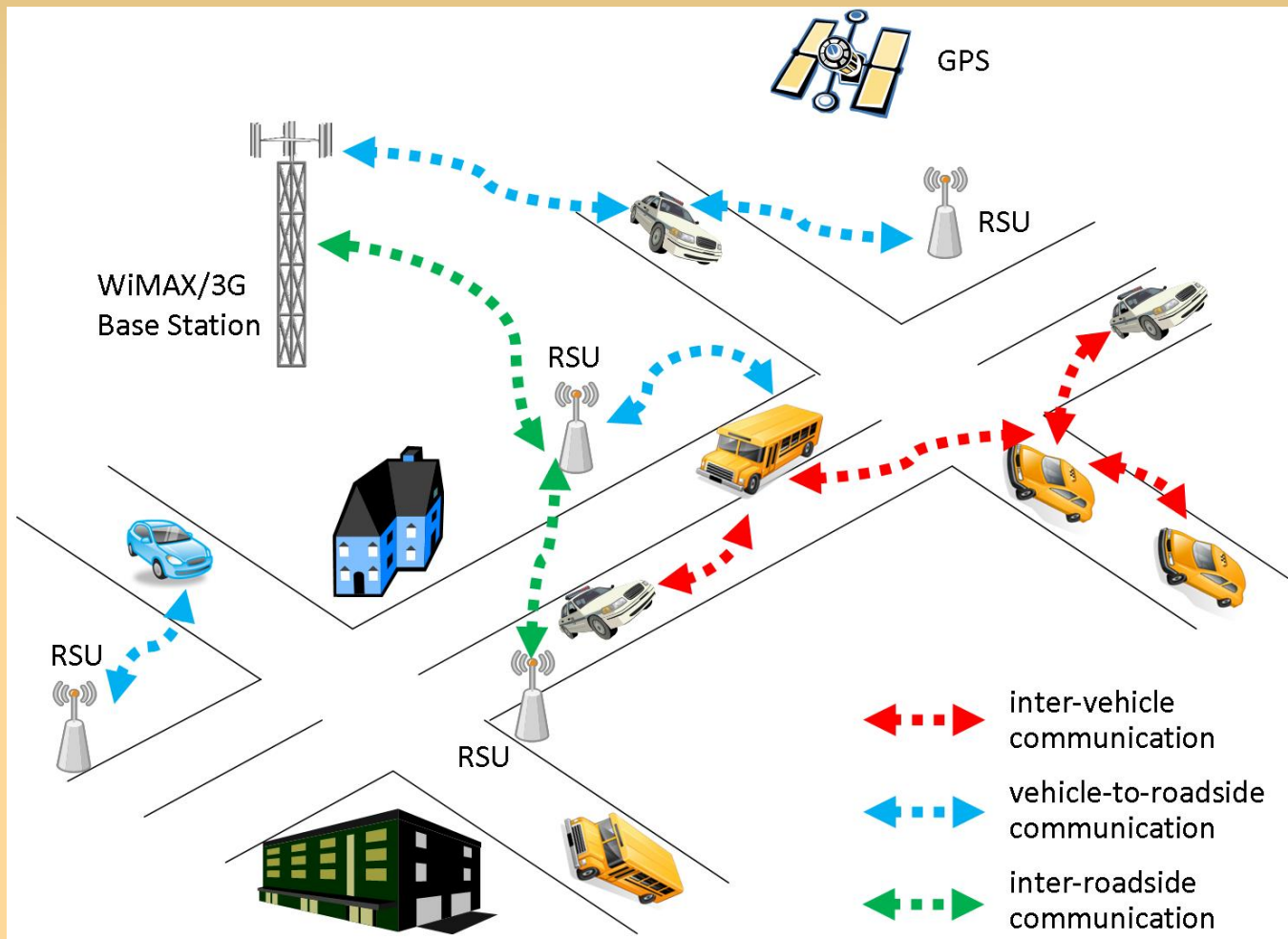
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Context

Vehicular Ad-hoc NETWORKS (VANETs)



An example of VANETs

Context

VANETs Characteristic

- High Mobility

VANETs Standard

- IEEE 802.11p

State of art

- Advantage : lot of realistic mobility models,
- Drawback : few accurate channel models, realistic physical layer ...

