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Technical Report

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
Cross Link Interference (CLI) handling and
Remote Interference Management (RIM) for NR;
(Release 16)

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Contents

Foreword

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document provides the results of co-existence evaluation for CLI and RIM for NR.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] RP-182864: "Revised WID on Cross link Interference (CLI) handling and Remote Interference Management (RIM) for NR".

[3] 3GPP TR 38.802: "Study on new radio access technology Physical layer aspects".

[4] 3GPP TR 38.866: "Study on remote interference management for NR".

[5] 3GPP TR 38.803: "Study on new radio access technology: Radio Frequency (RF) and co-existence aspects".

[6] 3GPP TR 36.828: "Further enhancements to LTE Time Division Duplex (TDD) for Downlink-Uplink (DL-UL) interference management and traffic adaptation".

[7] 3GPP TS 38.101-1: "User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".

[8] 3GPP TR 36.873: "Study on 3D channel model for LTE".

[9] 3GPP TR 36.942 (V15.0.0): "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Frequency (RF) system scenarios".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

Downlink: in general the direction from a Network to a UE.

Macro cells: "Macro cells" are outdoor cells with a large cell radius.

Micro cells: "Micro cells" are small cells.

Throughput: A parameter describing service speed. The number of data bits successfully transferred in one direction between specified reference points per unit time (source: ITU-T I.113).

Uplink: An "uplink" is a unidirectional radio link for the transmission of signals from a UE to a base station, from a Mobile Station to a mobile base station or from a mobile base station to a base station.

3.2 Symbols

Void

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

ACI Adjacent Channel Interference
ACIR Adjacent Channel Interference Ratio
ACLR Adjacent Channel Leakage Power Ratio
ACS Adjacent Channel Selectivity
BS Base Station
CBW Carrier Band Width
CLI Cross Link Interference
DL Downlink
DTDD Dynamic TDD
eNB E-UTRAN Node B
FDD Frequency Division Duplex
FR Frequency Range
gNB Next generation Node B
LOS Line Of Sight
NLOS Non Line Of Sight
NR New Radio
RIM Remote Interference Management
RSRP Reference Signal Received Power
RU Resource Usage
SINR Signal-to-Interference Noise Ratio
SLA Side Lobe Attenuation
TDD Time division duplex(ing)
TDM Time division multiplex(ing)

TRP	Total Radiated Power
UE	User Equipment
UL	Uplink

4 Background

4.1 General

RAN4 requirements designed to ensure co-existence between different networks operating on adjacent carriers in the same band (i.e. ACLR, ACS) were developed in release 15 under the assumption of synchronized TDD. Interference between adjacent carriers is mitigated as long as all networks apply uplink and downlink at the same occasions.

Dynamic TDD describes a mode of operation in which a network adapts the DL/UL subframe pattern according to traffic conditions. If different nodes in the same network apply DL and UL at different times, then interference between different UEs and different BS occurs. RAN1 has specified measurements to enable co-channel Cross Link Interference (CLI) mitigation within the same network.

Dynamic TDD also causes interferers between networks on adjacent channels. Unlike the co-channel case, interference between adjacent channel networks cannot be coordinated. Instead, the interference is mitigated by transmitter and receiver selectivity (ACLR and ACS) as analogue filtering is not generally feasible within an operating band.

As part of the CLI WI, RAN4 has been tasked to investigate the adjacent channel co-existence effects arising when CLI, or more generically dynamic TDD is operated in an aggressor network. The scope of the investigation is to target no or very minimal impact on RF requirements, and so the investigation examines the throughput losses experienced in a victim network assuming that all base stations and UEs conform to the release 15 requirements.

This report captures a description of the adjacent channel interference effects that arise with dynamic TDD as well as a simulation investigation of adjacent channel interference in a number of different deployment scenarios.

4.2 WID description

4.2.1 Justification

As captured in TR38.802, NR aims to support duplexing flexibility in both paired and unpaired spectrum.

> "NR supports paired and unpaired spectrum and strives to maximize commonality between the technical solutions, allowing FDD operation on a paired spectrum, different transmission directions in either part of a paired spectrum, TDD operation on an unpaired spectrum where the transmission direction of time resources is not dynamically changed, and TDD operation on an unpaired spectrum where the transmission direction of most time resources can be dynamically changing. DL and UL transmission directions at least for data can be dynamically assigned on a per-slot basis at least in a TDM manner. It is noted that transmission directions include all of downlink, uplink, sidelink, and backhaul link. NR supports at least semi-statically assigned DL/UL transmission direction as gNB operation, i.e., the assigned DL/UL transmission direction can be signaled to UE by higher layer signaling."

Rel-14 NR study showed that duplexing flexibility with cross-link interference mitigation shows better user throughput compared to static UL/DL operation or dynamic UL/DL operation without interference mitigation in indoor hotspot (4GHz and 30GHz) and urban macro scenarios (4GHz and 2GHz). The mitigation techniques include coordinated scheduling scheduling/beamforming, power control, link adaptation, hybrid dynamic/static UL/DL resource assignment.

During Rel-15 NR WI, enablers for basic support of cross-link interference mitigation schemes to support duplexing flexibility for paired and unpaired spectrum were discussed but could not specified as the work has been deprioritized. Mainly, it was agreed to introduce UE-to-UE measurement for CLI, and Transmission Reception Point-to-Transmission Reception Point measurement/coordination techniques were discussed. Rel-15 NR specification supports mechanisms to allow dynamic DL/UL assignments. Yet, any cross-link interference mitigation techniques and coexistence requirements have not been specified and thus the use of dynamic DL/UL assignment operation is considerably restricted.

As observed during study, dynamic DL/UL resource assignments would be more beneficial in indoor hotspot and urban macro scenarios where gNB TX power is rather limited, and ISD is small. During the study, dynamic DL/UL assignment operations offers performance gain in high frequencies such as 4 GHz and 30 GHz. In such frequencies, advanced MIMO techniques can be utilized to mitigate cross-link interference which has not been fully evaluated.

Furthermore, semi-static and/or dynamic DL/UL resource assignments should also consider coexistence issues particularly among different operators where tight coordination are challenged. Coexistence mechanisms among different operators in co-channel and adjacent channels are essential regardless whether each cell operates in semi-static or dynamic DL/UL assignment mechanism. For efficient coexistence, not only coexistence requirements need to be understood but also advanced mechanisms to mitigate interference such as transmission reception point-to-transmission reception point measurement and adaptation based on measurements should be considered.

In commercial TD-LTE network with macro deployment scenario, it is observed in relatively large scale of eNBs that IoT (amounts to above -105dBm, even to -90dBm in some extreme cases) in these eNBs intermittently deteriorated to severely impact the network coverage and connection successful rate. Jointed with several approaches, e.g., IoT statistics from the eNBs in some regions over the forecast of troposphere bending (http://www.dxinfocentre.com/tropo.html) , as well as the symptoms varying with the artificially constructed transmission patterns, it is identified that this kind of IoT degradation is caused by the downlink signal of remote eNB (furthest as 300km away with observed record) as long as the atmospheric conditions favourable for producing troposphere bending of radio waves are available. To mitigate the impact of this kind of remote base station interference as it intermittently happens, but not to scarify the network resources all the time, in the field TD-LTE network, some adaptive mechanisms are introduced, where abnormal IoT enhancement will trigger the victim eNB to transmit a specific signal in a window, each eNB that detected the specific signal in a window will identify itself as the contributor of the deteriorated IoT in some eNB(s), and then it will reconfigure the GP or some other parameters to reduce its weight to the interference. In this framework, the impact of troposphere bending is mitigated to some extension, however, some disadvantages are also apparent in the proprietary implementation, e.g., rely on some static mechanism for detection signal transmission and detection due to lack inter-vendor inter-eNB coordination, decision making is per individual eNB based implementation, etc.

In NR deployment on lower TDD frequency, the impact of the troposphere bending will continue existing if no special mechanisms are introduced. Though the design of the frame structure in NR has already considered much more flexible GP to leave larger room for avoiding the remote interference, it is necessary to study mechanisms for identifying when or how long will the long enough GP be configured, as well as corresponding gNB’s behaviour and inter-gNB’s coordination procedure.

In the RIM SI, the frameworks for mechanisms for gNBs to start and terminate the transmission/detection of reference signal(s), the functionalities and requirements of the corresponding RS(s) as well as the design of the RS(s), and the backhaul-based coordination mechanisms among gNBs have been studied, where the outcome and conclusions of the SI was captured in TR38.866. It is recommended to specify RIM RS(s) to support identifying remote interference related information, it is also recommended to specify the inter-set RIM backhaul signalling via the core network for backhaul-based solution.

4.2.2 Objective

In the WID on Cross Link Interference (CLI) handling and Remote Interference Management (RIM) for NR , the detailed objectives for cross-link interference mitigation to support flexible resource adaptation for unpaired NR cells are:

- Specify cross-link interference measurements and reporting at a UE (e.g., CLI-RSSI and/or CLI-RSRP) [RAN1, RAN2, RAN4]
- Perform coexistence study to identify conditions of coexistence among different operators in adjacent channels [RAN4]
    - Target no or very minimal impact on RF requirement

NOTE: Measurement and coordination mechanisms should be applicable to IAB nodes.

The detailed objectives for remote-interference management are:

- Specify RIM RS resource and configurations, including [RAN1]

- A basic RIM-RS resource
- Configuration of RIM-RS and distinguishable RIM RS-1/2 resources, including sequence type, time and frequency transmission pattern
- Determine gNB set identification information through detection of RIM-RS(s) by implicit or explicit indication. Determine further information that can be carried by the RIM-RS, such as "Ducting phenomenon exists", "Enough mitigation" & "Not enough mitigation", [RAN1, SA5]
- Specify the inter-set RIM backhaul signalling via the core network to convey the messages of "RIM-RS detected" and "RIM-RS disappeared [RAN3]
- Identify corresponding OAM functions to support RIM operation [RAN1, RAN3].

This technical report focuses on evaluating co-existence of CLI among different operators in adjacent channels and RAN4 targets no or very minimal impact on RF requirement.

4.3 Dynamic TDD adjacent interference scenarios

4.3.1 General

This section provides a description of the interference scenarios that occur between different TDD networks within the same operating band. Section 4.3.2 describes interference scenarios that occur during periods of time in which both networks transmit DL or both UL. These interference scenarios occur in both synchronized and unsynchronized networks. Section 4.3.3 describes additional interference scenarios that arise in unsynchronized networks when one network is transmitting downlink whilst another transmits uplink.

4.3.2 Interference scenarios that occur for both synchronized and unsynchronized TDD (including CLI)

In synchronized TDD networks, there are two aspects of co-existence; DL-DL and UL-UL. For DL-DL co-existence, UEs in a victim network are impacted by nearby BS from an aggressor network during DL subframes.

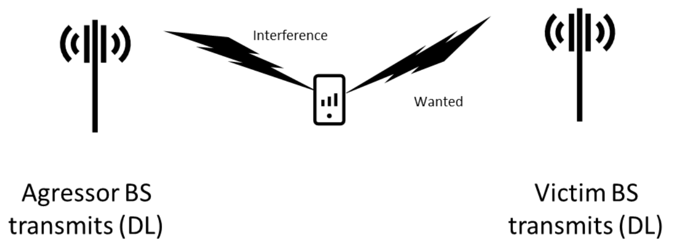


Figure 4.3.2-1: DL-DL inter-operator interference scenario

The impact of the aggressor BS may be twofold; adjacent channel leakage from the aggressor BS may raise the interference floor at the victim UE. Alternatively, the wanted power from the aggressor BS may leak into the wanted carrier due to the UE adjacent channel selectivity. Thus, BS ACLR and UE ACS are the key RF parameters relating to DL-DL co-existence.

UL-UL co-existence refers to degradation of a BS receiver due to the impact of nearby aggressor network UEs during UL subframes.

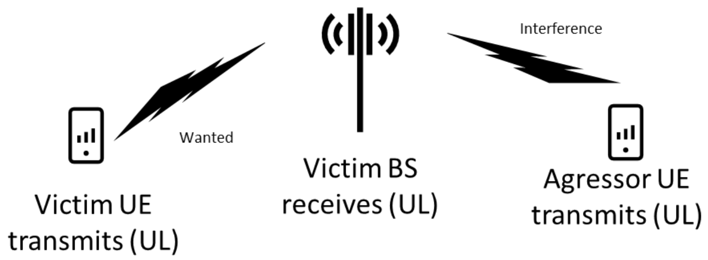


Figure 4.3.2-2: UL-UL inter-operator interference scenario

The impact of the UEs may be twofold; adjacent channel leakage from the aggressor UEs may degrade the BS interference floor. Alternatively, the wanted power from aggressor UEs may leak into the BS receive carrier due to the adjacent channel selectivity of the BS. Thus, UE ACLR and BS ACS are the key RF parameters relating to UL-UL coexistence.

When operating dynamic TDD or CLI, BS to UE and UE to BS interference of this type can occur during subframes that are aligned in the same direction for both operators.

4.3.3 Additional interference scenarios that occur for unsynchronized TDD (including dynamic TDD and CLI)

Dynamic TDD in at least one network implies additional scenarios for adjacent channel interference. When both networks transmit in the same direction, then the DL-DL and UL-UL scenarios described in section 4.3.2 still occur. However, there will be additional instances of DL (aggressor) – UL (victim) and UL (aggressor) – DL (victim).

CLI techniques may be used within an individual network to avoid interference due to dynamic TDD. However, between adjacent frequency networks, it must be assumed that the interference is not coordinated and hence the interference is only mitigated by suppression of adjacent channel and interference and receiver selectivity (ACLR/ACS).

In the DL (aggressor) – UL (victim) scenario, an aggressor BS is transmitting whilst BS in a receiver network are receiving.

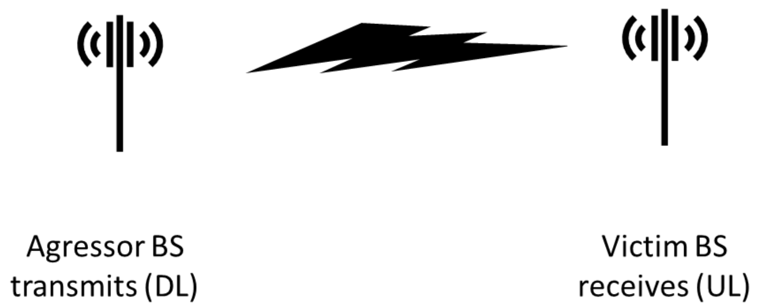


Figure 4.3.3-1: DL-UL adjacent channel interference scenario

For co-located BS, the interference from the aggressor will cause blocking, as described in section 4.4. For non-co-located BS, the extent of degradation will depend on the inter-site distance and the antenna gains of the two BS.

In the UL (aggressor) – DL (victim) scenario, an aggressor UE is transmitting whilst close to a victim UE.

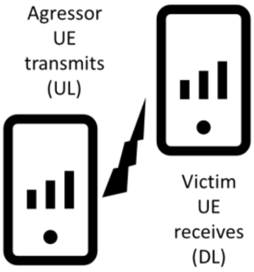


Figure 4.3.3-2: UL-DL adjacent channel interference scenario

The statistical co-existence will depend on UE TX power, separation, traffic etc. and needs to be explored with system simulation.

4.4 BS-BS interference for zero grid shift scenarios

When dynamic TDD is operated by at least two operators that are co-located at the same site and transmit in the same band, then BS-BS interference will occur. If the victim is receiving and the aggressor transmitting, then the victim will suffer interference. Conversely, if the aggressor is receiving and the victim transmitting, then the aggressor will suffer the interference.

It was concluded that if dynamic TDD is operated at co-located base stations, during subframes in which the victim BS is receiving uplink whilst an aggressor BS is transmitting downlink the victim BS receiver would fail due to interference from the aggressor. No simulation analysis is required for the co-located base station scenario, since the uplink receiver blocking will occur in all subframes for which one BS receives whilst the other transmits. Details of the analysis leading to this conclusion are provided in Annex B.

5 Co-existence analysis

5.1 Scenarios

5.1.1 FR1

Table 5.1.1-1 summarizes agreed simulation scenarios for FR1 (4 GHz).

Table 5.1.1-1: Summary of simulation scenarios for FR1 (4 GHz)

Scenario No.	Deployment Scenario (Aggressor -> Victim)	Aggressor baseline	Aggressor in CLI	Victim
1	Macro → Macro	NR, 100 MHz, DL	1. NR, 100 MHz, DL50%+UL50% 2. NR, 100MHz, UL100%	NR, 100 MHz, DL
2		NR, 100 MHz, UL	1. NR, 100 MHz, DL50%+UL50% 2. NR, 100MHz, DL100%	NR, 100 MHz, UL
3	Macro → Indoor	NR, 100 MHz, DL	1. NR, 100 MHz, DL50%+UL50% 2. NR, 100MHz, UL100%	NR, 100 MHz, DL
4		NR, 100 MHz, UL	1. NR, 100 MHz, DL50%+UL50% 2. NR, 100MHz, DL100%	NR, 100 MHz, UL
5	Indoor → Macro	NR, 100 MHz, DL	1. NR, 100 MHz, DL50%+UL50% 2. NR, 100MHz, UL100%	NR, 100 MHz, DL
6		NR, 100 MHz, UL	1. NR, 100 MHz, DL50%+UL50% 2. NR, 100MHz, DL100%	NR, 100 MHz, UL
7	Indoor → Indoor	NR, 100 MHz, DL	1. NR, 100 MHz, DL50%+UL50% 2. NR, 100MHz, UL100%	NR, 100 MHz, DL
8		NR, 100 MHz, UL	1. NR, 100 MHz, DL50%+UL50% 2. NR, 100MHz, DL100%	NR, 100 MHz, UL

5.1.2 FR2

Table 5.1.2-1 summarizes agreed simulation scenarios for FR2 (30 GHz).

Table 5.1.2-1: Summary of simulation scenarios for FR2 (30 GHz)

Scenario No.	Deployment Scenario (Aggressor -> Victim)	Aggressor baseline	Aggressor in CLI	Victim
9	Macro → Macro	NR, 200 MHz, DL	1. NR, 200 MHz, DL50%+UL50% 2. NR, 200MHz, UL100%	NR, 200 MHz, DL
10		NR, 200 MHz, UL	1. NR, 200 MHz, DL50%+UL50% 2. NR, 200MHz, DL100%	NR, 200 MHz, UL
11	Micro → Micro	NR, 200 MHz, DL	1. NR, 200 MHz, DL50%+UL50% 2. NR, 200MHz, UL100%	NR, 200 MHz, DL
12		NR, 200 MHz, UL	1. NR, 200 MHz, DL50%+UL50% 2. NR, 200MHz, DL100%	NR, 200 MHz, UL
13	Indoor → Macro	NR, 200 MHz, DL	1. NR, 200 MHz, DL50%+UL50% 2. NR, 200MHz, UL100%	NR, 200 MHz, DL
14		NR, 200 MHz, UL	1. NR, 200 MHz, DL50%+UL50% 2. NR, 200MHz, DL100%	NR, 200 MHz, UL
15	Indoor → Indoor	NR, 200 MHz, DL	1. NR, 200 MHz, DL50%+UL50% 2. NR, 200MHz, UL100%	NR, 200 MHz, DL
16		NR, 200 MHz, UL	1. NR, 200 MHz, DL50%+UL50% 2. NR, 200MHz, DL100%	NR, 200 MHz, UL

5.2 Simulation assumptions

5.2.1 FR1

5.2.1.1 Network layout model

5.2.1.1.1 Urban macro

Details on urban macro network layout model are listed in Table 5.2.1.1.1-1.

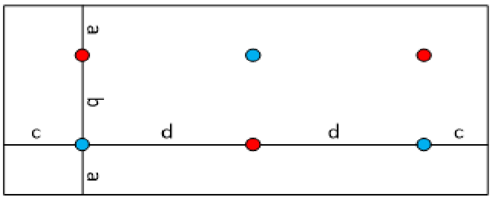
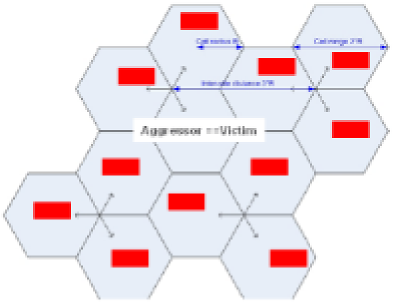
Table 5.2.1.1.1-1: Single operator layout for urban macro in FR1 (4 GHz)

Layout	Single layer with 19 hexagonal cell with wrap around
Inter-BS distance	500 m
Carrier frequency	4 GHz
Path-loss model	- Macro(Aggressor) → Macro(Victim) - Macro-to-UE: UMa see TR 38.803 [5] - Macro-to-Macro: UMa (h_UE = 25 m) see TR 38.803 [5] - UE-to-UE: Outdoor UE – Outdoor UE see TR 36.828 [6] + penetration loss see TR 38.803 [5]
BS Tx power	49 dBm
UE Tx power	23 dBm
BS antenna configurations	(Mg,Ng,M,N,P)=(1,1,8,8,2) (dH,dV)=(0.5,0.8)λ Note 1,2
BS antenna height	25 m
BS antenna element gain + connector loss	5 dBi (assuming antenna 1.8dB loss)
BS receiver noise figure	5 dB
UE antenna configuration	Omni
UE antenna height	h_{UT}=3(n_{fl}-1)+1.5 n_{fl} for outdoor UEs: 1 n_{fl} for indoor UEs: n_{fl}~uniform(1,N_{fl}) where N_{fl} = 1
UE antenna gain	0 dBi
UE receiver noise figure	9 dB
Multi operators layout	uncoordinated operation (100% Grid Shift)
Note 1: Mg = number of antenna panels in elevation, Ng – number of antenna panels in azimuth, M = number of antenna elements/subarrays in elevation, N= number of antenna elements/subarrays in azimuth, P = number of polarizations. Note 2: TX power is specified per polarization, a single polarization may be simulated under the assumption of polarization match.	

5.2.1.1.2 Indoor

Details on indoor network layout model are listed in Table 5.2.1.1.2-1.

Table 5.2.1.1.2-1: Single operator layout for Indoor scenarios in FR1 (4 GHz)

Layouts	1. Indoor-to-Indoor : 6 BSs per 120 m x 50 m  2. Indoor-to-Macro : the number of Indoor per macro cell (drop randomly) = 1 
Inter-BS distance	Indoor-to-Indoor: 20 m
	The minimum distance between Macro to Indoor: [35] m
Minimum BS-UE (2D) distance	Indoor-to-Indoor: 0 m
Minimum UE-UE (2D) distance	Indoor-to-Indoor: 1 m ~ 3 m
Carrier frequency	4G Hz
BS TX power	24 dBm
UE TX power	23 dBm
Path-loss model	- Indoor (Aggressor) → Macro (Victim): - BS-to-BS: InH-office + penetration loss see TR 38.803 [5] - BS-to-UE: InH-office + penetration loss see TR 38.803 [5] - UE-to-UE: Outdoor UE – Outdoor UE + penetration loss see TR 38.803 [5], TR 36.828 [6] - Indoor (Aggressor) → Indoor (Victim) - BS-to-BS: InH-office see TR 38.803 [5] - BS-to-UE: InH-office see TR 38.803 [5] - UE-to-UE: InH-office see TR 38.803 [5]
BS antenna	FR1 BS antenna element pattern for Indoor scenario from subclause 5.2.1.5.1 / ceiling
BS antenna height:	3 m
UE antenna	Omni
UE antenna height	1.5 m
Antenna gain of UE	0 dBi
Cell selection criteria	Cell selection is based on RSRP
BS receiver noise figure	5 dB
UE receiver noise figure	9 dB
UE power control	Power control as defined in Section 5.2.3.4
Multi operators layout	uncoordinated operation (100% Grid Shift)

5.2.1.2 ACIR

Table 5.2.1.2-1: ACIR for FR1

Parameter	Assumption/Value
ACIR BS-BS	43 dB
ACIR BS-UE	33 dB
ACIR UE-BS	30 dB
ACIR UE-UE	28 dB

5.2.1.3 UE distribution

Table 5.2.1.3-1: UE distribution for FR1

Scenarios	UE distribution
Indoor-to-Indoor	Indoor -> Indoor = 1 user per Transmission Reception Point; 100% indoor
Macro-to-Indoor	Indoor <-> macro = 1 user per Transmission Reception Point; Indoor has 100% indoor UE. Macro victim has 50% indoor UE and 50% outdoor. Indoor <-> macro = Aggressor: 1 user per Transmission Reception Point, 100% indoor. Victim: 1 user per Transmission Reception Point, 100% outdoor
Urban Macro (Macro-to-Macro)	20% indoor and 80% outdoor

5.2.1.4 Other simulation parameters

Table 5.2.1.4-1: Other simulation parameters for FR1

Parameters	Indoor	Urban macro
Channel bandwidth	100 MHz	100 MHz
Scheduled channel bandwidth per UE (DL)	100 MHz	100 MHz
Scheduled channel bandwidth per UE (UL)	100 MHz	100 MHz
Traffic model	Low (RU 10%) and Full buffer	Low (RU 10%) and Full buffer
DL power control	NO	NO
UL power control	YES	YES
BS max TX power in dBm TRP (Total Radiated Power)	24 dBm	49 dBm
UE max TX power in dBm	23 dBm	23 dBm
UE min TX power in dBm	-33 dBm (100 MHz CBW) see TS 38.101-1 [7]	-33 dBm (100 MHz CBW) see TS 38.101-1 [7]
BS Noise figure in dB	5 dB	5 dB
UE Noise figure in dB	9 dB	9 dB
Handover margin	3 dB (Same as FR2)	3 dB (Same as FR2)

5.2.1.5 Antenna configuration

5.2.1.5.1 Urban macro scenario

Table 5.2.1.5.1-1: FR1 BS antenna element pattern for Urban Macro scenario

Parameter	Values
Antenna element vertical radiation pattern (dB)	$A_{E,V}(\theta'') = -min\left\{12\left(\frac{\theta'' - 90°}{\theta_{3dB}}\right)^2, SLA_V\right\}, \theta_{3dB} = 65°, SLA_V = 25\text{dB}$
Antenna element horizontal radiation pattern (dB)	$A_{E,H}(\phi'') = -min\left\{12\left(\frac{\phi''}{\phi_{3dB}}\right)^2, A_m\right\}, \phi_{3dB} = 65°, A_m = 25\text{dB}$
Combining method for 3D antenna element pattern (dB)	$A''(\theta'',\varphi'') = -\min\left\{-\left[A_{E,V}(\theta'') + A_{E,H}(\varphi'')\right], A_m\right\}$
Maximum directional gain of an antenna element $G_{E,max}$	5 dBi (assuming 1.8dB loss)
Note 1: Mg = number of antenna panels in elevation, Ng – number of antenna panels in azimuth, M = number of antenna elements/subarrays in elevation, N= number of antenna elements/subarrays in azimuth, P = number of polarizations. Note 2: TX power is specified per polarization, a single polarization may be simulated under the assumption of polarization match. Note 3: A 65 degree horizontal element beamwidth was assumed for simulations, even though the physically correct beamwidth would be 130 degrees. The difference in assumption does not substantially impact the simulation results.	

5.2.1.5.2 Indoor scenario

Table 5.2.1.5.2-1: FR1 BS antenna element pattern for Indoor scenario

Parameter	Values
Antenna element vertical radiation pattern (dB)	$A_{E,V}(\theta'') = -\min\left\{12\left(\frac{\theta'' - 90°}{\theta_{3dB}}\right)^2, SLA_V\right\}, \theta_{3dB} = 120°, SLA_V = 25\text{dB}$
Antenna element horizontal radiation pattern (dB)	$A_{E,H}(\varphi'') = -\min\left\{12\left(\frac{\varphi''}{\varphi_{3dB}}\right)^2, A_m\right\}, \varphi_{3dB} = 120°, A_m = 25\text{dB}$
Combining method for 3D antenna element pattern (dB)	$A''(\theta'',\varphi'') = -\min\left\{-\left[A_{E,V}(\theta'') + A_{E,H}(\varphi'')\right], A_m\right\}$
Maximum directional gain of an antenna element $G_{E,max}$	3.5 dBi (assuming 1.8dB loss)

5.2.1.5.3 UE antenna element pattern

The UE antenna element is assumed to be omnidirectional with 0dBi gain.

5.2.2 FR2

5.2.2.1 Network layout model

5.2.2.1.1 Urban macro

Table 5.2.2.1.1-1: Single operator layout for urban macro in FR2 (30 GHz)

Network layout	hexagonal grid, 19 macro sites, 3 sectors per site with wrap around
Inter-site distance	200 m
BS antenna height	25 m
Path-loss model	- Macro (Aggressor) – Macro (Victim) - Macro-to-Macro: UMa (h_UE = 25 m) see TR 38.803 [5] - Macro-to-UE(V): Uma + penetration loss see TR 38.803 [5] - UE-to-UE: UMi (h_BS=1.5 m ~ 22.5 m) + penetration loss see TR 38.803 [5]
Shadowing correlation	Between cells: 1.0 Between sites: 0.5
Multi operators layout	uncoordinated operation (100% Grid Shift)

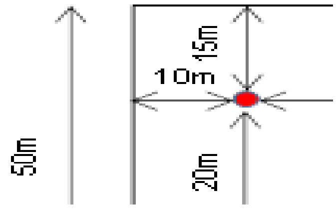
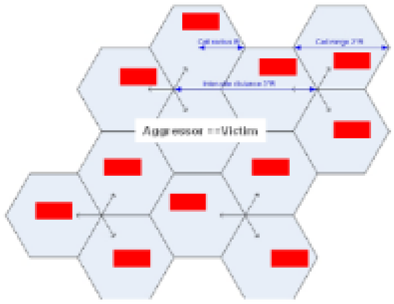
5.2.2.1.2 Dense urban

Table 5.2.2.1.2-1: Single operator layout for Dense urban in FR2 (30 GHz)

Parameters	Values	Remark
Network layout	Fixed cluster circle within a macro cell.	note1
Number of micro BSs per macro cell	3	3 cluster circles are in a macro cell. 1 cluster circle has 1 micro BS.
Radius of UE dropping within a micro cell	< 28.9 m	
BS antenna height	10 m	
Channel model	Micro (A) – Micro (V) see TR 38.803 [5] - Micro-to-Micro: UMi (h_UE=10 m) - Micro-to-Micro UE: UMi + penetration loss - Micro (UE)-to-Micro (UE): UMi (h_BS=1.5 m ~ 22.5 m) + penetration loss between UEs	
Shadowing correlation	Between cite: 0.5	
Multi operator layout	Cluster circle is coordinated	Note 2
Minimum distance between micro BSs in different operator	10 m	
Note 1: Micro BS is randomly dropped on an edge of the cluster circle. All UEs communicate with micro BS, i.e. macro cell is only used for determining position of micro BS. As a layout of macro cell, hexagonal grid, 19 macro sites, 3 sectors per site model with wrap around with ISD = 200 m is assumed. Note 2: Macro cell is collocated. Micro BS itself is randomly dropped.		

