

# Performance Evaluation of LTE in Unlicensed Spectrum

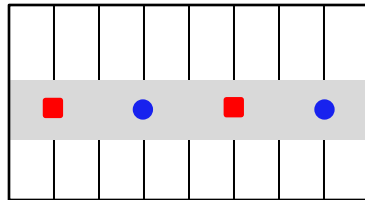
Samsung

- **Evaluation assumptions for Small Cell Enhancement\* as baseline**
  - Unlicensed spectrum used for downlink only
  - Two operators deploy Wi-Fi and/or LTE-U in 5GHz spectrum for the following scenarios
    - Indoor scenario
      - APs/cells of different operators may be (almost) co-located
    - Outdoor scenario
      - Cluster-based deployment
- **Mandatory features of 802.11ac as baseline**
  - Common Wi-Fi platform needs to be decided

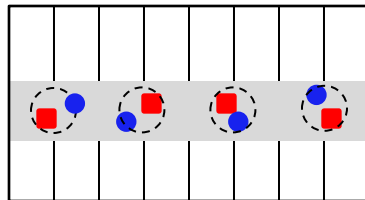
\* 3GPP TR 36.872, "Small cell enhancements for E-UTRA and E-UTRAN"

## ■ Indoor scenario (based on SCE scenario 2b or 3)

- Operators have their own APs/cells in the same building
  - Case 1 : fixed position
    - well-coordinated between operators

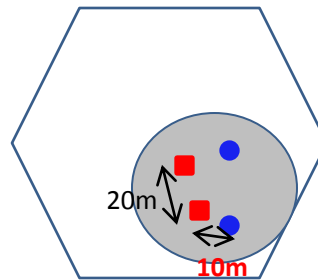


- Case 2 : cluster-based random AP/cell dropping
  - Cluster radius for dropping AP/cell should be decided, e.g. 10m
  - 1 (or multiple) AP/cell per operator is randomly distributed in each cluster



■ Operator A    ● Operator B

- **Outdoor scenario (based on SCE scenario 2a)**
  - All cells are distributed within a cluster in each macro area
    - Cluster radius : 50m
    - Minimum distance between cells : 20m
  - For closely located cells of different operators, additional minimum distance requirement is needed
    - Minimum distance between cells of different operators : 10m

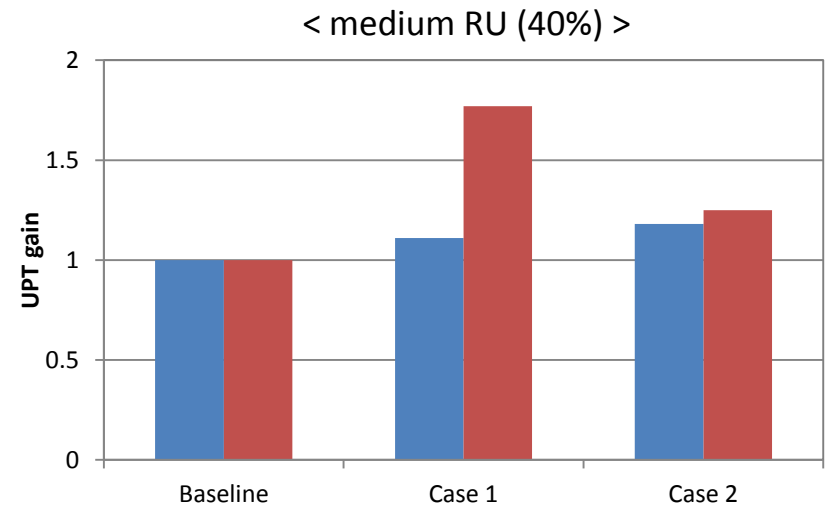
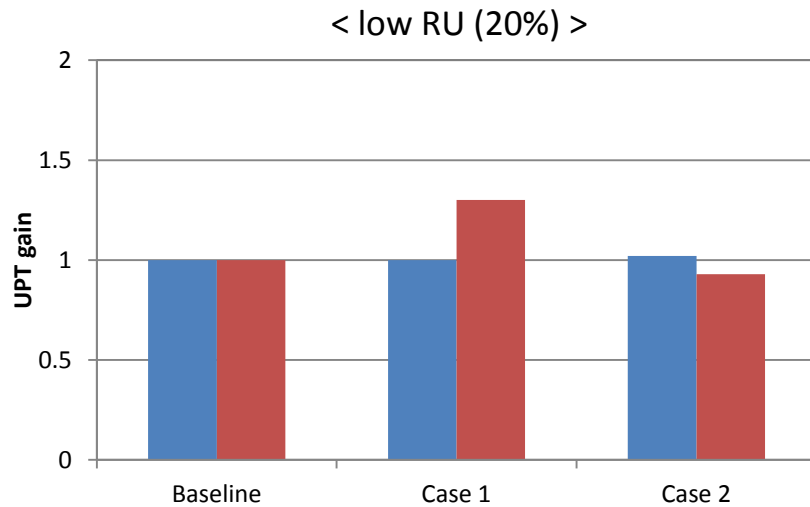