Simulators

- **Network Simulator 2 (NS-2)**, OPNET, ...

Context

Channel models for VANETs Simulations

Deterministic channel model

- + Realistic
- High computation time (~ a fortnight)
- Low

Statistical channel model

- Not realistic enough
- + Low computation time
- + Fast

Challenge:

Associate **realism** and **low computation time**



Semi-deterministic channel model

Overview

1. Statistical model (SCME-UM)
2. Deterministic simulator (CRT)
3. Contribution: semi-deterministic model (UM-CRT)
4. UM-CRT Evaluation
5. Conclusion and Future Work

Statistical Channel Model

Spatial Channel Model Extended (SCME)

What is SCME?

- Statistical geometric Model
- Developed within the European project WINNER
- B3G systems simulation (Beyond 3G)

Characteristics :

- Mobility integrated
- 5 GHz frequency and 100 MHz bandwidth implemented
- 802.11p (SISO) and 802.11n (MIMO)
- 3 types of environments available:
 - Urban Macrocell, Suburban Macrocell, **Urban Microcell (UM)**

Realistic Simulator

Communication Ray Tracer (CRT) Simulator

What is CRT?

- Deterministic propagation simulator based on ray tracing
- 802.11p and 802.11n physical layer implemented



- +Error model based on the specificities of transmission environment
- +BER computation based on transmitter–receiver **positions**
- +BER associated to every packet



Realistic physical layer



+ Integrated into NS-2

Realistic Simulator



Example FreeSpace vs CRT:

SISO, 120 nodes,
802.11p, 1 communication.

FreeSpace Propagation model
(1 Hop)

CRT Propagation model
(5 Hops)

Realistic environment: the Munich city center.

UM-CRT

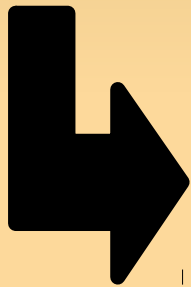
Semi-deterministic Model

Contribution: semi-deterministic model (UM-CRT)

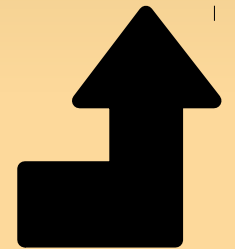
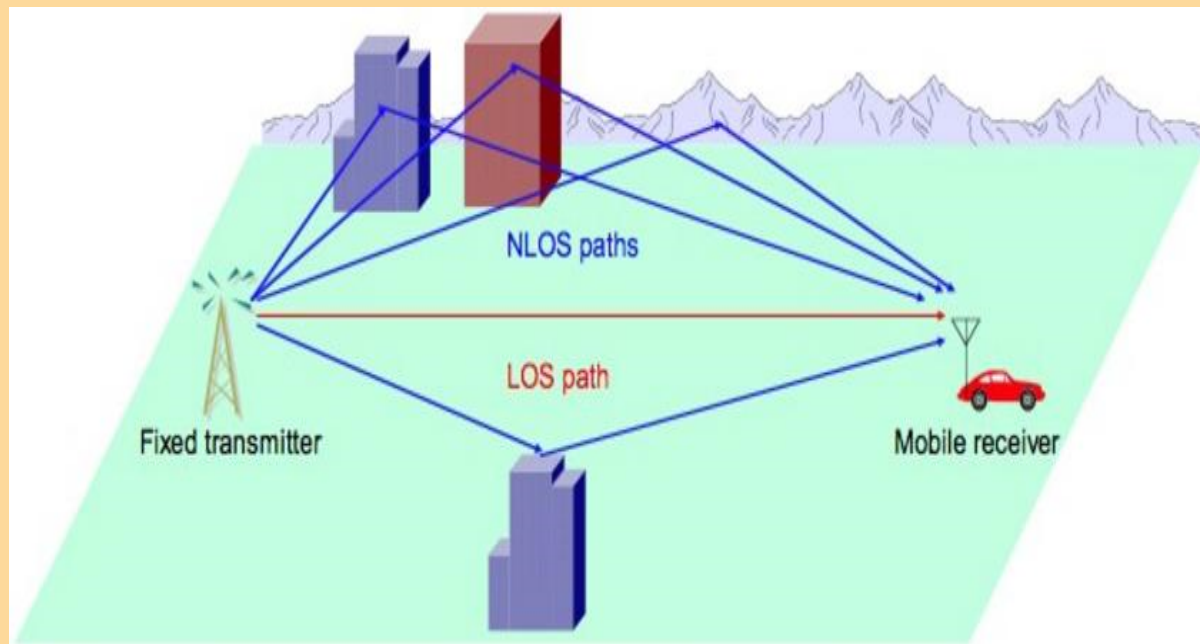
Deterministic model (CRT)

