Performance Comparison of Dual Connectivity and Hard Handover for LTE-5G Tight Integration

*Michele Polese**, Marco Mezzavilla+, Michele Zorzi*

*Department of Information Engineering, University of Padova, Italy

e-mail: {polesemi, zorzi}@dei.unipd.it

+Tandon School of Engineering, New York University, Brooklyn NY, USA

e-mail: mezzavilla@nyu.edu

SIMUTools 2016, Prague, Czech Republic

August 23rd, 2016

DEPARTMENT OF INFORMATION ENGINEERING

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Outline

- LTE-5G Tight Integration
- Dual Connectivity Architecture
- Extension of NYU ns-3 mmWave Simulator
- Metrics and Preliminary Results
- Conclusions and Future Work

5G networks

- Different targets:
  - Very high bandwidth
  - Ultra-low latency

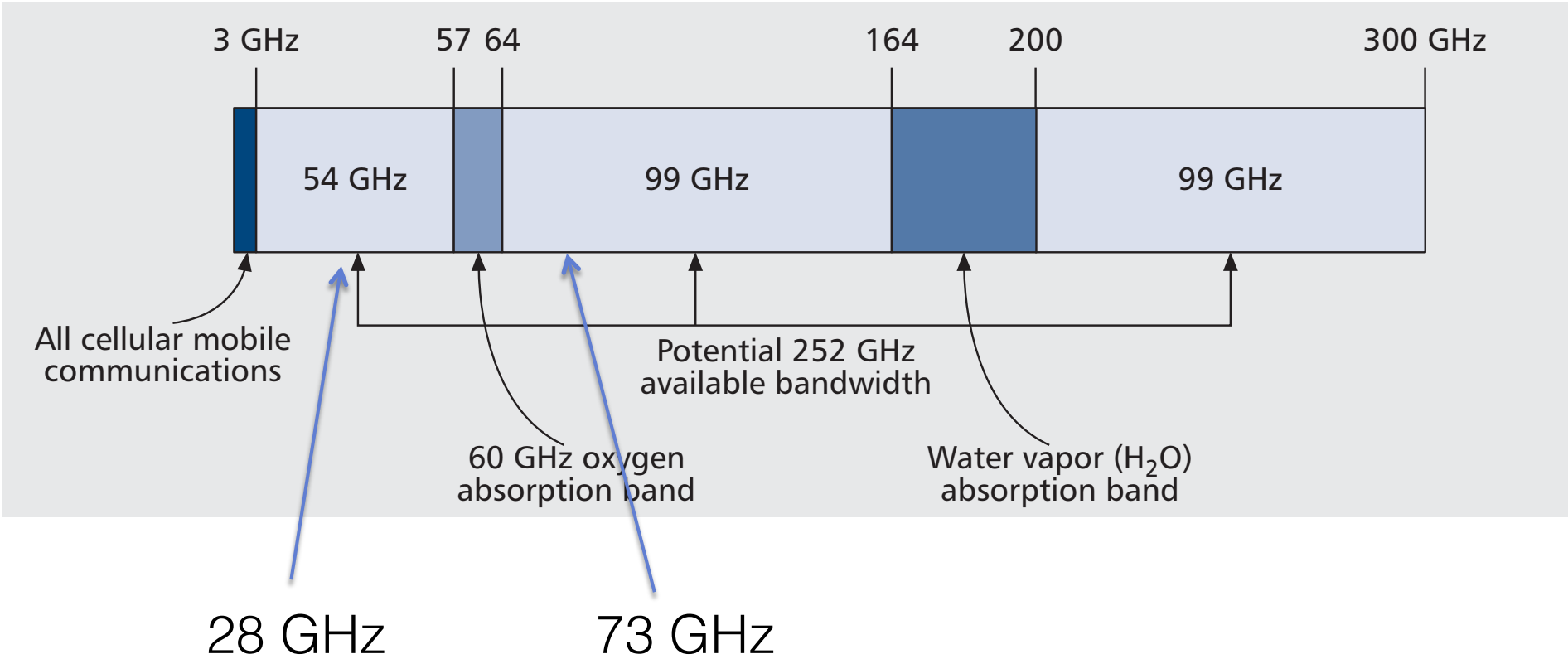
  } mmWave communications

  - Massive number of devices

  } Sub 1 GHz comms

Different targets – different technologies

MmWave Communications



Z. Pi and F. Khan, "An introduction to millimeter-wave mobile broadband systems," IEEE Communications Magazine, vol. 49, no. 6, pp. 101–107, June 2011