■ Operator A    ● Operator B

- **Baseline** : downlink Wi-Fi performance without LTE-U
  
- **Deployment** :
  - Two operators deploy outdoor Wi-Fi APs in the same cluster area
    - 2 APs per operator
  - Number of channels : 1
  
- **Scenarios** : one operator changes their Wi-Fi APs to LTE-U
  - Case 1 : LTE-U as SDL without co-existence mechanism
  
  - Case 2 : LTE-U with co-existence mechanism
    - Uplink subframes in UL-DL configuration 3 for TDD are muted for Wi-Fi
  
- **Evaluation environments**:
  - Details on parameters and values are summarized in the Appendix

## ■ Average DL UPT performance

- LTE-U offers more than 70% performance gain compared to Wi-Fi for medium RU
  - Due to higher spectral efficiency and robustness of LTE, time for packet transmission is reduced, which results in reduced interference impacts to the neighbors
- Non-optimized muting gives an negative impact on LTE-U



■ Operator A (Wi-Fi) ■ Operator B (LTE-U)

- **Initial evaluation results show that LTE-U could make better interference condition to neighbor Wi-Fi APs due to higher spectral efficiency of LTE**
- **Various scenarios should be carefully considered to evaluate the pros and cons of operating LTE in unlicensed spectrum**
  - Indoor, outdoor, sparse, dense, etc.

# Appendix





- Most parameters and values in 3GPP TR36.872 for SCE evaluation are applied for LTE-U and Wi-Fi

	Outdoor (based on SCE scenario 2a)
System bandwidth per carrier	20MHz
Carrier frequency	5GHz
Number of channels	1
TX power	23dBm
Distance-dependent pathloss	ITU Umi
Penetration	For outdoor UEs:0dB, For indoor UEs: 23dB+0.5din (din : [ 0, min(25,UE-to-eNB distance))
shadowing	ITU UMi
Fading	ITU UMi
Antenna pattern	2D Omni-directional
Antenna gain + connector loss	3dBi
Antenna gain of UE	0dBi
Antenna configuration	2Tx2Rx in DL, Cross-polarized
Number of APs/cells	4
Number of users	60 (randomly dropped within the clusters, 20% UEs are outdoor, and 80% UEs are indoor)
Traffic model	FTP2 (0.1Mbyte File size)
UE receiver	MMSE-IRC as baseline
UE noise figure	9dB
UE speed	3km/h
Network synchronization	Synchronous
Backhaul assumptions	Ideal

- **Wi-Fi specific parameters**
  - Most mandatory features of 802.11ac are baseline

		Wi-Fi
System bandwidth		20MHz
Carrier frequency		5GHz
Number of channels		1
TX power		23dBm
MAC	Coordination	DCF
	SIFS, DIFS	SIFS, DIFS
	Detection	Energy detection
	RTS/CTS	N/A
	Contention window	Min : 15 slot, max : 1023 slot
Frame aggregation		A-MPDU
TXOP limit		8ms
MIMO		2x2 , SU-MIMO
CCA		-82dBm for Wi-Fi, -62dBm for others
MCS		0~7 in MCS table (not support 256QAM)
Channel coding		BCC