5.2.2.1.3 Indoor

Table 5.2.2.1.3-1: Single operator layout for Indoor scenarios in FR2 (30 GHz)

Parameters	Values	Remark
Network layout	Indoor-to-Indoor : Total 12 BSs (operator A: 6 BSs & operator B: 6 BSs) 120 m x 50 m  Indoor-to-macro: Indoors are placed at different locations 	
Inter-site distance	Indoor – Indoor = 20 m	
	The minimum distance between Macro to Indoor: [35] m	
BS antenna height	3 m	ceiling
Path-loss model	Indoor(Aggressor) → Indoor(Victim) - BS-to-BS: InH-office see TR 38.803 [5] - BS-to-UE: InH-office see TR 38.803 [5] - UE-to-UE: InH-office see TR 38.803 [5] Indoor (Agressor) → Macro (Victim) - BS-to-BS: InH-office (h_UE = 3 m) + penetration loss see TR 38.803 [5] - BS-to-UE: InH-office (h_UE = 3 m) + penetration loss see TR 38.803 [5] - UE-to-UE: InH-office (h_BS = 1.5 m) + penetration loss see TR 38.803 [5]	
Shadowing correlation	N/A	
Multi operators layout for indoor	Uncoordinated operation (100%)	

5.2.2.2 ACLR and ACS

Table 5.2.2.2-1: ACLR and ACS for FR2

Parameter	Assumption/Value
BS ACLR	28 dB
UE ACLR	17 dB
BS ACS	23.5 dB
UE ACS	23 dB

5.2.2.3 UE distribution

5.2.2.3.1 Urban Macro (Macro-to-Macro)

Table 5.2.2.3.1-1: UE distribution for Urban Macro case in FR2

UE location	**Outdoor/indoor**	Outdoor and indoor
	Indoor UE ratio	0%
	LOS/NLOS	LOS and NLOS
	UE antenna height	1.5 m ≦ hUT ≦ 22.5 m
UE distribution (horizontal)		Uniform
Minimum BS - UE distance (2D)		35 m

5.2.2.3.2 Dense Urban (Micro-to-Micro)

Table 5.2.2.3.2-1: UE distribution for Dense Urban case in FR2

UE location	**Outdoor/indoor**	Outdoor and indoor
	Indoor UE ratio	80 %
	50% low loss, 50% high loss	Low/high Penetration loss ratio
	LOS/NLOS	LOS and NLOS
	UE antenna height	Same as 3D-UMi in TR 36.873 [8]
UE distribution (horizontal)		Uniform
Minimum BS - UE distance (2D)		3m

5.2.2.3.3 Indoor-to-Indoor and Indoor-to-Macro

Table 5.2.2.3.3-1: UE distribution for Indoor cases in FR2

Scenarios	UE distribution
Indoor-to-Indoor	Indoor -> Indoor = 1 user per Transmission Reception Point; 100% indoor
Macro-to-Indoor	Indoor <-> macro = Aggressor: 1 user per Transmission Reception Point, 100% indoor. Victim: 1 user per Transmission Reception Point, 100% outdoor

5.2.2.4 Other simulation parameters

Table 5.2.2.4-1: Other simulation parameters

Parameters	Indoor	Urban macro	Dense urban
Channel bandwidth	200MHz	200MHz	200MHz
Scheduled channel bandwidth per UE (DL)	200MHz	200MHz	200MHz
Scheduled channel bandwidth per UE (UL)	200MHz	200MHz	200MHz
Traffic model	Low (RU 10%) and Full buffer	Low (RU 10%) and Full buffer	Low (RU 10%) and Full buffer
DL power control	NO	NO	NO
UL power control	YES	YES	YES
BS max TX power in dBm TRP (Total Radiated Power)	23dBm	43dBm	33dBm
UE Peak EIRP in dBm	22.4 dBm	22.4 dBm	22.4 dBm
UE min TX power in dBm	-40dBm	-40dBm	-40dBm
BS Noise figure in dB	10 (note 1)	10 (note 1)	10 (note 1)
UE Noise figure in dB	10 (note 1)	10 (note 1)	10 (note 1)
Handover margin	3dB	3dB	3dB
Note 1: ITU WP5D response			

5.2.2.5 Antenna configuration

5.2.2.5.1 Urban macro scenario

Table 5.2.2.5.1-1: FR2 BS antenna modelling for urban macro scenario

Parameter	Values
Antenna element vertical radiation pattern (dB)	$A_{E,V}(\theta'') = -\min\left\{12\left(\frac{\theta''-90°}{\theta_{3dB}}\right)^2, SLA_V\right\}, \theta_{3dB} = 65°, SLA_V = 30\,\mathrm{dB}$
Antenna element horizontal radiation pattern (dB)	$A_{E,H}(\varphi'') = -\min\left\{12\left(\frac{\varphi''}{\varphi_{3dB}}\right)^2, A_m\right\}, \varphi_{3dB} = 65°, A_m = 30\,\mathrm{dB}$
Combining method for 3D antenna element pattern (dB)	$A''(\theta'',\varphi'') = -\min\left\{-\left[A_{E,V}(\theta'') + A_{E,H}(\varphi'')\right], A_m\right\}$
Maximum directional gain of an antenna element $G_{E,max}$	3 dBi (assuming 1.8dB loss)
(M_g, N_g, M, N, P)	For 30 GHz: (1, 1, 8, 16, 2) Note1,2
(d_v, d_h)	(0.5λ, 0.5λ)
Note 1: Mg = number of antenna panels in elevation, Ng – number of antenna panels in azimuth, M = number of antenna elements/subarrays in elevation, N= number of antenna elements/subarrays in azimuth, P = number of polarizations. Note 2: TX power is specified per polarization, a single polarization may be simulated under the assumption of polarization match. Note 3: A 65 degree element beamwidth was assumed for simulations, even though the physically correct beamwidth would be 130 degrees. The difference in assumption does not substantially impact the simulation results.	

5.2.2.5.2 Dense urban scenario

Table 5.2.2.5.2-1: FR2 BS antenna element pattern for dense urban scenario

Parameter	Values
Antenna element vertical radiation pattern (dB)	$A_{E,V}(\theta'') = -\min\left\{12\left(\frac{\theta''-90°}{\theta_{3dB}}\right)^2, SLA_V\right\}, \theta_{3dB} = 65°, SLA_V = 30\,\mathrm{dB}$
Antenna element horizontal radiation pattern (dB)	$A_{E,H}(\varphi'') = -\min\left\{12\left(\frac{\varphi''}{\varphi_{3dB}}\right)^2, A_m\right\}, \varphi_{3dB} = 65°, A_m = 30\,\mathrm{dB}$
Combining method for 3D antenna element pattern (dB)	$A''(\theta'',\varphi'') = -\min\left\{-\left[A_{E,V}(\theta'') + A_{E,H}(\varphi'')\right], A_m\right\}$
Maximum directional gain of an antenna element $G_{E,max}$	3 dBi (assuming 1.8dB loss)
BS antenna configuration	(M_g, N_g, M, N, P) = (1, 1, 8, 16, 2) Note 1,2
(d_v, d_h)	(0.5λ, 0.5λ)
Note 1: Mg = number of antenna panels in elevation, Ng – number of antenna panels in azimuth, M = number of antenna elements/subarrays in elevation, N= number of antenna elements/subarrays in azimuth, P = number of polarizations. Note 2: TX power is specified per polarization, a single polarization may be simulated under the assumption of polarization match. Note 3: A 65 degree element beamwidth was assumed for simulations, even though the physically correct beamwidth would be 130 degrees. The difference in assumption does not substantially impact the simulation results	

5.2.2.5.3 Indoor scenario

Table 5.2.2.5.3-1: FR2 BS antenna element pattern for indoor scenario

Parameter	Values
Antenna element vertical radiation pattern (dB)	$A_{E,V}(\theta'') = -\min\left\{12\left(\frac{\theta''-90°}{\theta_{3dB}}\right)^2, SLA_V\right\}, \theta_{3dB} = 90°, SLA_V = 25\mathrm{dB}$
Antenna element horizontal radiation pattern (dB)	$A_{E,H}(\varphi'') = -\min\left\{12\left(\frac{\varphi''}{\varphi_{3dB}}\right)^2, A_m\right\}, \varphi_{3dB} = 90°, A_m = 25\,\mathrm{dB}$
Combining method for 3D antenna element pattern (dB)	$A''(\theta'',\varphi'') = -\min\left\{-\left[A_{E,V}(\theta'') + A_{E,H}(\varphi'')\right], A_m\right\}$
Maximum directional gain of an antenna element $G_{E,max}$	3 dBi (assuming 2dB loss)
(M_g, N_g, M, N, P) note	For 30 GHz: (1, 1, 4, 8, 2)
(d_v, d_h)	(0.5λ, 0.5λ)
Note 1: Mg = number of antenna panels in elevation, Ng – number of antenna panels in azimuth, M = number of antenna elements/subarrays in elevation, N= number of antenna elements/subarrays in azimuth, P = number of polarizations. Note 2: TX power is specified per polarization, a single polarization may be simulated under the assumption of polarization match. Note 3: A 90 degree element beamwidth was assumed for simulations, even though the physically correct beamwidth would be 130 degrees. The difference in assumption does not substantially impact the simulation	

5.2.2.5.4 UE antenna element pattern

Table 5.2.2.5.4-1: FR2 UE antenna element pattern

Parameter	Values
Antenna element vertical radiation pattern (dB)	$A_{E,V}(\theta'') = -\min\left\{12\left(\frac{\theta''-90°}{\theta_{3dB}}\right)^2, SLA_V\right\}, \theta_{3dB} = 90°, SLA_V = 25\text{dB}$
Antenna element horizontal radiation pattern (dB)	$A_{E,H}(\varphi'') = -\min\left\{12\left(\frac{\varphi''}{\varphi_{3dB}}\right)^2, A_m\right\}, \varphi_{3dB} = 90°, A_m = 25\text{dB}$
Combining method for 3D antenna element pattern (dB)	$A''(\theta'',\varphi'') = -\min\left\{-\left[A_{E,V}(\theta'') + A_{E,H}(\varphi'')\right], A_m\right\}$
Maximum directional gain of an antenna element $G_{E,max}$	3 dBi (assuming 5dBi directivity and 2dB loss)
BS antenna configuration	(M_g, N_g, M, N, P) = (1, 1, 2, 2, 2) Note 1,2
(d_v, d_h)	(0.5λ, 0.5λ)
UE orientation	Random orientation in the azimuth domain: uniformly distributed between -90 and 90 degrees Note 3 Fixed elevation: 90 degrees

Note 1: Mg = number of antenna panels in elevation, Ng – number of antenna panels in azimuth, M = number of antenna elements/subarrays in elevation, N= number of antenna elements/subarrays in azimuth, P = number of polarizations.
Note 2: TX power is specified per polarization, a single polarization may be simulated under the assumption of polarization match.
Note3: This is done to emulate two panels: the configuration is equivalent to 2 panels with 180 shift in horizontal orientation and UE orientation uniformly distributed in the azimuth domain between -180 and 180 degrees.
Note 4: A 90 degree element beamwidth was assumed for simulations, even though the physically correct beamwidth would be 130 degrees. The difference in assumption does not substantially impact the simulation

5.2.3 Common assumptions

5.2.3.1 Propagation model

The Path loss model is summarized in Table 5.2.3.1-1. Note that the distribution of the shadow fading is log-normal, and its standard deviation for each scenario is given in Table 5.2.3.1-1.

Table 5.2.3.1-1: Path-loss models

Scenario	Pathloss [dB], f_c is in GHz and d is in meters (6)	Shadow fading std [dB]	Applicability range, antenna height default values
UMa LOS	$PL_1 = 32.4 + 20\log 10(d_{3D}) + 20\log 10(f_c)$ $PL_2 = 32.4 + 40\log 10(d_{3D}) + 20\log 10(f_c) - 10\log 10((d'_{BP})^2 + (h_{BS} - h_{UT})^2)$	σ_{SF}=4.0 σ_{SF}=4.0	10m < d_{2D} < d'_{BP} 1) d'_{BP} < d_{2D} <5000m 1.5m ≦ h_{UT}≦ 22.5m h_{BS} = 25 m
UMa NLOS	$PL = \max(PL_{UMa-LOS}, PL_{UMa-NLOS})$ $PL_{UMa-NLOS} = 13.54 + 39.08\log_{10}(d_{3D}) + 20\log_{10}(f_c) - 0.6(h_{UT} - 1.5)$	σ_{SF} =6	10 m < d_{2D} < 5 000 m 1.5 m ≦ h_{UT}≦ 22.5 m h_{BS} = 25 m

			Explanations: see note 3
UMi - Street Canyon LOS	$PL = 32.4 + 21\log 10(d_{3D}) + 20\log 10(f_c)$ $PL = 32.4 + 40\log 10(d_{3D}) + 20\log 10(f_c) - 9.5\log 10((d'_{BP})^2 + (h_{BS} - h_{UT})^2)$	σ_{SF}=4.0 σ_{SF}=4.0	10m < d_{2D} < d'_{BP} 1) d'_{BP} < d_{2D} <5000m 1.5m ≦ h_{UT}≦ 22.5m h_{BS} = 10 m
UMi – Street Canyon NLOS	$PL = \max(PL_{UMi-LOS}(d_{3D}), PL_{UMi-NLOS}(d_{3D}))$ $PL_{UMi\text{-}NLOS} = 35.3\log_{10}(d_{3D}) + 22.4 + 21.3\log_{10}(f_c) - 0.3(h_{UT} - 1.5)$	σ_{SF}=7.82	10 m < d_{2D} < 5000m 1.5m ≦ h_{UT}≦ 22.5m h_{BS} = 10 m Explanations: see note 4
InH - Office LOS	$PL = 32.4 + 17.3\log 10(d_{3D}) + 20\log 10(f_c)$	σ_{SF}=3.0	1<d_{3D}<100m
InH - Office NLOS	$PL = \max(PL_{\text{InH-LOS}}, PL_{\text{InH-NLOS}})$ $\text{PL}_{\text{InH-NLOS}} = 38.3\log_{10}(d_{3D}) + 17.30 + 24.9\log_{10}(f_c)$	σ_{SF}=8.03	1<d_{3D}<86m

Note 1: d'_{BP} = 4 h'_{BS} h'_{UT} f_c/c, where f_c is the centre frequency in Hz, c = 3.0×10^8 m/s is the propagation velocity in free space, and h'_{BS} and h'_{UT} are the effective antenna heights at the BS and the UT, respectively. In UMi scenario the effective antenna heights h'_{BS} and h'_{UT} are computed as follows: h'_{BS} = h_{BS} – 1.0 m, h'_{UT} = h_{UT}–1.0 m, where h_{BS} and h_{UT} are the actual antenna heights, and the effective environment height is assumed to be equal to 1.0 m. In UMa scenario the effective antenna heights h'_{BS} and h'_{UT} are computed as follows: h'_{BS} = h_{BS} – h_E, h'_{UT} = h_{UT} – h_E, where h_{BS} and h_{UT} are the actual antenna heights, and the effective environment height h_E is a function of the link between a BS and a UT. In the event that the link is determined to be LOS, h_E=1m with a probability equal to 1/(1+C(d_{2D}, h_{UT})) and chosen from a discrete uniform distribution uniform(12,15,…,(h_{UT}-1.5)) otherwise.

Note 2: The applicable frequency range of the PL formula in this table is 0.8 < f_c < f_H GHz, where f_H = 30 GHz for RMa and f_H = 100 GHz for all the other scenarios. It is noted that RMa pathloss model for >7 GHz is validated based on a single measurement campaign conducted at 24 GHz.

Note 3: UMa NLOS pathloss is from TR36.873 with simplified format and and $PL_{UMa\text{-}LOS}$ = Pathloss of UMa LOS outdoor scenario.

Note 4: $PL_{UMi\text{-}LOS}$ = Pathloss of UMi-Street Canyon LOS outdoor scenario.

Note 5: Break point distance d_{BP} = 2π h_{BS} h_{UT} f_c/c, where f_c is the centre frequency in Hz, c = 3.0 × 10^8 m/s is the propagation velocity in free space, and h_{BS} and h_{UT} are the antenna heights at the BS and the UT, respectively.

Note 6: f_c denotes the center frequency normalized by 1GHz, all distance related values are normalized by 1m, unless it is stated otherwise.

5.2.3.2 LOS model

The Line-Of-Sight (LOS) probabilities are given in Table 5.2.3.2-1.

Table 5.2.3.2-1: LOS probability

Scenario	LOS probability (distance is in meters)
UMi – Street canyon	Outdoor users: $P_{LOS} = \min(18/d_{2D},1)(1-\exp(-d_{2D}/36)) + \exp(-d_{2D}/36)$ Indoor users: Use $d_{2D\text{-}out}$ in the formula above instead of d_{2D}

UMa	Outdoor users: $$P_{LOS} = \min(18/d_{2D},1)(1-\exp(-d_{2D}/63)) + \exp(-d_{2D}/63)(1+C(d_{2D},h_{UT}))$$ where $$C(d_{2D},h_{UT}) = \begin{cases} 0 & ,h_{UT} < 13\text{m} \\ \left(\frac{h_{UT}-13}{10}\right)^{1.5} g(d_{2D}) & ,13\text{m} \le h_{UT} \le 23\text{m} \end{cases}$$ and $$g(d_{2D}) = \begin{cases} 0 & ,d_{2D} \le 18\text{m} \\ (1.25e-6)(d_{2D})^3 \exp(-d_{2D}/150) & ,18\text{m} < d_{2D} \end{cases}$$ Indoor users: Use $d_{2D\text{-}out}$ in the formula above instead of d_{2D}
Indoor – Open office	$$P_{LOS}^{Open\_office} = \begin{cases} 1, & d_{2D} \le 5 \\ \exp(-(d_{2D}-5)/70.8), & 5 < d_{2D} \le 49 \\ \exp(-(d_{2D}-49)/211.7) \cdot 0.54, & d_{2D} > 49 \end{cases}$$
Note: The LOS probability is derived with assuming antenna heights of 3m for indoor, 10m for UMi, and 25m for Uma	

5.2.3.3 O-to-I penetration loss

The Path loss incorporating O-to-I building penetration loss is modelled as in the following:

$$\text{PL} = \text{PL}_b + \text{PL}_{tw} + \text{PL}_{in} + N(0, \sigma_P^2)$$

where PL_b is the basic outdoor path loss given in Section 5.1.2.2.1. PL_{tw} is the building penetration loss through the external wall, PL_{in} is the inside loss dependent on the depth into the building, and σ_P is the standard deviation for the penetration loss.

PL_{tw} is characterized as:

$$\text{PL}_{tw} = \text{PL}_{npi} - 10\log_{10} \sum_{i=1}^{N} \left(p_i \times 10^{\frac{L_{material\_i}}{-10}} \right)$$

PL_{npi} is an additional loss is added to the external wall loss to account for non-perpendicular incidence;

$L_{material\_i} = a_{material\_i} + b_{material\_i} \cdot f$, is the penetration loss of material i, example values of which can be found in Table 5.2.3.3-1.

p_i is proportion of i-th materials, where $\sum_{i=1}^{N} p_i = 1$; and

N is the number of materials.

Table 5.2.3.3-1: Material penetration losses

Material	Penetration loss [dB]
Standard multi-pane glass	$L_{glass} = 2 + 0.2 \cdot f$
IRR glass	$L_{IRRglass} = 23 + 0.3 \cdot f$
Concrete	$L_{concrete} = 5 + 4 \cdot f$
Wood	$L_{wood} = 4.85 + 0.12 \cdot f$
Note: f is in GHz	

Table 5.2.3.3-2 gives PL_{tw}, PL_{in} and σ_P for two O-to-I penetration loss models. The O-to-I penetration is UT-specifically generated, and is added to the SF realization in the log domain.

Table 5.2.3.3-2: O-to-I penetration loss model

	Path loss through external wall: $\mathbf{PL_{tw}}$ [dB]	Indoor loss: $\mathbf{PL_{in}}$ [dB]	Standard deviation: σ_P [dB]
Low-loss model	$5 - 10\log_{10}\left(0.3 \cdot 10^{-L_{glass}/10} + 0.7 \cdot 10^{-L_{concrete}/10}\right)$	$0.5d_{2D\text{-}in}$	4.4
High-loss model	$5 - 10\log_{10}\left(0.7 \cdot 10^{-L_{IRRglass}/10} + 0.3 \cdot 10^{-L_{concrete}/10}\right)$	$0.5d_{2D\text{-}in}$	6.5

$d_{2D\text{-}in}$ is minimum of two independently generated uniformly distributed variables between 0 and 25 m for RMa, UMa and UMi-Street Canyon. $d_{2D\text{-}in}$ shall be UT-specifically generated.

Both low-loss and high-loss models are applicable to UMa and UMi-Street Canyon.

Only the low-loss model is applicable to RMa.

The composition of low and high loss is a simulation parameter that should be determined by the user of the channel models, and is dependent on the use of metal-coated glass in buildings and the deployment scenarios. Such use is expected to differ in different markets and regions of the world and also may increase over years to new regulations and energy saving initiatives. Furthermore, the use of such high-loss glass currently appears to be more predominant in commercial buildings than in residential buildings in some regions of the world.

The pathloss incorporating O-to-I car penetration loss is modelled as in the following:

$$PL = PL_b + N(\mu, \sigma_P^2)$$

where PL_b is the basic outdoor path loss given in Section 7.4.1. $\mu = 9$, and $\sigma_P = 5$. Optionally, for metallized car windows, $\mu = 20$ can be used. The O-to-I car penetration loss models are applicable for at least 0.6-60 GHz.

5.2.3.4 Transmission power control model

For downlink scenario, no power control scheme is applied.

For uplink scenario, TPC model specified in Section 9.1 TR 36.942 [9] is applied with following parameters.

- CLx-ile = 88 + 10*log10(200/X), where X is UL transmission BW (MHz)
- $\gamma = 1$

5.2.3.5 Received signal power model

The following model is applied.

$$RX\_PWR = TX\_PWR - \text{Path loss} + G\_TX + G\_RX$$

where:

RX_PWR is the received power.

TX_PWR is the transmitted power.

G_TX is the transmitter antenna gain (directional array gain).

G_RX is the receiver antenna gain (directional array gain).

5.2.3.6 Evaluation metric

Table 5.2.3.6-1: Parameters describing baseline Link Level performance for 5G NR

Parameter	DL	UL	Notes
α, attenuation	0.6	0.4	Represents implementation losses
$SNIR_{MIN}$, dB	-10	-10	Based on QPSK, 1/8 rate (DL) & 1/5 rate (UL)
$SNIR_{MAX}$, dB	30	22	Based on 256QAM 0.93(DL) & 64QAM 0.93 (UL)

5.2.3.7 Antenna modelling

Note the above gives the correct antenna array radiation pattern, however the correct gain is only achieved if the element pattern $A_A(\theta,\varphi)$ is selected for the exact element spacing. For other element spacing's, the element pattern $A_A(\theta,\varphi)$ must be separately calculated such that it is correct for the element spacing ($d_{g,H}$ *and* $d_{g,V}$). If $A_A(\theta,\varphi)$ is not linked to the element spacing then the calculated absolute gain may diverge from the correct value in a manner that varies as the beam is steered.

The correct composite array radiation pattern directivity(D) is given by:

$$D_A(\theta,\varphi) = 10 \cdot \log\left(\frac{4\pi\left(\left|A_A(\theta,\varphi)\right|^2\right)}{\int_{-\pi}^{\pi}\int_{0}^{\pi}\left|P(\theta,\varphi)\right|^2 \sin(\theta)\, d\theta d\varphi} \right),$$

The composite array radiation pattern gain can then be calculated as:

$$G_A(\theta,\varphi) = D_A(\theta,\varphi) - L$$

Where L is the Loss associated with the antenna. This is currently included in the estimate for element gain $A_E(\theta,\varphi)$, and is 1.8dB.

5.2.3.8 Simulation description

Adopt following simulation steps.

1. Aggressor and victim network are generated.

   - UEs are distributed randomly across the network.

2. UE associations: UEs are associated to base station based on coupling loss.

   - Associations are made assuming a single element at both UE and BS.

3. Once association is done, round robin scheduling is used. BF weights are adjusted to point to the LOS direction between BS-UE. This is done for both victim and aggressor networks.

4. (Optional) Throughput is computed in the victim systems without considering ACI as below:

   - $Thput_{\text{NO ACI}}[bpshz] = f(SINR_{ICI}) = f\left(\frac{S}{N+I_{ICI}}\right)$, where I_{ICI} is the inter-cell interference.

5. Throughput is computed considering ACI as below:

   - $\text{Thput}_{\text{ACI}}[\text{bpshz}] = \text{f}(\text{SINR}_{\text{ICI+ACI}}) = \text{f}\left(\frac{\text{S}}{\text{N}+\text{I}_{\text{ICI}}+\text{I}_{\text{ACI}}}\right)$, where I_{ACI} is the adjacent channel interference.

NOTE: Simulation results should be in the form of the throughput with adjacent network with DTDD and without DTDD and the relative difference between the two can be compared at 50% and 5% points.

5.3 Simulation results

5.3.1 General

This sub-clause captures the co-existence simulation results for scenarios in Table 5.1.1-1 and Table 5.1.1-2. The following cases are considered as follows:

- Case 1: (Baseline) the transmission directions of aggressor and victim are set as all DL.
- Case 2: The transmission direction of aggressor is randomly set as DL and UL with a 50% probability.
- Case 3: The transmission direction of aggressor is set as UL, which is opposite to the victim's transmission direction.

5.3.2 Simulation limitations

Some limitations may have the potential to influence the impact to neighbor operator networks in the co-existence simulation. The limitations are not necessarily specific to the CLI simulations. Some of these aspects may be as follows:

- The simulations currently schedule a single UE at a time. For FR2 with beamforming, this makes most sense, but for FR1 and sectorized base station antennas, multi-user frequency domain scheduling could reveal more interference cases. There may be many UEs transmitting in uplink simultaneously resulting in a higher total radiated UL power. This could change the UL-to-DL and also UL-to-UL ACI interference environment.
- Lack of co-channel interference mitigation schemes in the indoor scenarios. For any adjacent channel UL transmission to exceed the co-channel interference level, the interfering UE would need to be extremely close to the victim UE. Different geometries and ICIC mechanisms could improve the co-channel performance, thereby making adjacent channel interference more visible.
- In addition to the base station geometry, the UE geometry may also have an impact on the results. The UEs are dropped in the simulations uniformly in the specified simulation area, whereas in reality users would sometimes group e.g. in a meeting room.

The RF performance parameters used in the simulation are according to RAN4 minimum requirements at the specified test points. For example, when it comes to UE performance:

- The TX leakage on the adjacent channel (ACLR) depends on the actual resource allocation, with the specified minimum requirement typically occurring only with a fully populated channel.
- ACLR also depends on transmit power, typically improving when less than maximum output power is configured.