A Case for LTE-5G Tight Integration

mmWave: very high throughput

BUT

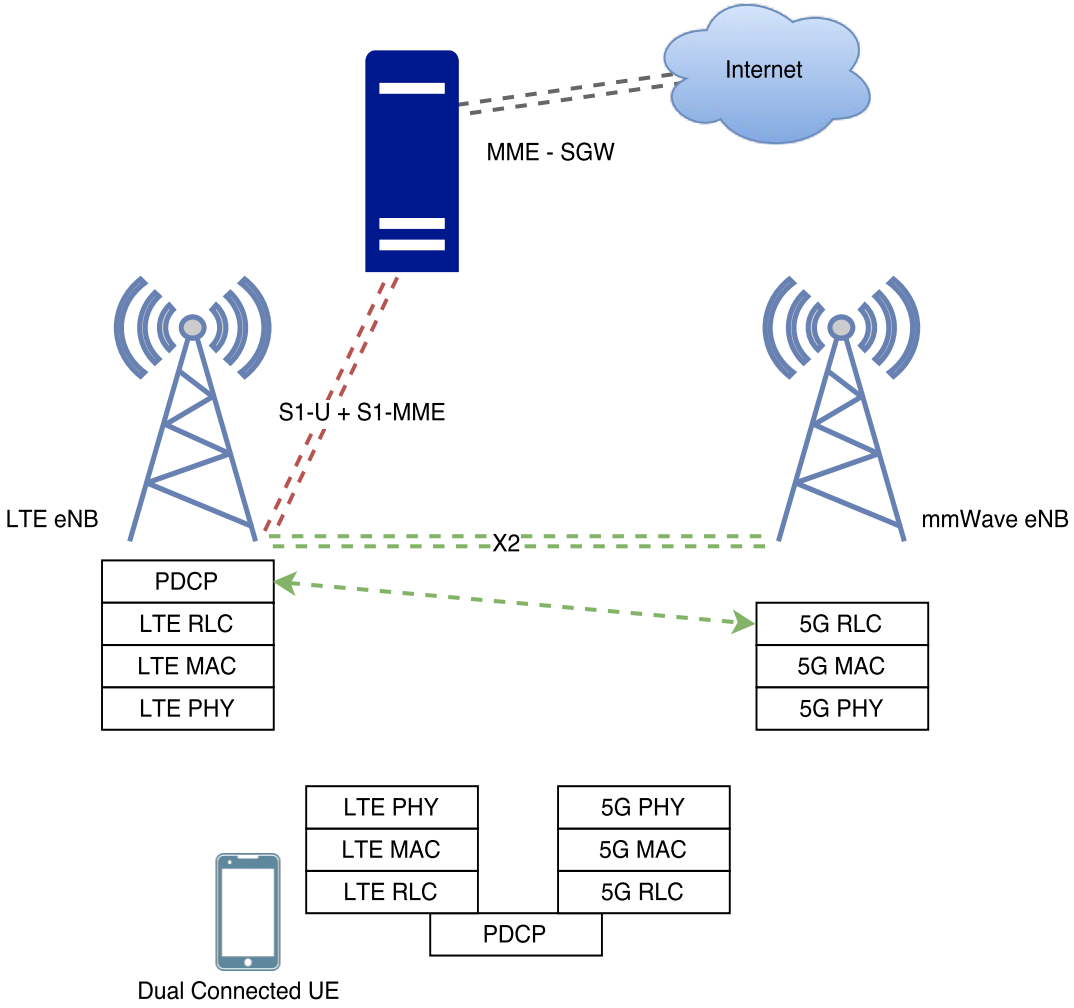
Variable signal quality, possible link failures

LTE network as fallback – coverage layer

Hard Handover (HH)

Dual Connectivity (DC) with Fast Switching

Dual Connectivity Architecture



- Single PDCP layer in the "coordinator" (new node or LTE eNB)
- RLC entity in the LTE and mmWave eNBs
- Single connection to Core Network

