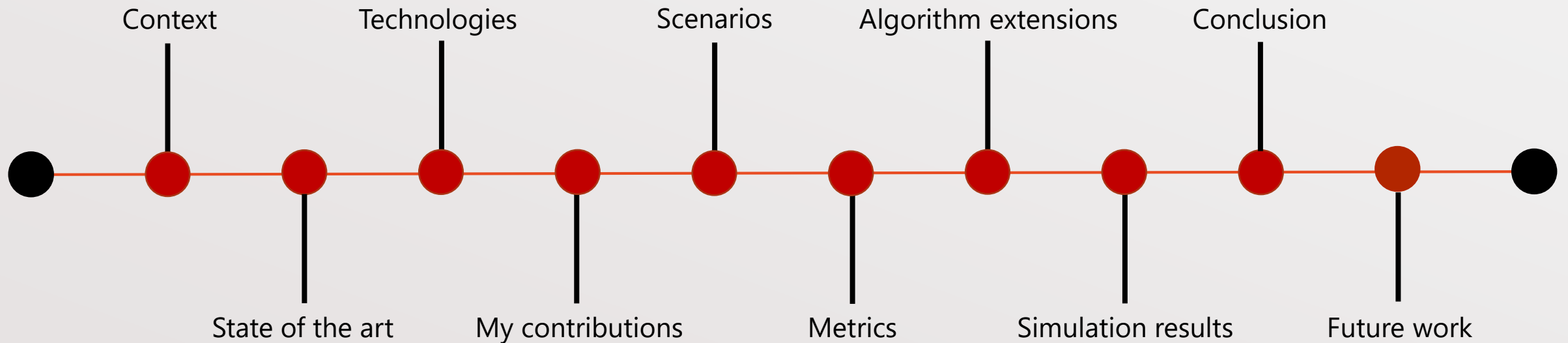# FAST MESSAGE PROPAGATION OVER IOV SCENARIOS

Relatore: Prof. Claudio Enrico Palazzi
Co-relatore: Dott. Armir Bujari

Jordan Gottardo 1179739
Esame di laurea - 18 Luglio 2019

CONTENTS

CONTEXT

- Vehicular and Flying Ad-Hoc Networks (VANETs and FANETs)
- Several applications
  - Smart city management
  - Video streaming
  - Traffic control
- Focus: Emergency Message Distribution (EMD)
  - Message delivery
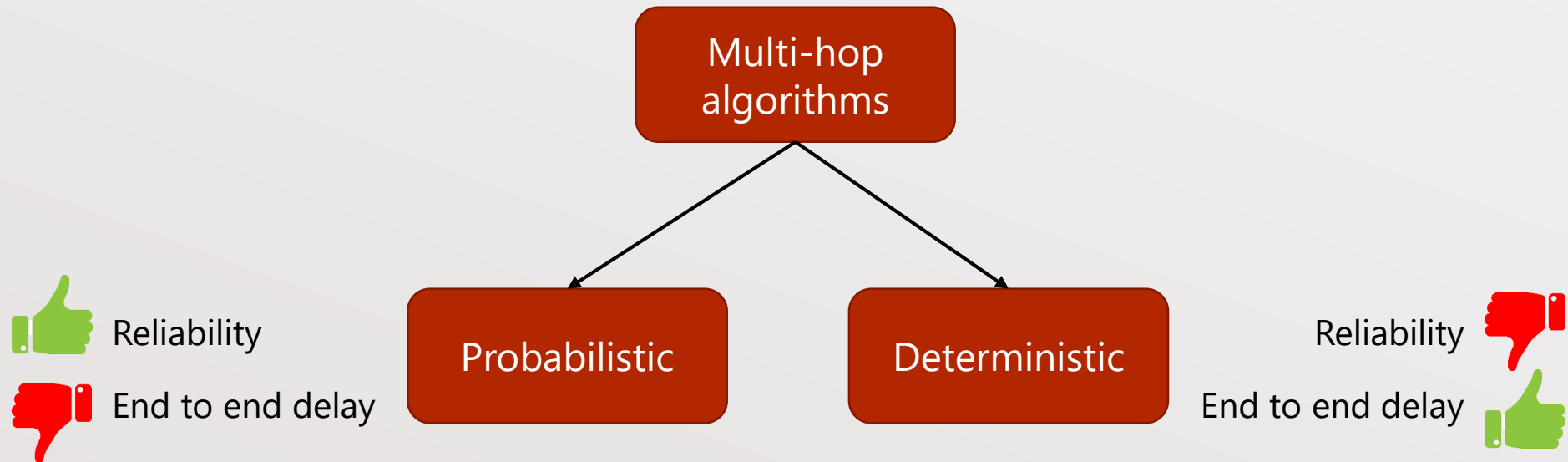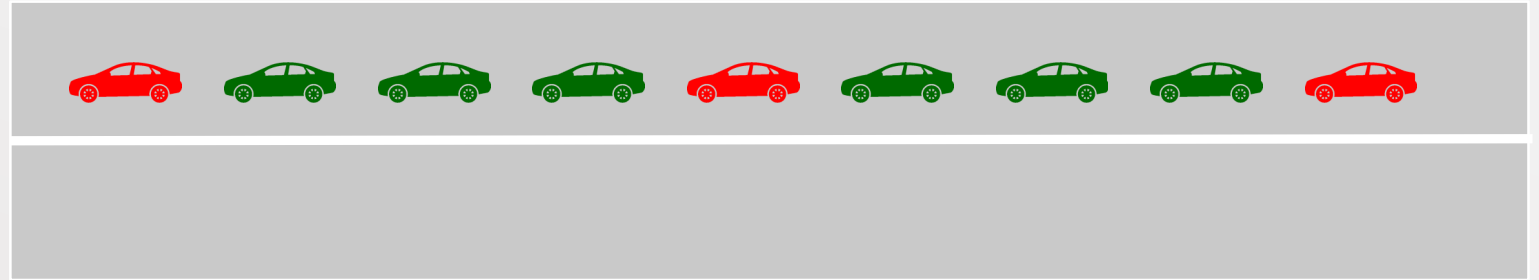 - Timeliness
  - Avoid medium saturation

TECHNOLOGIES AND TOOLS

- Expensive large scale tests
  - Need to use simulators (ns-3)

- Additional tools and models
  - Real map data
  - Road junction modeling

- Signal propagation models
  - Two-Ray Ground
  - Obstacle shadowing (with 3D extension)
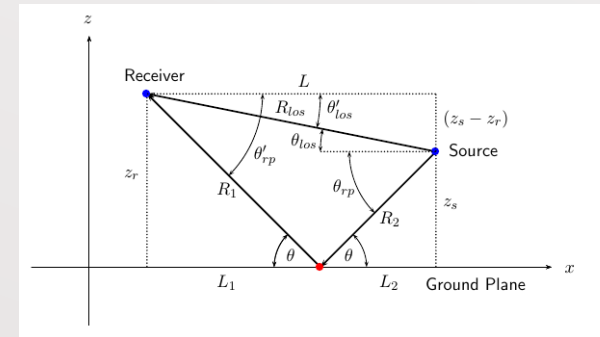
ALGORITHM CLASSIFICATION

- Multi-hop propagation
  - Farthest forwarder definition
  - Two main approaches

Multi-hop algorithms

Probabilistic

Deterministic

👍 Reliability

👎 End to end delay

👎 Reliability

👍 End to end delay

FAST-BROADCAST

- Multi-hop **probabilistic** delay-based broadcasting protocol

- Dynamic transmission range estimation

  - No need to know it *a priori*, as often assumed in other protocols

- Estimation Phase:

  - Vehicles exchange small *Hello Messages* (beacons) to estimate their transmission range

  - **1 Hello Message** sent every *BeaconInterval* (e.g., 100ms) within each transmission range

- Broadcast Phase:

Waiting time		[0...1024]	[0...512]	[0...32]
	A	B	C	D
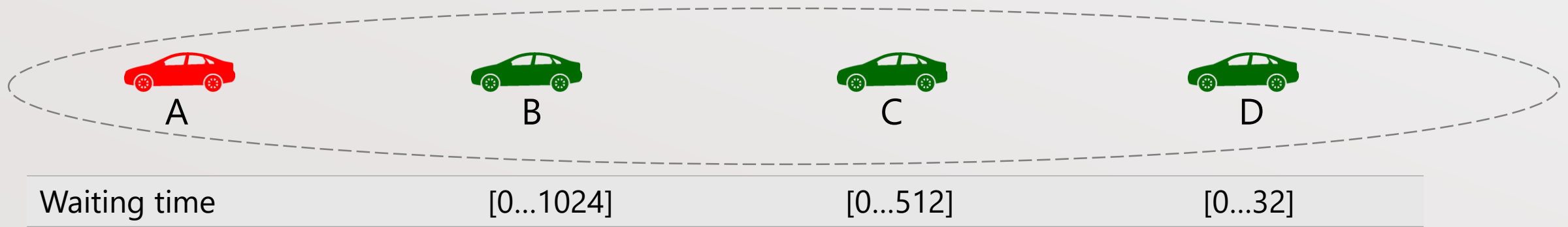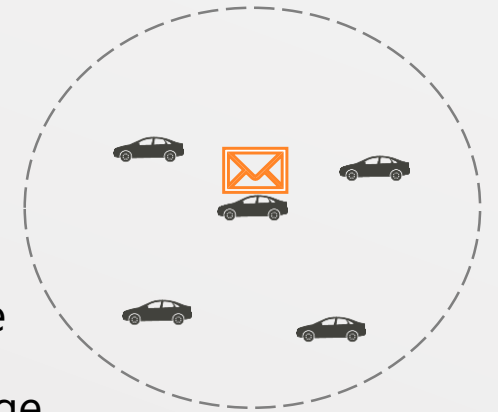
ROFF (RObust Fast Forwarding)

- Multi-hop **deterministic** delay-based broadcasting protocol

- Estimation Phase:

  - **Each vehicle** sends a Hello Message every *BeaconInterval* (e.g., 100ms)

  - Neighborhood discovery process

- Broadcast Phase:
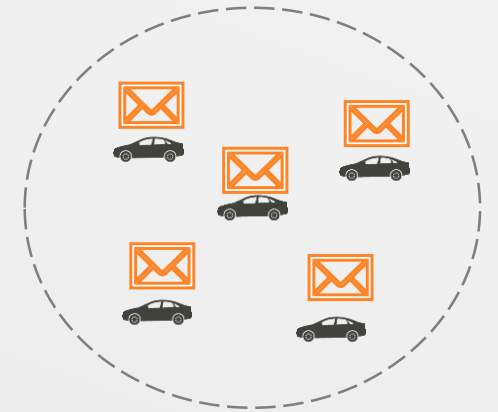
	A	B	C	D
Priority		3	2	1
Waiting time		2	1	0

MY CONTRIBUTIONS

- Improvements to Fast-Broadcast

- Implementation and extension to 2D and 3D scenarios of ROFF

- Evaluation and comparison of Fast-Broadcast and ROFF through simulations

  o Urban scenarios of increasing complexity and realism

- Proposal of extension to exploit road junctions to increase message delivery ratios