Statistical model SCME-UM

- +Accurate channel impulse response
- +Visibility
- +Distance



+Environment taken into consideration

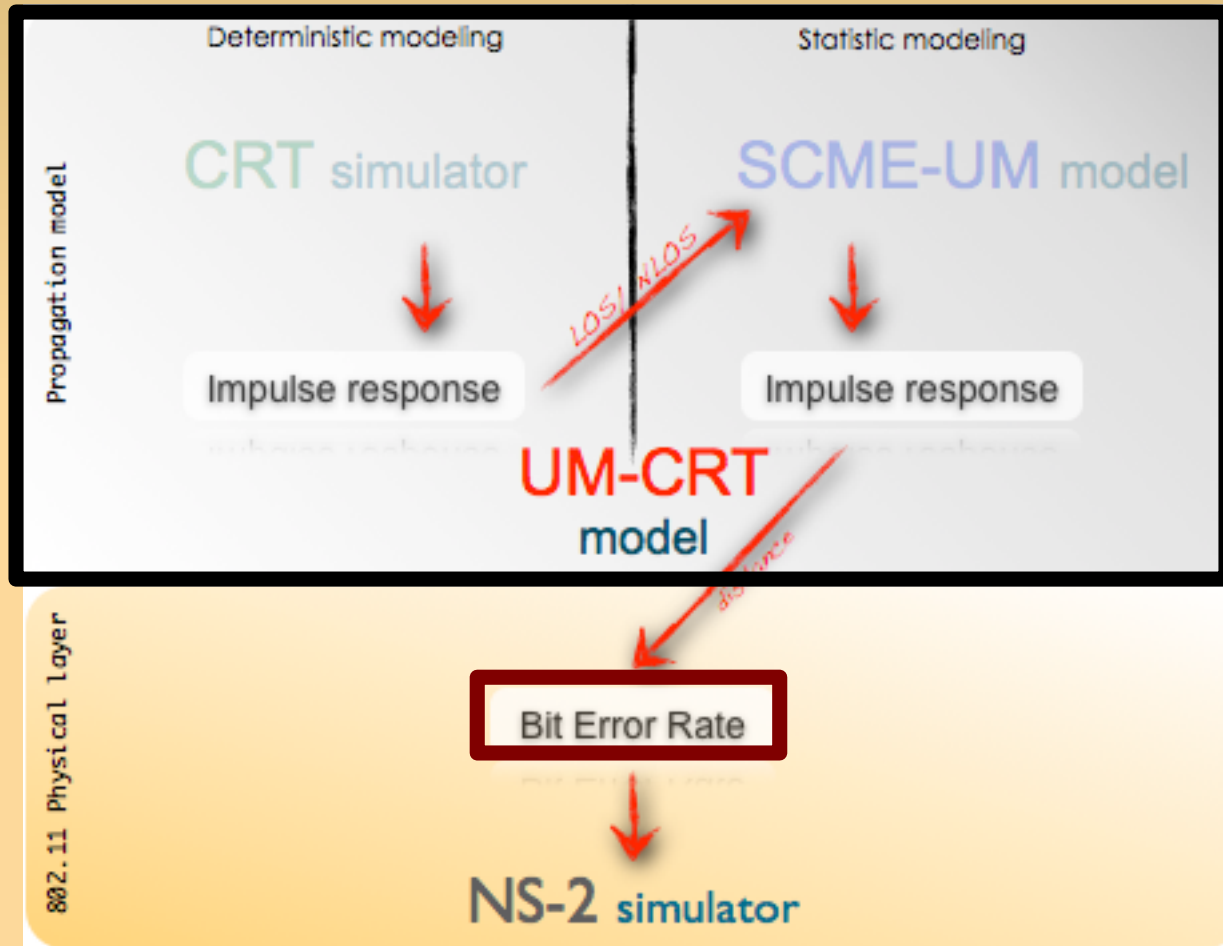


To customise

Our work focuses at first on the **LOS** – **NLOS** criteria

UM-CRT

Semi-deterministic Model



Realistic physical layer

=

CRT Simulator
(Deterministic)
+
SCME-UM Model
(Statistical)