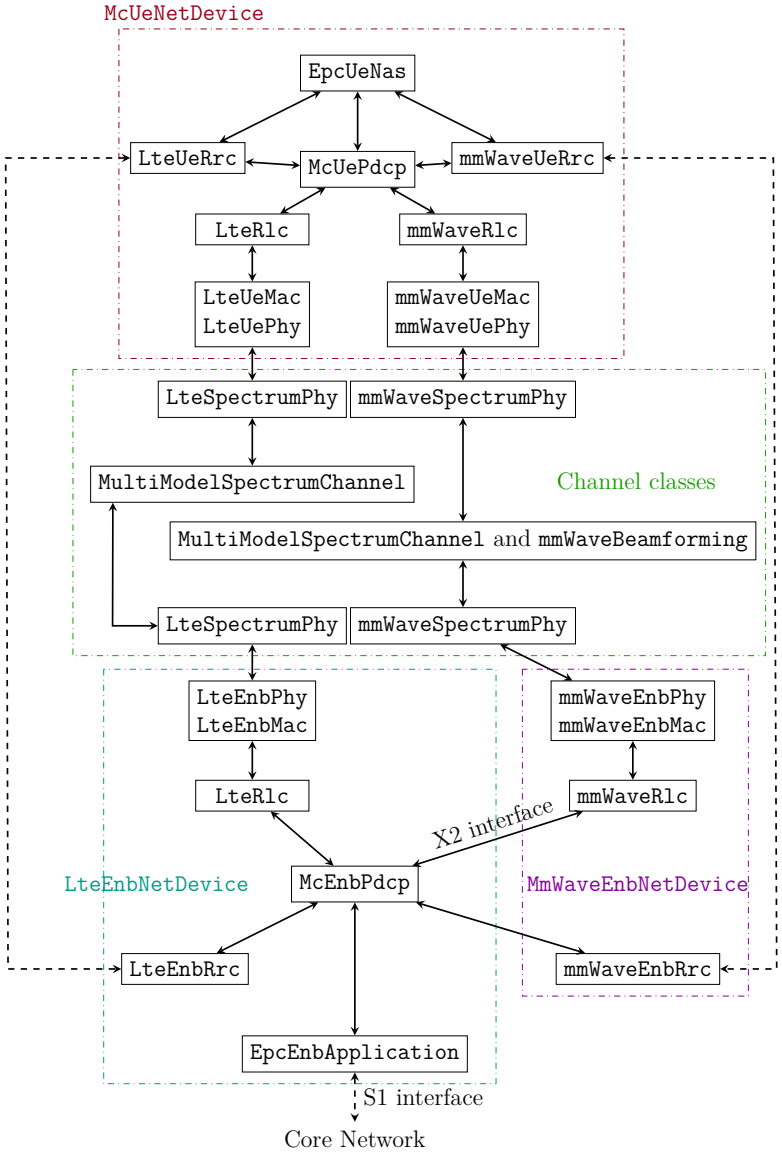
Switch:

- a RRC message to UE
- X2 notification to mmWave eNB

NYU ns-3 mmWave Simulator

- Channel model based on real measurements
- Fully configurable TDD physical layer
- MAC layer with HARQ, scheduler
- Upper layers (RLC, PDCP, RRC) from LTE ns-3 module

Extension to LTE-5G Integration



- Dual Connected UE
- New PDCP layer
- PDCP-RLC forwarding on X2
- Integration of LTE and mmWave channels