5.3.3 FR1

5.3.3.1 Scenario 1: 4 GHz Macro→ Macro (DL)

5.3.3.1.1 Results

Table 5.3.3.1-1: SINR and throughput degradation for Macro aggressor Macro victim

Source	Observation Point	Victim DL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	UL	50DL/50UL	UL
Huawei (1905522)	5%	-0.47	-0.13	-10.13	-2.83
	50%	-0.12	-0.37	-0.57	-1.75
	95%	-0.74	-0.21	0.00	0.00
LGE (1907601)	5%	-	2.5	-	31.33
	50%	-	0.04	-	0.2
	95%	-	0.2	-	0.47
Ericsson (1906097)	5%	<1	<1	3.1	3.1
	50%	<1	<1	1.2	1.2
	95%	<1	<1	1.1	2.1
Nokia (1907604)	5%	-0.7	-1.5	-7.9	-31.1
	50%	-0.3	-0.7	-3	-9
	95%	-0.1	-0.4	1.7	-1.1
Qualcomm (1906703)	5%	-	-0.70	-	-8.44
	50%	-	-0.38	-	-1.78
	95%	-	-0.27	-	0

Table 5.3.3.1.1-2: SINR and throughput degradation for Macro aggressor Macro victim (low traffic)

Source	Observation Point	Victim DL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	UL	50DL/50UL	UL
LGE (1907601)	5%	-	0.58		7.61
	50%	-	0.07		0.33
	95%	-	0.55		1.33
Ericsson (1906097)	5%	<1	<1	4	4
	50%	<1	<1	1.5	2
	95%	<1	<1	<1	<1

5.3.3.2 Scenario 2: 4 GHz Macro→ Macro (UL)

5.3.3.2.1 Results

Table 5.3.3.2.1-1: SINR and throughput degradation for Macro aggressor Macro victim

Source	Observation Point	Victim UL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	DL	50DL/50UL	DL
Huawei (1905522)	5%	0.27	0.76	4.98	13.90
	50%	0.28	0.52	1.70	3.19
	95%	-0.02	-0.03	-0.11	-0.15
LGE (1907601)	5%	-	2.63	-	44.99
	50%	-	0.46	-	3.13
	95%	-	0.05	-	0.25
Ericsson (1906097) (NOTE 1)	5%	<1	<1	<1	-1.3
	50%	<1	<1	-1.5	-3
	95%	<1	<1	<1	-1.1
Nokia (1907604)	5%	0.1	0.8	-3.1	2
	50%	0.1	0.4	2.2	2.8
	95%	0.1	0.3	0.4	0.1
NOTE 1: Further Ericsson results in this scenario with reduced cell size and grid shift indicated throughput losses					

Table 5.3.3.2.1-2: SINR and throughput degradation for Macro aggressor Macro victim (low traffic)

Source	Observation Point	Victim UL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	DL	50DL/50UL	DL
LGE (1907601)	5%	-	1.08	-	21.72
	50%	-	0.08	-	0.52
	95%	-	0	-	-0.02
Ericsson (1906097)	5%	<1	<1	-3.3	-3.4
	50%	<1	<1	<1	-1
	95%	<1	<1	<1	<1

5.3.3.3 Scenario 3: 4 GHz Macro → Indoor (DL)

5.3.3.3.1 Results

Table 5.3.3.3.1-1: SINR and throughput degradation for Macro aggressor Indoor victim

Source	Observation Point	Victim DL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	UL	50DL/50UL	UL
Huawei (1905522)	5%	-0.06	-0.02	-1.25	-0.42
	50%	0.04	-0.02	0.56	-0.40
	95%	0.1	-0.09	0.81	-0.74
Nokia (1907604)	5%	-0.1	-0.1	9	7.1
	50%	-0.1	0.1	0.9	1.2
	95%	0.2	1.5	1.3	1.7
Qualcomm (1906703)	5%	-	0	-	0
	50%	-	0.07	-	0.76
	95%	-	1.02	-	3.45

5.3.3.4 Scenario 4: 4 GHz Macro → Indoor (UL)

5.3.3.4.1 Results

Table 5.3.3.4.1-1: SINR and throughput degradation for Macro aggressor Indoor victim

Source	Observation Point	Victim UL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	DL	50DL/50UL	DL
Huawei (1905522)	5%	-0.06	0.01	-1.01	0.34
	50%	-0.04	0.03	-0.64	0.33
	95%	0.18	0.28	1.55	2.43
Nokia (1907604)	5%	-0.6	-2.2	-0.9	-19
	50%	-1	-2	-4.2	-9.5
	95%	-0.6	-2.1	-0.1	-11.1

5.3.3.5 Scenario 5: 4 GHz Indoor → Macro (DL)

5.3.3.5.1 Results

Table 5.3.3.5.1-1: SINR and throughput degradation for Indoor aggressor Macro victim

Source	Observation Point	Victim DL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	UL	50DL/50UL	UL
Huawei (1905522)	5%	0.04	0.09	0.71	1.52
	50%	-0.42	0	-2.90	-0.02
	95%	-0.03	-0.11	-0.12	-0.38
LGE (1907601)	5%	-	-0.73	-	-14.31
	50%	-	0.06	-	0.32
	95%	-	0.81	-	2.07
Nokia (1907604)	5%	5.5	-0.1	38.2	31.8
	50%	1.2	-0.4	7.4	-5.9
	95%	0.7	-0.6	4	4.9

Table 5.3.3.5.1-2: SINR and throughput degradation for Indoor aggressor Macro victim (24 dBm TX power of a local BS)

Source	Observation Point	Victim DL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	UL	50DL/50UL	UL
LGE (1907601)	5%	-	-0.83	-	-16.3
	50%	-	-0.13	-	-0.69
	95%	-	0.84	-	2.14

5.3.3.6 Scenario 6: 4 GHz Indoor → Macro (UL)

5.3.3.6.1 Results

Table 5.3.3.6.1-1: SINR and throughput degradation for Indoor aggressor Macro victim

Source	Observation Point	Victim UL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	DL	50DL/50UL	DL
Huawei (1905522)	5%	-0.07	-0.27	-1.33	-5.13
	50%	0.2	-0.03	1.07	-0.18
	95%	0	-0.01	0.00	0.00
LGE (1907601)	5%	-	-2.31	-	-70.18
	50%	-	-1.44	-	-14.28
	95%	-	-0.05	-	-0.22
Nokia (1907604)	5%	0	0	7.2	20.9
	50%	0.1	0	17.1	15
	95%	0.1	0.1	-0.8	0

Table 5.3.3.6.1-2: SINR and throughput degradation for Indoor aggressor Macro victim (24 dBm TX power of a local BS)

Source	Observation Point	Victim UL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	DL	50DL/50UL	DL
LGE (1907601)	5%	-	-2.54	-	-79.15
	50%	-	-1.24	-	-12.03
	95%	-	-0.04	-	-0.2

5.3.3.7 Scenario 7: 4 GHz Indoor → Indoor (DL)

5.3.3.7.1 Results

Table 5.3.3.7.1-1: SINR and throughput degradation for Indoor aggressor Indoor victim

Source	Observation Point	Victim DL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	UL	50DL/50UL	UL
Huawei (1905522)	5%	0.13	0	2.51	-0.11
	50%	0.03	-0.01	0.51	-0.10
	95%	0.06	0.01	0.50	0.06
LGE (1907601)	5%	-	-0.08	-	-1.4
	50%	-	-0.11	-	-1.16
	95%	-	-0.43	-	-1.49
Ericsson (1906099)	5%	<1	<1	<1	<1
	50%	<1	<1	<1	<1
	95%	<1	<1	<1	<1
Nokia (1907604)	5%	0.2	0	0.6	-0.5
	50%	-0.2	-0.5	-0.8	-0.8
	95%	-0.2	-2.8	-1.8	-1.2

Table 5.3.3.7.1-2: SINR and throughput degradation for Indoor aggressor Indoor victim (24 dBm TX power of a local BS)

Source	Observation Point	Victim DL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	UL	50DL/50UL	UL
LGE (1907601)	5%	-	-0.02	-	-0.33
	50%	-	-0.02	-	-0.2
	95%	-	0.75	-	2.62
Ericsson (1906099)	5%	<1	<1	<1	<1
	50%	<1	<1	<1	<1
	95%	<1	<1	<1	<1
Qualcomm (1906703)	5%	-	-0.01	-	-0.17
	50%	-	-0.07	-	-0.71
	95%	-	1.15	-	0.26

5.3.3.8 Scenario 8: 4 GHz Indoor → Indoor (UL)

5.3.3.8.1 Results

Table 5.3.3.8.1-1: SINR and throughput degradation for Indoor aggressor Indoor victim (30 dBm TX power of a local BS)

Source	Observation Point	Victim UL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	DL	50DL/50UL	DL
Huawei (1905522)	5%	0.06	0.01	0.95	0.20
	50%	0.19	0.03	2.94	0.53
	95%	-0.43	0.12	-3.90	1.08
LGE (1907601)	5%	-	-0.04	-	-0.76
	50%	-	-0.19	-	-2.06
	95%	-	-0.28	-	-1.39
Ericsson (1906099)	5%	<1	<1	-5.5	-8.1
	50%	<1	<1	-4.1	-8.1
	95%	-1	-1.1	-3	-7
Nokia (1907604)	5%	-0.2	0.3	-8.3	-3.2
	50%	0.5	0.8	-1.9	-2.8
	95%	0.3	0.3	3.5	1.5

Table 5.3.3.8.1-2: SINR and throughput degradation for Indoor aggressor Indoor victim (24 dBm TX power of a local BS)

Source	Observation Point	Victim UL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	DL	50DL/50UL	DL
LGE (1907601)	5%	-	-0.05	-	-0.97
	50%	-	-0.24	-	-2.64
	95%	-	-0.52	-	-2.63
Ericsson (1906099)	5%	<1	<1	-1	-1
	50%	<1	<1	<1	-1
	95%	<1	<1	1	<1

5.3.4 FR2

5.3.4.1 Scenario 9: 30 GHz Macro → Macro (DL)

5.3.4.1.1 Results

Table 5.3.4.1.1-1: SINR and throughput degradation for Macro aggressor Macro victim

Source	Observation Point	Victim DL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	UL	50DL/50UL	UL
Huawei (1905523)	5%	-0.36	-0.4	-3.75	-4.07
	50%	0	-0.68	0.00	0.00
	95%	-0.22	-0.82	0.00	0.00
LGE (1907062)	5%	-	5.5	-	37.08
	50%	-	2.9	-	9.5
	95%	-	2.19	-	4.96
Ericsson (196098)	5%	<1	<1	<1	<1
	50%	<1	<1	<1	<1
	95%	<1	<1	<1	<1
Qualcomm (1906703)	5%	-	-0.38	-	-1.95
	50%	-	-0.22	-	0
	95%	-	-0.32	-	0
Nokia (1907604)	5%	-0.7	-1.5	-16.8	-35.0
	50%	-0.3	-0.7	-1.2	-7.0
	95%	-0.1	-0.4	0.7	-1.2

5.3.4.2 Scenario 10: 30 GHz Macro → Macro (UL)

5.3.4.2.1 Results

Table 5.3.4.2.1-1: SINR and throughput degradation for Macro aggressor Macro victim

Source	Observation Point	Victim UL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	DL	50DL/50UL	DL
Huawei (1905523)	5%	1.209	0.4108	1.04	0.66
	50%	0.0604	0.126	0.37	0.78
	95%	0.0011	0.0023	0.01	0.02
LGE (1907062)	5%	-	0.56	-	10.04
	50%	-	0.79	-	5.18
	95%	-	0.01	-	0.08
Ericsson (196098) (NOTE 1)	5%	0.35	0.64	<1	<1
	50%	0.74	1.55	8	14.5
	95%	0.48	1.04	4.11	8.53
Nokia (1907604)	5%	0.2	0.9	-0.7	4.2
	50%	0.1	0.5	0.4	0.5
	95%	0.1	0.2	1.9	-0.9
NOTE 1: Further Ericsson results in this scenario with reduced cell size and grid shift indicated throughput losses					

5.3.4.3 Scenario 11: 30 GHz Micro → Micro (DL)

5.3.4.3.1 Results

Table 5.3.4.3.1-1: SINR and throughput degradation for Micro aggressor Micro victim

Source	Observation Point	Victim DL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	UL	50DL/50UL	UL
Huawei (1905523)	5%	-0.17	0.03	-3.50	0.50
	50%	-0.38	-0.26	-1.81	-1.24
	95%	-1.04	-0.88	0.00	0.00
Ericsson (1906101)	5%	<1	<1	<1	<1
	50%	<1	<1	<1	<1
	95%	<1	<1	<1	<1
Qualcomm (1906703)	5%	-	0.06	-	0.33
	50%	-	-0.44	-	0
	95%	-	-0.37	-	0

5.3.4.4 Scenario 12: 30 GHz Micro → Micro (UL)

5.3.4.4.1 Results

Table 5.3.4.4.1-1: SINR and throughput degradation for Micro aggressor Micro victim

Source	Observation Point	Victim UL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	DL	50DL/50UL	DL
Huawei (1905523)	5%	1.387	4.8167	NA	NA
	50%	1.3956	3.5008	10.24	25.23
	95%	0.0024	0.0068	0.02	0.04
Ericsson (1906101)	5%	<1	<1	<1	<1
	50%	<1	<1	<1	<1
	95%	<1	<1	<1	<1

5.3.4.5 Scenario 13: 30 GHz Indoor → Macro (DL)

5.3.4.5.1 Results

Table 5.3.4.5.1-1: SINR and throughput degradation for Micro aggressor Micro victim

Source	Observation Point	Victim DL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	UL	50DL/50UL	UL
Huawei (1905523)	5%	-0.46	0.05	-2.36	0.25
	50%	-0.32	0.01	0.00	0.00
	95%	-0.25	0.04	0.00	0.00
LGE (1907062)	5%	-	0.14	-	0.92
	50%	-	0.25	-	0.81
	95%	-	0.29	-	0.64

5.3.4.6 Scenario 14: 30 GHz Indoor → Macro (UL)

5.3.4.6.1 Results

Table 5.3.4.6.1-1: SINR and throughput degradation for Indoor aggressor Macro victim

Source	Observation Point	Victim UL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	DL	50DL/50UL	DL
Huawei (1905523)	5%	-0.51	-0.31	-4.28	-2.64
	50%	-0.01	-0.02	-0.07	-0.12
	95%	0	0	0.00	0.00
LGE (1907062)	5%	-	-1.03	-	-20.33
	50%	-	-0.19	-	-1.23
	95%	-	0	-	-0.03

5.3.4.7 Scenario 15: 30 GHz Indoor → Indoor (DL)

5.3.4.7.1 Results

Table 5.3.4.7.1-1: SINR and throughput degradation for Indoor aggressor Indoor victim

Source	Observation Point	Victim DL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	UL	50DL/50UL	UL
Huawei (1905523)	5%	-2.44	0.61	NA	NA
	50%	0.02	0.84	0.06	5.22
	95%	-0.82	1	0.00	0.00
LGE (1907062)	5%	-	1.3	-	19.72
	50%	-	0.46	-	4.7
	95%	-	0.17	-	1.01
Ericsson (1906100)	5%	<1	<1	<1	<1
	50%	<1	<1	<1	<1
	95%	<1	<1	<1	<1
Nokia (1907604)	5%	0.1	0.3	3.7	26.7
	50%	-0.1	0.4	6.3	9.2
	95%	-0.1	-0.1	-7.5	0.4
Qualcomm (1906703)	5%	-	0.01	-	0.08
	50%	-	-0.06	-	-0.21
	95%	-	0.10	-	0

Table 5.3.4.7.1-2: SINR and throughput degradation for Indoor aggressor Indoor victim (low traffic)

Source	Observation Point	Victim DL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	UL	50DL/50UL	UL
LGE (1907062)	5%	-	0.16	-	2.61
	50%	-	-0.02	-	0.19
	95%	-	-0.09	-	0.55

5.3.4.8 Scenario 16: 30 GHz Indoor → Indoor (UL)

5.3.4.8.1 Results

Table 5.3.4.8.1-1: SINR and throughput degradation for Indoor aggressor Indoor victim

Source	Observation Point	Victim UL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	DL	50DL/50UL	DL
Huawei (1905523)	5%	-1.5532	0.3189	NA	NA
	50%	-0.2514	0.0858	-2.19	0.75
	95%	-0.0048	-0.0026	-0.03	-0.02
LGE (1907062)	5%	-	-0.13	-	-2.17
	50%	-	-0.11	-	-1.1
	95%	-	-0.09	-	-0.55
Ericsson (1906100)	5%	1,1	2,6	12	19
	50%	1,6	4,1	17	32
	95%	1,1	2,5	11	23
Nokia (1907604)	5%	1.7	3	8.8	49.4
	50%	-0.1	0.8	-0.7	9.9
	95%	0	-0.5	1.5	-1.1

Table 5.3.4.8.1-2: SINR and throughput degradation for Indoor aggressor Indoor victim (low traffic)

Source	Observation Point	Victim UL			
		SNR degradation (dB)		Throughput degradation (%)	
		50DL/50UL	DL	50DL/50UL	DL
LGE (1907062)	5%	-	-0.12	-	-1.98
	50%	-	-0.08	-	-0.78
	95%	-	-0.04	-	-0.27

6 Summary and recommendations

6.1 Zero grid shift

As discussed in Annex B, for zero grid shift, RX blocking (and hence zero UL throughput) occurs at the victim base station during subframes in which a co-located aggressor BS transmits in all scenarios.

6.2 Summary of results for 100% grid shift

6.2.1 FR1

For the evaluated adjacent channel for FR1 scenarios, the following observations have been made for Cross link interference (CLI) based on different traffic conditions (full buffer and low traffic mode) and different BS Tx power levels without any RF requirement change or interference mitigation:

6.2.1.1 Macro-to-Macro scenario

- For BS to BS interference, performance degradation was observed in adjacent channel.
- No performance degradation relating to ACLR/ACS due to UE to UE interference was observed in adjacent channel.

6.2.1.2 Indoor-to-Macro scenario

- For BS to BS interference and UE to UE interference, no performance degradation relating to ACLR/ACS was observed in adjacent channel.

6.2.1.3 Indoor-to-Indoor scenario

- For BS to BS interference, no performance degradation was observed in adjacent channel based on both full buffer and low traffic mode provided that the BS and UE have similar power.
- When higher BS transmission power is assumed, some performance degradation was observed for BS to BS interference.
- For UE to UE interference, no performance degradation relating to ACLR/ACS was observed in adjacent channel based on both full buffer and low traffic mode.

6.2.1.4 Macro-to-Indoor scenario

- For BS to BS interference, no performance degradation was observed in adjacent channel.
- For UE to UE interference, performance degradation was observed in adjacent channel by some companies.

It is noted that there may be a possibility of UE blocking occurring but this was not investigated as the studies in this WI are focused on ACLR/ACS co-existence impact.

6.2.2 FR2

For the evaluated adjacent channel for FR2 scenarios, the following observations have been made for Cross link interference (CLI) based on different traffic conditions (full buffer and low traffic mode) and different BS Tx power levels without any RF requirement change or interference mitigation:

6.2.2.1 Macro-to-Macro scenario

- For BS to BS interference, some performance degradation was observed in adjacent channel with 100% grid shift. The extent of the observed degradation varied from minor to significant between companies. The degradations increase with lower grid shift and decrease with lower output power.
- For UE to UE interference, no performance degradation relating to ACLR/ACS was observed in adjacent channel.

6.2.2.2 Indoor-to-Macro scenario

- For BS to BS interference and UE to UE interference, no performance degradation was observed in adjacent channel.

6.2.2.3 Indoor-to-Indoor scenario

- For BS to BS interference, some results showed no performance degradation in the adjacent channel, and other results showed performance degradation. The performance degradation has some dependency on how power control is operated.
- For UE to UE interference, no performance degradation relating to ACLR/ACS was observed in adjacent channel based on both full buffer and low traffic mode.

6.2.2.4 Micro-to-Micro scenario

- Simulations were performed by 3 companies the results for BS-BS interference were contradictory as summarized below:
    - no performance degradation relating to ACLR/ACS was observed.

- Significant BS to BS interference was observed relating to ACLR/ACS observed.

- All results showed that there was no UE to UE interference relating to ACLR/ACS.

- Some deployments in which the micro is close to the victim may cause losses in a victim network, but this is lost in the statistics. Operators may need to take care about the distance between micros in close range.

It is noted that there may be a possibility of UE blocking occurring but this was not investigated as the studies in this WI are focused on ACLR/ACS co-existence impact.

6.3 Recommendations

6.3.1 FR1

6.3.1.1 Macro-to-Macro scenario

- Performance degradation was observed from the BS-to-BS interference for macro-macro scenario, which suggests that dynamic TDD should not be operated in such scenarios.

6.3.1.2 Indoor scenarios (Indoor-to-Macro and Indoor-to-Indoor)

- Performance degradations were not observed from operating dynamic TDD between an indoor network and a macro network and vice versa if there is sufficient isolation between them. No significant impact from operating dynamic TDD for the indoor scenario was observed as long as the BS and UE powers are similar and the operators co-ordinate so that basestation positions are offset. If higher BS power is assumed, some throughput degradation in the indoor scenario was observed due to BS to BS interference. The observations imply that dynamic TDD can be used in indoors as long as care is taken.

6.3.2 FR2

6.3.2.1 Macro-to-Macro scenario

- Some performance degradation was observed from the BS-to-BS interference for macro-macro scenario. The differences in the simulation results imply that operating dynamic TDD in this scenario without impact to neighbor network may be deployment dependent and requires at least careful planning and collaboration between operators to avoid performance impact.

6.3.2.2 Indoor scenarios (Indoor-to-Macro and Indoor-to-Indoor)

- Performance degradations were not observed from operating dynamic TDD between an indoor network and a macro network if there is sufficient isolation between them. Results suggested that to avoid degradation, careful layout and parameterization are necessary for indoor to indoor scenario. Overall, the observations imply that dynamic TDD can be used indoors as long as care is taken.

6.3.2.3 Micro-to-Micro scenario

- For micro to micro, the differences in the simulation results imply that to avoid BS to BS interference, operators may need to consider the proximity of micro BS in the same area. Overall, the observations imply that dynamic TDD can be used in certain micro deployments as long as care is taken.

Annex A:
Detailed simulation results for non-zero grid shift

A.1 FR1

A.1.1 Scenario 1: 4GHz Macro → Macro (DL)

A.1.1.1 Ericsson

A.1.1.1.1 100% utilization

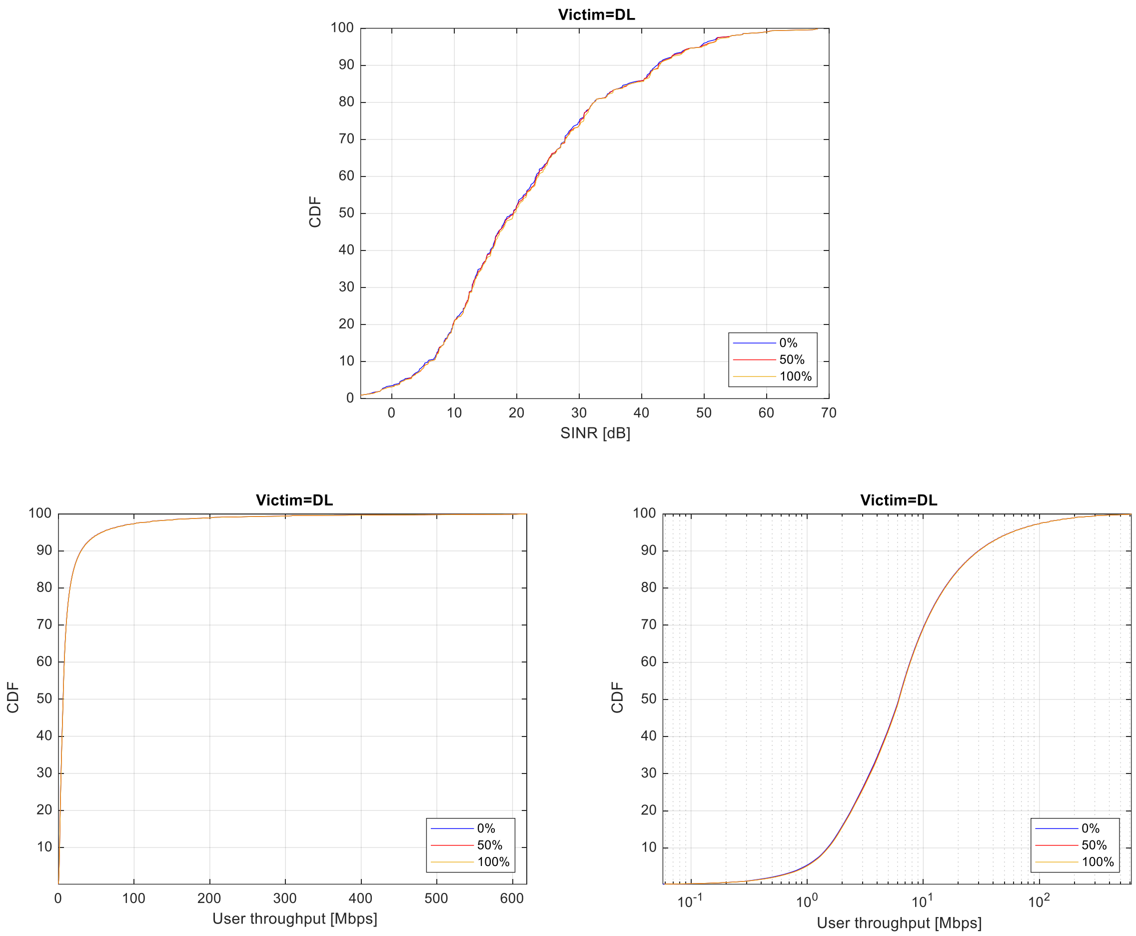


Figure A.1.1.1.1-1: DL SINR and throughput CDFs with 100% grid shift, 500m ISD

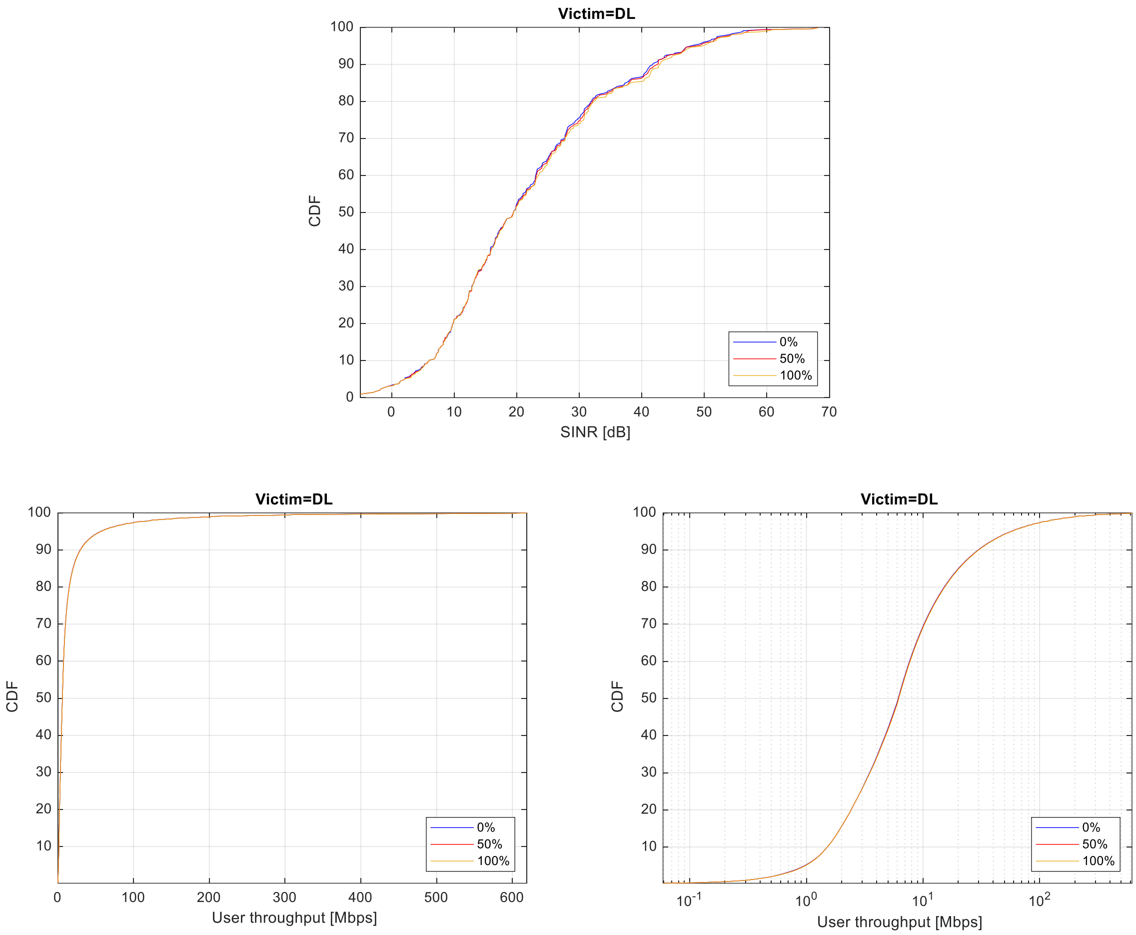


Figure A.1.1.1.1-2: DL throughput CDFs with 50% grid shift, 500m ISD

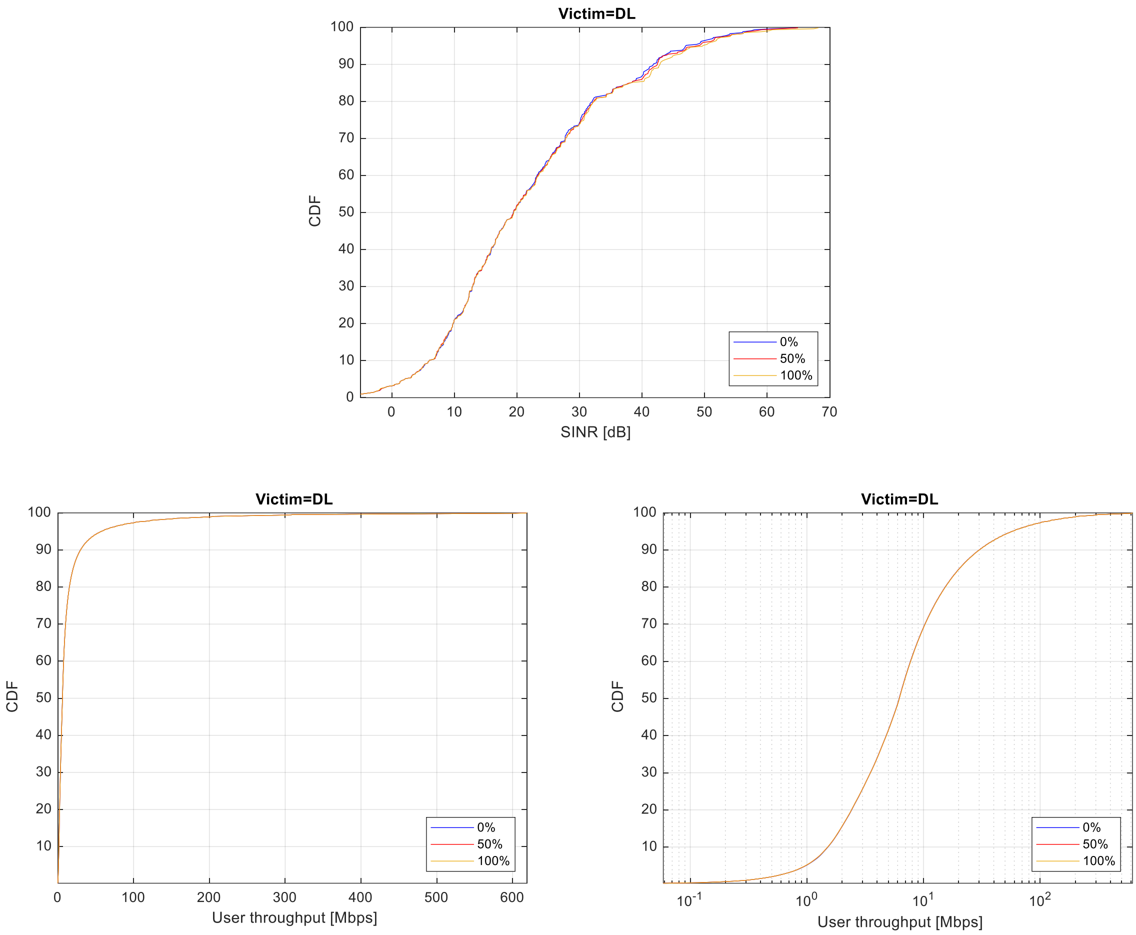


Figure A.1.1.1.1-3: DL SINR and throughput CDFs with 10% grid shift, 500m ISD

A.1.1.1.2 50% utilization

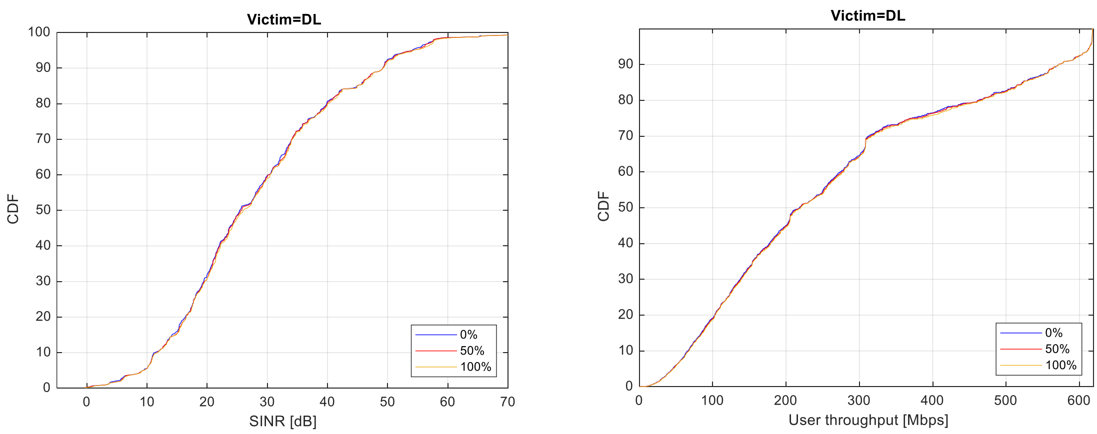


Figure A.1.1.1.2-1: DL SINR and throughput CDFs with 100% grid shift, 500m ISD

A.1.1.1.3 10% utilization

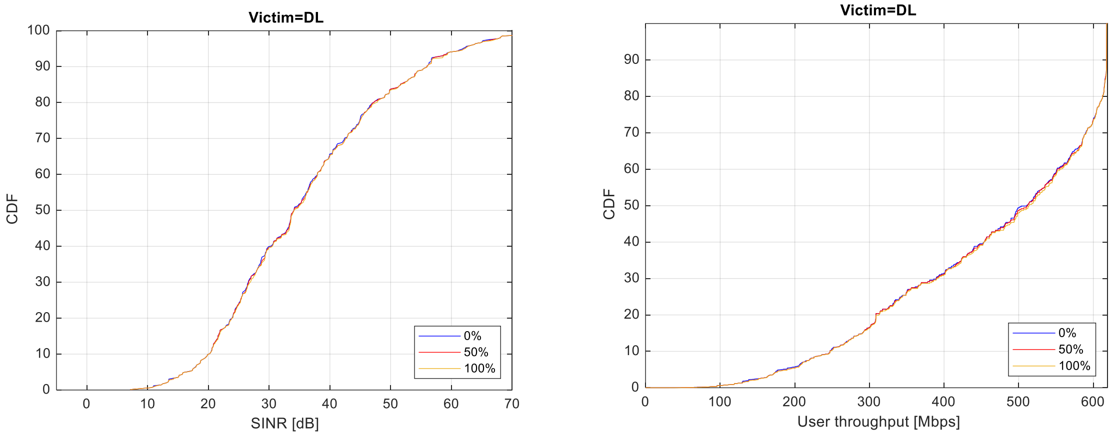


Figure A.1.1.1.3-1: DL SINR CDF with 100% grid shift, 500m ISD.