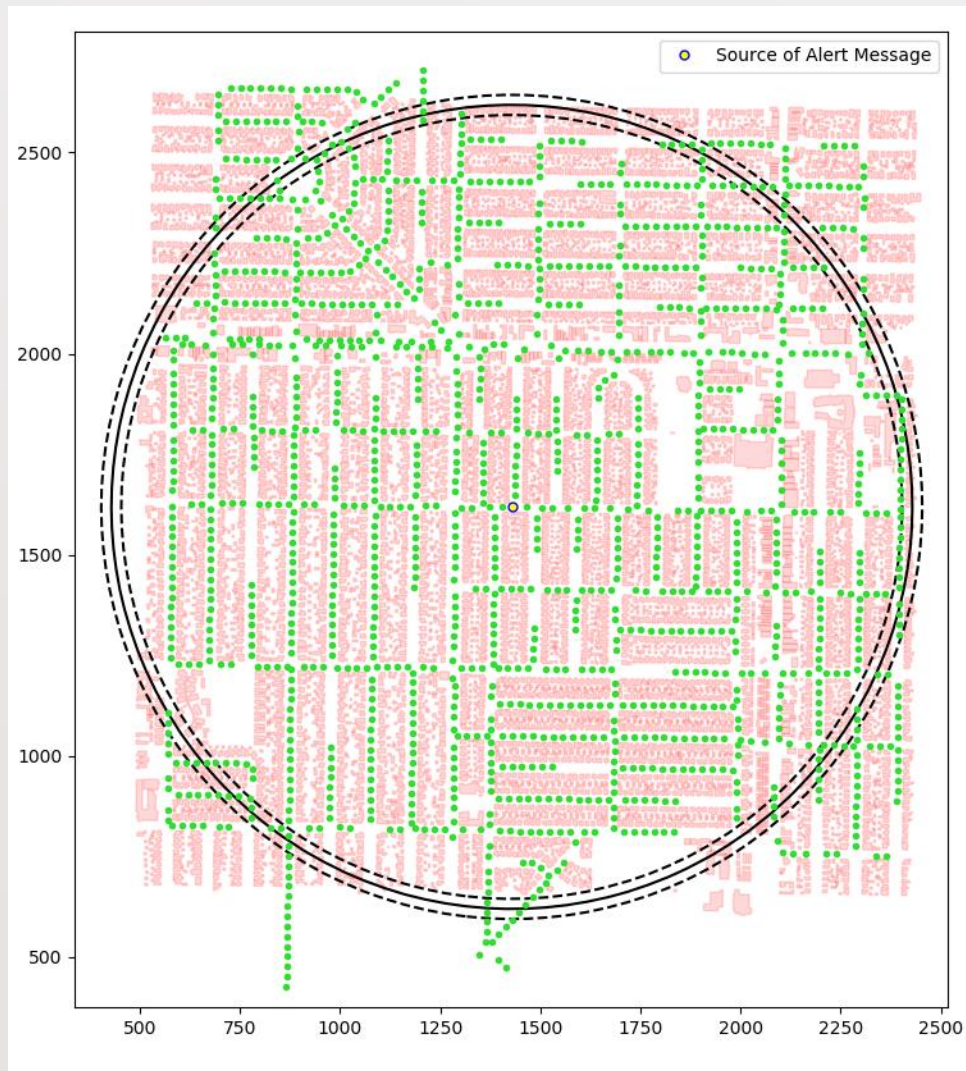 o **SJ-Fast-Broadcast** and **SJ-ROFF** (SJ=Smart Junction)

SIMULATIONS – SCENARIOS AND METRICS

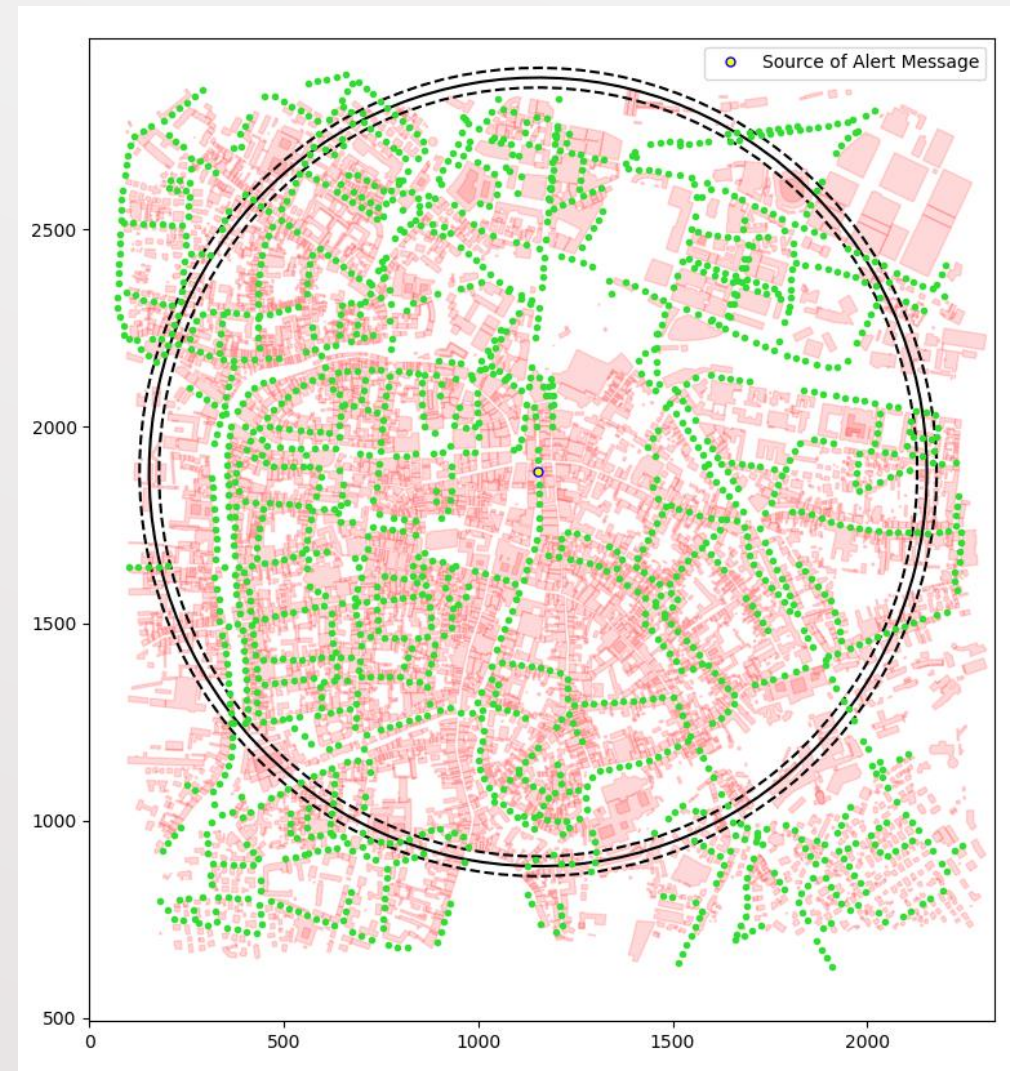- Several scenarios of increasing complexity and realism

Scenario name	Type	Buildings	Drones
Platoon	1D	✗	✗
Grid	2D	✓	✗
Los Angeles	2D	✓	✗
Padua	2D	✓	✗
Los Angeles smart city	3D	✓	✓

- Metrics:
  - Coverage ↑
  - End-to-end delay ↓
  - Redundancy ↓

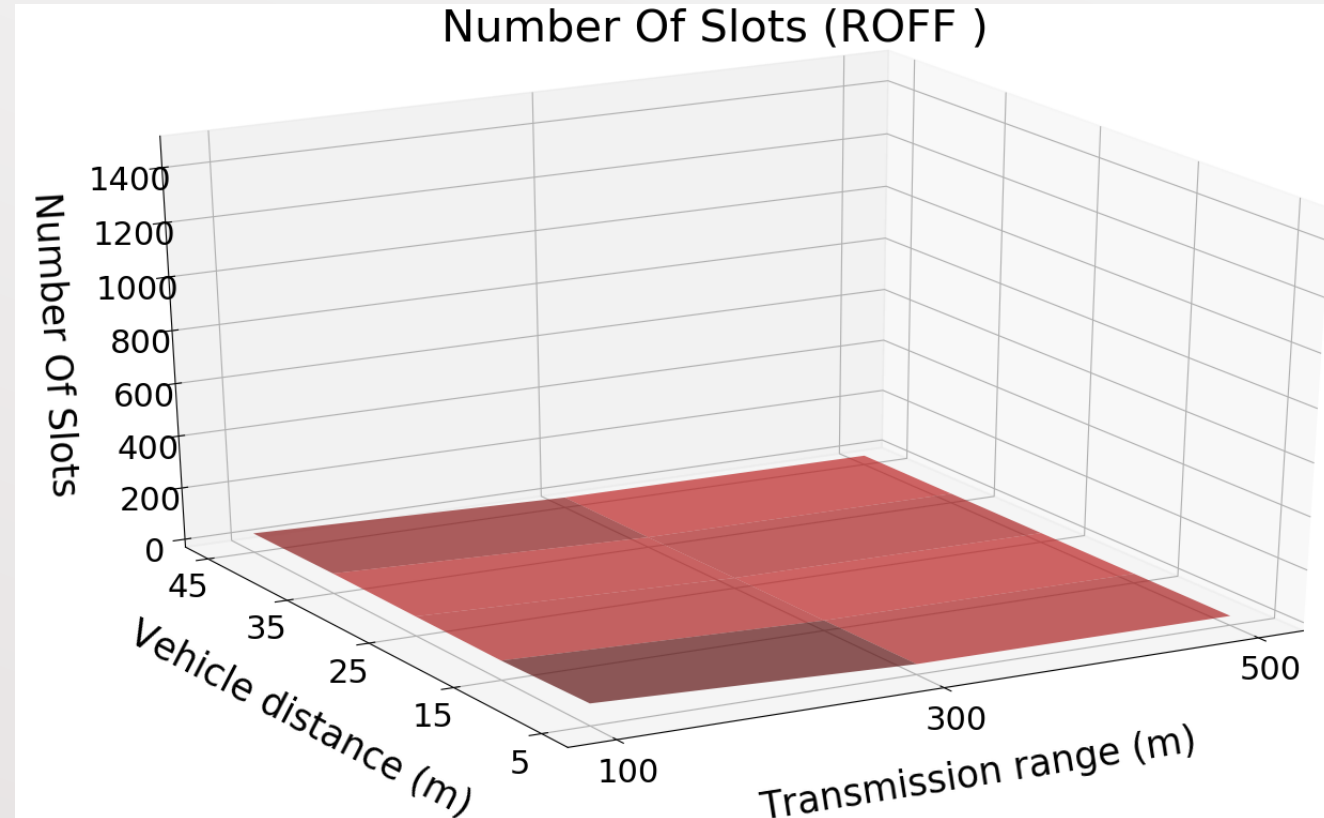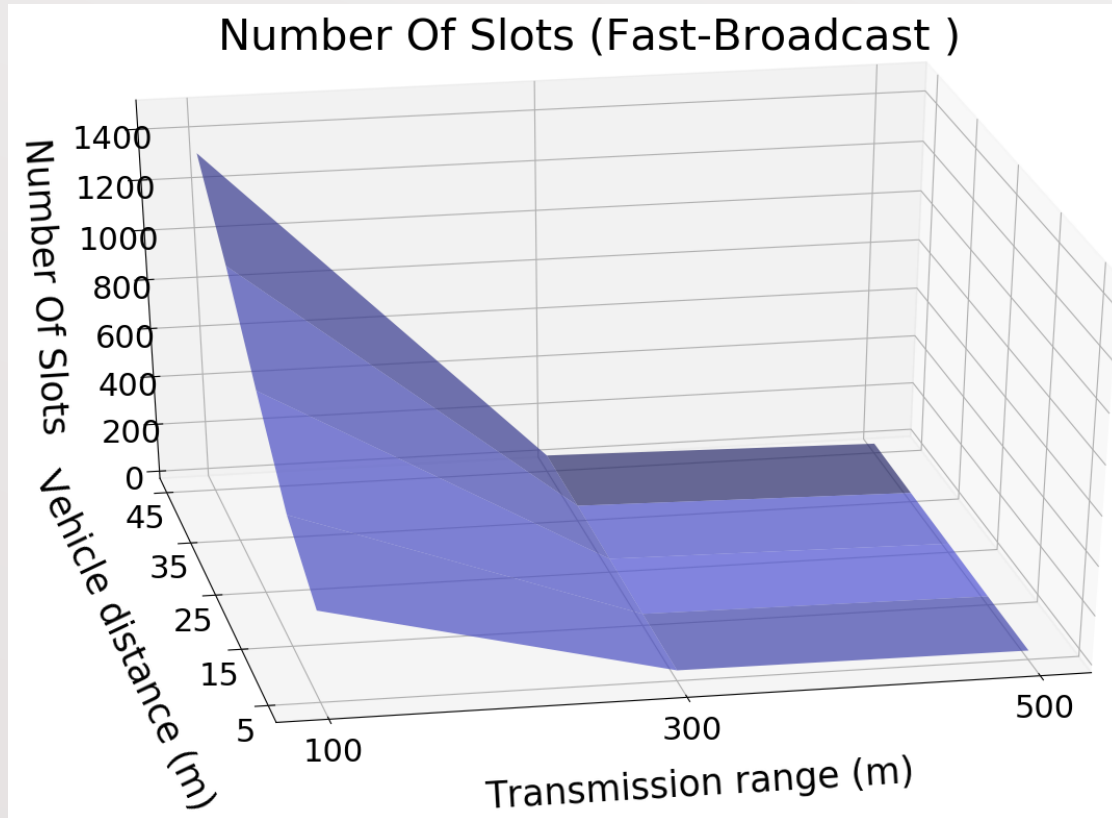# URBAN SCENARIOS