+

Error Model
(Based on **distances**
between 2 nodes
instead of theirs
positions)

UM-CRT

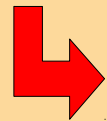
Semi-deterministic Model

- Step 1: Pre-computation
 - Accurate Impulse Response computation
 - BER computation based on transmitter-receiver **distances**
- Step 2: Simulation
 - BER is associated to each packet with **LOS-NLOS** criteria for

SCME-UM

For example :

- Simulation of 40 seconds VANET scenario with 40 mobile nodes :
STEP1 : 2 hours & **STEP2** : few minutes.



**UM-CRT = Advantage of CRT and SCME-UM
(Déterministic) + (Fast computation time)**

UM-CRT Evaluation

Comparison Evaluation

- To be as close as possible to the real-world situation

Reference Model

- CRT deterministic simulation program

Evaluation Criteria

- Average packets delivery ratio
- Average number of hops

UM-CRT Evaluation

5 VANETs Scenarios

Scenario	Nb vehicles	Speed (m/s)	Nb communications
1	40	0	3
2	40	4	3
3	40	8	3
4	10	8	3
5	40	8	1

2 Channel Models:

- CRT
- UM-CRT

2 Strategies:

- SISO
- MIMO

2 Evaluation Criteria:

- Average packets delivery ratio
- Average number of hops

UM-CRT Evaluation (SISO)