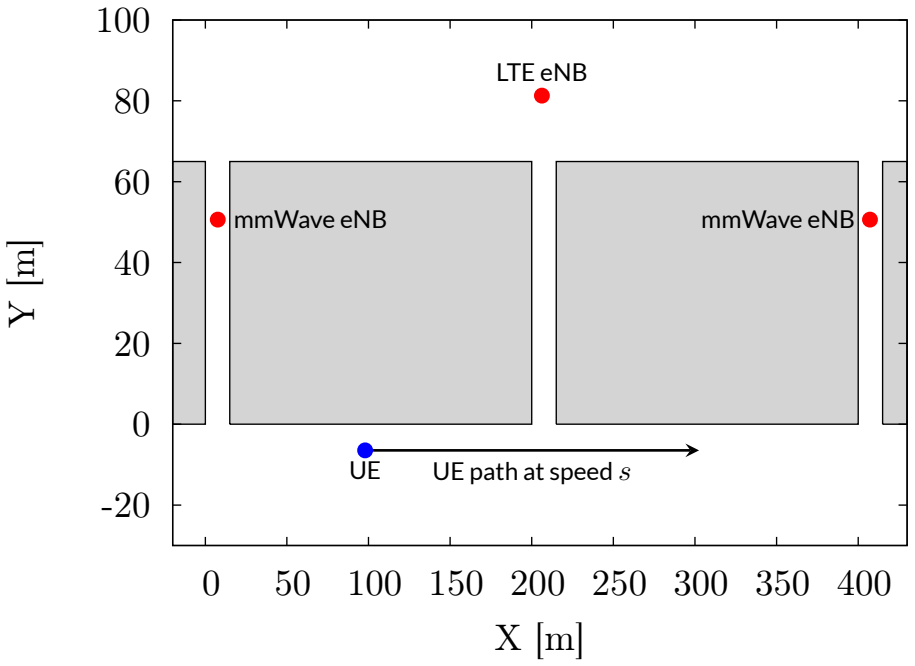
Main Features

- Procedures for Fast Switching:
  - Initial Access, Secondary Cell Handover, Switch
- mmWave SINR estimation with reference signals
- RLC with finite-size buffers
- X2-based handover between LTE and 5G

Metrics

- Throughput at different layers
- Packet losses
- Latency at different layers
- Control traffic (RRC)
- X2 and S1 traffic

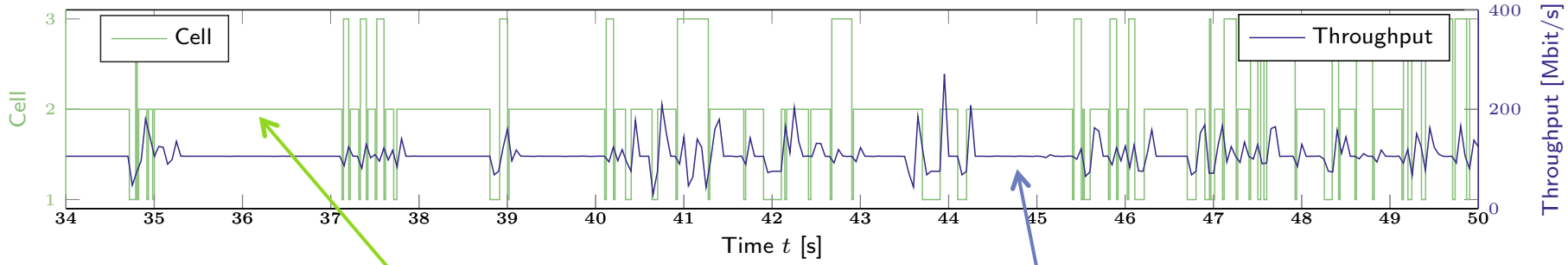
Simulation Scenario



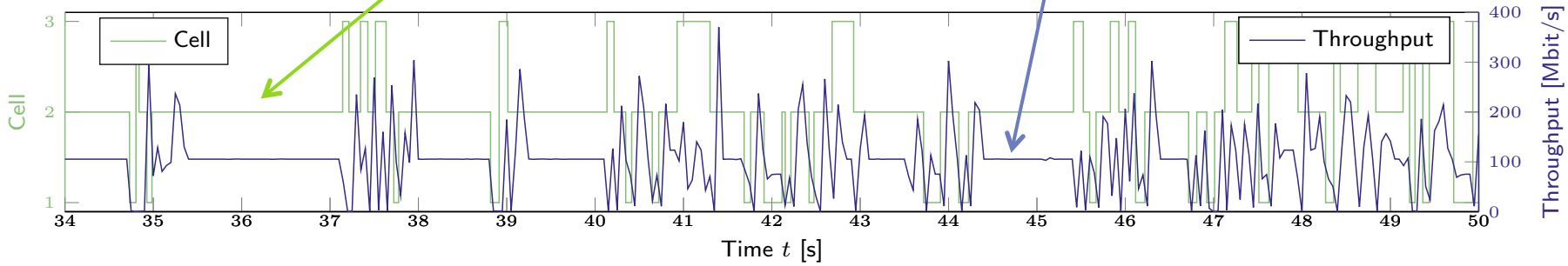
Parameter	Value
Outage threshold	-5 dB
mmWave carrier frequency	28 GHz
mmWave bandwidth	1 GHz
LTE carrier frequency (DL)	2.1 GHz
LTE bandwidth	20 MHz
X2 link latency D_{X2}	1 ms
RLC AM buffer size B_{RLC}	10 MB
S1-MME link latency	10 ms
UDP packet size	1024 byte
UDP packet interarrival	80 μs
UE speed s	2 m/s along the x axis (Fig. 3)
Iterations	$N = 10$