A.1.1.2 Huawei

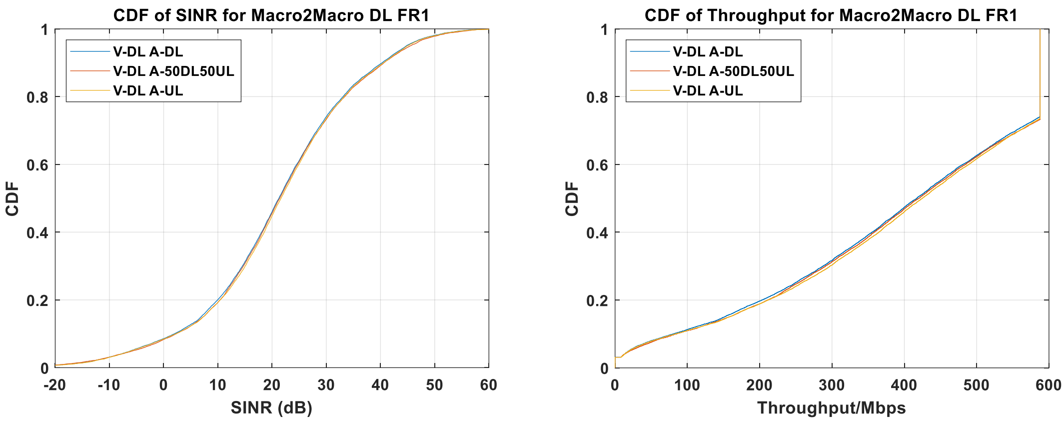


Figure A.1.1.2-1: CDF of DL SINR and throughput from Huawei

A.1.1.3 LGE

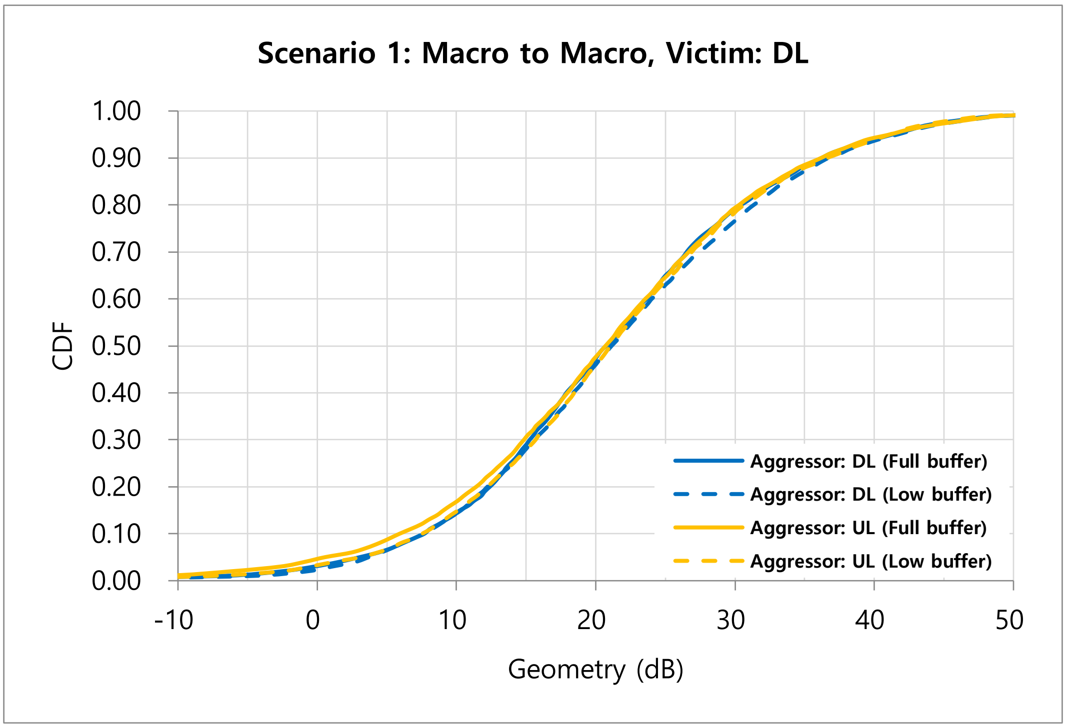


Figure A.1.1.3-1: Macro-to-Macro SINR result (victim: DL)

A.1.1.4 Qualcomm

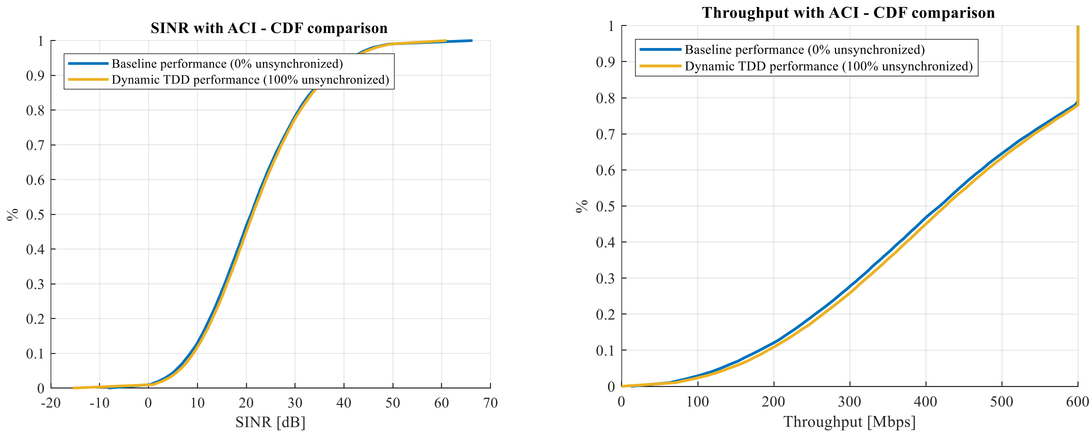


Figure A.1.1.4-1: Comparison of SINR and throughput performance with ACI in UMa-to-UMa scenario

A.1.2 Scenario 2: 4GHz Macro → Macro (UL)

A.1.2.1 Ericsson

A.1.2.1.1 100% grid shift

A.1.2.1.1.1 100% utilization

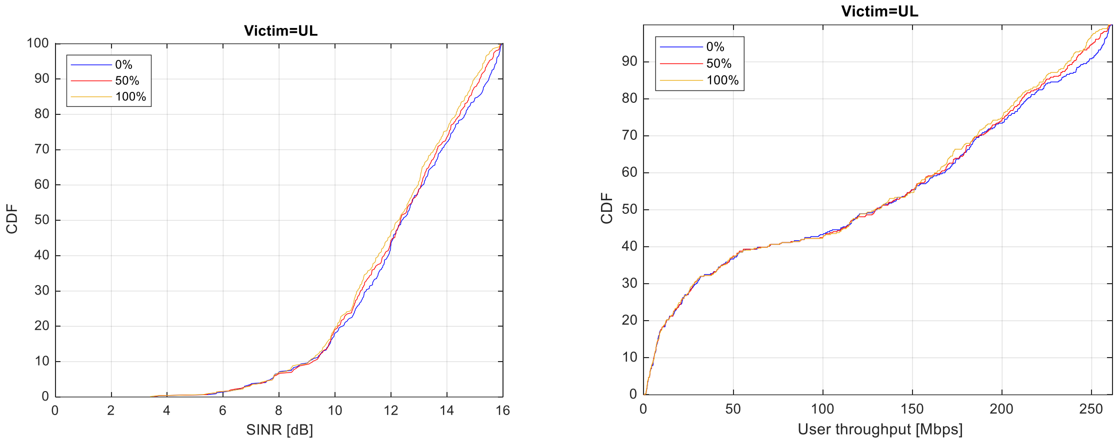


Figure A.1.2.1.1.1-1: UL SINR and throughput CDFs with 100% grid shift, 500m ISD.

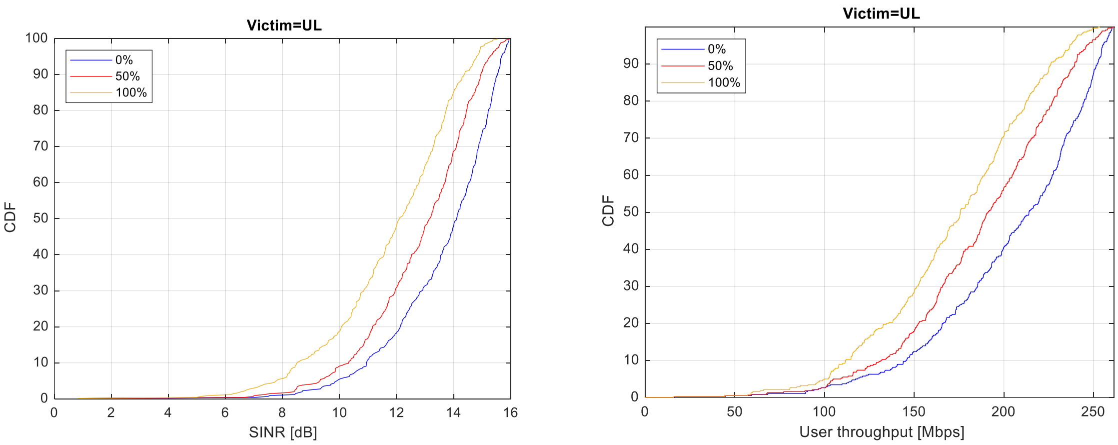


Figure A.1.2.1.1.1-2: UL SINR and throughput CDFs with 100% grid shift, 200m ISD

A.1.2.1.1.2 50% utilization

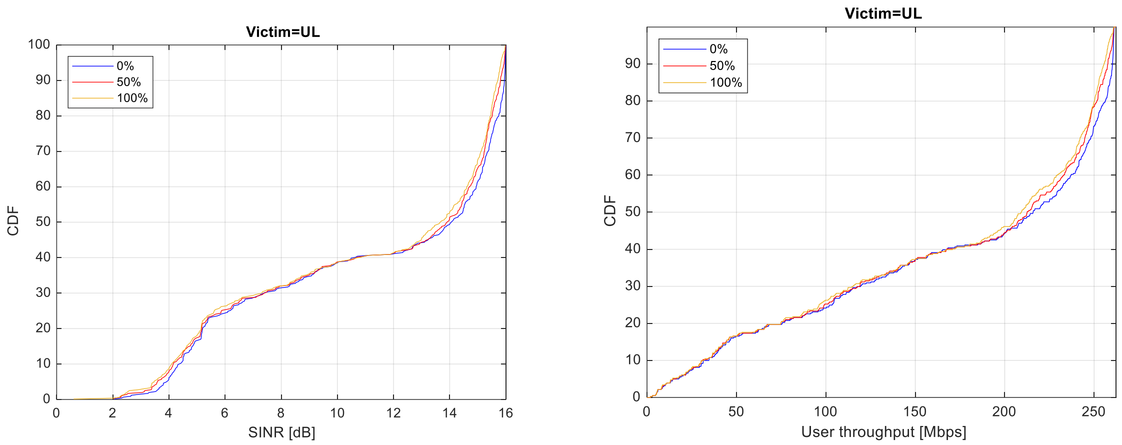


Figure A.1.2.1.1.2-1: UL SINR and throughput CDFs with 100% grid shift, 500m ISD

A.1.2.1.1.3 10% utilization

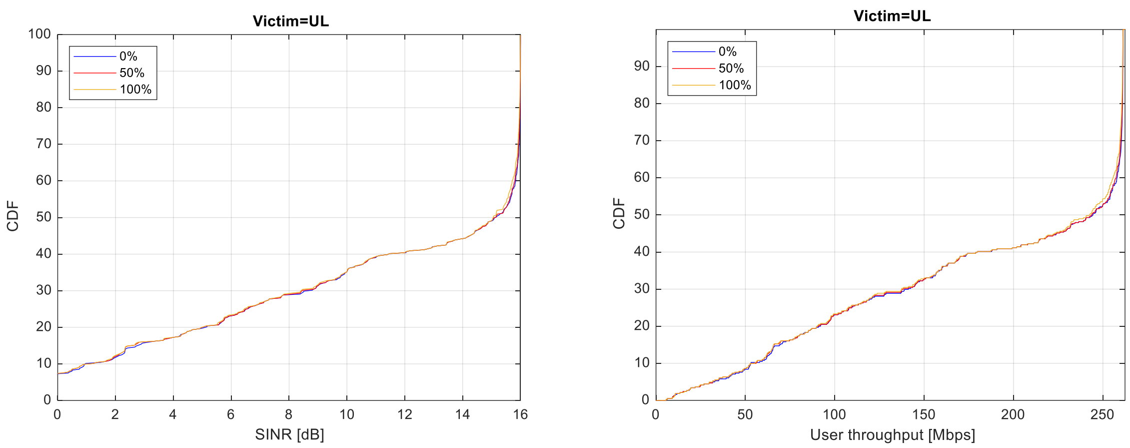


Figure A.1.2.1.1.3-1: UL SINR and throughput CDFs with 100% grid shift, 500m ISD.

A.1.2.1.2 Other grid shifts

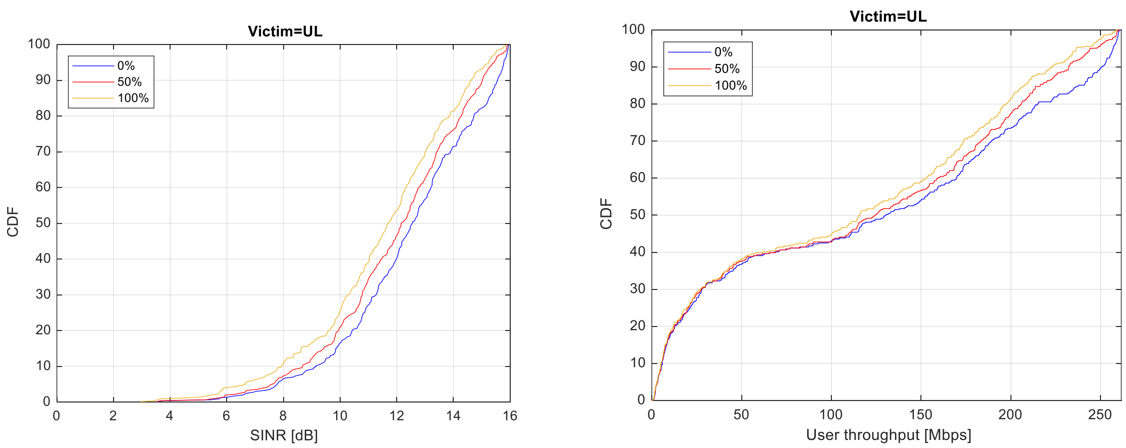


Figure A.1.2.1.2-1: UL SINR and throughput CDFs with 50% grid shift, 500m ISD.

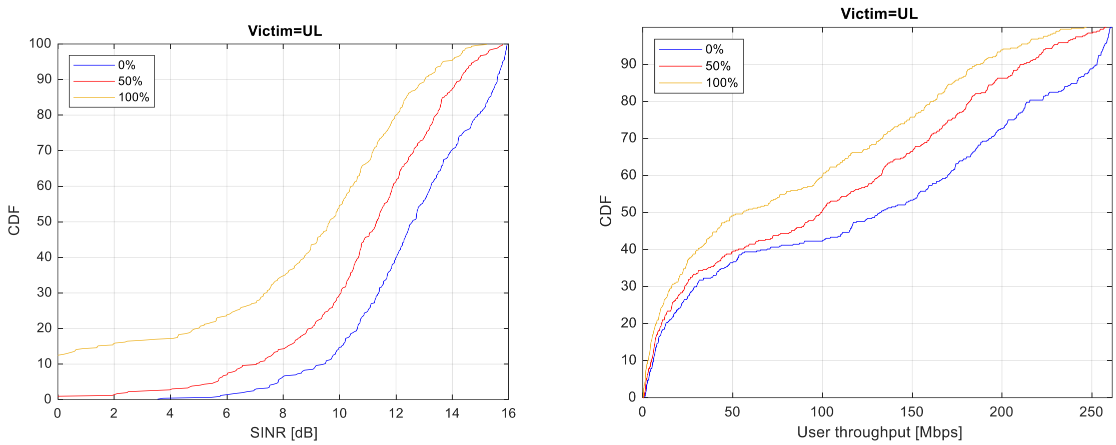


Figure A.1.2.1.2-2: UL SINR and throughput CDFs with 10% grid shift, 500m ISD.

A.1.2.2 Huawei

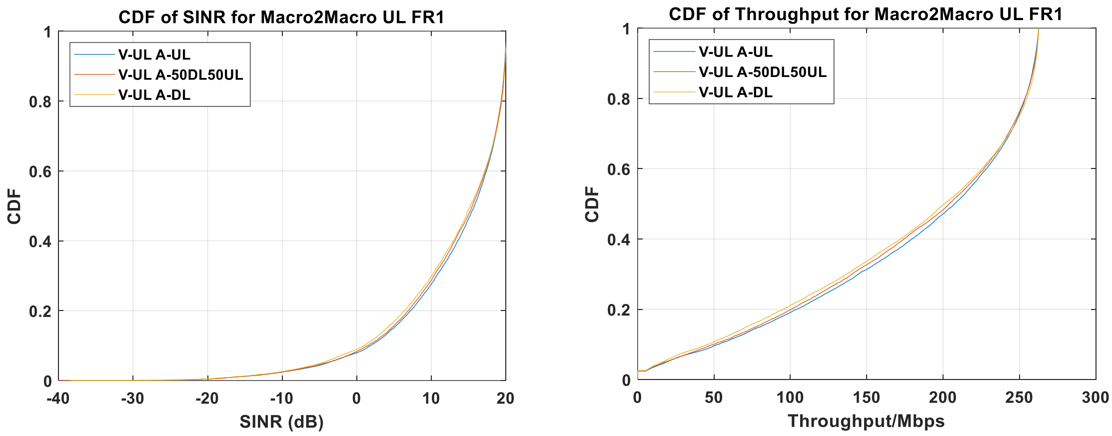


Figure A.1.2.2-1: CDF of UL SINR and throughput from Huawei

A.1.2.3 LGE

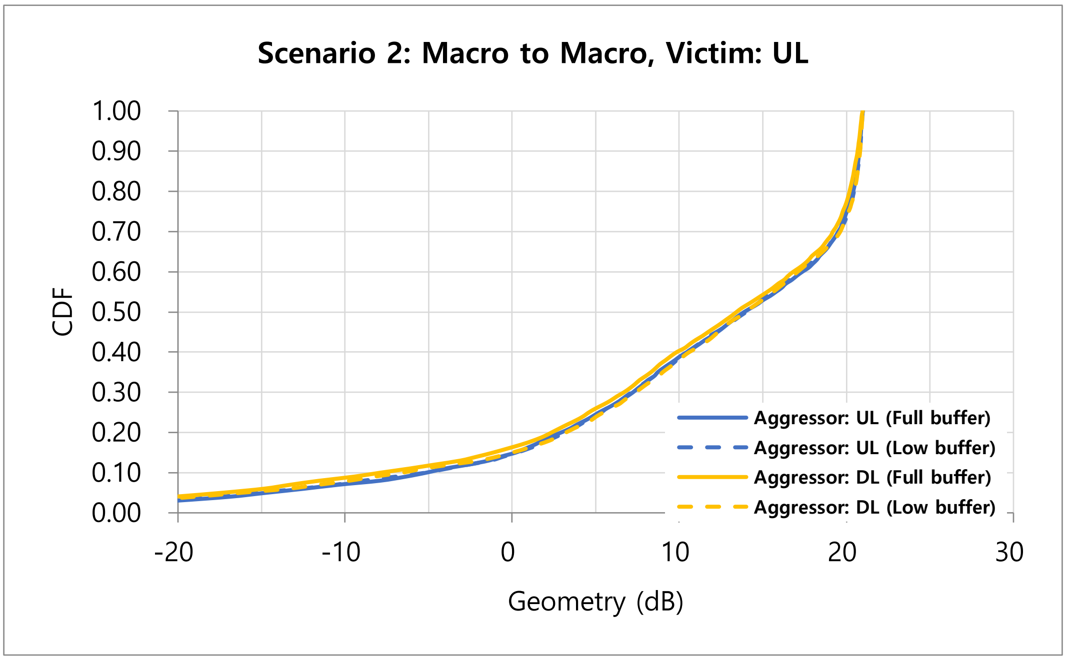


Figure A.1.2.3-1: Macro-to-Macro SINR result (victim: UL)

A.1.3 Scenario 3: 4GHz Macro → Indoor (UL)

A.1.3.1 Huawei

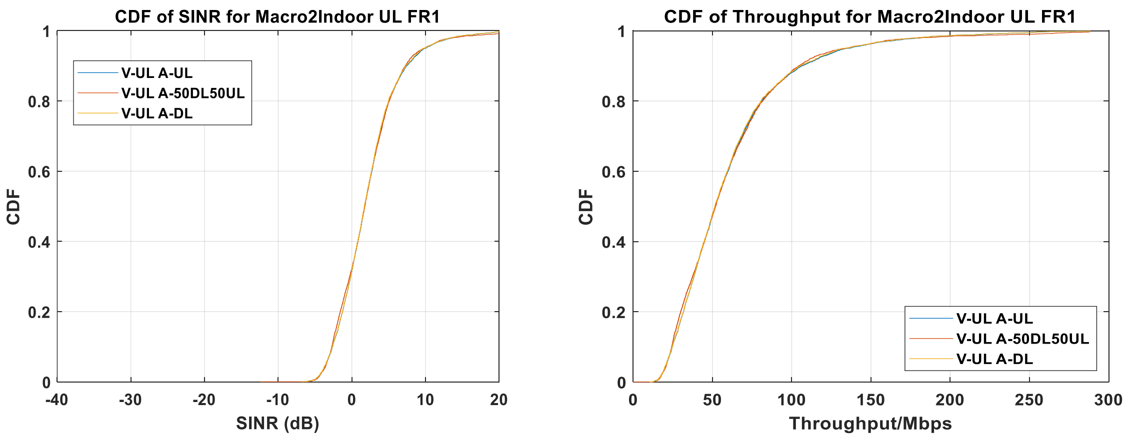


Figure A.1.3.1-1: CDF of UL SINR and throughput from Huawei

A.1.3.2 Nokia

A.1.3.2.1 Full buffer

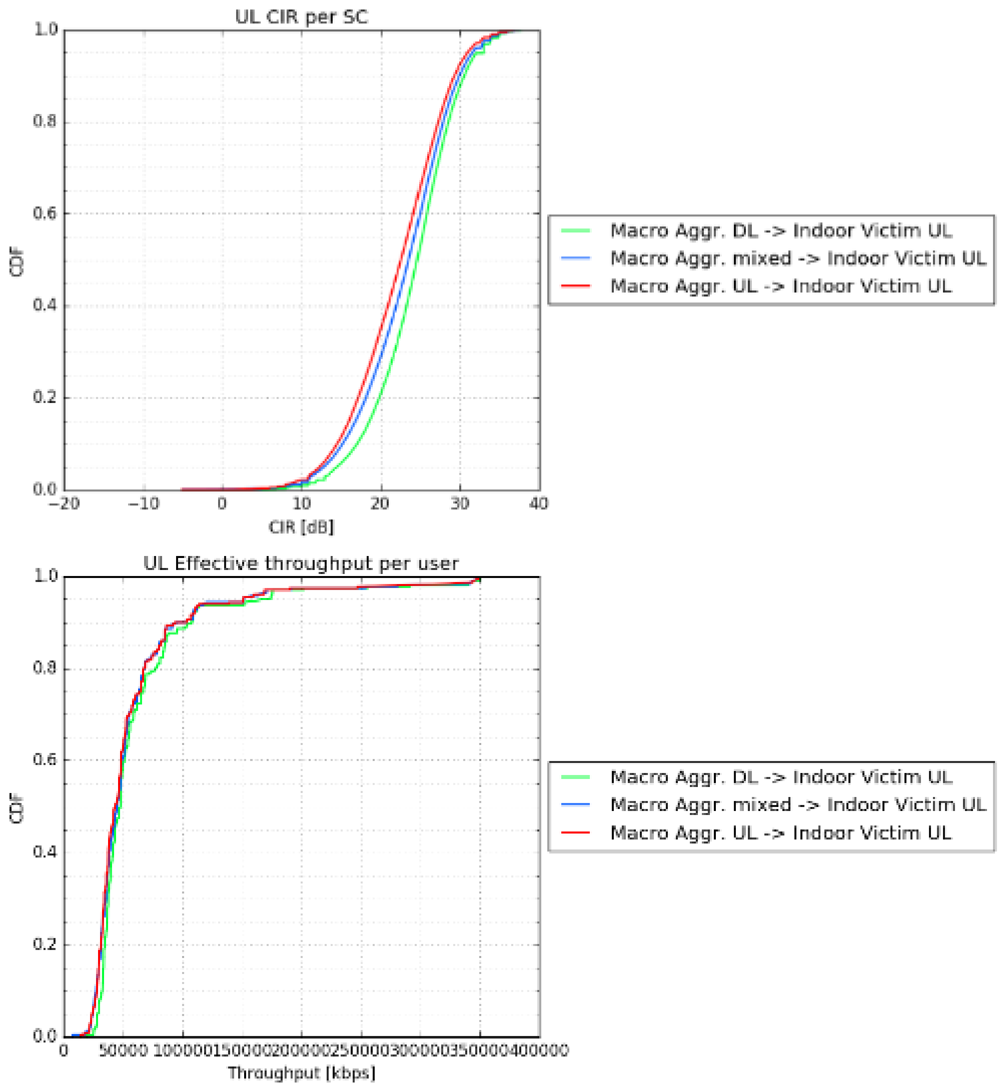


Figure A.1.3.2.1-1: SINR (top) and throughput (bottom) degradation for Macro aggressor Indoor UL victim (full buffer)

A.1.3.2.2 FTP3 with 10% load

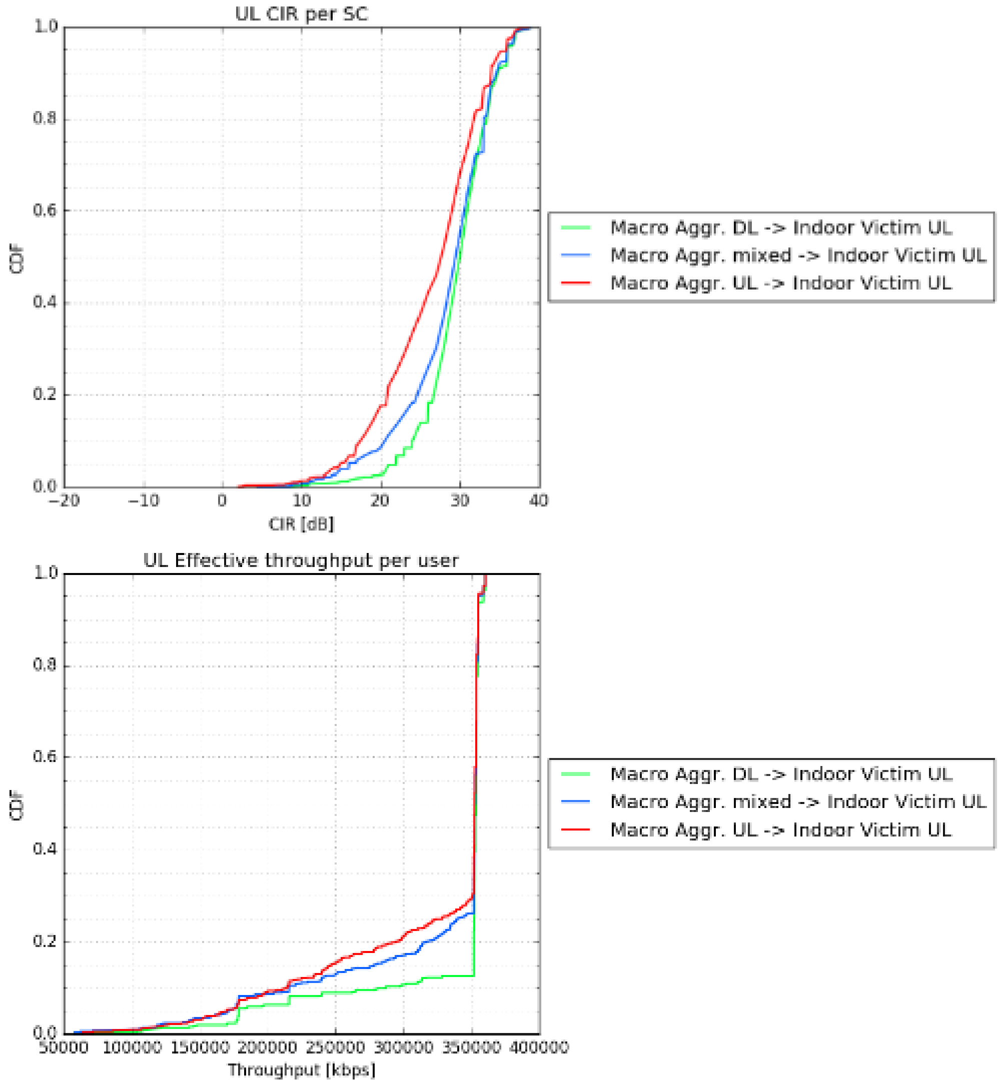


Figure A.1.3.2.2-1: SINR (top) and throughput (bottom) degradation for Macro aggressor Indoor UL victim, 10% traffic

A.1.4 Scenario 4: 4GHz Macro → Indoor (DL)