Agreement between results

- Scenarios 2, 3 and 5

Non agreement between results

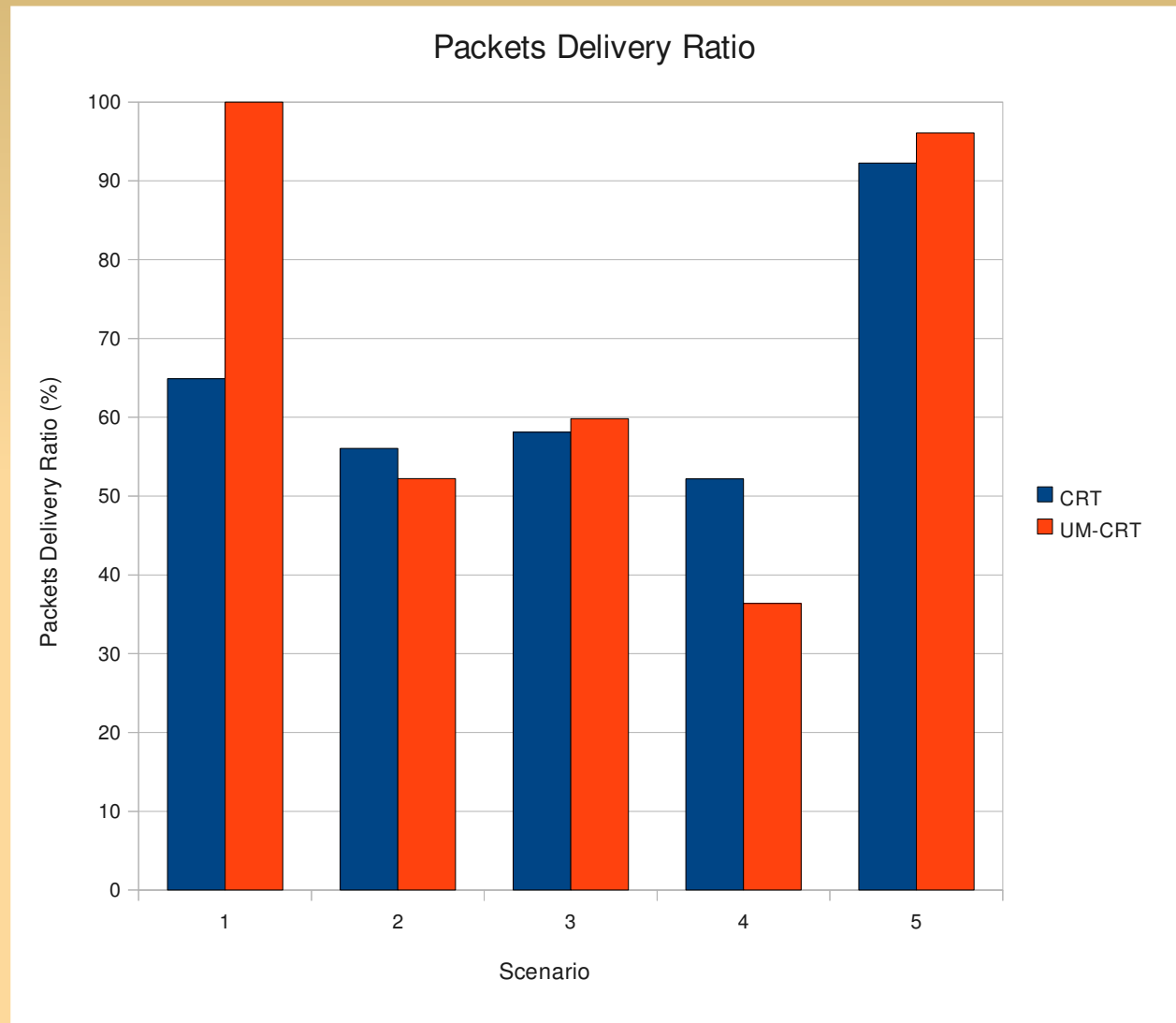
- Scenarios 1 and 4

➔ As the speed increases, results become close. (Cf. 1, 2 et 3)

➔ As the number of nodes decreases, results disagree. (Cf. 4)

➔ The number of simultaneous communications does not impact the realism of the model. (Cf. 5)

➔ Packet delivery ratio remains constant as the speed increases. (Cf. 1, 2 et 3)



UM-CRT Evaluation (SISO)