Los Angeles

Padua

PRELIMINARY TESTS - CONFIGURATION

Scenario configuration	
Scenario name	Padua
Latitude N [°]	45.4171
Latitude S [°]	45.3981
Longitude W [°]	11.8654
Longitude E [°]	11.8923
Circumference radius [m]	1000
Distance between vehicles [m]	5, 15, 25, 35, 45
Number of vehicles	4975, 2856, 1775, 1318, 1072
Number of simulations	4500

Simulator configuration	
Packet payload size	100 byte
Frequency [GHz]	2.4
Channel bandwidth [MHz]	22
Transmission speed [Mbps]	11
Transmission powers [dBm]	-7.0, 4.6, 13.4
Transmission ranges [m]	100, 300, 500
Modulation	DSSS
Propagation loss model	ns3::TwoRayGround
Propagation delay model	ns3::ConstantSpeed

END-TO-END DELAY ↓

- Coverage ↑ : comparable results
- End-to-end delay ↓ :

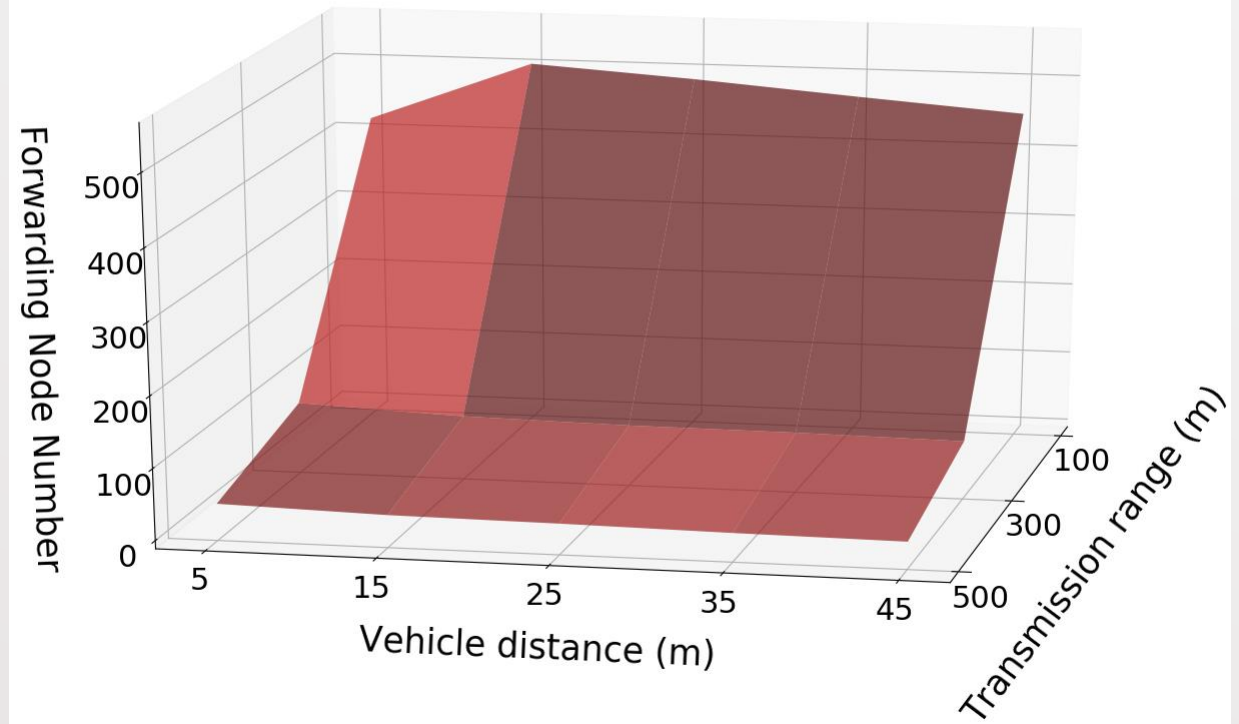Number Of Slots (Fast-Broadcast)

Number Of Slots (ROFF)

REDUNDANCY ↓

Forwarding Node Number (Fast-Broadcast)
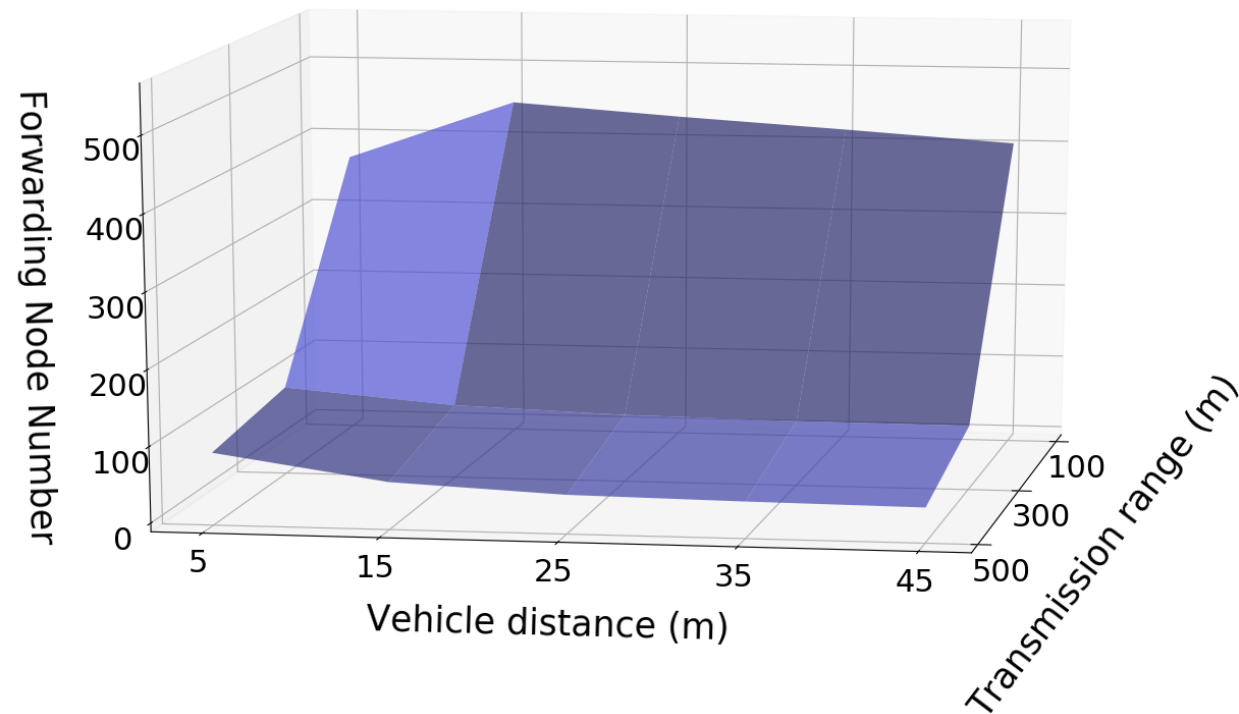
Forwarding Node Number (ROFF)

PADUA WITH BUILDINGS

Scenario configuration	
Scenario name	Padua
Latitude N [°]	45.4171
Latitude S [°]	45.3981
Longitude W [°]	11.8654
Longitude E [°]	11.8923
Circumference radius [m]	1000
Distance between vehicles [m]	25
Number of vehicles	1775
Number of buildings	**6322**
Number of simulations	4500

Simulator configuration	
Packet payload size	100 byte
Frequency [GHz]	2.4
Channel bandwidth [MHz]	22
Transmission speed [Mbps]	11
Transmission powers [dBm]	-7.0, 4.6, 13.4
Transmission ranges [m]	100, 300, 500
Modulation	DSSS
Propagation loss model	ns3::TwoRayGround
Propagation delay model	ns3::ConstantSpeed
Shadowing model	**ns3::ObstacleShadowing**