A.1.4.1 Huawei

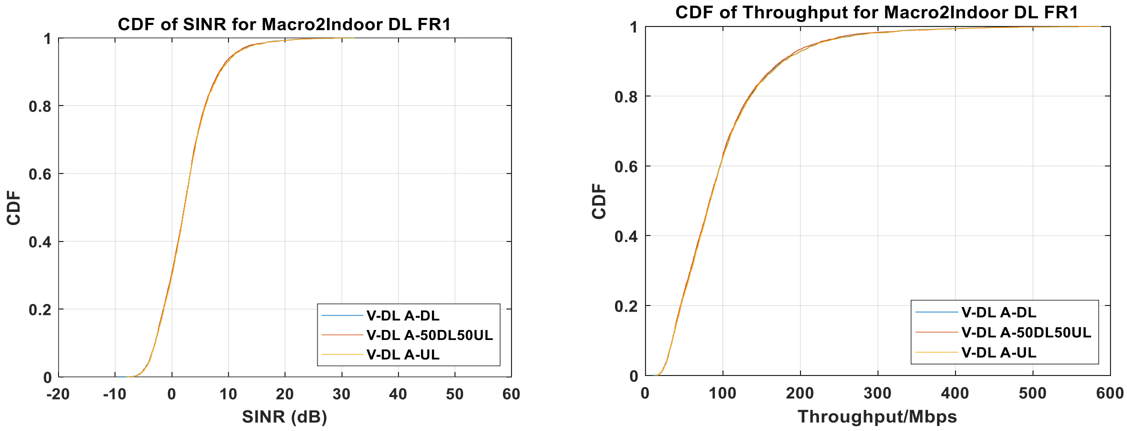


Figure A.1.4.1-1: CDF of DL SINR and throughput from Huawei

A.1.4.2 Nokia

A.1.4.2.1 Full buffer

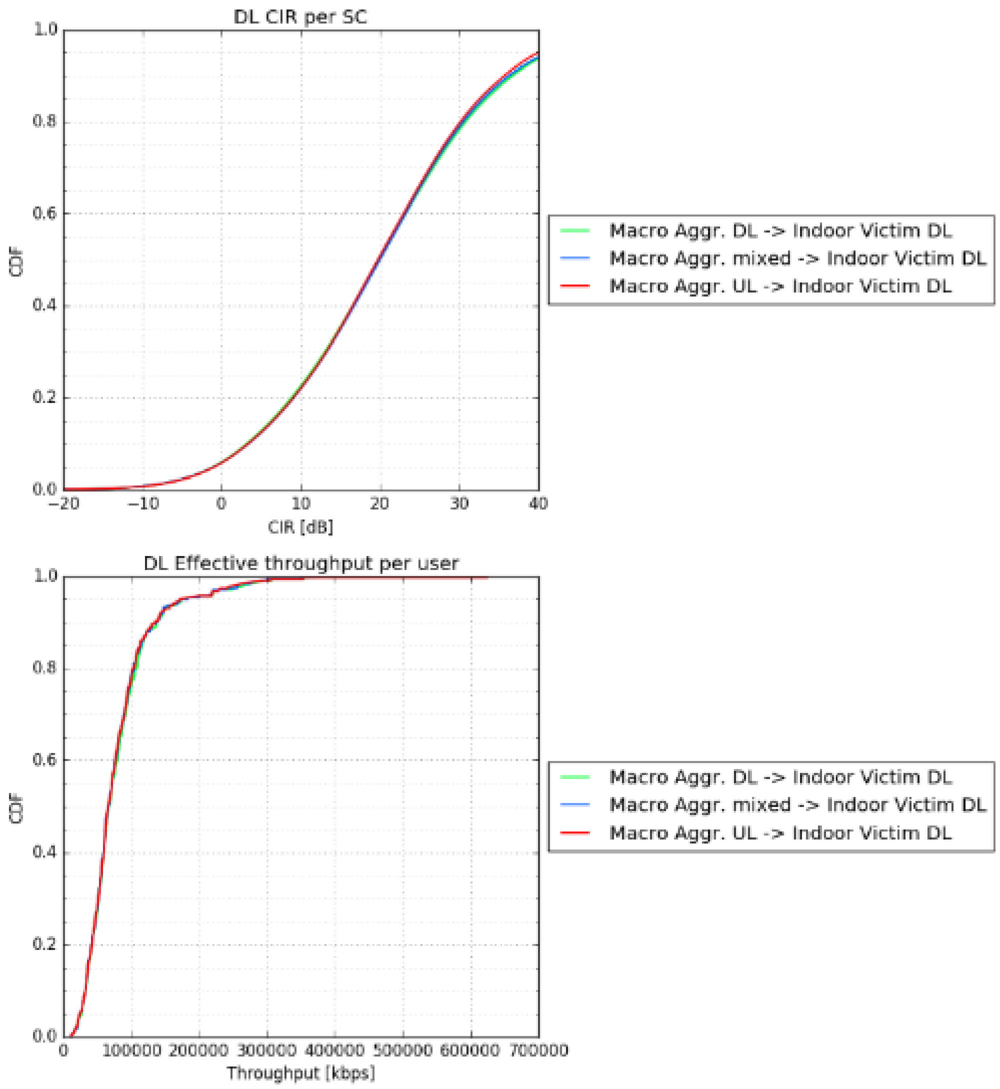


Figure A.1.4.2.1-1: SINR (top) and throughput (bottom) degradation for Macro aggressor Indoor DL victim**, full buffer traffic**

A.1.4.2.2 FTP3 with 10% load

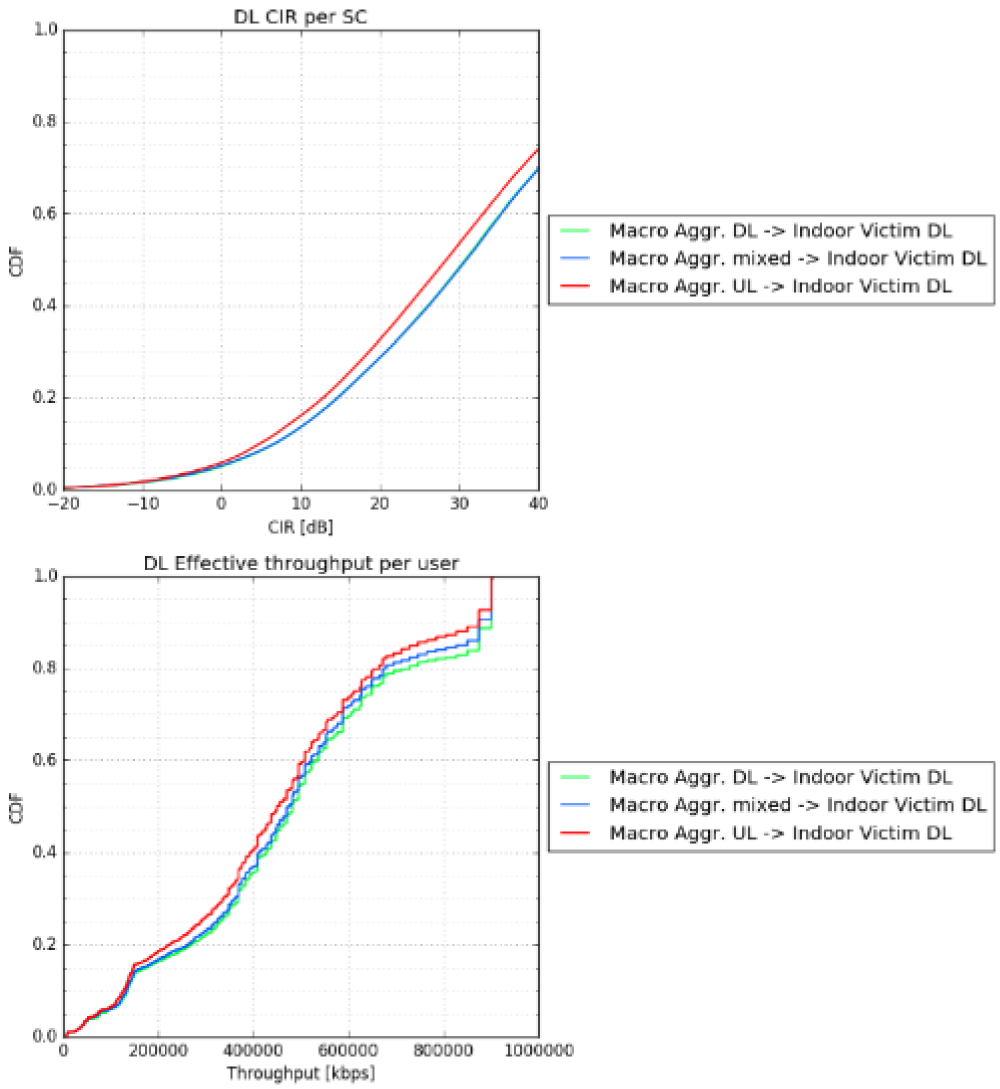


Figure A.1.4.2.2-1: SINR (top) and throughput (bottom) degradation for Macro aggressor Indoor DL victim, 10% traffic

A.1.4.3 Qualcomm

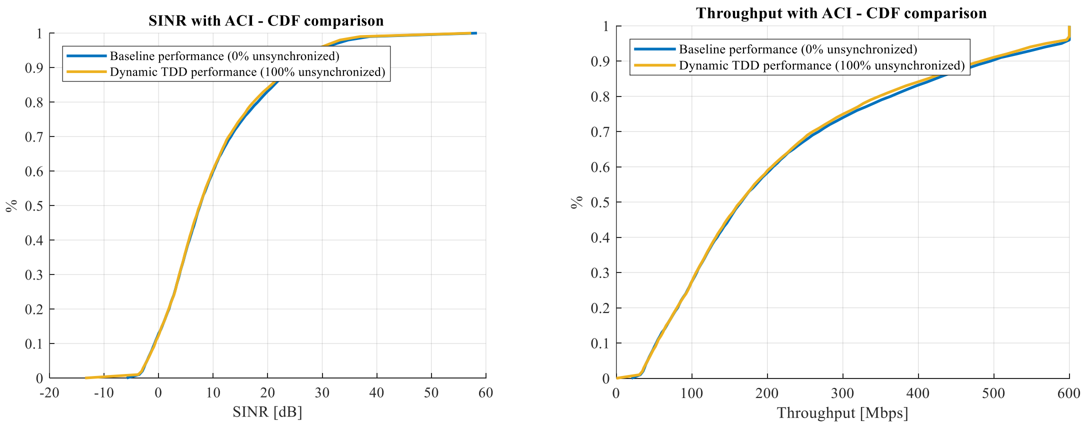
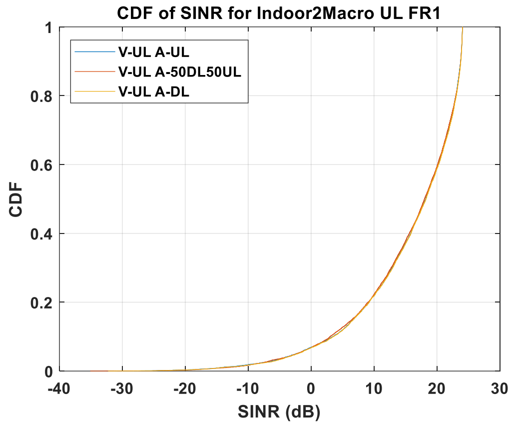


Figure A.1.4.3-1: Comparison of SINR and throughput performance with ACI in UMa-to-InH scenario

A.1.5 Scenario 5: 4GHz Indoor → Macro (UL)

A.1.5.1 Huawei



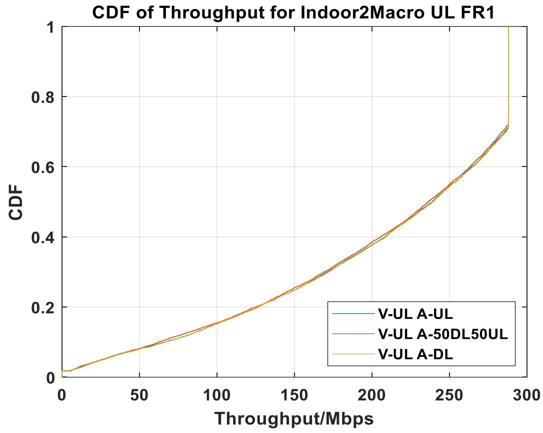


Figure A.1.5.1-1: CDF of UL SINR and throughput from Huawei

A.1.5.2 LGE

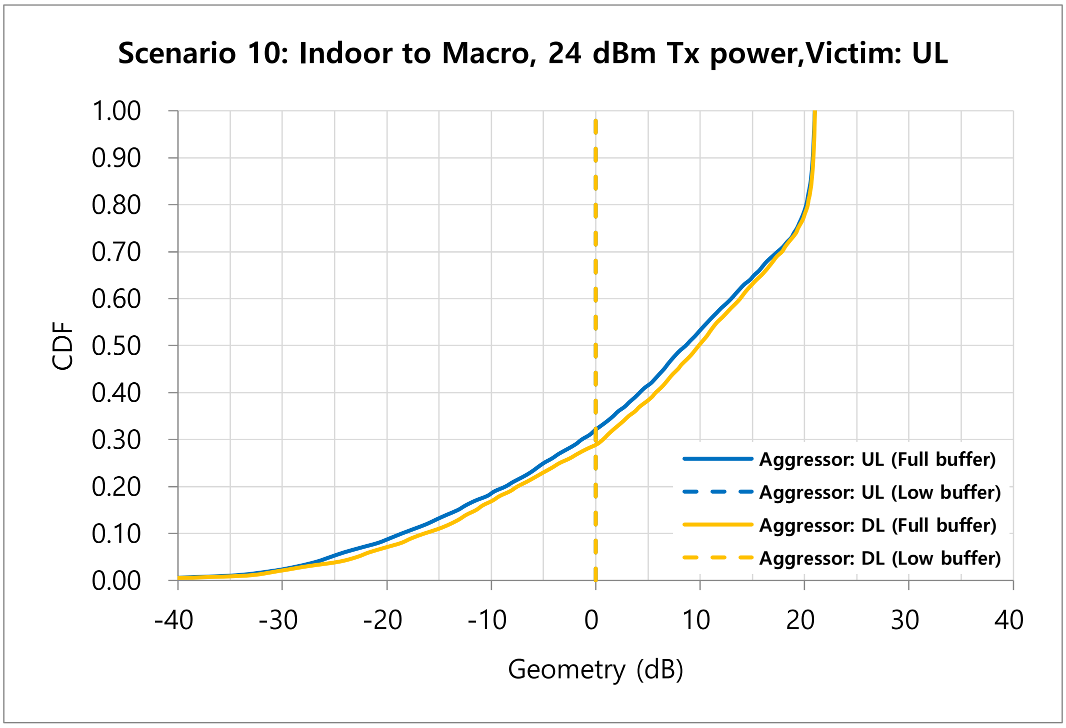


Figure A.1.5.2-1: Indoor-to-Macro (victim: UL) SINR result (24 dBm Tx power)

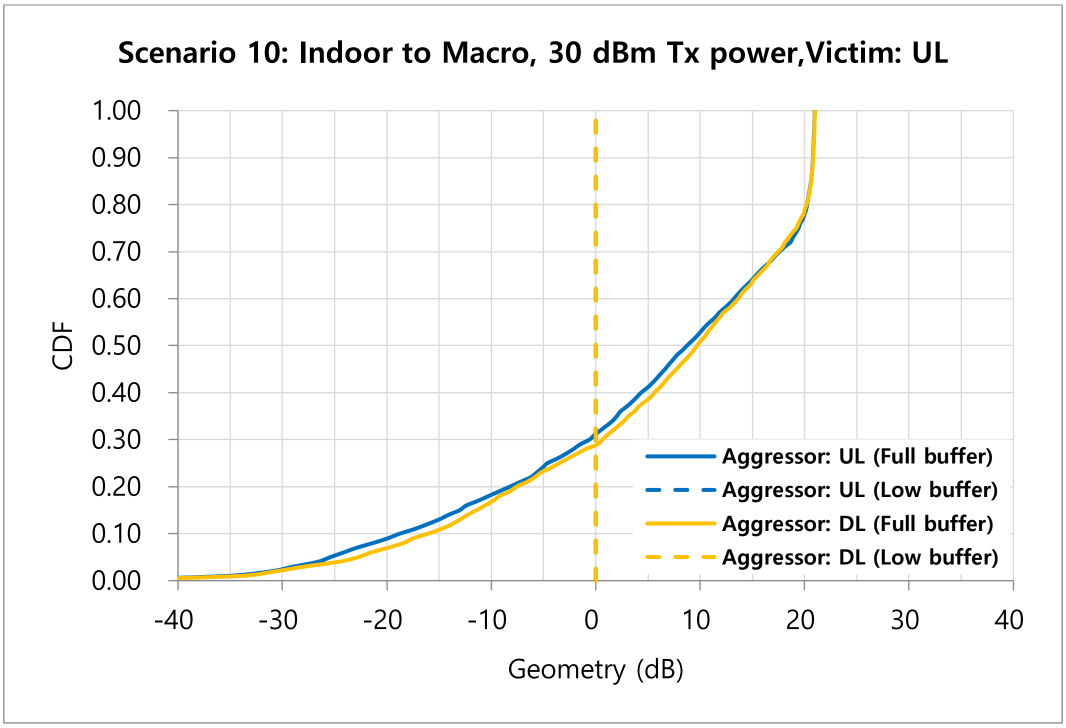


Figure A.1.5.2-2: Indoor-to-Macro (victim: UL) SINR result (30 dBm Tx power)

A.1.5.3 Nokia

A.1.5.3.1 Full buffer

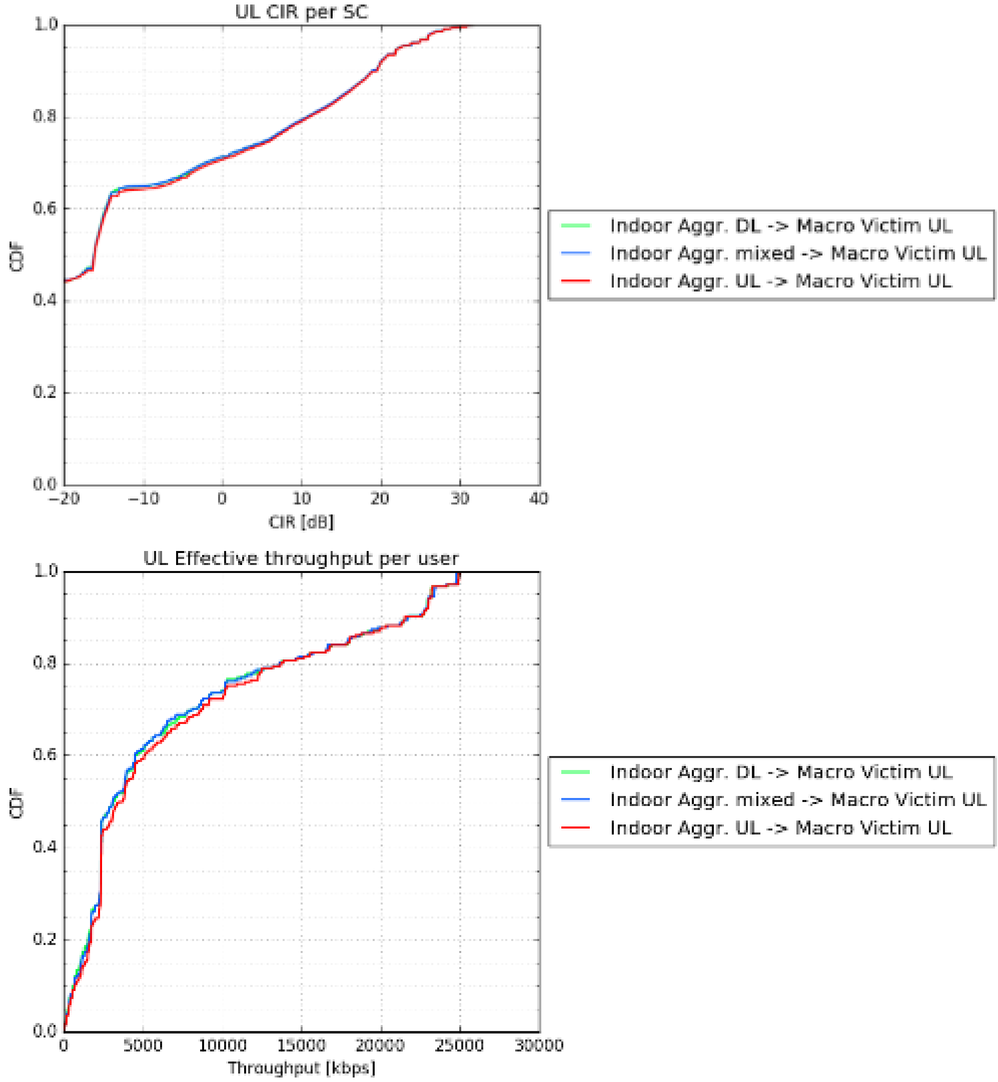


Figure A.1.5.3.1-1: SINR (top) and throughput (bottom) degradation for Indoor aggressor Macro UL victim, full buffer traffic

A.1.5.3.2 FTP3 with 10% load

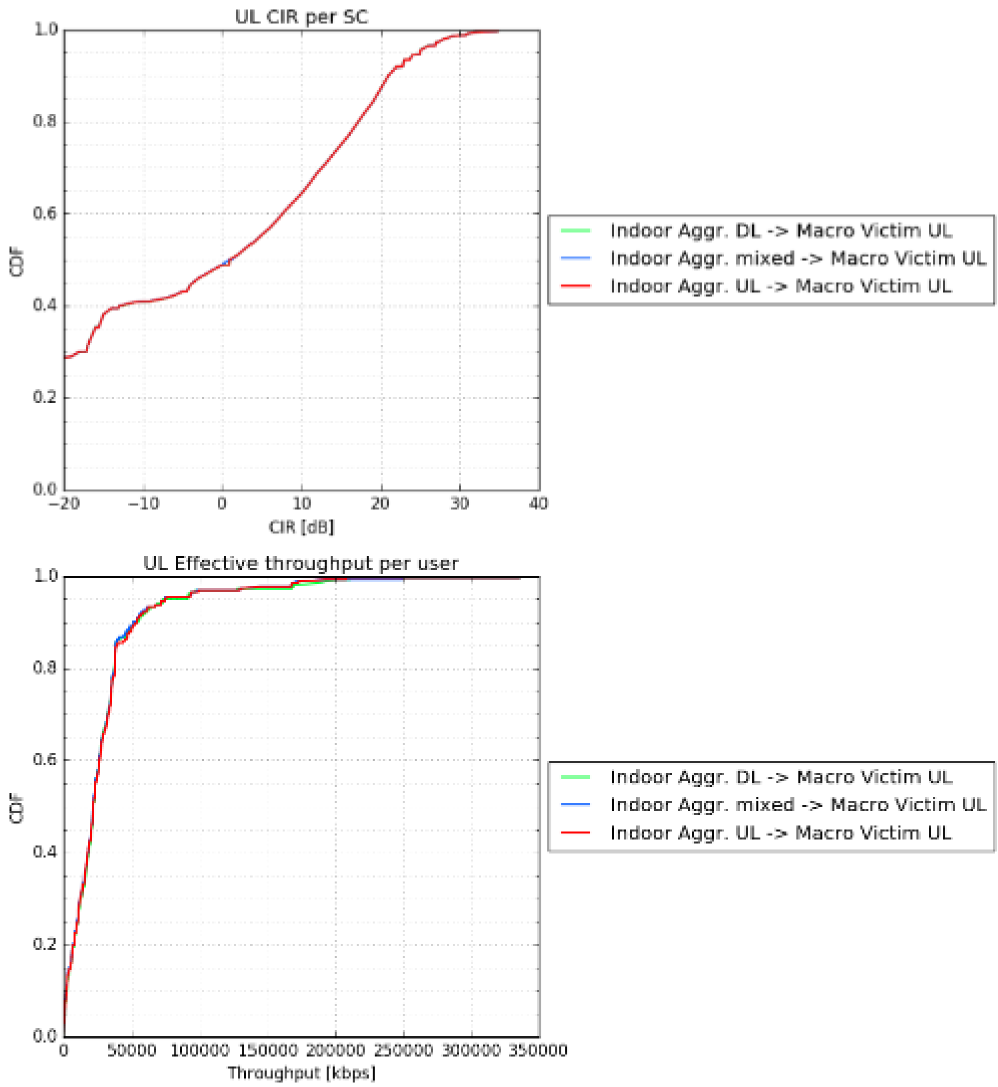


Figure A.1.5.3.2-1: SINR (top) and throughput (bottom) degradation for Indoor aggressor Macro UL victim, 10% traffic

A.1.6 Scenario 6: 4GHz Indoor → Macro (DL)

A.1.6.1 Huawei

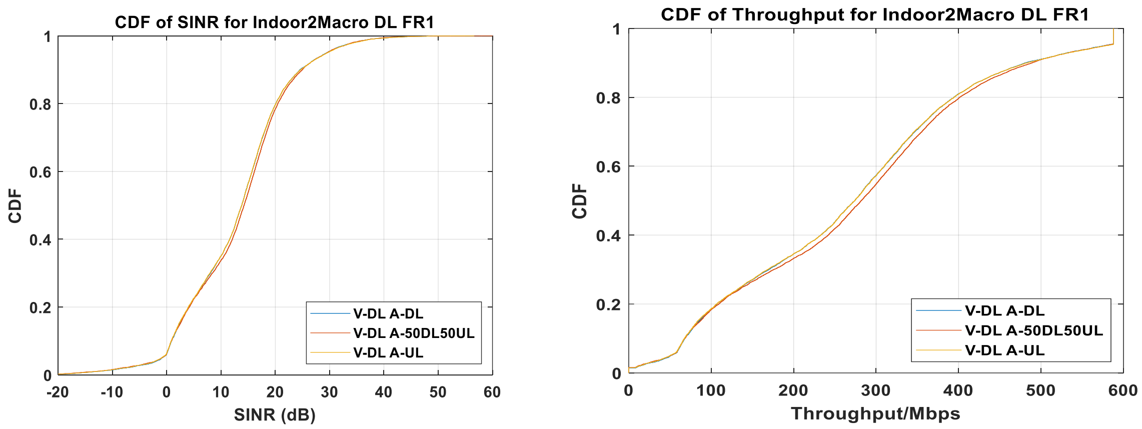


Figure A.1.6.1-1: CDF of DL SINR and throughput from Huawei

A.1.6.2 LGE

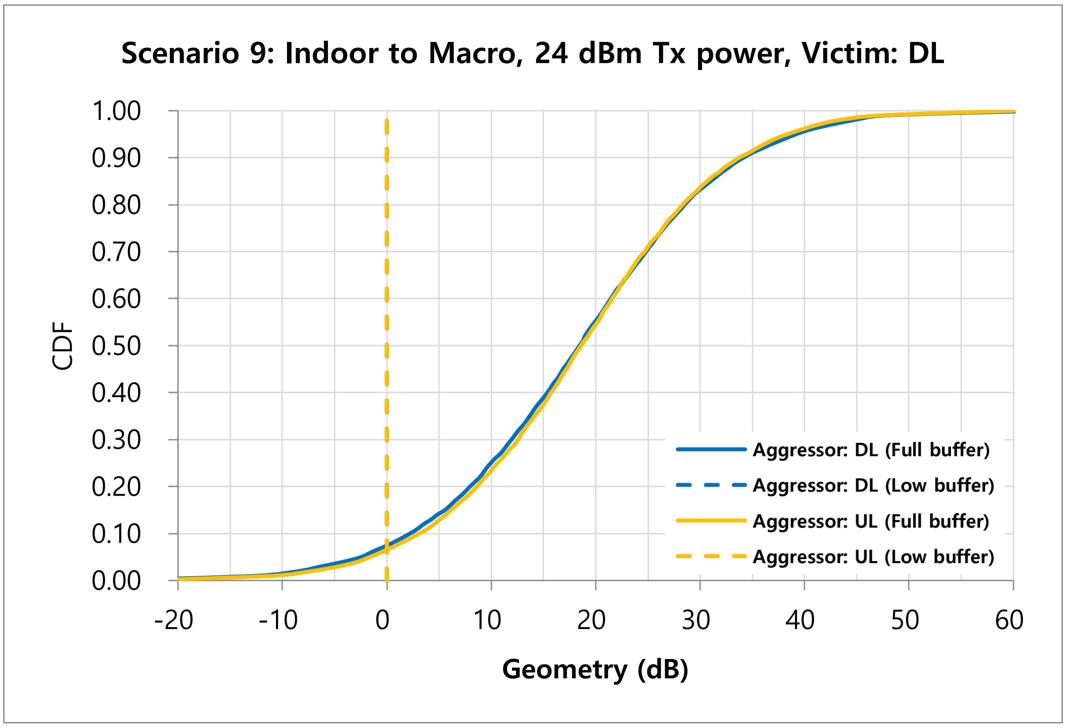


Figure A.1.6.2-1: Indoor-to-Macro (victim: DL) SINR result (24 dBm Tx power)

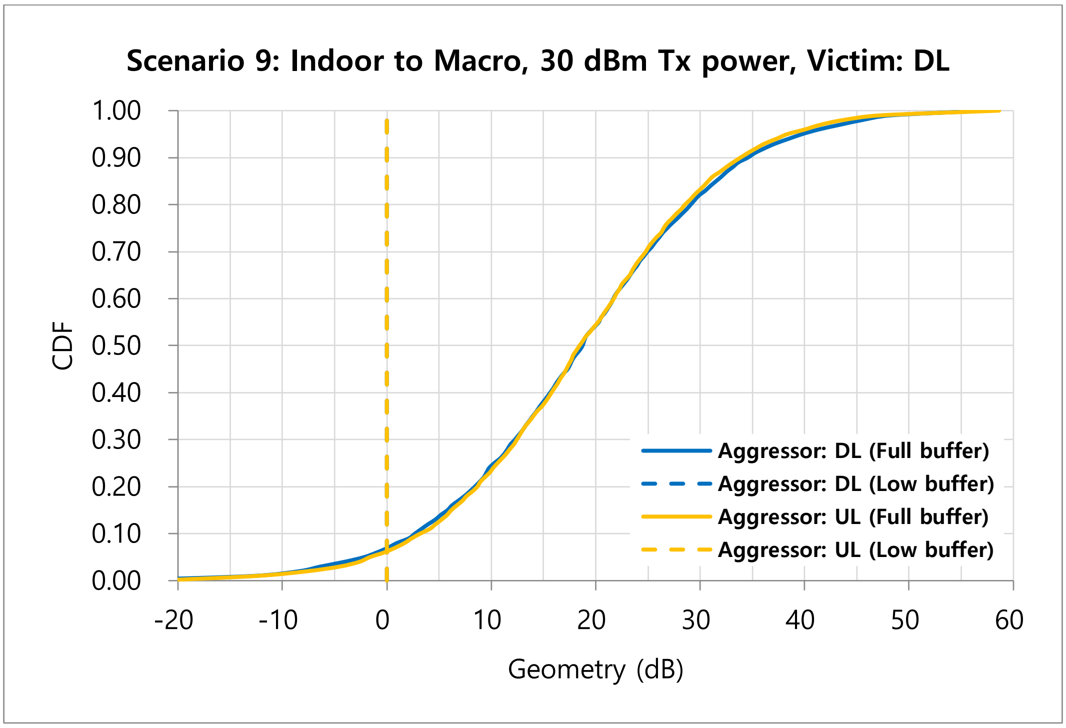


Figure A.1.6.2-2: Indoor-to-Macro (victim: DL) SINR result (30 dBm Tx power)