Agreement between results

- Scenarios 1, 2, 3 and 5

Non agreement between results

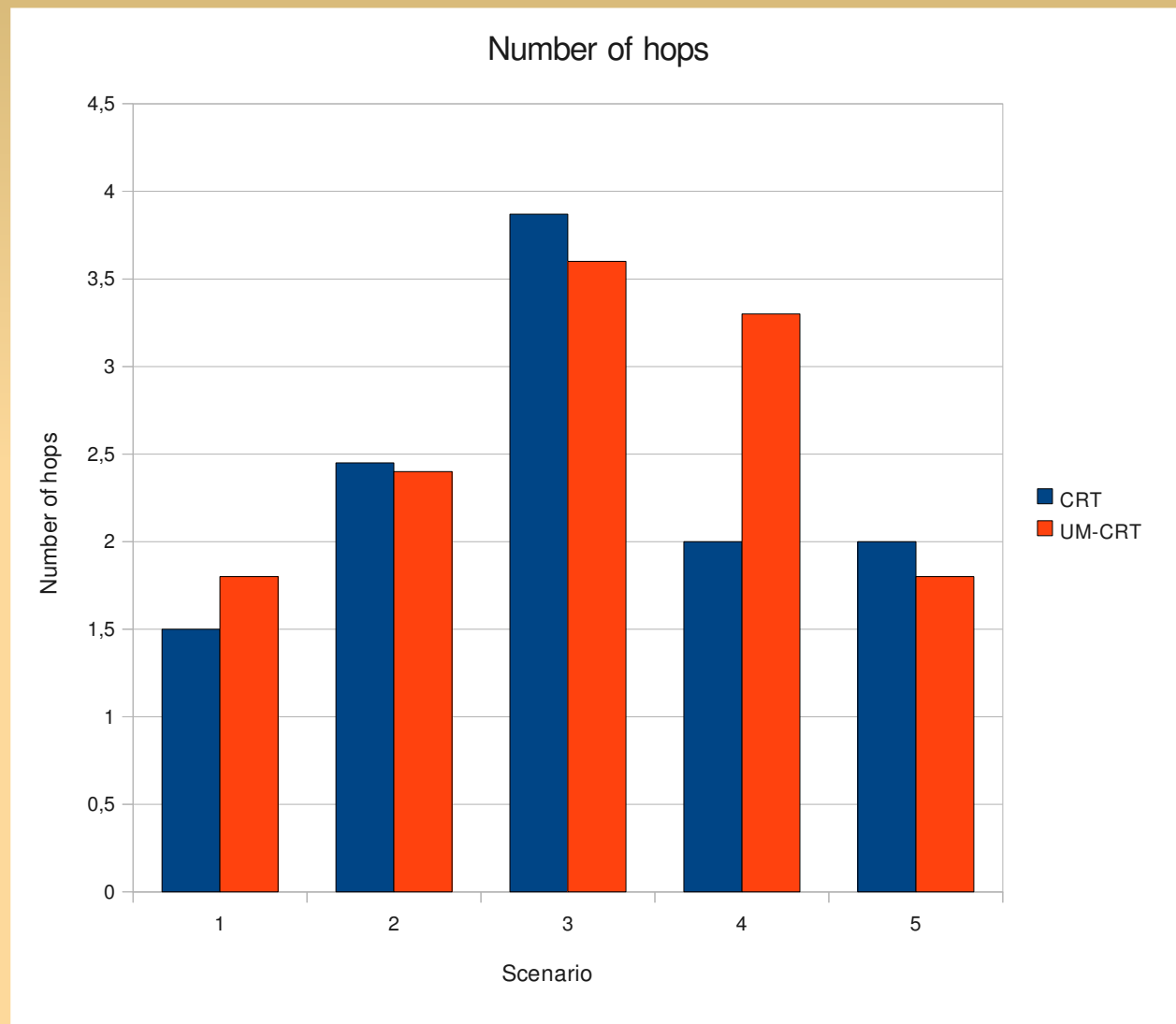
- Scenario 4

➔ Speed does not impact the realism of the number of hops. (Cf. 1, 2 et 3)

➔ As the number of nodes decreases, results diverge. (Cf. 4)

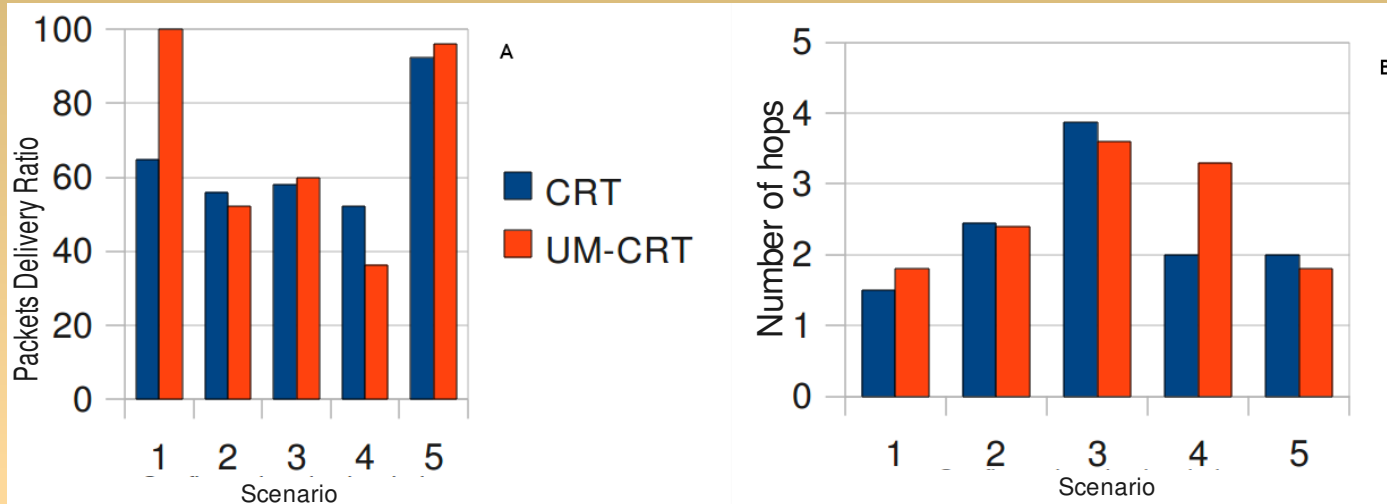
➔ The number of simultaneous communications does not impact the realism of the model. (Cf. 5)

➔ The number of hops increases as the speed increases. (Cf. 1, 2 et 3)