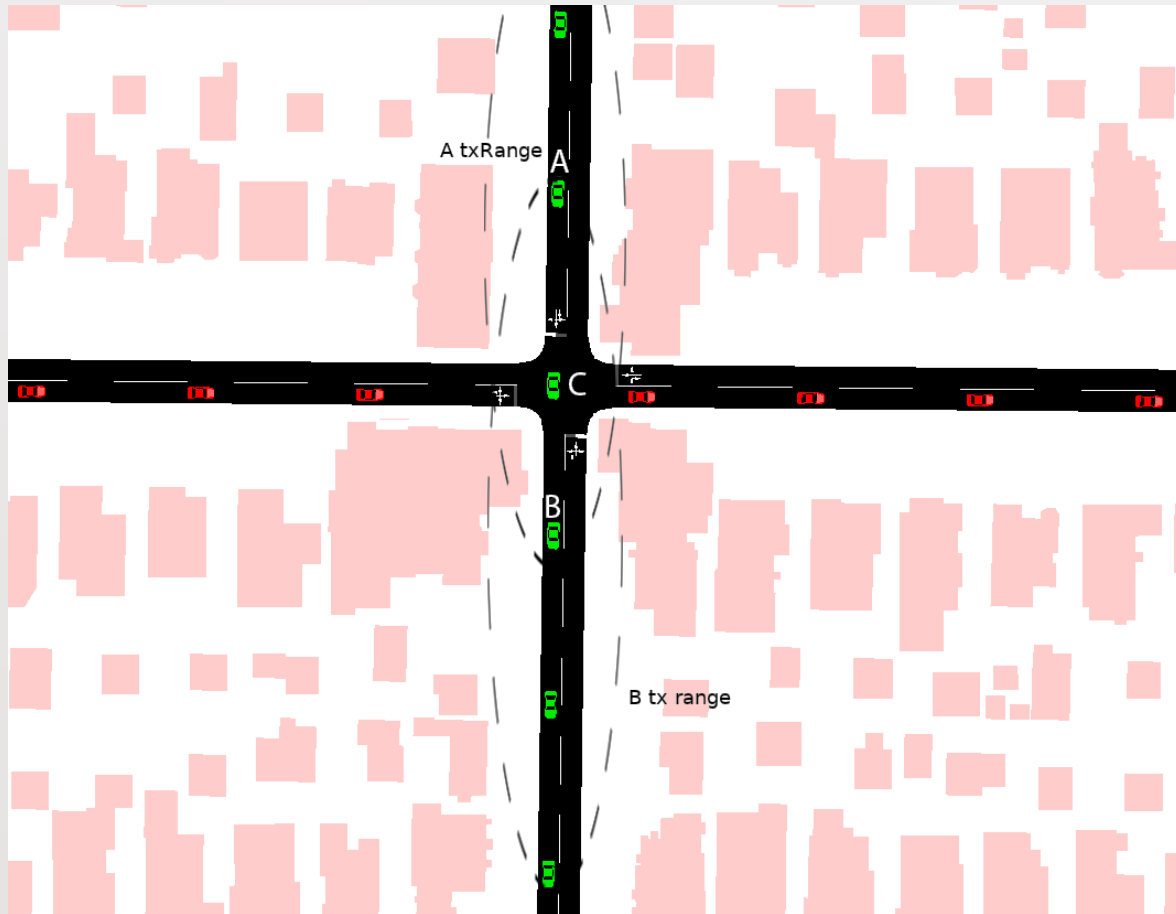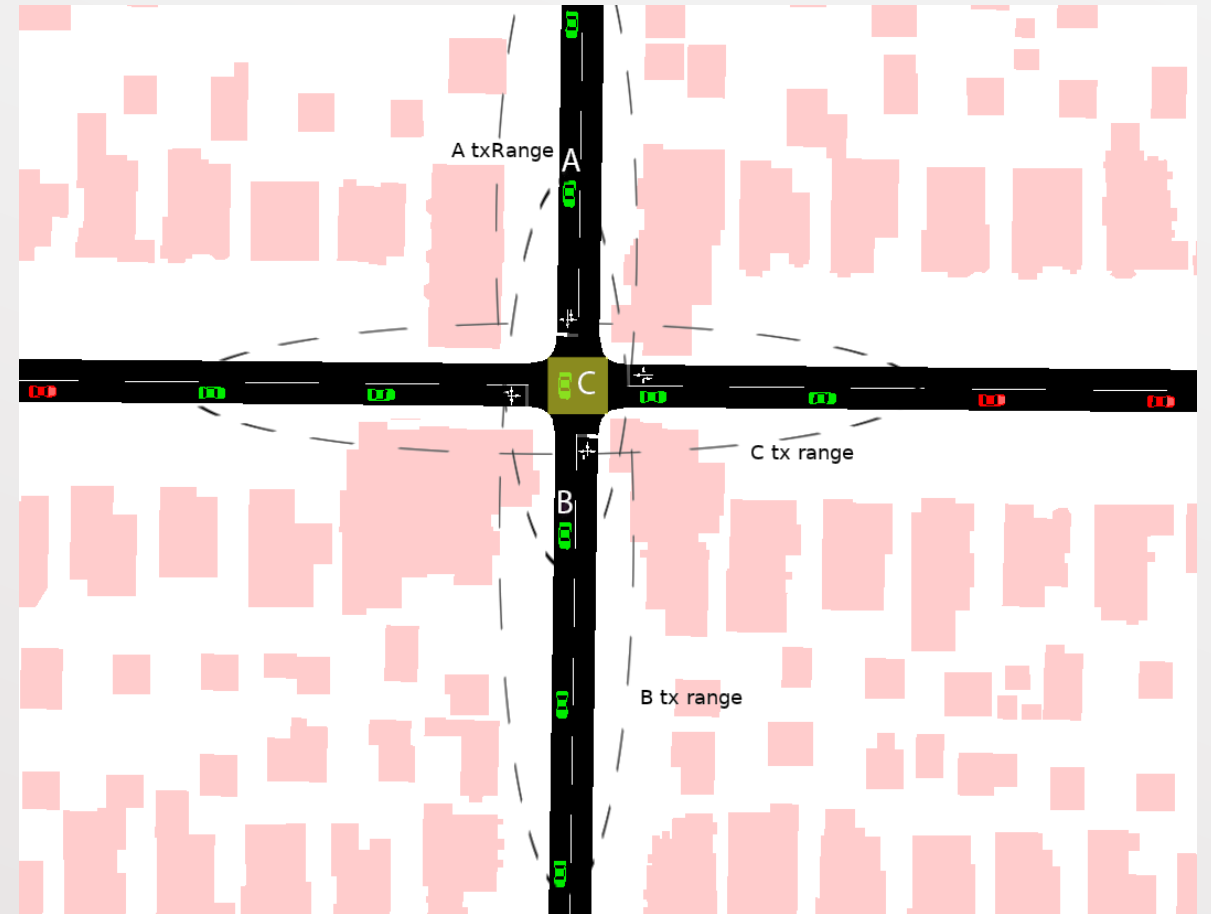# PADUA WITH BUILDINGS – COVERAGE ↑
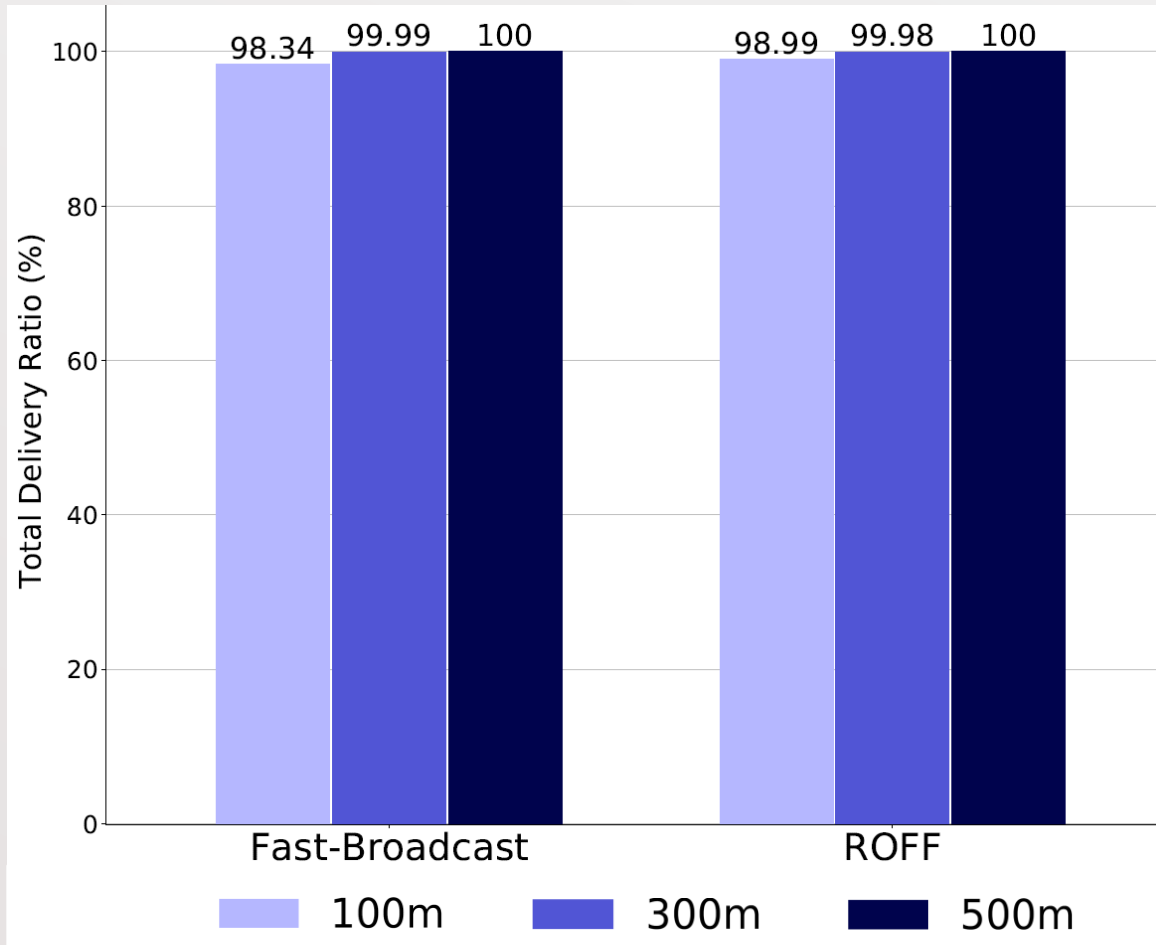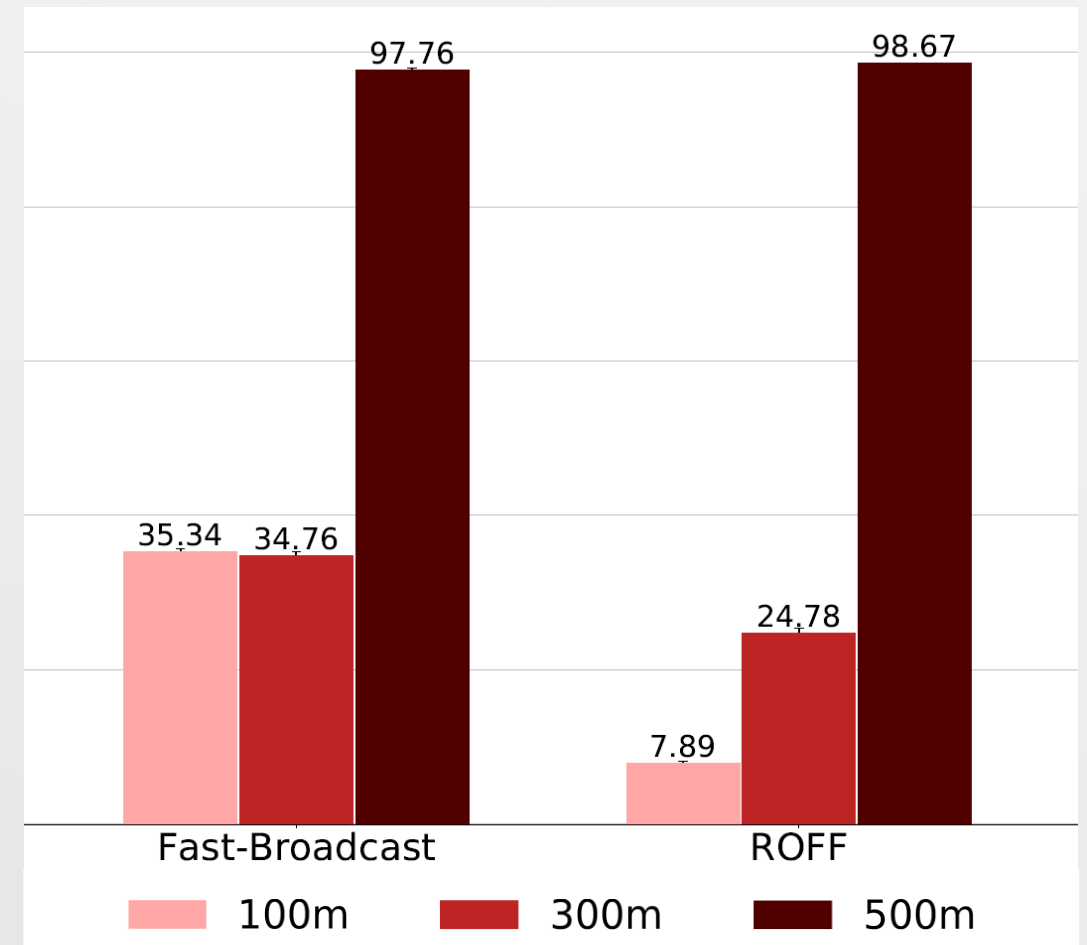
Without buildings