A.1.6.3 Nokia

A.1.6.3.1 Full buffer

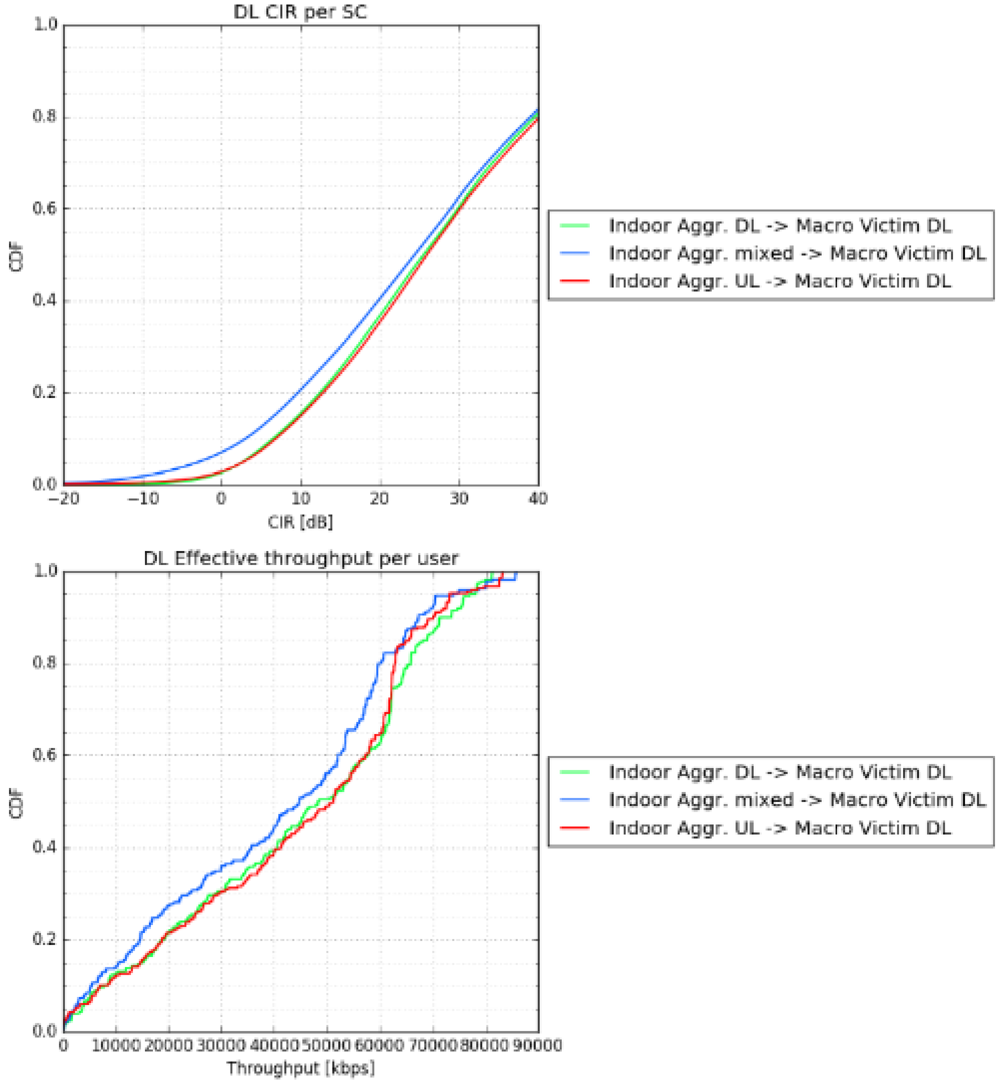


Figure A.1.6.3.1-1: SINR (top) and throughput (bottom) degradation for Indoor aggressor Macro DL victim, full buffer traffic

A.1.6.3.2 FTP3 with 10% load

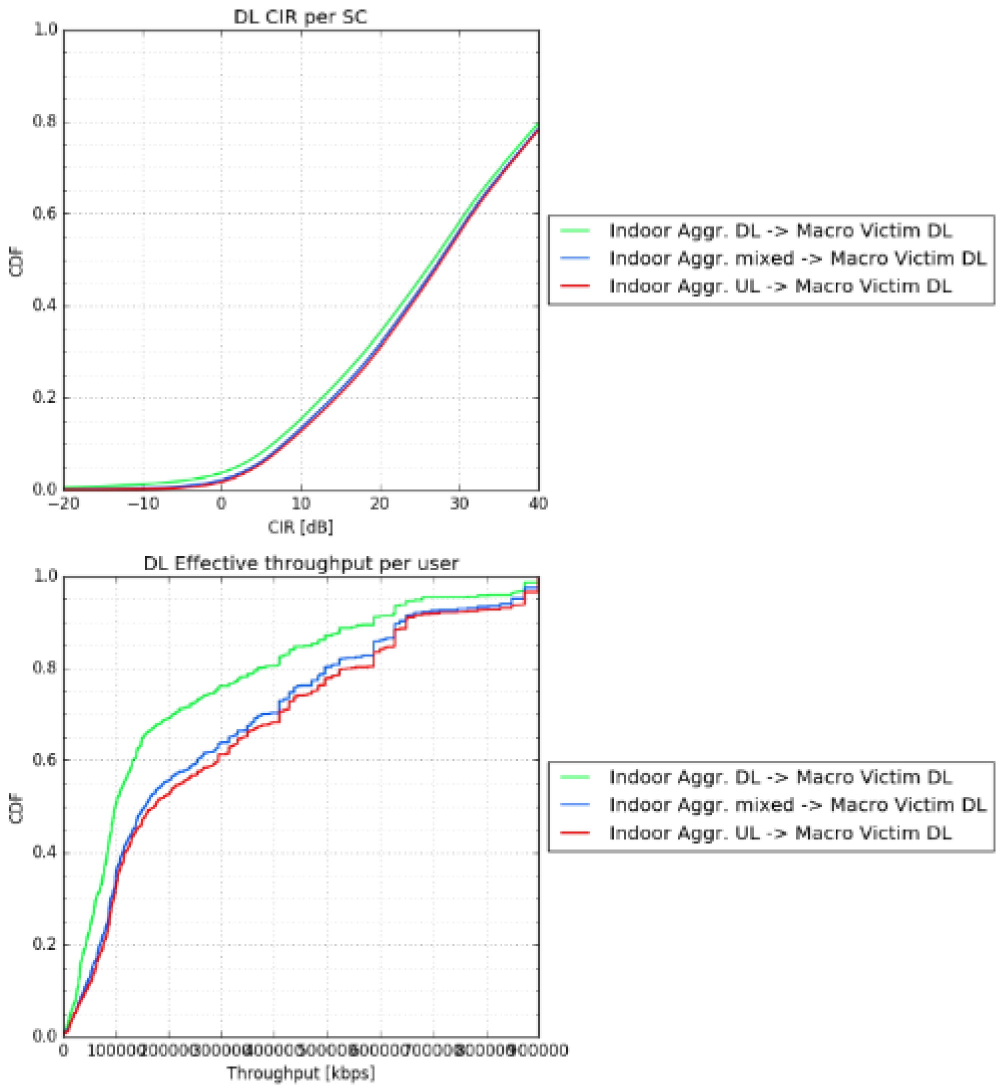


Figure A.1.6.3.2-1: SINR (top) and throughput (bottom) degradation for Indoor aggressor Macro DL victim, 10% traffic

A.1.7 Scenario 7: 4GHz Indoor → Indoor (UL)

A.1.7.1 Ericsson

A.1.7.1.1 100% utilization

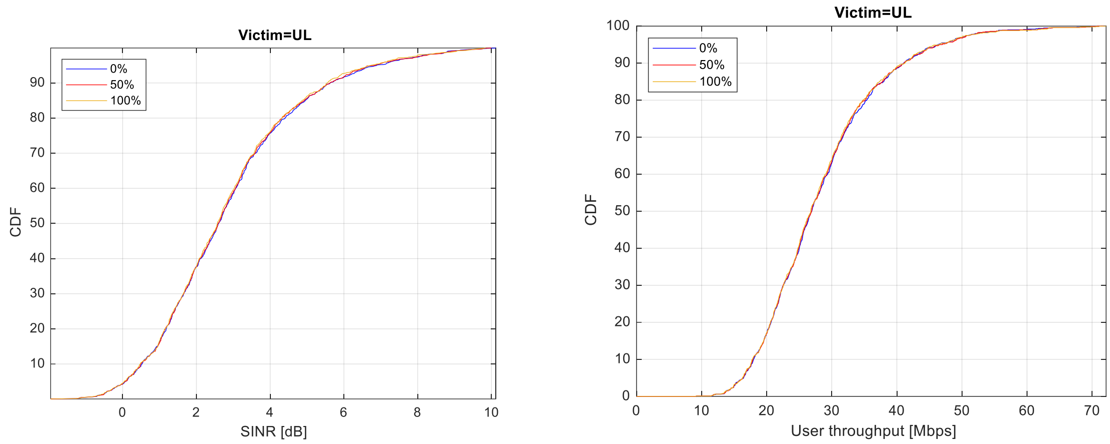


Figure A.1.7.1.1-1: CDF for the SINR and throughput for the UL victim (24 dBm BS transmission power)

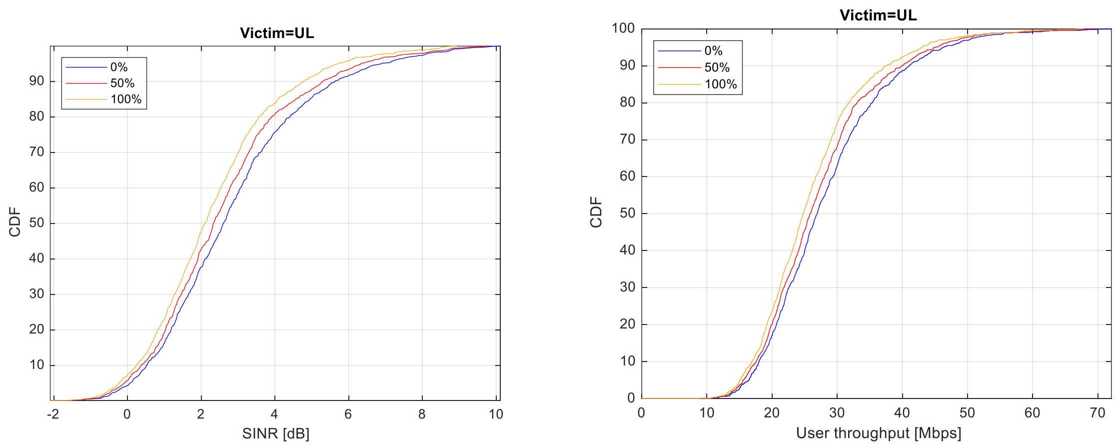


Figure A.1.7.1.1-2: CDF for the SINR and throughput for the UL victim (30 dBm BS transmission power)

A.1.7.1.2 0% utilization

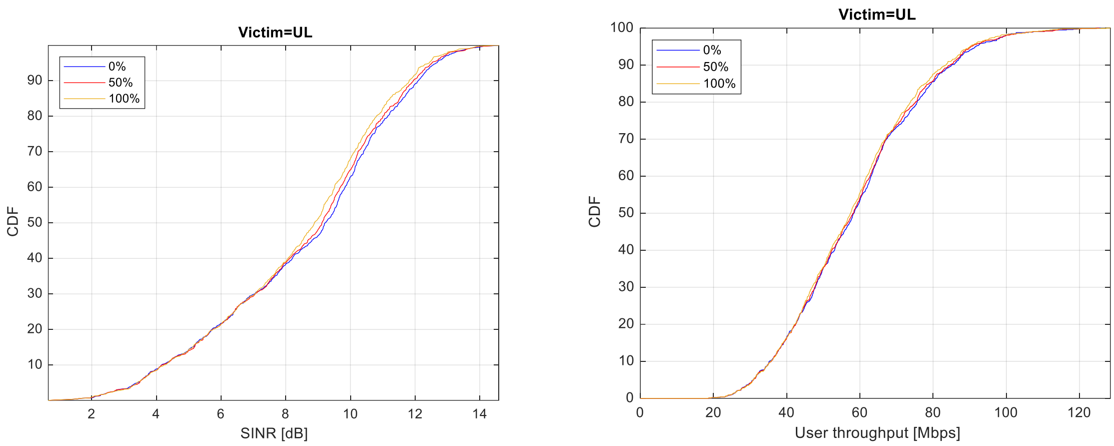


Figure A.1.7.1.2-1: CDF for the SINR and throughput for the UL victim

A.1.7.1.3 10% utilization

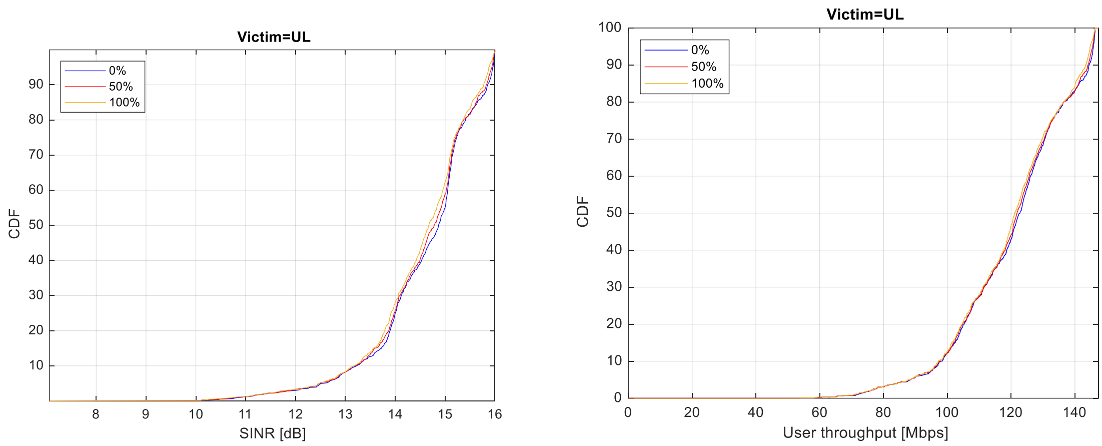


Figure A.1.7.1.3-1: CDF for the SINR and corresponding throughput for the UL victim.

A.1.7.2 Huawei

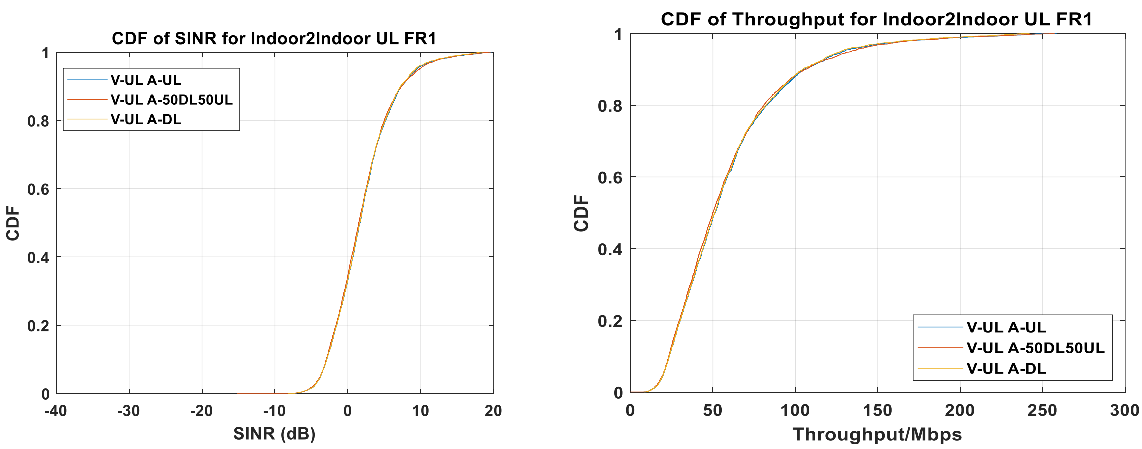


Figure A.1.7.2-1: CDF of UL SINR and throughput from Huawei

A.1.7.3 LGE

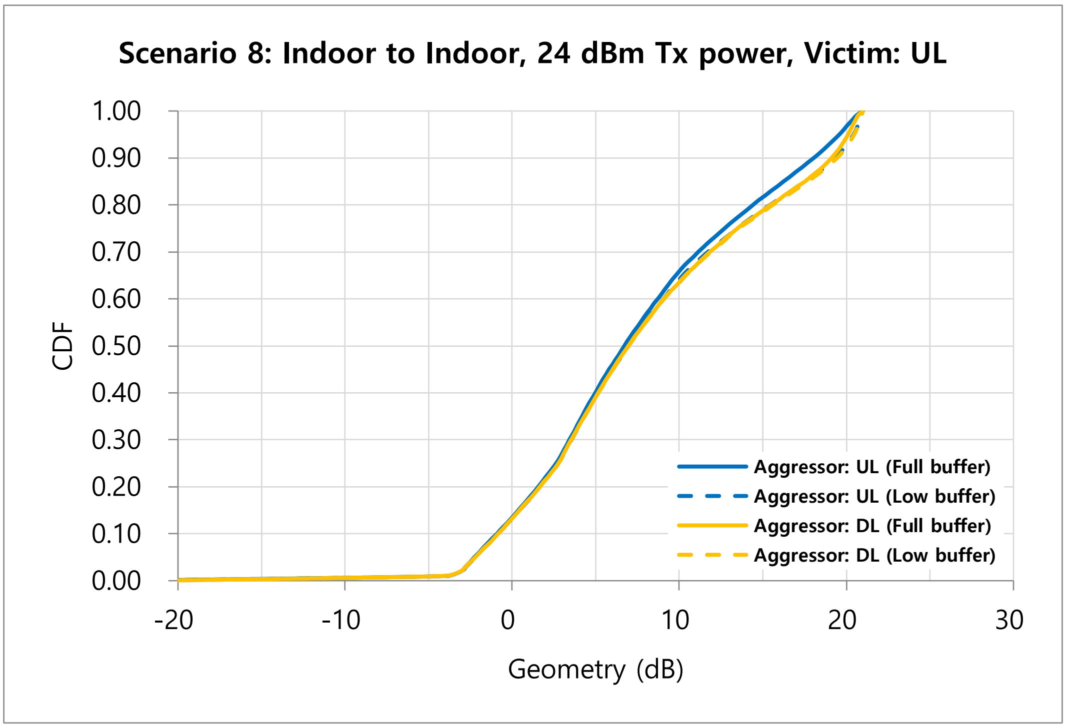


Figure A.1.7.3-1: Indoor-to-Indoor (victim: UL) SINR result (24 dBm Tx power)

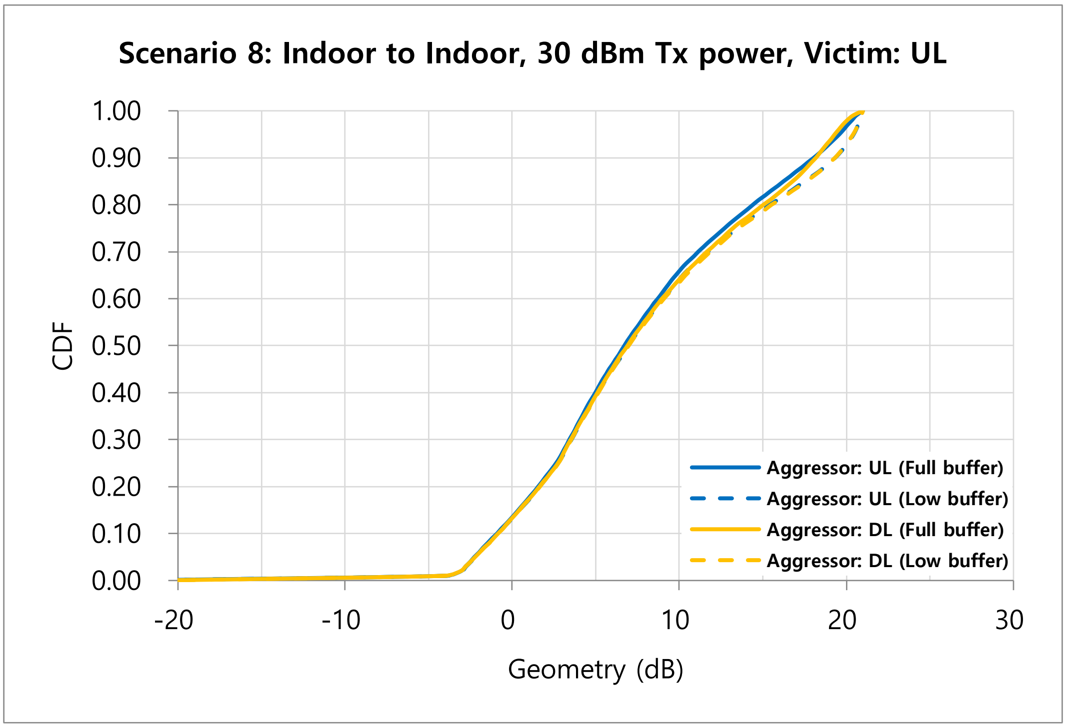


Figure A.1.7.3-2: Indoor-to-Indoor (victim: UL) SINR result (30 dBm Tx power)

A.1.7.4 Nokia

A.1.7.4.1 Full buffer

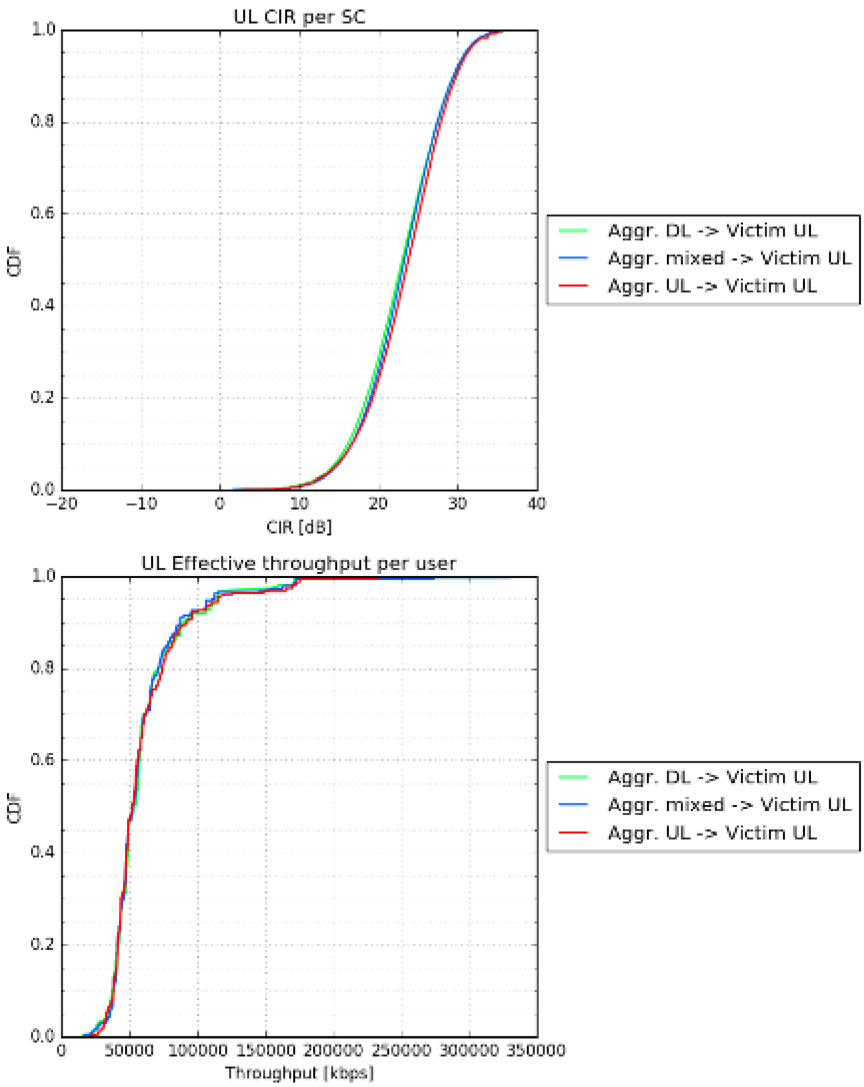


Figure A.1.7.4.1-1: SINR (top) and throughput (bottom) degradation for Indoor aggressor Indoor UL victim, full buffer traffic

A.1.7.4.2 FTP3 with 10% load

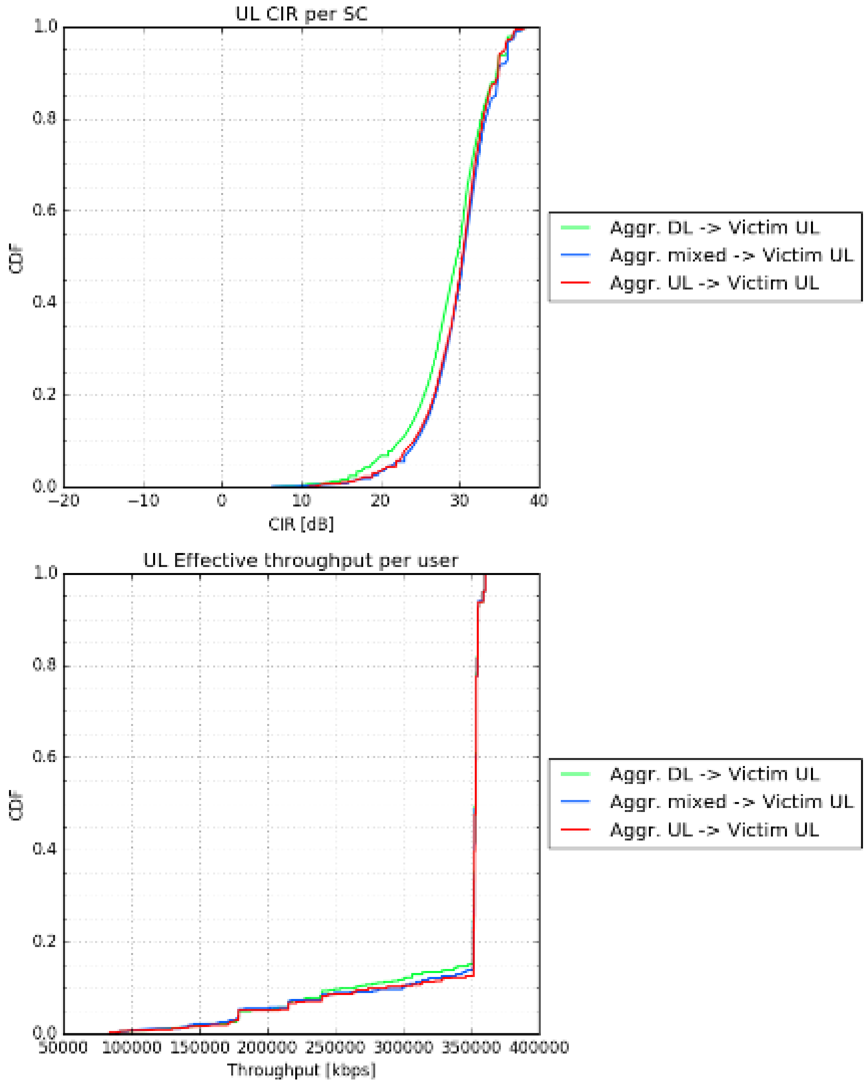


Figure A.1.7.4.2-1: SINR (top) and throughput (bottom) degradation for Indoor aggressor Indoor UL victim, 10% traffic

A.1.8 Scenario 8: 4GHz Indoor → Indoor (DL)

A.1.8.1 Ericsson

A.1.8.1.1 100% utilization

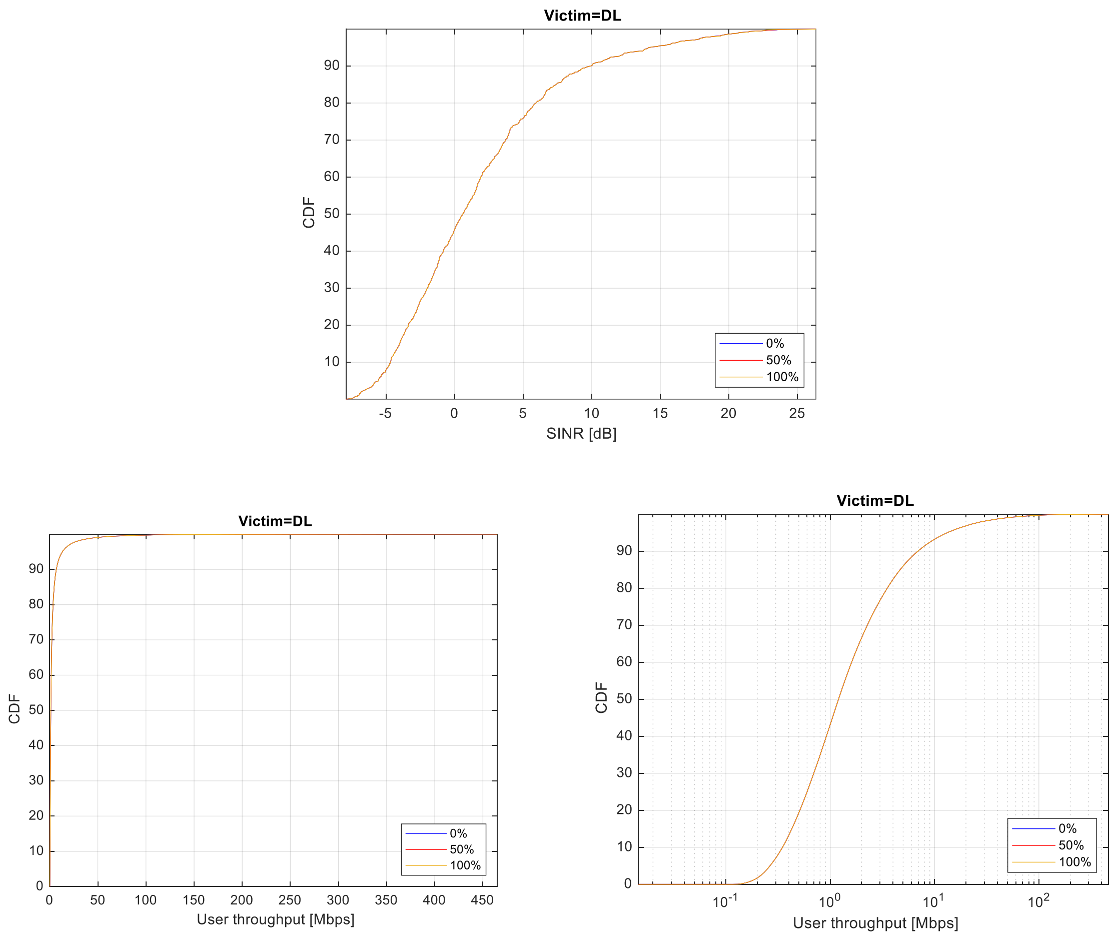


Figure A.1.8.1.1-1: CDFs for the SINR and throughput for the DL victim with linear and logarithmic scale (24 dBm BS transmission power)