UM-CRT Evaluation (MIMO)

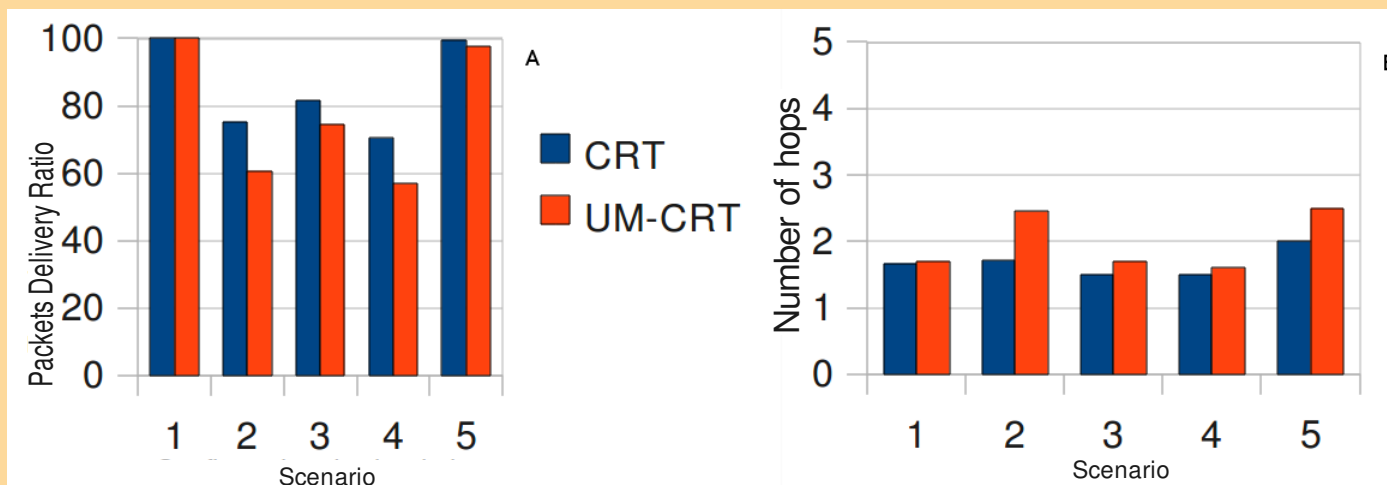
SISO – MIMO Comparison :



Packet delivery ratio (A) and number of hops (B) with SISO strategy

Simulations with the MIMO strategy confirms the results with SISO strategy

The higher the speed and the number of nodes, the better agreements in results.