With buildings

EXPLOITING JUNCTIONS – EXAMPLE

Without junction model
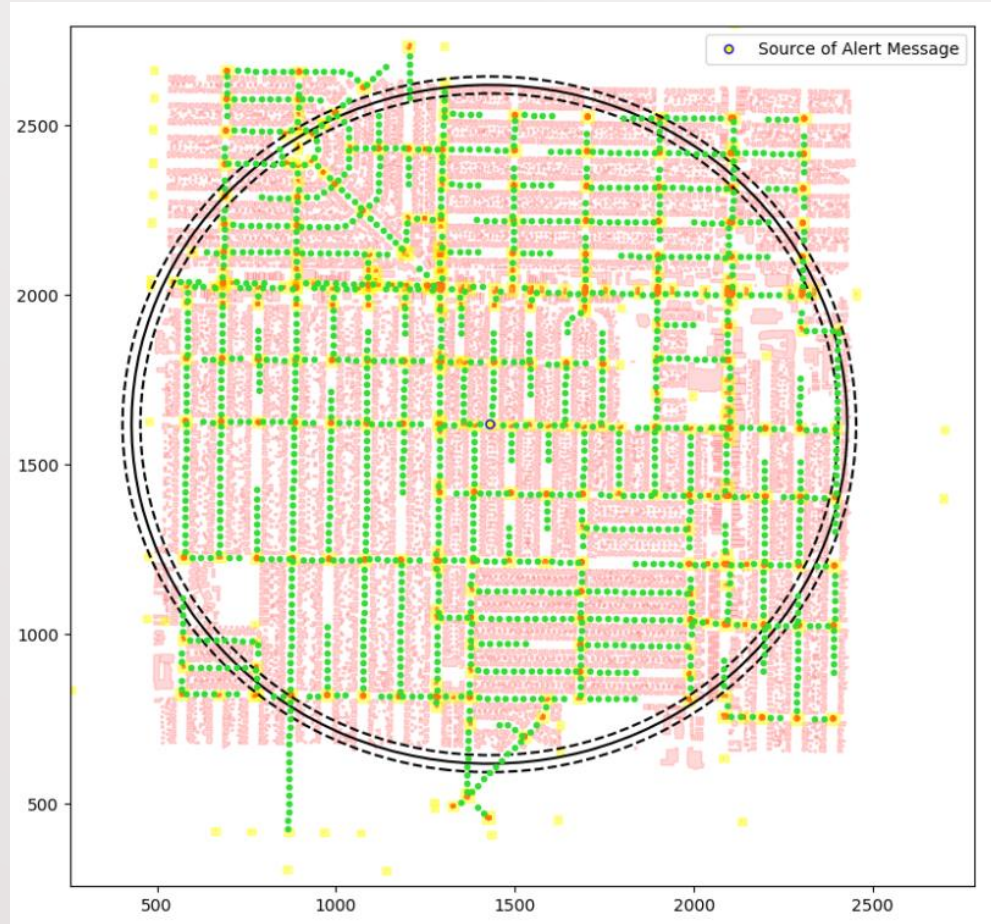
With junction model

JUNCTION MODEL

- Aim: exploit vehicles located within junctions to improve coverage

- Identification of junctions via OSM/SUMO tools

```
<junction id="1101896841" type="right_before_left" x="1261.31" y="2430.73"
incLanes="94925123#0_0 -94925123#1_0" intLanes=":1101896841_0_0 :1101896841_1_0
:1101896841_2_0 :1101896841_3_0 :1101896841_4_0 :1101896841_5_0"
shape="1262.20,2433.25 1263.07,2432.75 1262.80,2431.98 1262.85,2431.66 1263.03,
2431.39 1263.32,2431.17 1263.73,2430.99 1263.11,2429.09 1259.38,2430.19 1259.87,
2432.13 1260.78,2432.09 1261.18,2432.22 1261.56,2432.46 1261.90,2432.81">
```
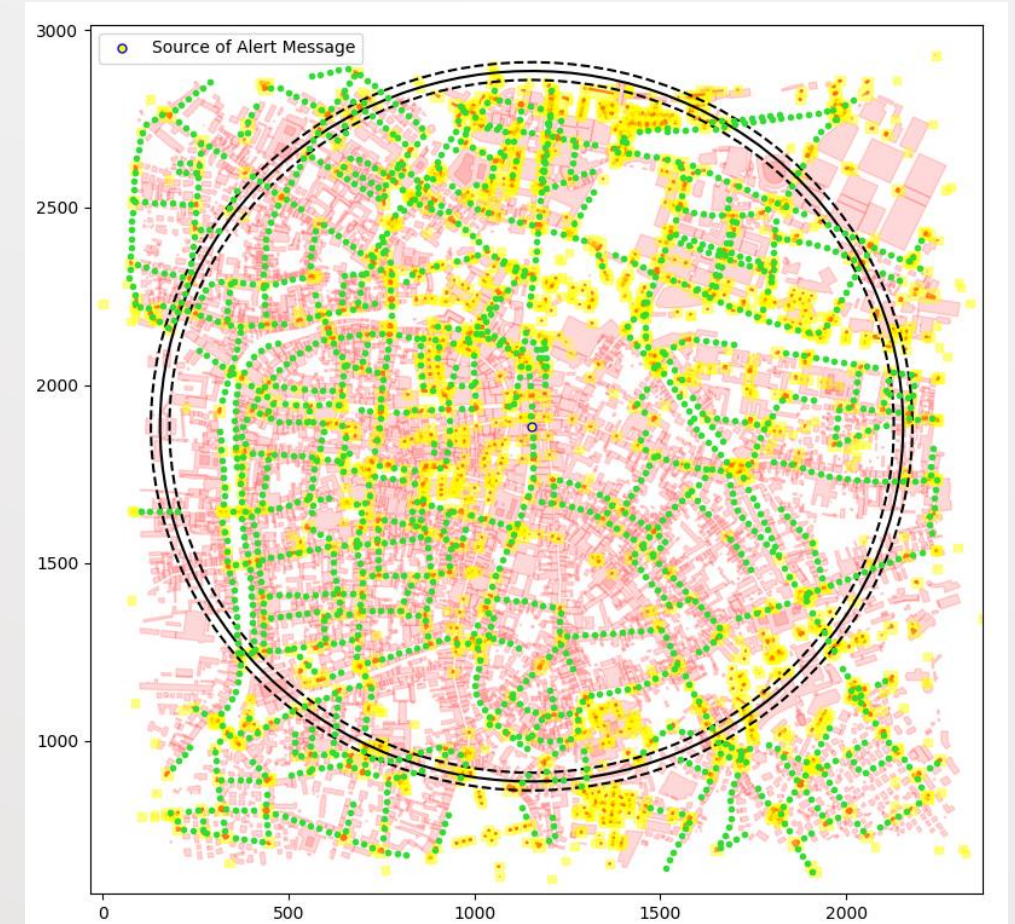
- 20x20m bounding box to extend the polygon

- Vehicles within a junction participate in a **second contention**

- Extension applicable both to Fast-Broadcast and ROFF
  - SJ-Fast-Broadcast and SJ-ROFF

JUNCTION MODEL - SCENARIOS

Los Angeles

Padua

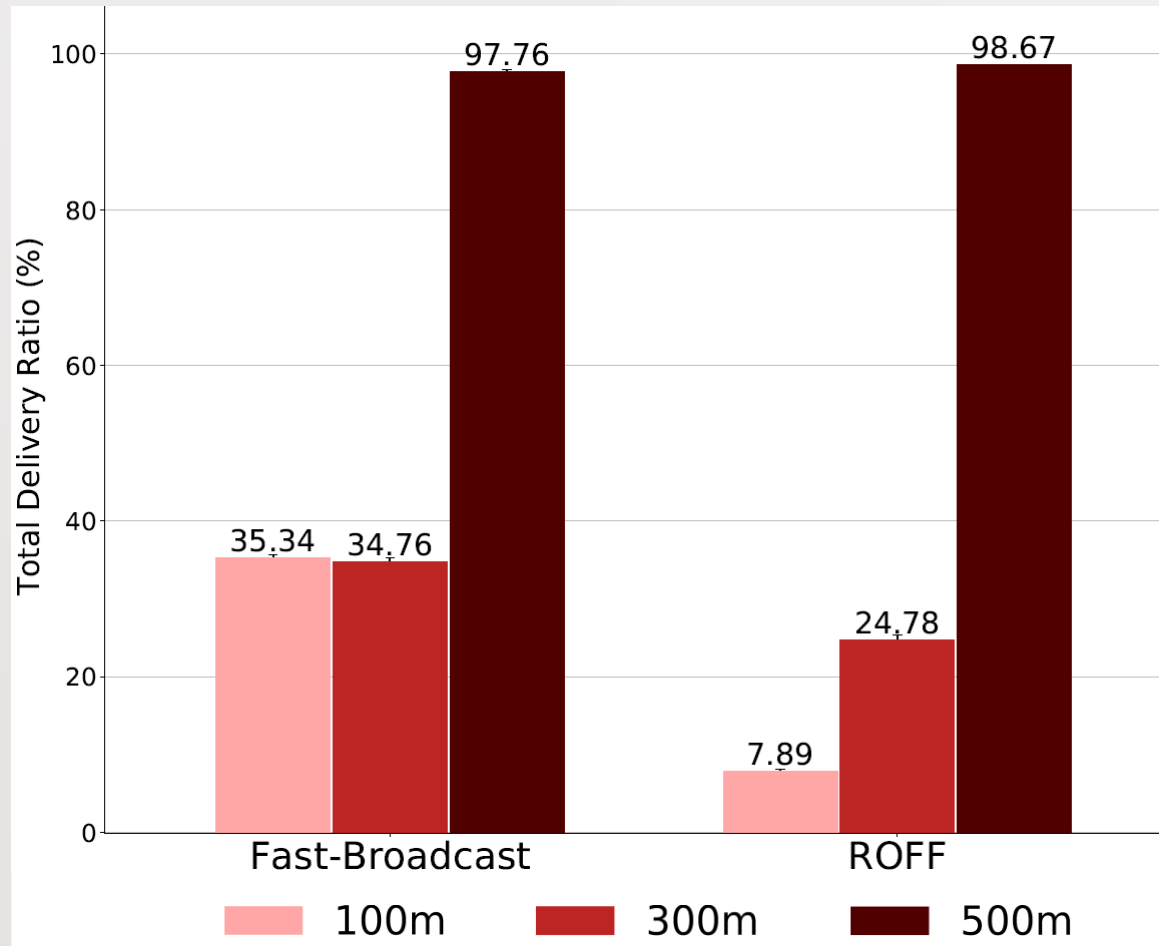# PADUA WITH JUNCTIONS

Scenario configuration	
Scenario name	Padua
Latitude N [°]	45.4171
Latitude S [°]	45.3981
Longitude W [°]	11.8654
Longitude E [°]	11.8923
Circumference radius [m]	1000
Distance between vehicles [m]	25
Number of vehicles	1775
Number of buildings	6322
Number of junctions	**3231**
Number of simulations	4500

| Simulator configuration	
Packet payload size	100 byte
Frequency [GHz]	2.4
Channel bandwidth [MHz]	22
Transmission speed [Mbps]	11
Transmission powers [dBm]	-7.0, 4.6, 13.4
Transmission ranges [m]	100, 300, 500
Modulation	DSSS
Propagation loss model	ns3::TwoRayGround
Propagation delay model	ns3::ConstantSpeed
Shadowing model	ns3::ObstacleShadowing