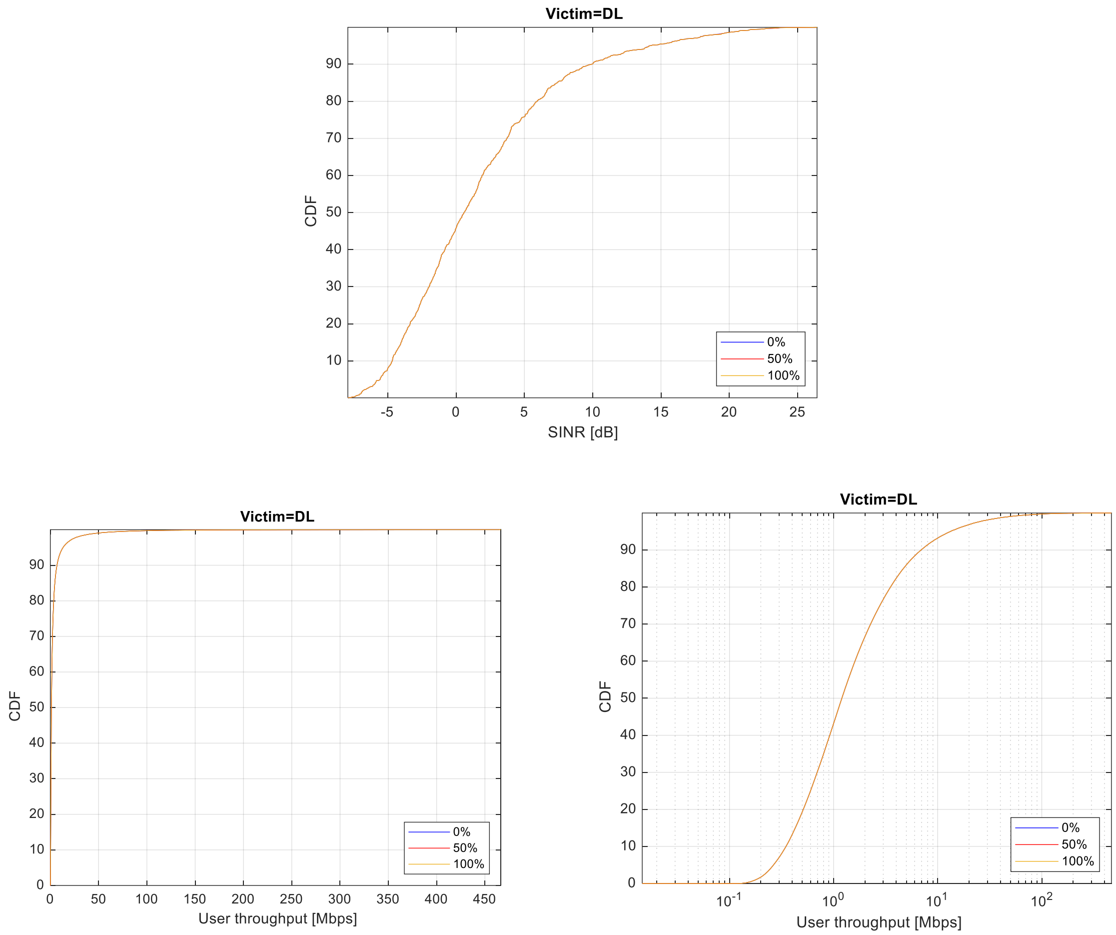


Figure A.1.8.1.1-2: CDFs for the SINR and throughput for the DL victim with linear and logarithmic scale (30 dBm BS transmission power)

A.1.8.1.2 50% utilization

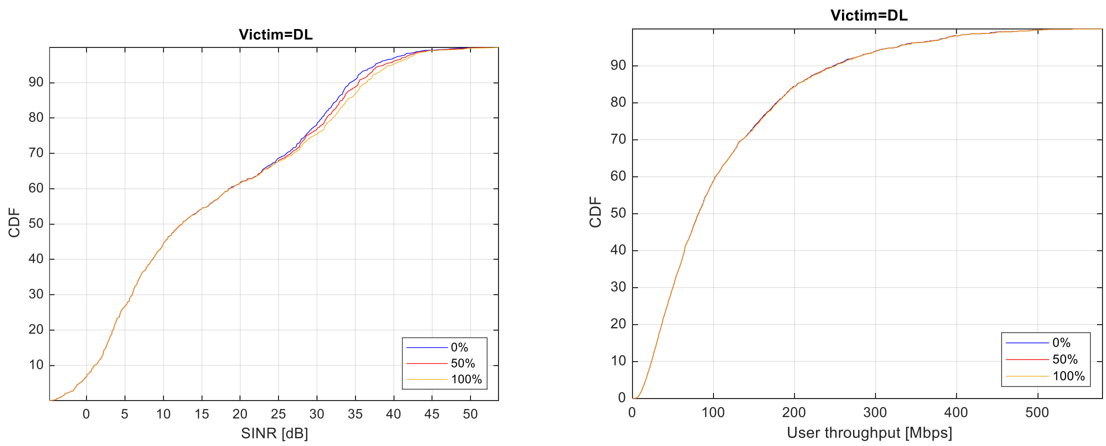


Figure A.1.8.1.2-1: CDF for the SINR and corresponding throughput for the DL victim.

A.1.8.1.3 10% utilization

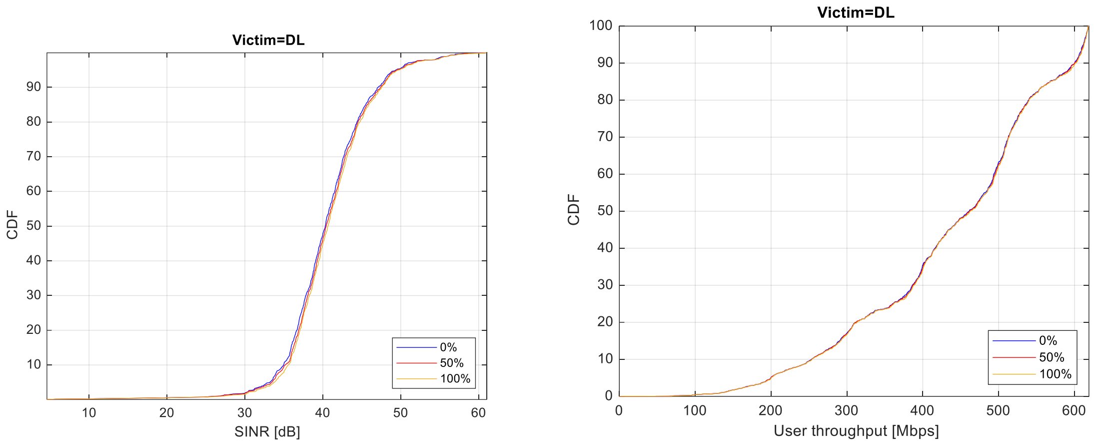


Figure A.1.8.1.3-1: CDF for the SINR and corresponding throughput for the DL victim.

A.1.8.2 Huawei

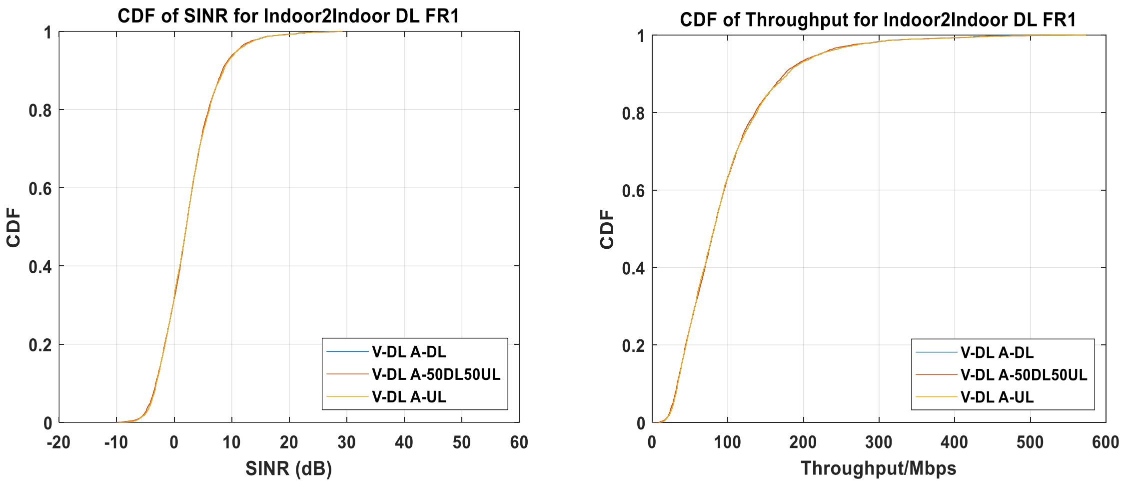


Figure A.1.8.2-1: CDF of DL SINR and throughput from Huawei

A.1.8.3 LGE

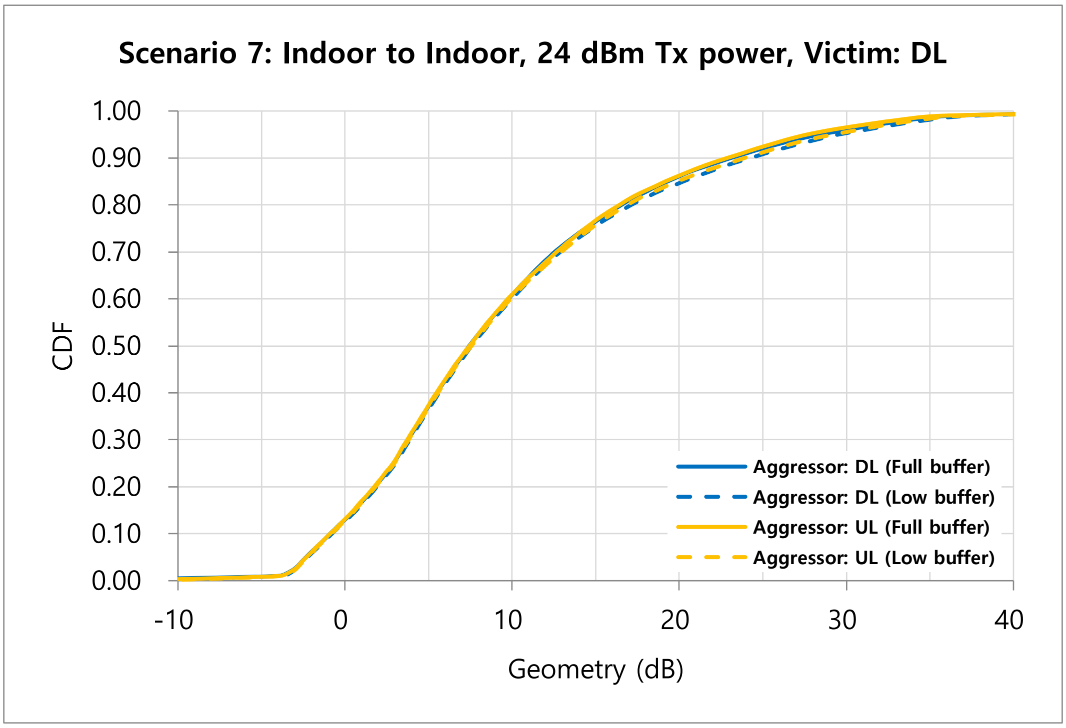


Figure A.1.8.3-1: Indoor-to-Indoor (victim: DL) SINR result (24 dBm Tx power)

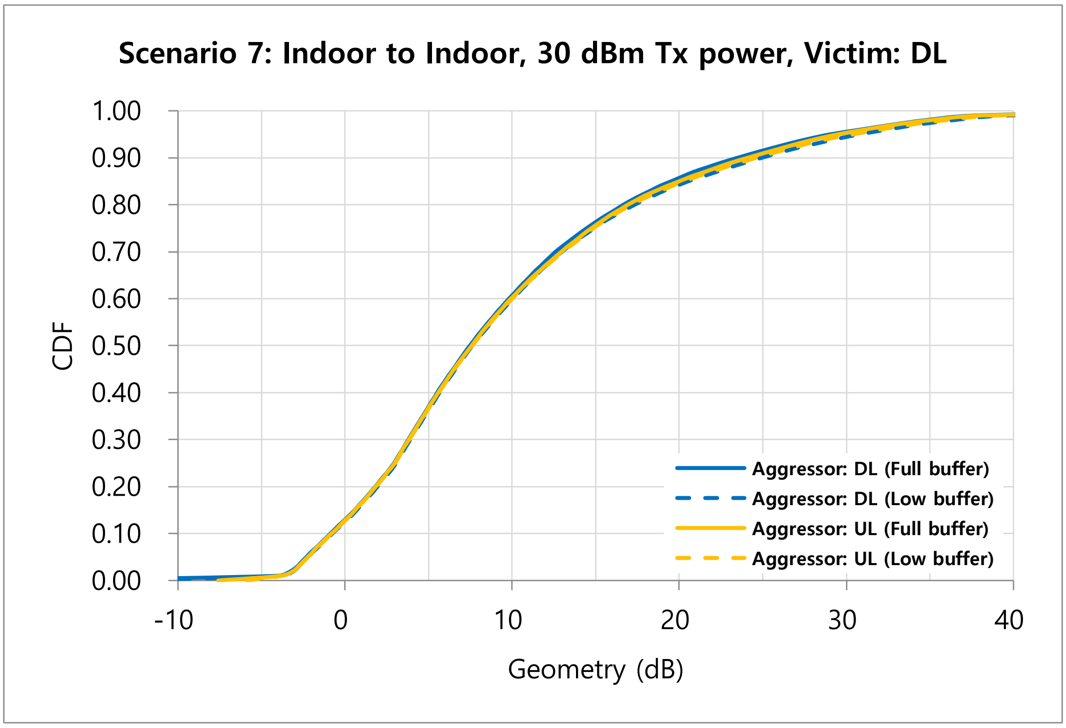


Figure A.1.8.3-2: Indoor-to-Indoor (victim: DL) SINR result (30 dBm Tx power)

A.1.8.4 Nokia

A.1.8.4.1 Full buffer

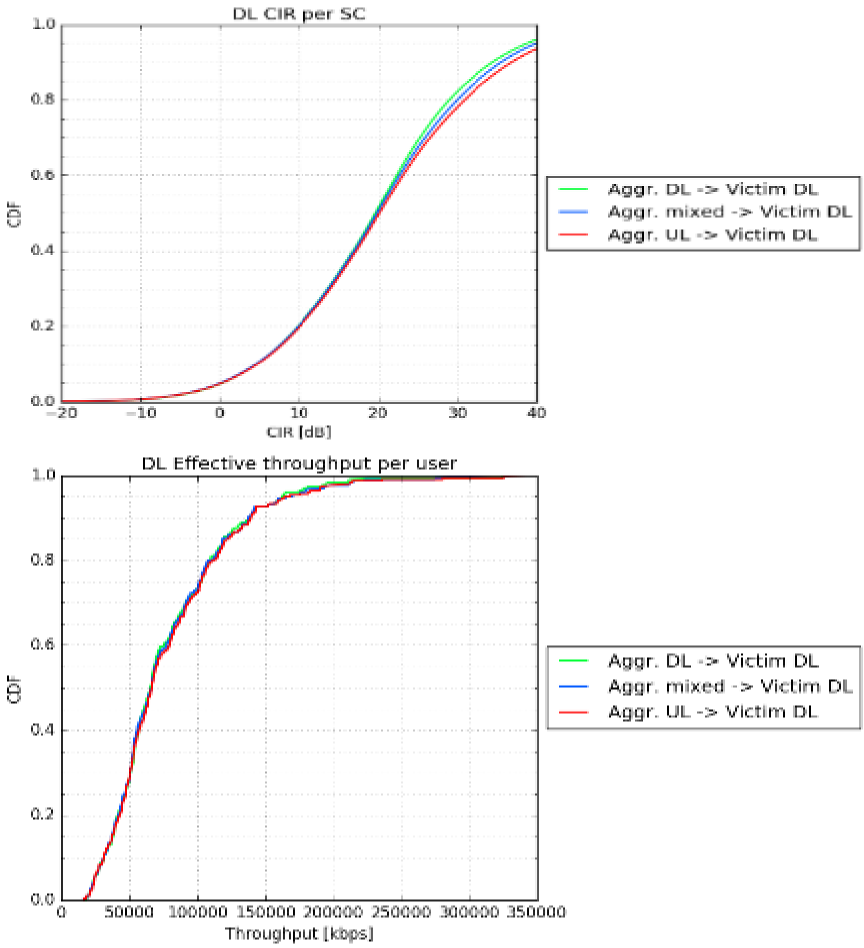


Figure A.1.8.4.1-1: SINR (top) and throughput (bottom) degradation for Indoor aggressor Indoor DL victim, full buffer traffic

A.1.8.4.2 FTP3 with 10% load

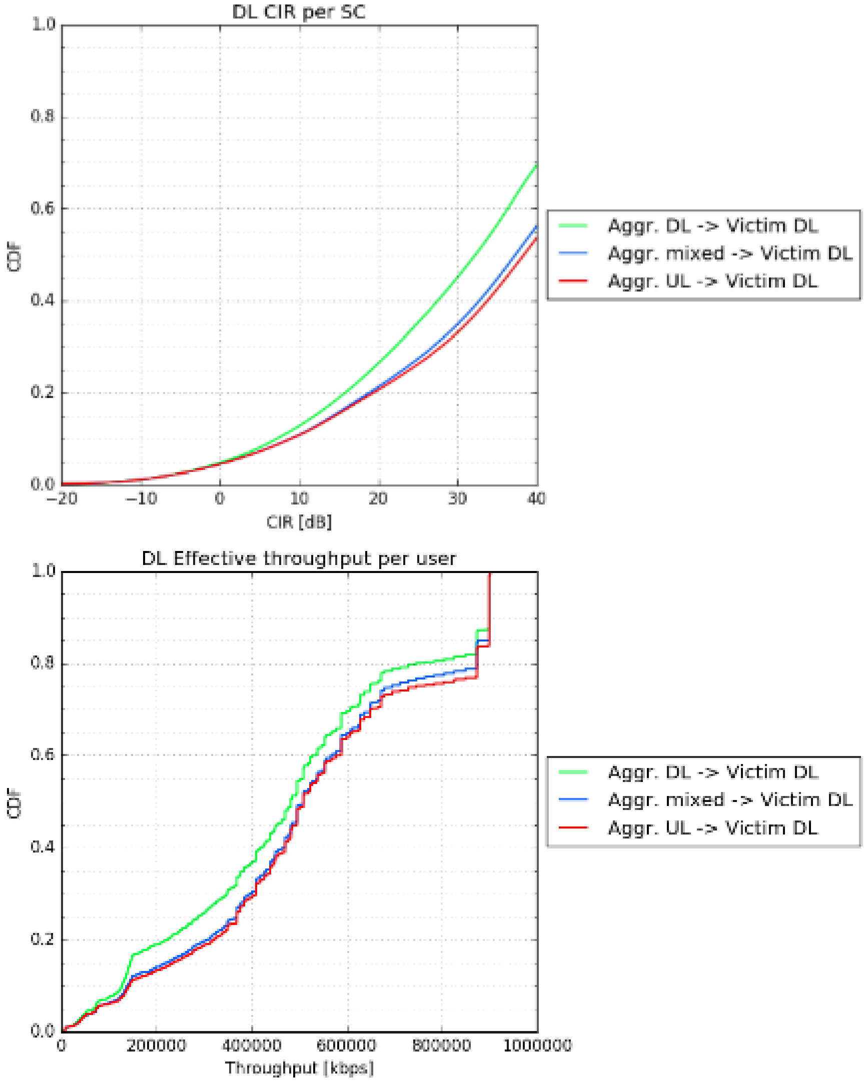


Figure A.1.8.4.2-1: SINR (top) and throughput (bottom) degradation for Indoor aggressor Indoor DL victim, 10% traffic

A.1.8.5 Qualcomm

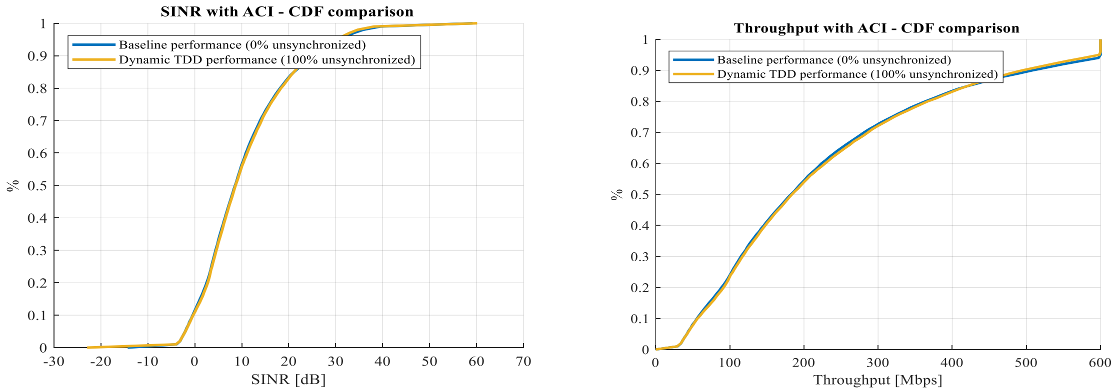


Figure A.1.8.5-1: Comparison of SINR and throughput performance with ACI in InH-to-InH scenario (24 dBm Tx power)

A.2 FR2

A.2.1 Scenario 9: 30 GHz Macro → Macro (DL)

A.2.1.1 Ericsson

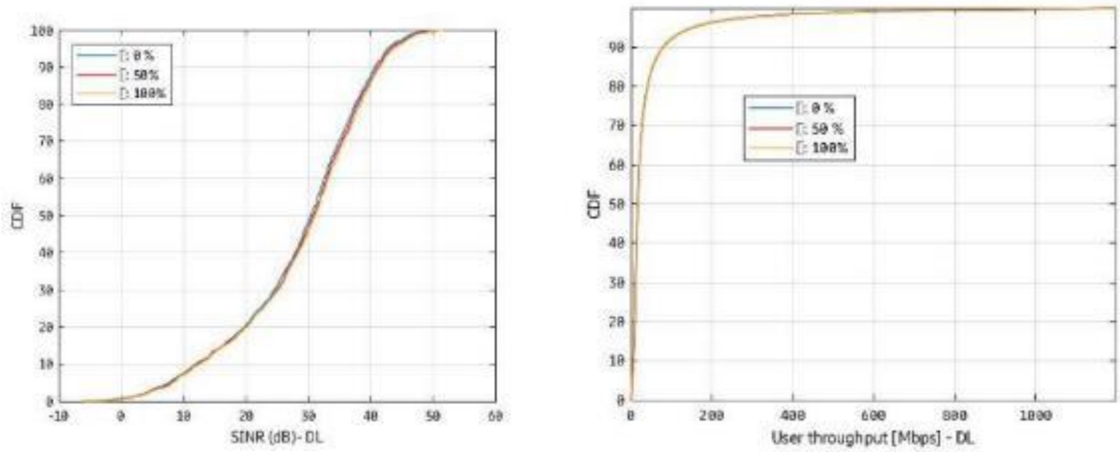


Figure A.2.1.1-1: Downlink SINR and Throughput CDFs with 100% grid shift

A.2.1.2 Huawei

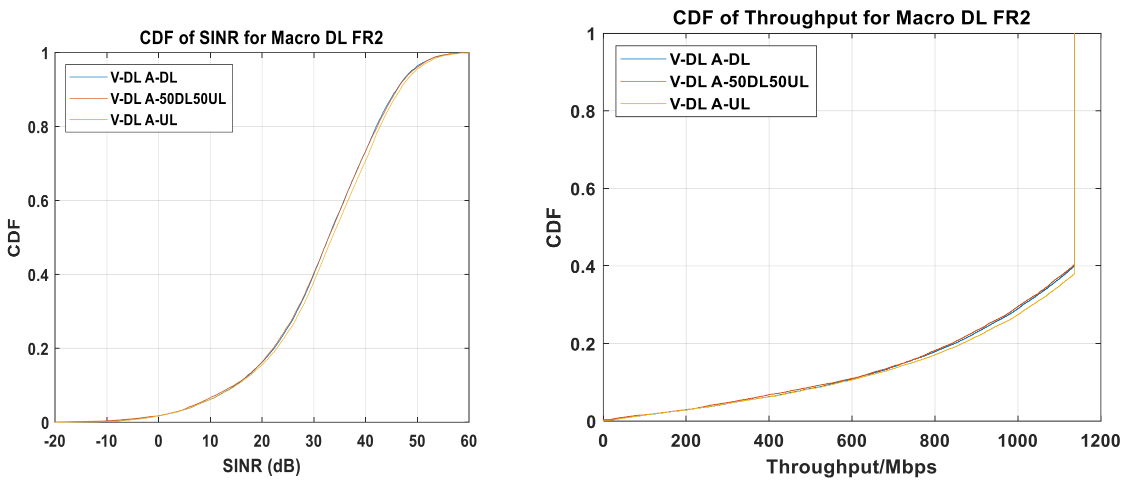


Figure A.2.1.2-1: CDF of DL SINR and throughput from Huawei

A.2.1.3 LGE

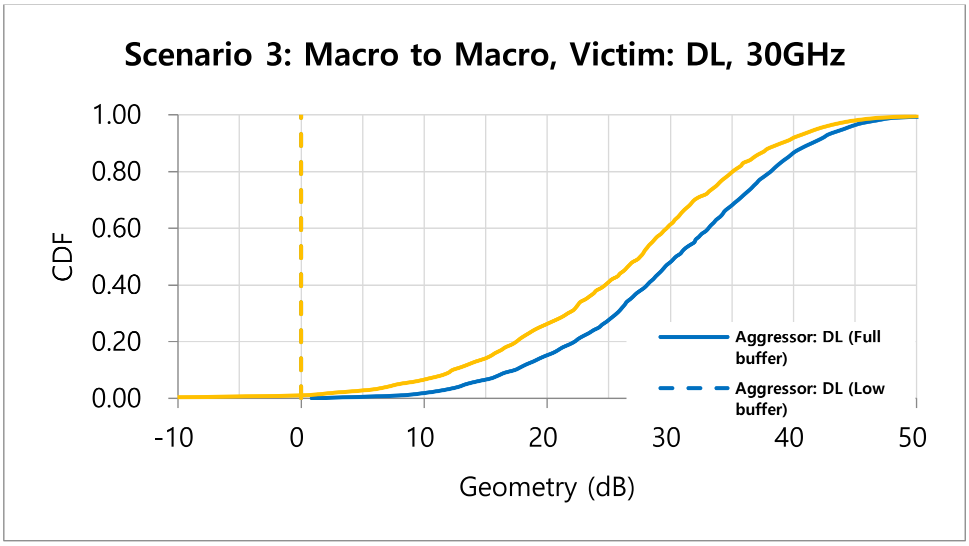
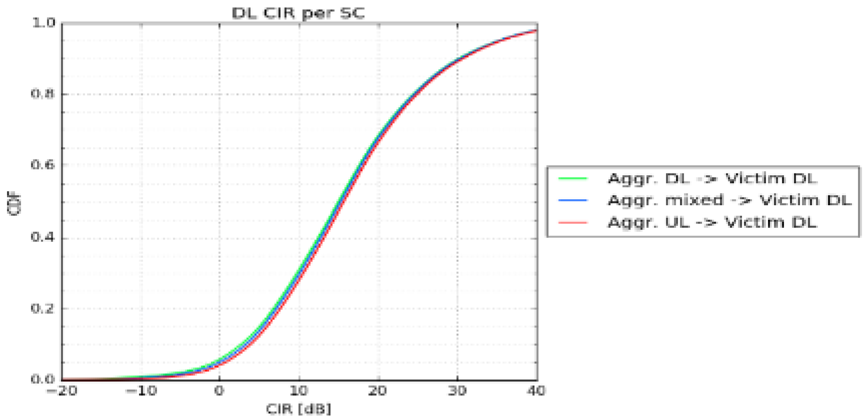


Figure A.2.1.3-1: Macro-to-Macro SINR result (victim: DL)

A.2.1.4 Nokia

A.2.1.4.1 Full buffer



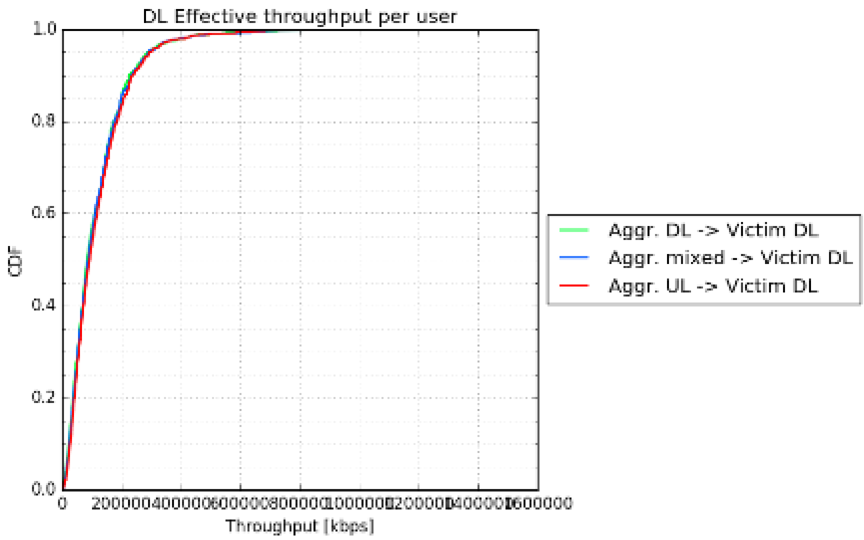


Figure A.2.1.4.1-1: SINR (top) and throughput (bottom) degradation for Macro aggressor Macro DL victim, full buffer traffic

A.2.1.4.2 FTP3 with 10% load

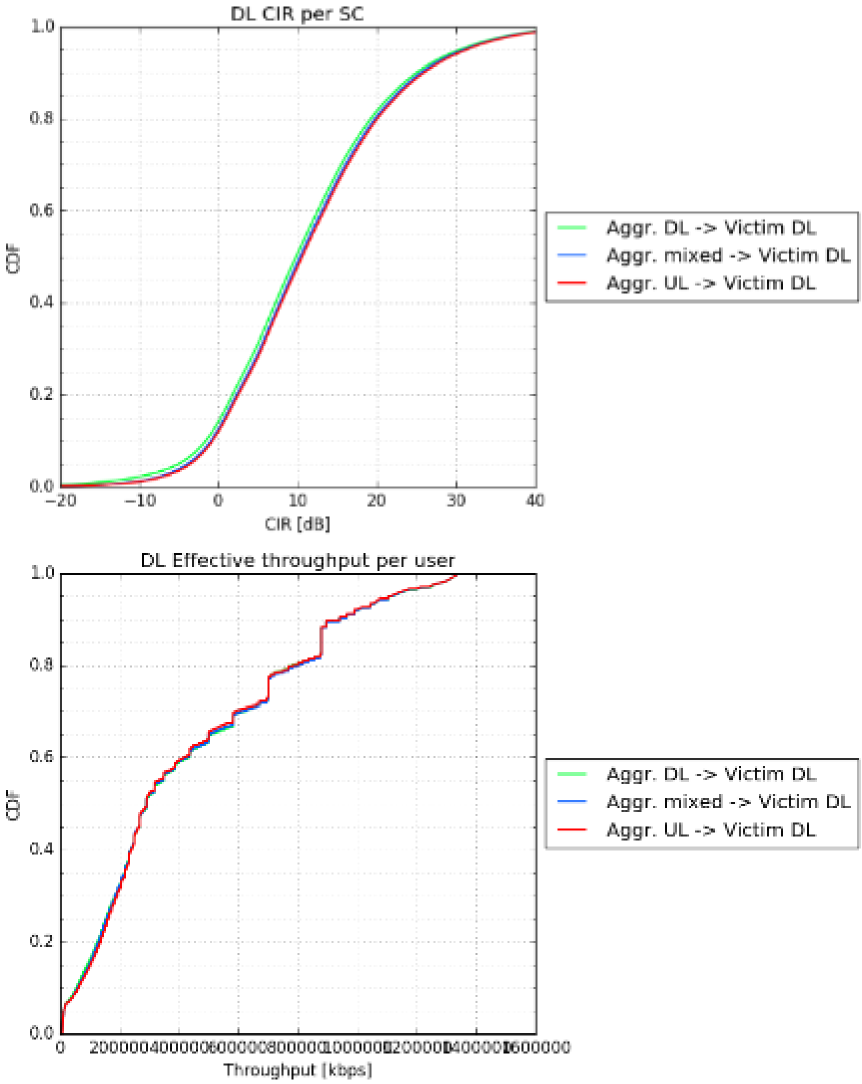


Figure A.2.1.4.2-1: SINR (top) and throughput (bottom) degradation for Macro aggressor Macro DL victim, 10% traffic