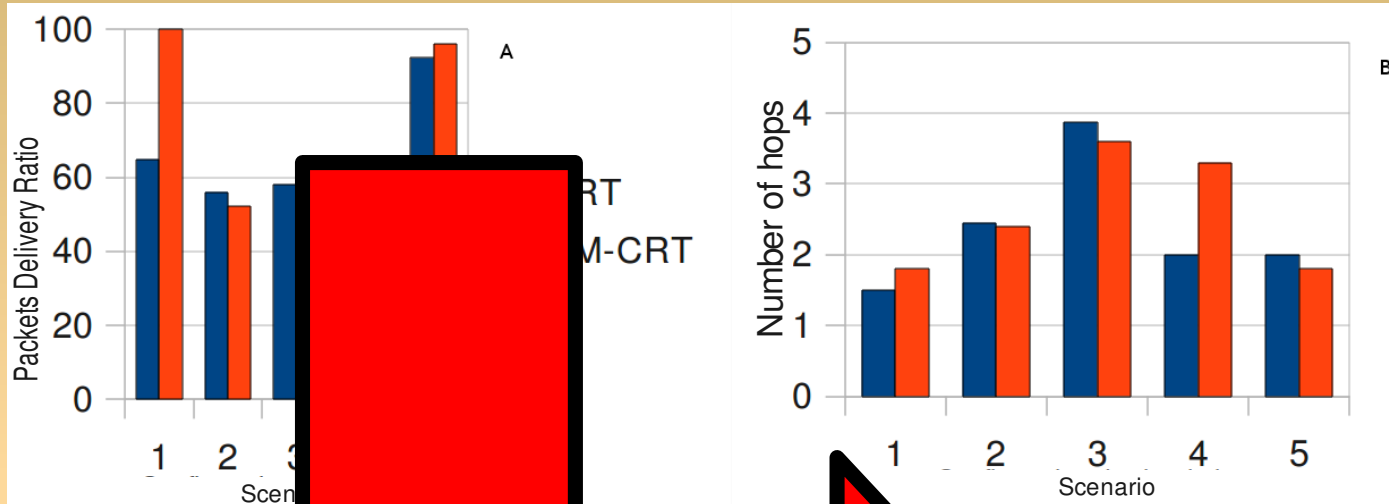


Packet delivery ratio (A) and number of hops (B) with MIMO strategy

Results with the MIMO strategy shows better results. This can be explained by the robustness of the MIMO transmission scheme.

UM-CRT Evaluation

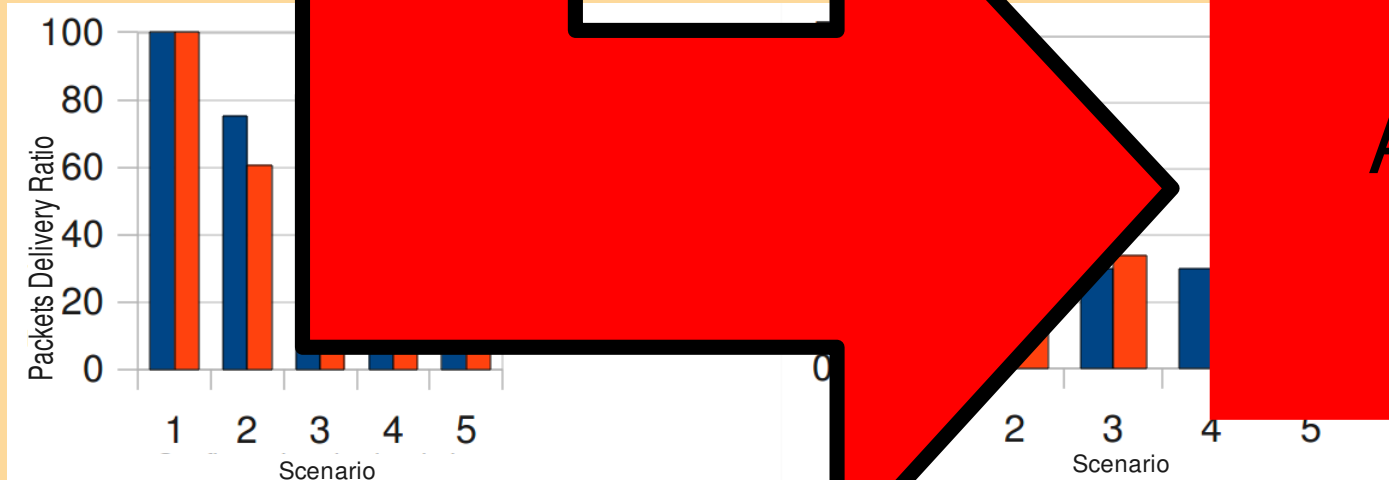
SISO – MIMO Comparison :



Simulations with the MIMO strategy confirms the results with SISO strategy

The higher the speed and the number of nodes, the better agreements in results.

Packet delivery ratio (A) and number of hops (B) with SISO strategy



Packet delivery ratio (A) and number of hops (B) with MIMO strategy

Adapted for VANETs

MIMO better be fitness of the MIMO transmission scheme.

Conclusion

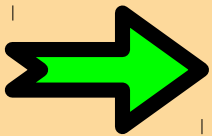
UM-CRT Model

Realistic + Low computation time

Adapted for VANETs simulations

SISO / MIMO

Integrated into NS-2



Future Work

Reduce pre-computation time

Find new relevant criteria extracted from IR

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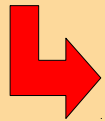


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VANETs simulations using UM-CRT

▪ Step 1: Pre-computation

- Impulse Response computation (**CRT**)
 - Important computation time (**but once**)
- BER computation based on transmitter-receiver **distances (SCME)**



- Low computation time

Computation time: A couple of hours

▪ Step 2: Simulation

- BER is associated to each packet based on **distance** and

LOS-NLOS criteria between transmitter and receiver



- Low computation time