PADUA WITH JUNCTIONS – COVERAGE ↑
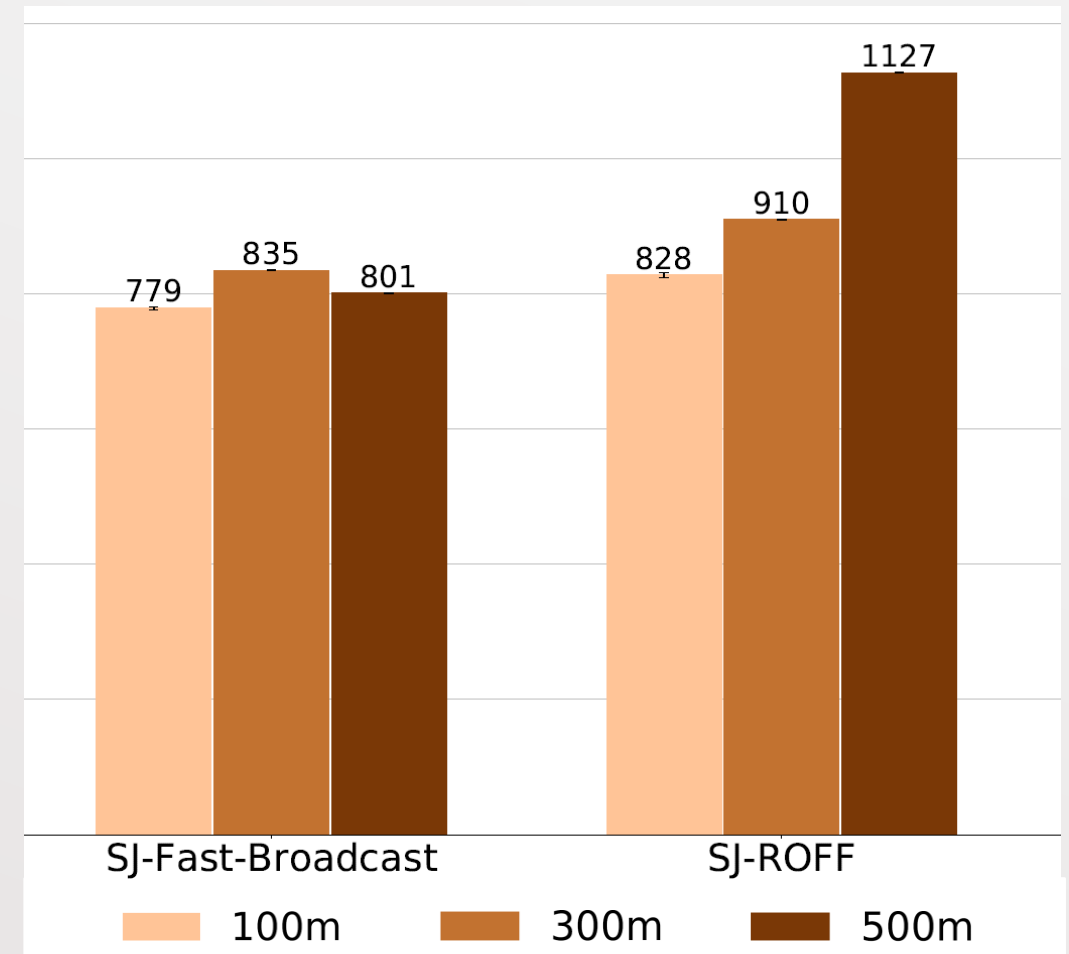

Without smart junction
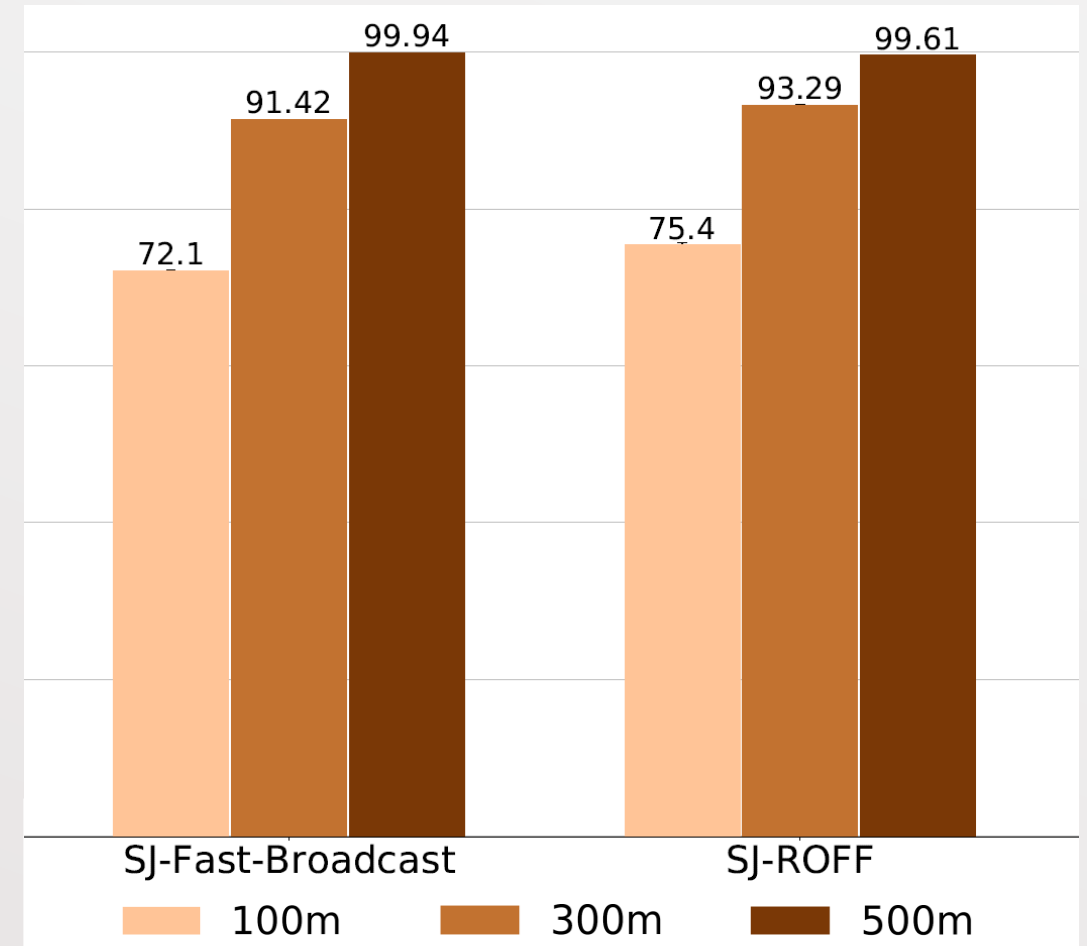
With smart junction
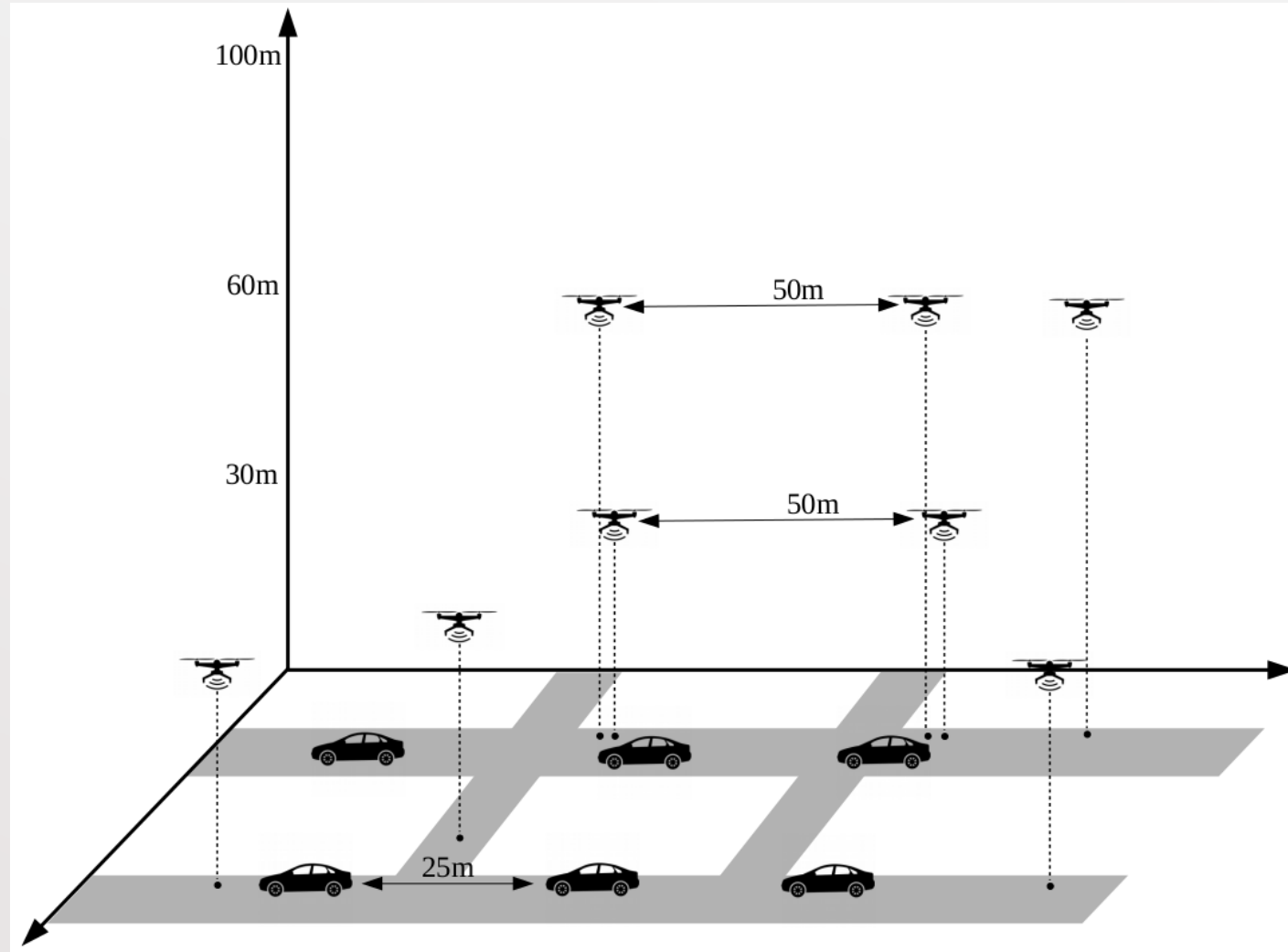
PADUA WITH JUNCTIONS – REDUNDANCY ⇩
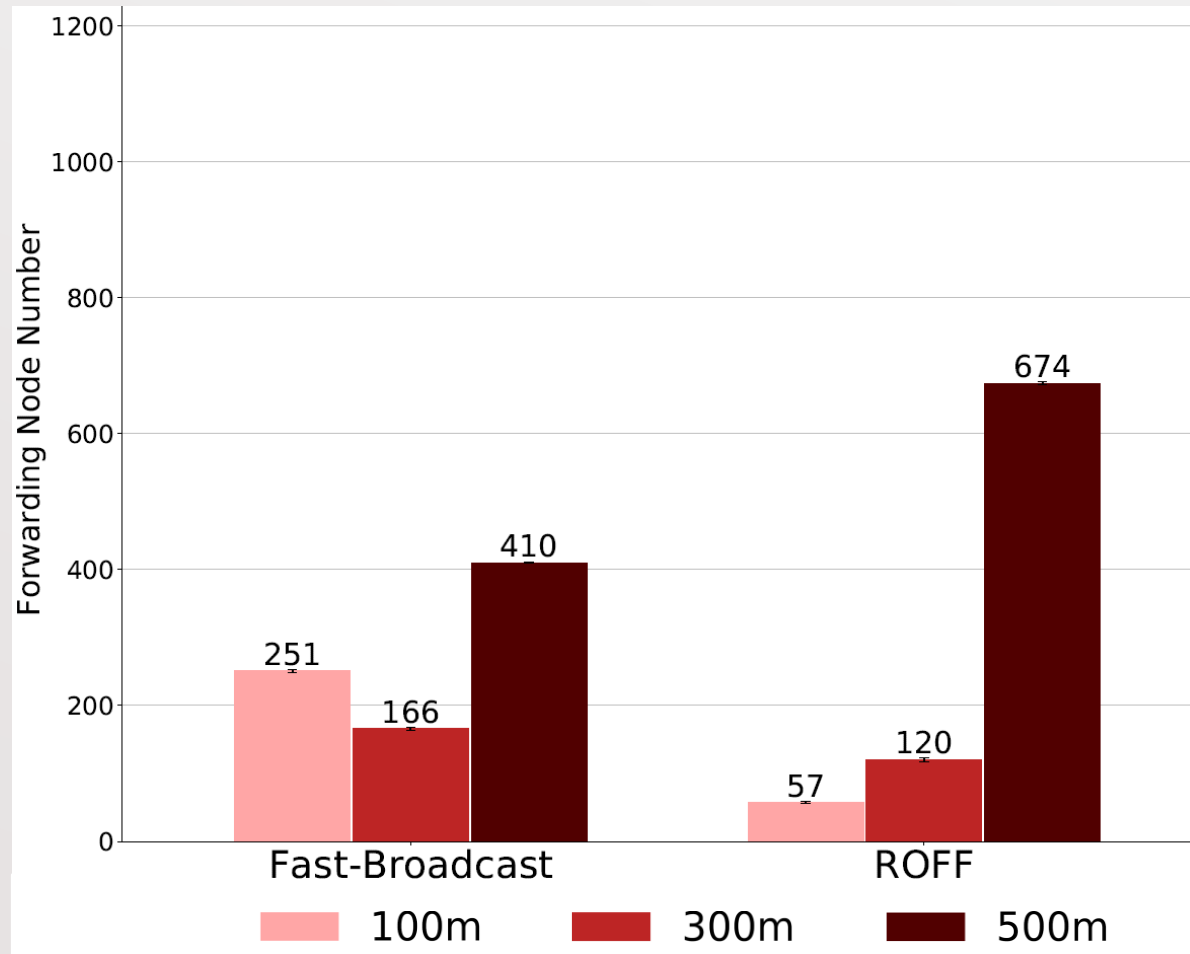
Without smart junction
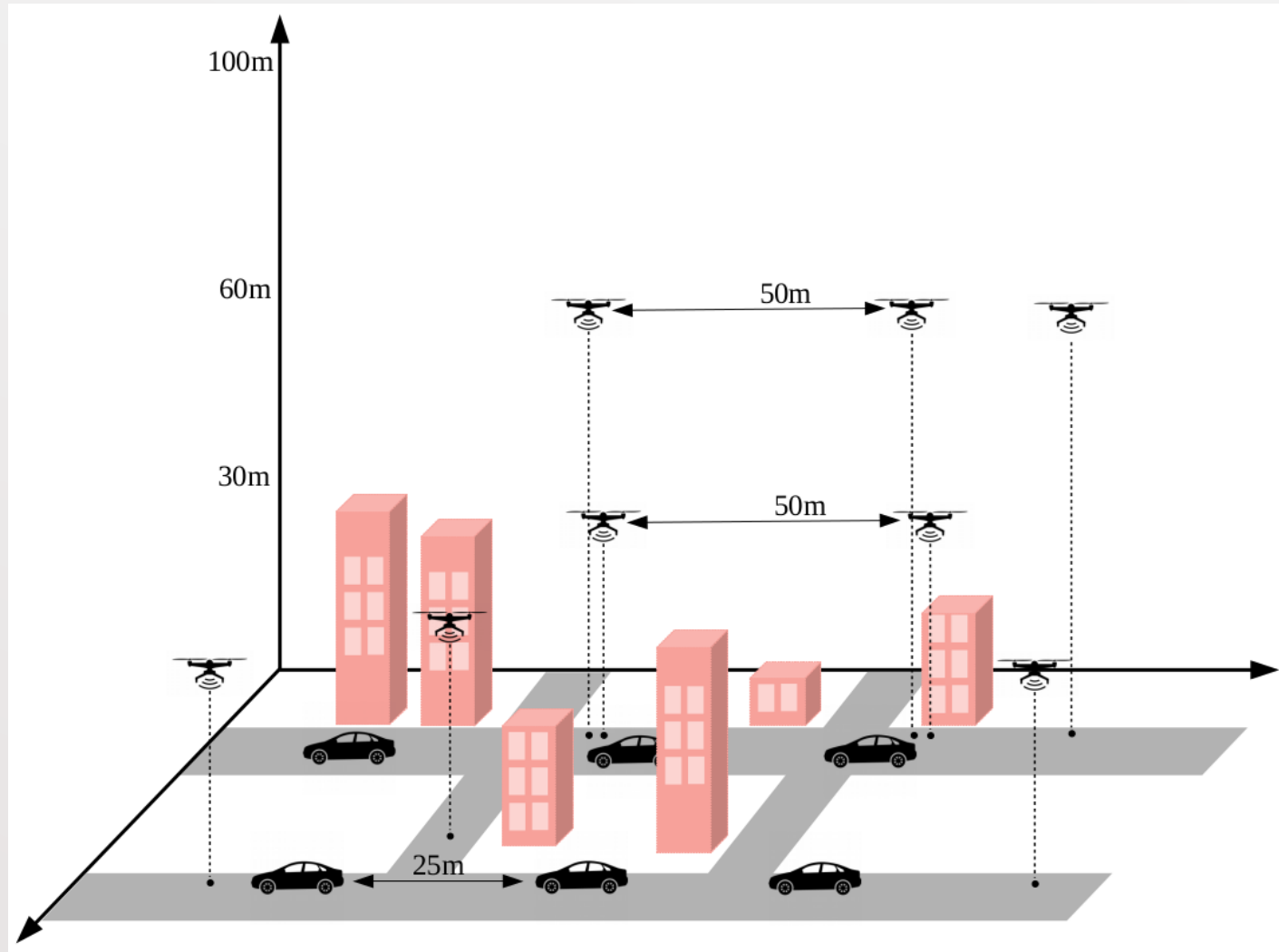
With smart junction