Example: throughput over time

DC setup



HH setup



Current cell in time

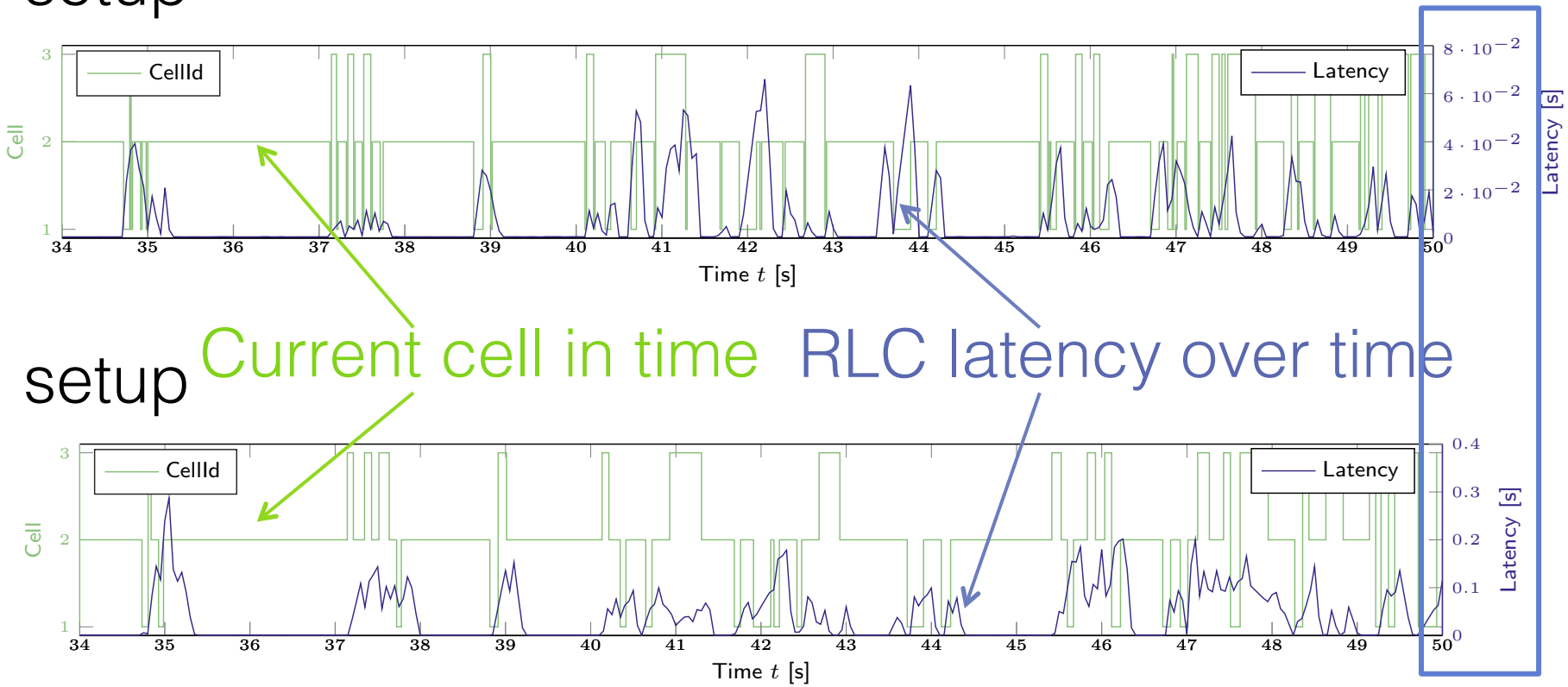
PDCP throughput over time

	PDCP Throughput
Dual Connectivity	106.70 Mbit/s
Hard Handover	104.98 Mbit/s

Example: latency over time

DC setup

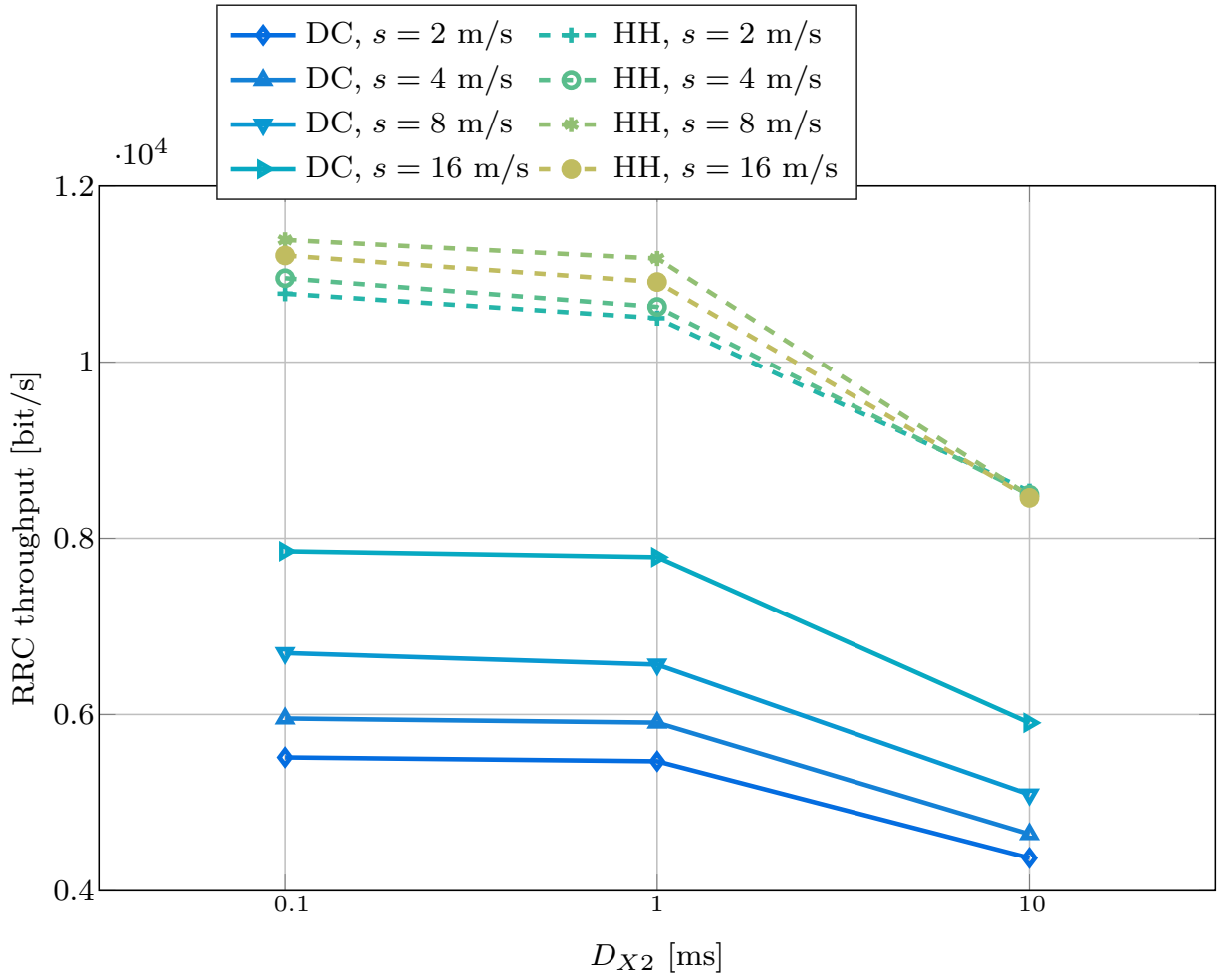
Different scales



HH setup

	RLC Latency
Dual Connectivity	5.1 ms
Hard Handover	18.1 ms

RRC Traffic


DC, $s = 2$ m/s
DC, $s = 4$ m/s
DC, $s = 8$ m/s
DC, $s = 16$ m/s
HH, $s = 2$ m/s
HH, $s = 4$ m/s
HH, $s = 8$ m/s
HH, $s = 16$ m/s
$\cdot 10^4$
1.2
1
0.8
0.6
0.4
RRC throughput [bit/s]
0.1
1
10
D_{X2} [ms]

Conclusions

- LTE-5G Dual Connectivity architecture
- Extension of NYU mmWave ns-3 simulator
- Examples of metrics that can be collected
  - DC performs better than HH, for more results see [1]
- Flexible framework, it opens many research directions

[1] M. Polese, *Performance Comparison of Dual Connectivity and Hard Handover for LTE-5G Tight Integration in mmWave Cellular Networks*, Master's thesis, Dept. of Information Engineering, University of Padova, July 2016. Available at http://arxiv.org/abs/1607.04330

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