L.A. SMART CITY SCENARIO

- Vehicular + drones mixed scenario
  - Message propagation in 3D
- Different buildings configurations
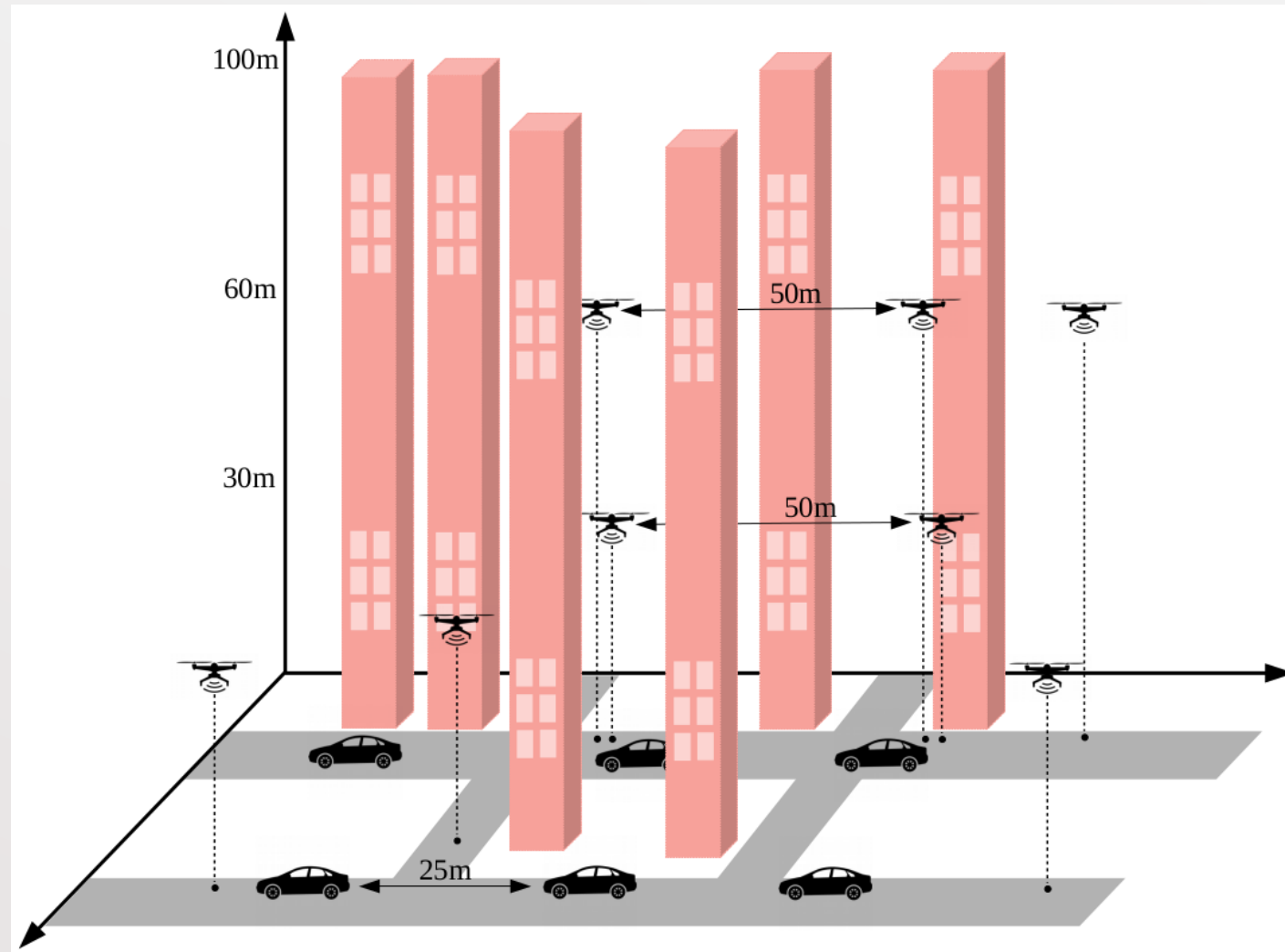 - **No buildings**

L.A. SMART CITY SCENARIO

- Vehicular + drones mixed scenario
  - Message propagation in 3D

- Different buildings configurations
  - No buildings
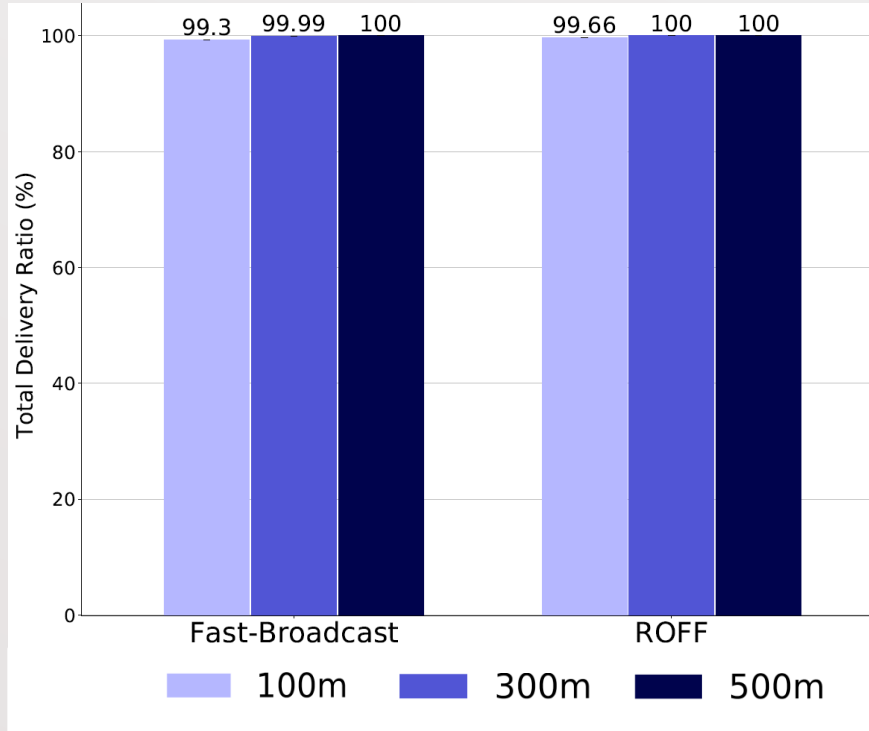 - **Buildings with real heights**
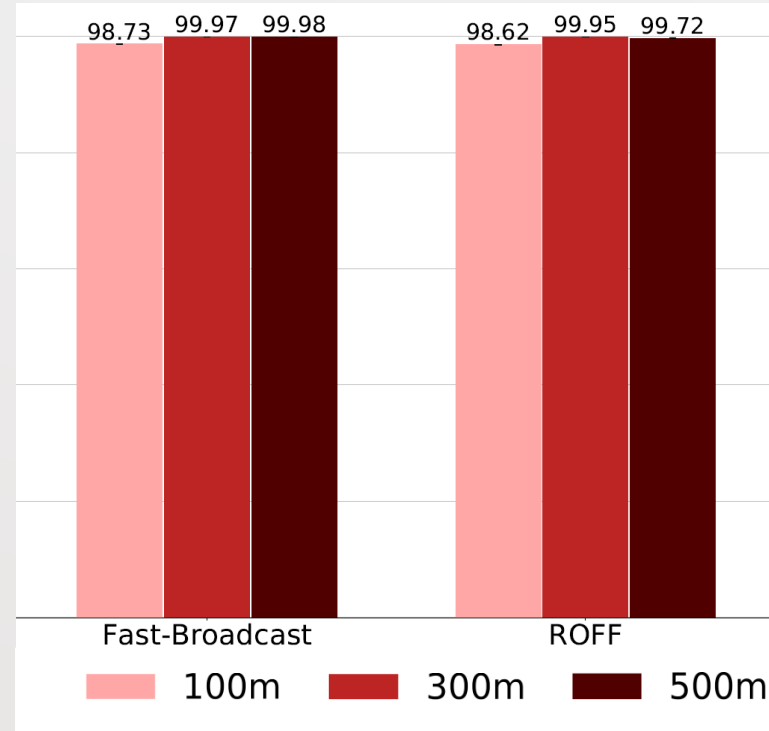
L.A. SMART CITY SCENARIO

- Vehicular + drones mixed scenario
  - Message propagation in 3D

- Different buildings configurations
  - No buildings
  - Buildings with real heights
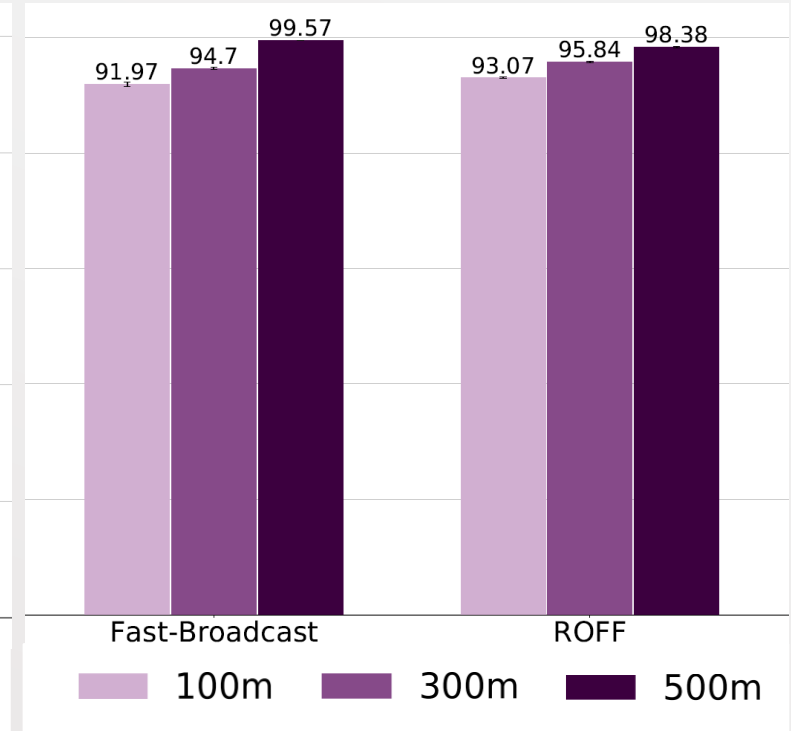 - **Very tall buildings**

LOS ANGELES – COVERAGE ↑

Without buildings

Real height buildings

Very tall buildings

CONCLUSION

- ROFF introduces a much smaller end-to-end delay than Fast-Broadcast

  - Greater redundancy

  - Determinism and collisions

  - High number of Hello Messages

- SJ-Fast-Broadcast and SJ-ROFF improve coverage greatly

  - At the cost of more retransmissions

- The algorithms work well even in mixed 3D scenarios

- *C.E. Palazzi, J. Gottardo, A. Bujari, D. Ronzani, "Message Dissemination in Urban IoV", IEEE/ACM DS-RT 2019: 23rd International Symposium on Distributed Simulation and Real Time Applications , Cosenza, Italy, Oct 2019 (submitted)*

- Working on journal version

FUTURE WORK
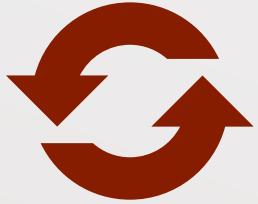
- Dynamic lower and upper bounds for Fast-Broadcast's waiting time calculation
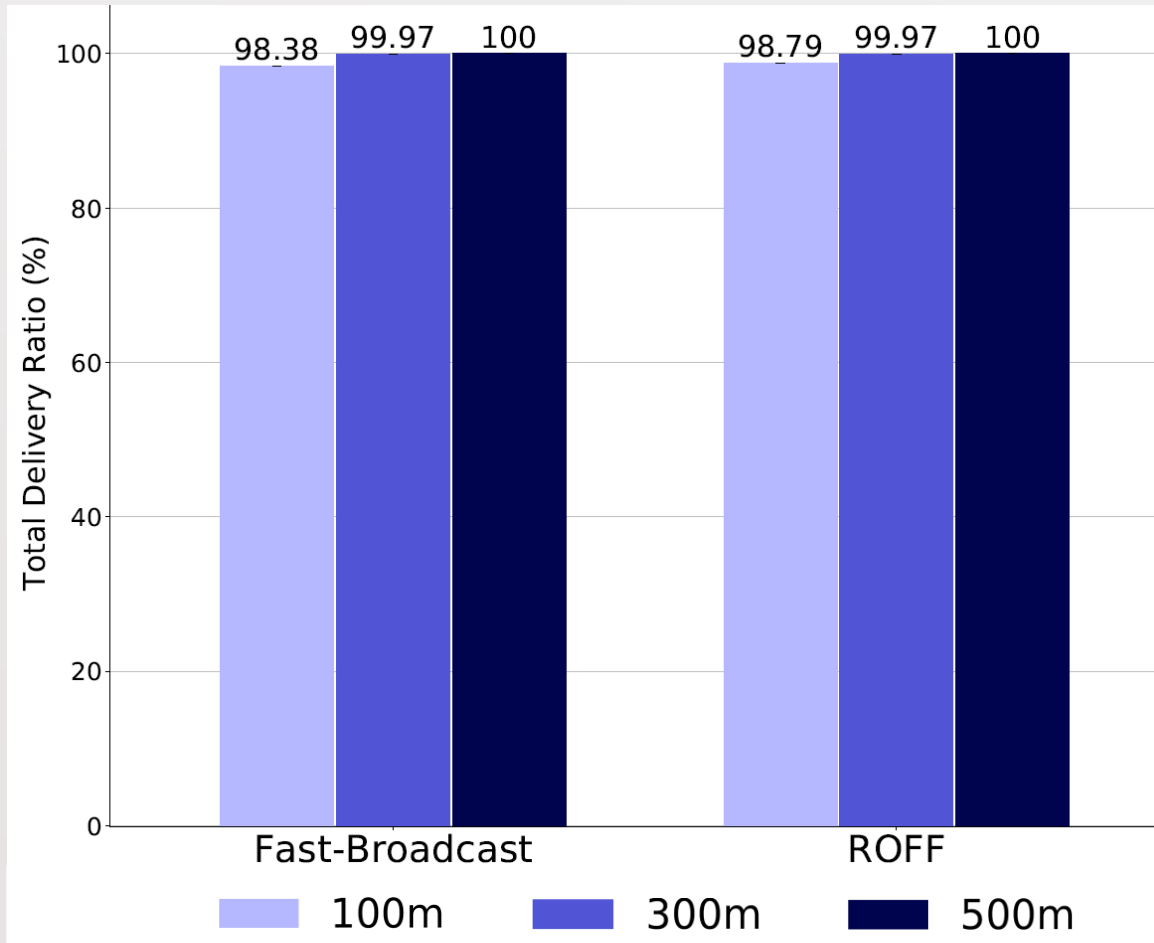 - Based on vehicle density

- Junction identification backup mode
  - Reliance on GPS
  - Compute angle between received messages to identify vehicles within junctions
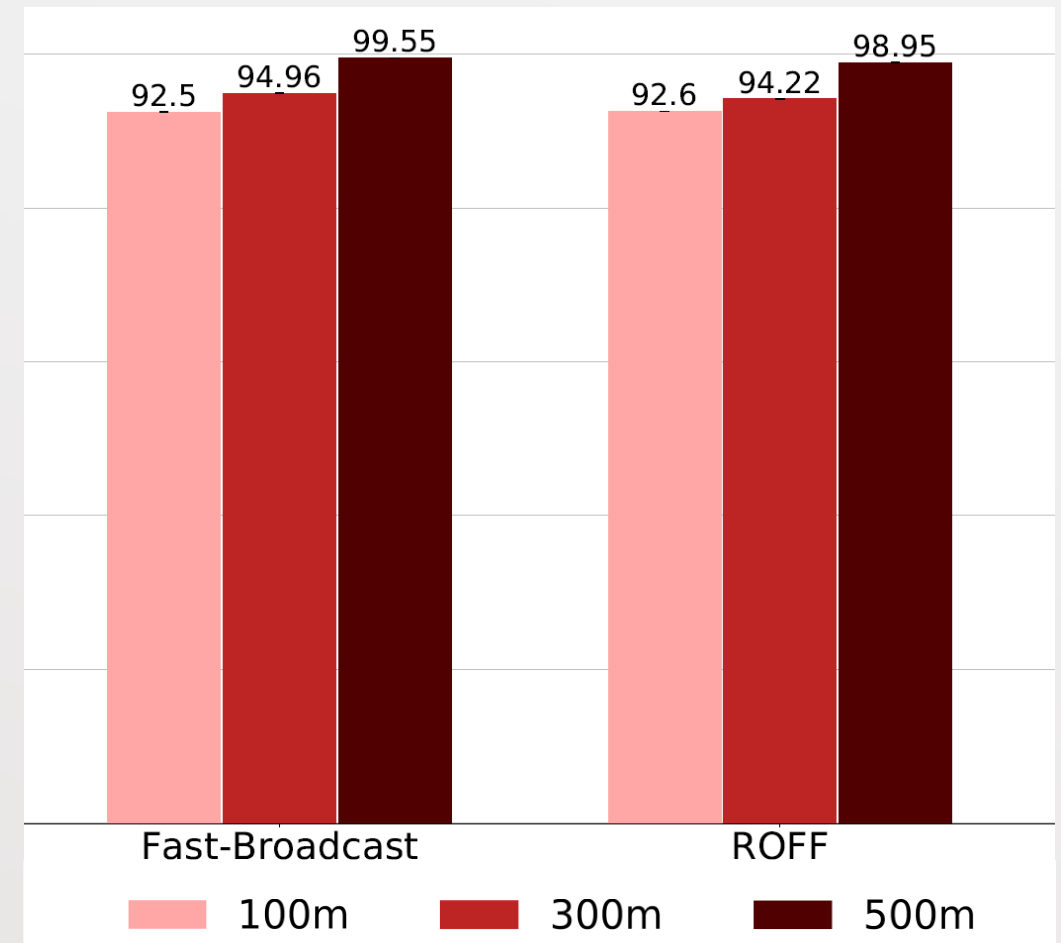
- Evaluation in more widespread FANETs

L.A. WITH BUILDINGS – COVERAGE ↑

Without buildings

With buildings

FORGING ATTACK – END TO END DELAY ↓