A.2.1.5 Qualcomm

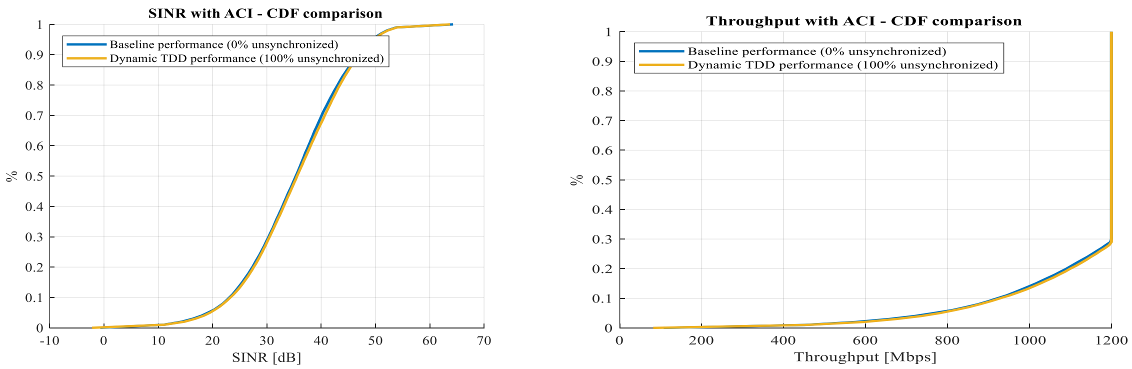


Figure A.2.1.5-1: Comparison of SINR and throughput performance with ACI in UMa-to-UMa scenario

A.2.2 Scenario 10: 30 GHz Macro → Macro (UL)

A.2.2.1 Ericsson

A.2.2.1.1 100% grid shift

A.2.2.1.1.1 100% Utilization

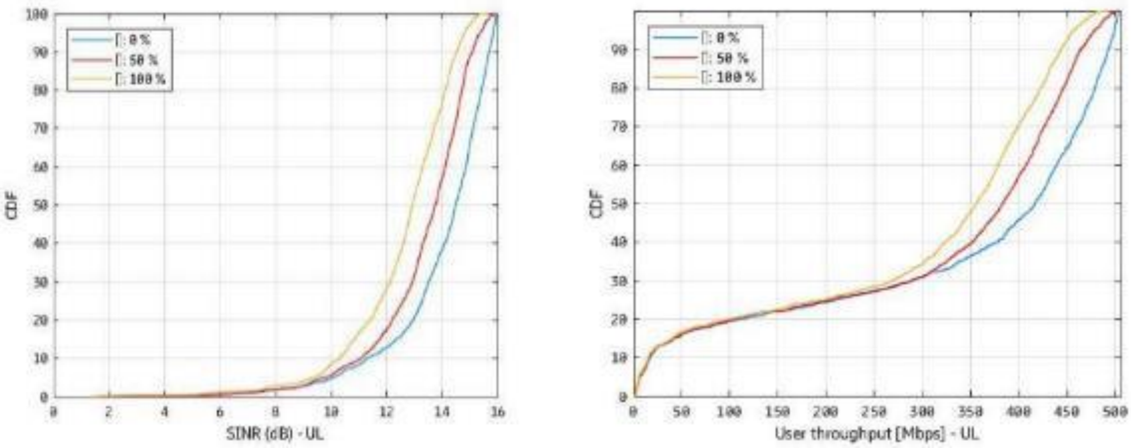


Figure A.2.2.1.1.1-1: Uplink SINR and Throughput CDFs with 100% grid shift, 100% utilization

A.2.2.1.1.2 50% Utilization

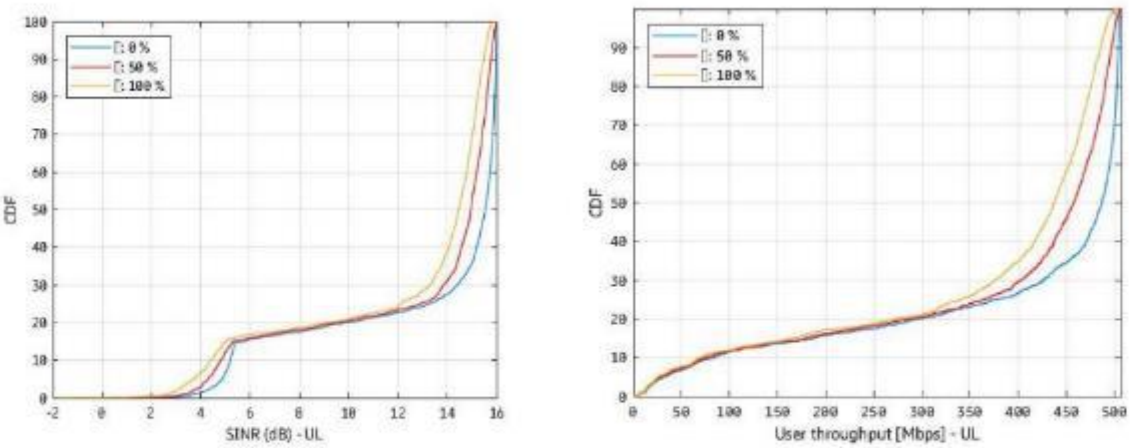


Figure A.2.2.1.1.2-1: Uplink SINR and Throughput CDFs with 100% grid shift, 50% utilization

A.2.2.1.1.3 10% Utilization

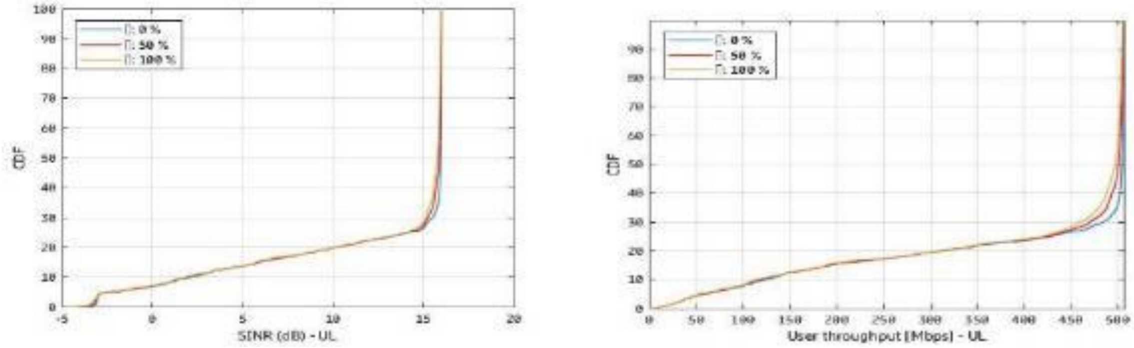


Figure A.2.2.1.1.3-1: Uplink SINR and Throughput CDFs with 100% grid shift, 10% utilization

A.2.2.1.2 50% grid shift

A.2.2.1.2.1 100% Utilization

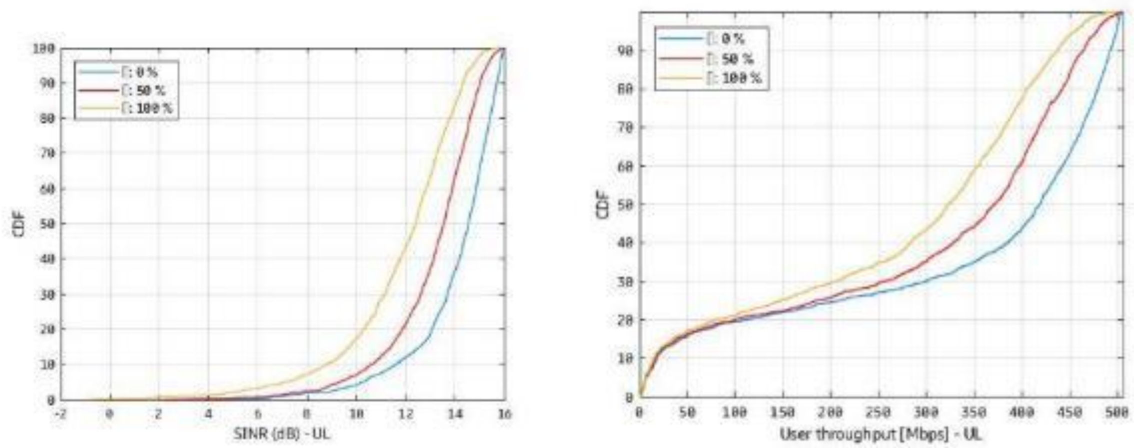


Figure A.2.2.1.2.1-1: Uplink SINR and Throughput CDFs with 50% grid shift, 100% utilization

A.2.2.1.2.2 50% Utilization

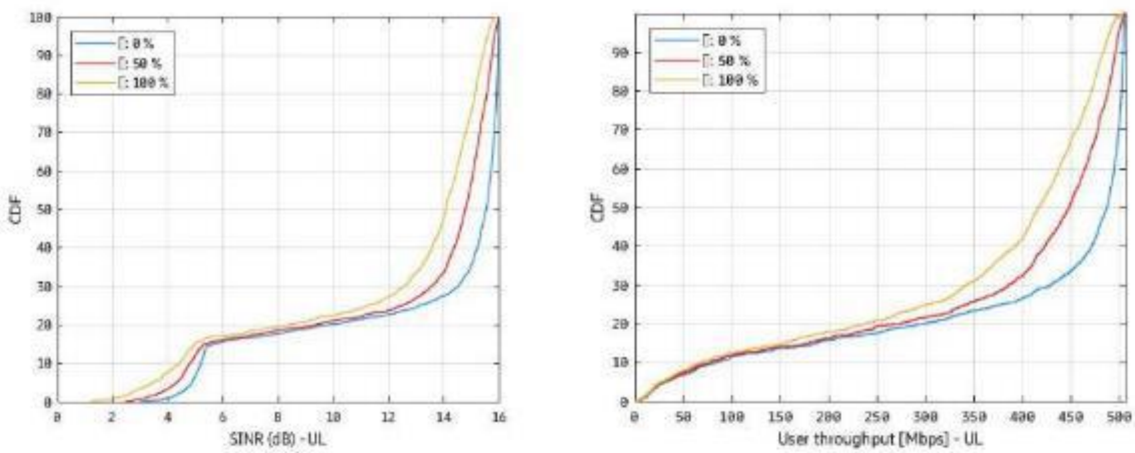


Figure A.2.2.1.2.2-1: Uplink SINR and Throughput CDFs with 50% grid shift, 50% utilization

A.2.2.1.2.3 10% Utilization

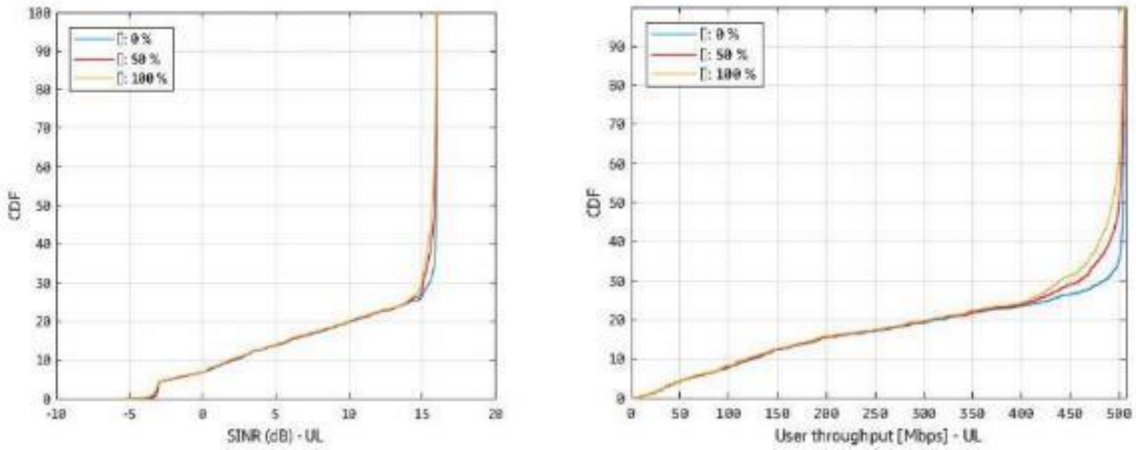


Figure A.2.2.1.2.3-1: Uplink SINR and Throughput CDFs with 50% grid shift, 10% utilization

A.2.2.2 Huawei

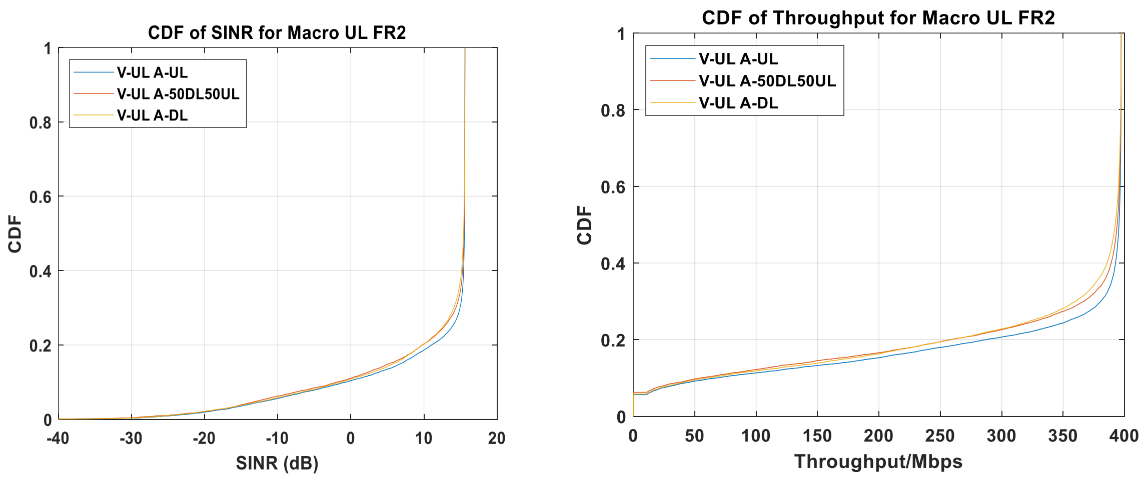


Figure A.2.2.2-1: CDF of UL SINR and throughput from Huawei

A.2.2.3 LGE

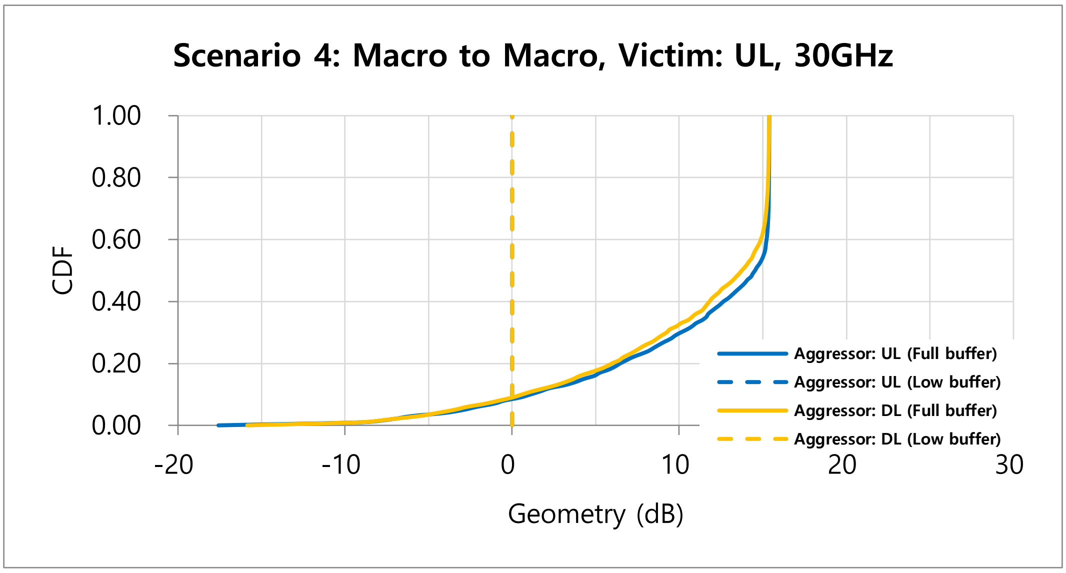


Figure A.2.2.3-1: Macro-to-Macro SINR result (victim: UL)

A.2.3 Scenario 11: 30 GHz Micro → Micro (UL)

A.2.3.1 Ericsson

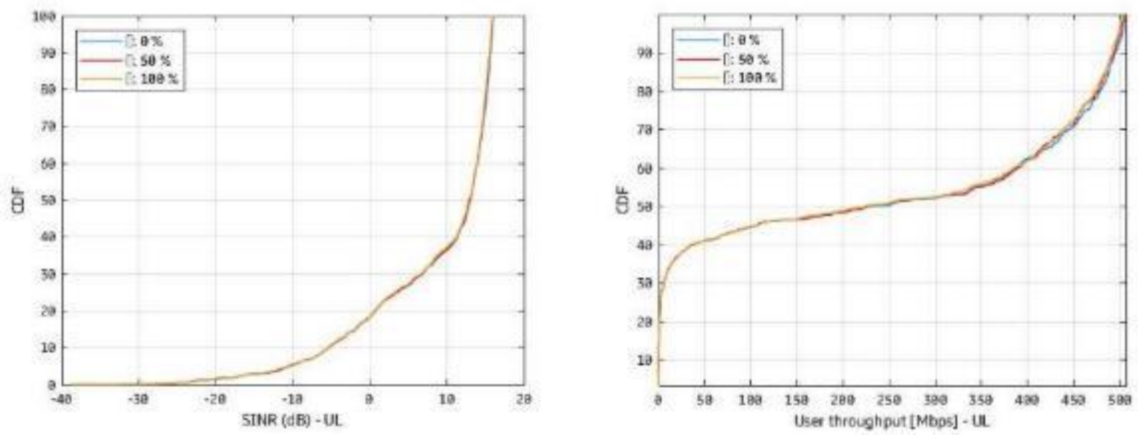


Figure A.2.3.1-1: CDF for the SINR and throughput for the UL victim.

A.2.3.2 Huawei

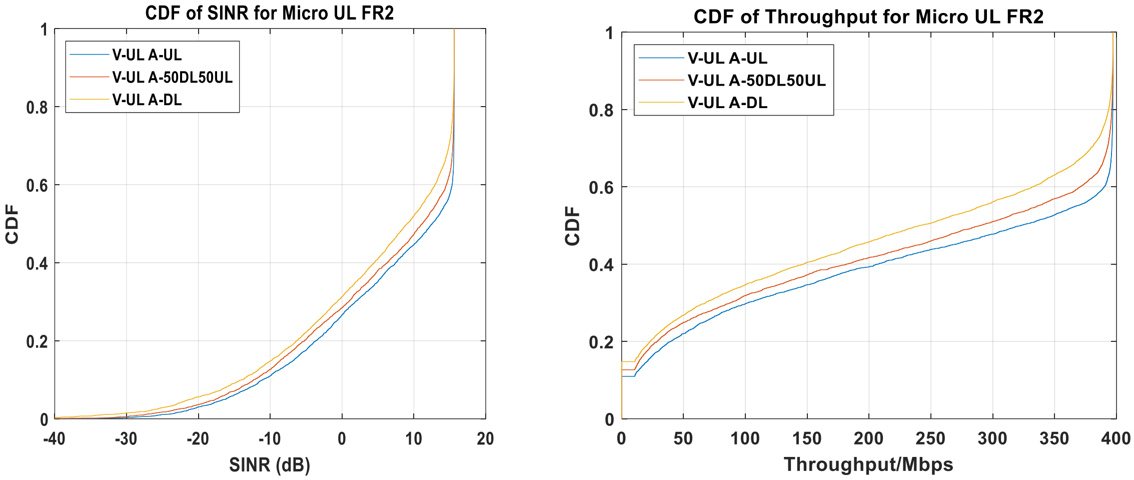


Figure A.2.3.2-1: CDF of UL SINR and throughput from Huawei

A.2.4 Scenario 12: 30 GHz Micro → Micro (DL)

A.2.4.1 Ericsson

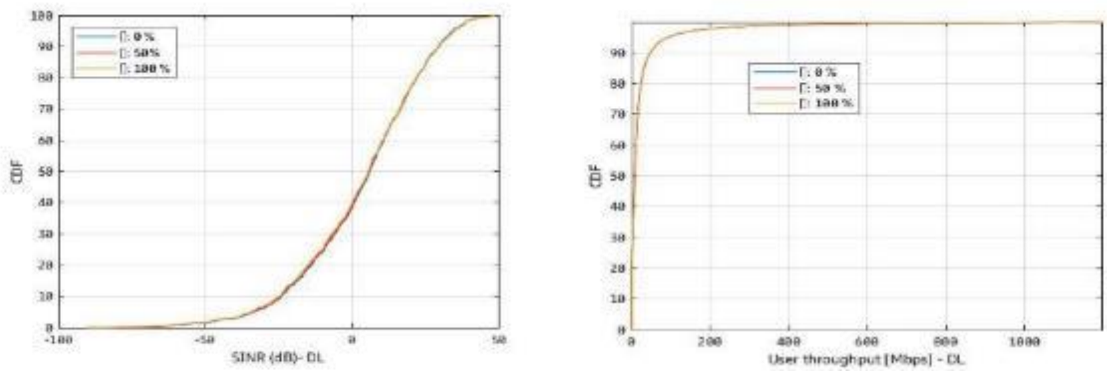


Figure A.2.4.1-1: CDF for the SINR and throughput for the DL victim.

A.2.4.2 Huawei

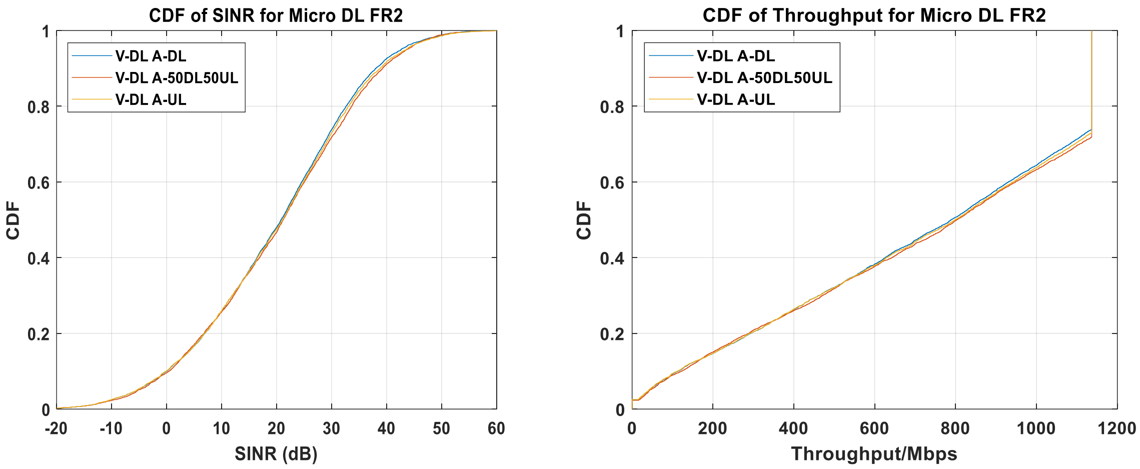


Figure A.2.4.2-1: CDF of DL SINR and throughput from Huawei

A.2.4.3 Qualcomm

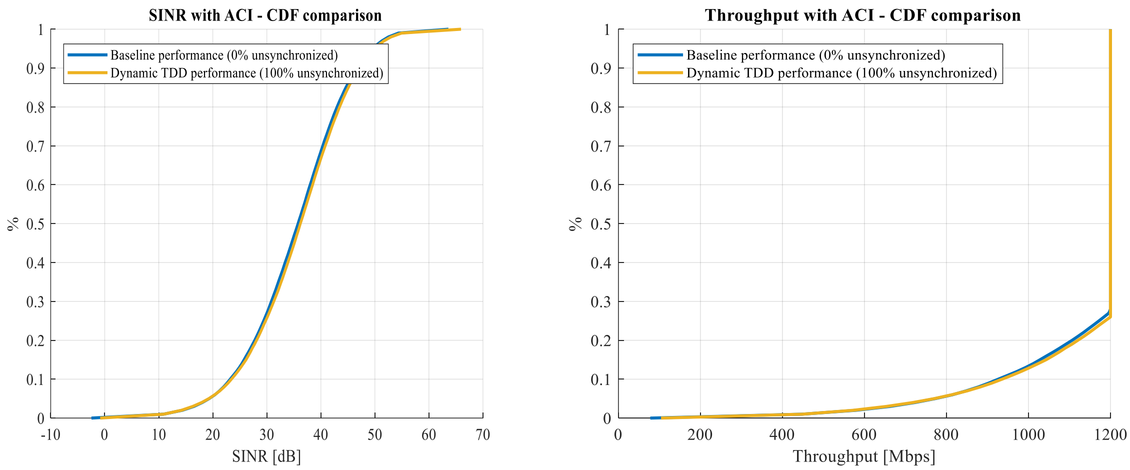


Figure A.2.4.3-1: Comparison of SINR and throughput performance with ACI in UMi-to-UMi scenario

A.2.5 Scenario 13: 30 GHz Indoor → Macro (UL)

A.2.5.1 Huawei

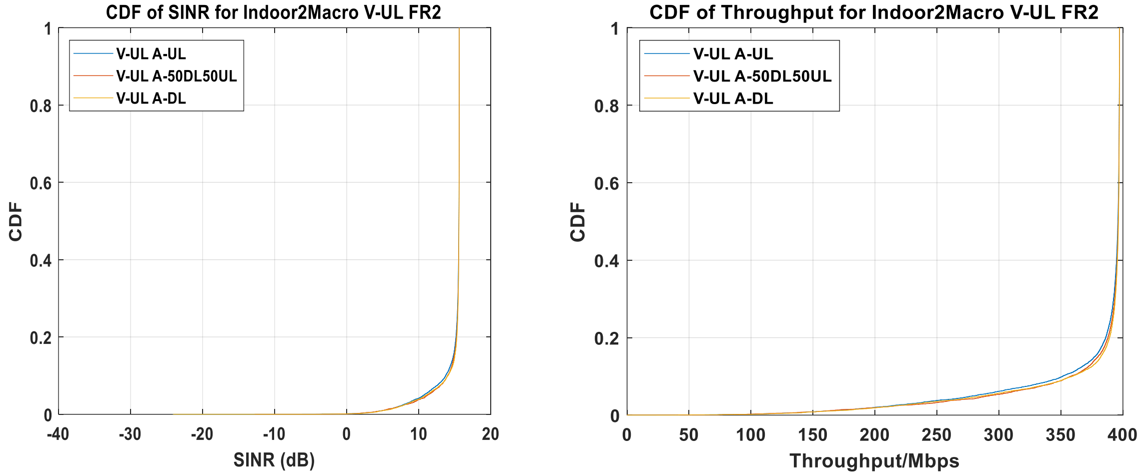


Figure A.2.5.1-1: CDF of UL SINR and throughput from Huawei

A.2.5.2 LGE

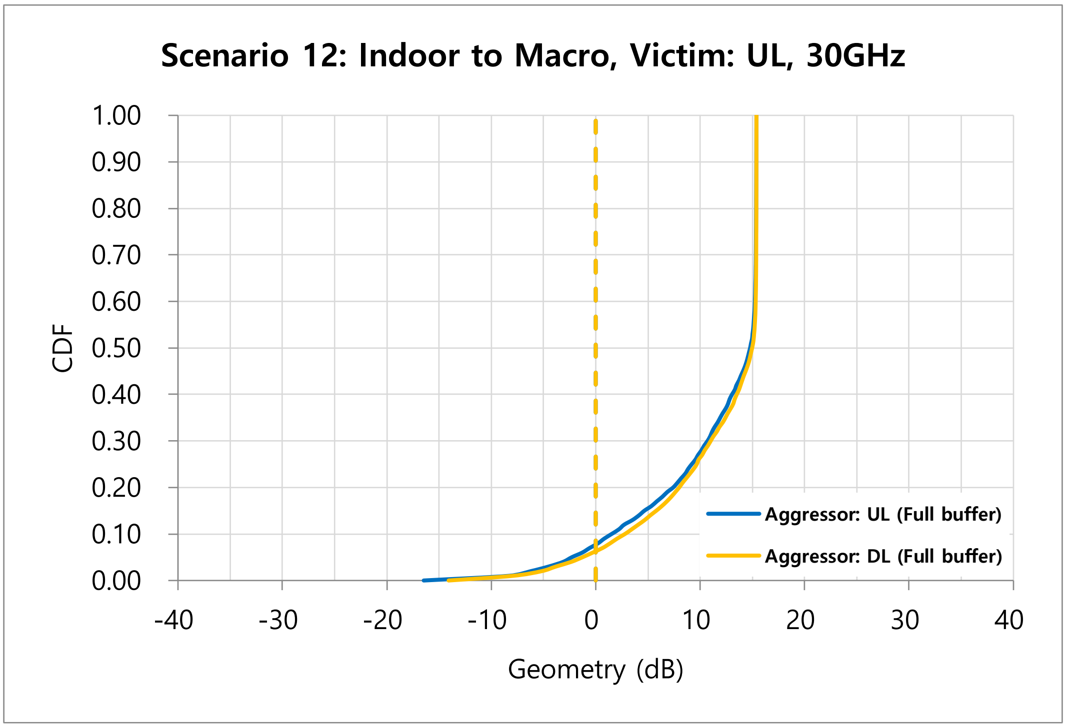


Figure A.2.5.2-1: Indoor-to-Macro SINR result (victim: UL)

A.2.6 Scenario 14: 30 GHz Indoor → Macro (DL)

A.2.6.1 Huawei

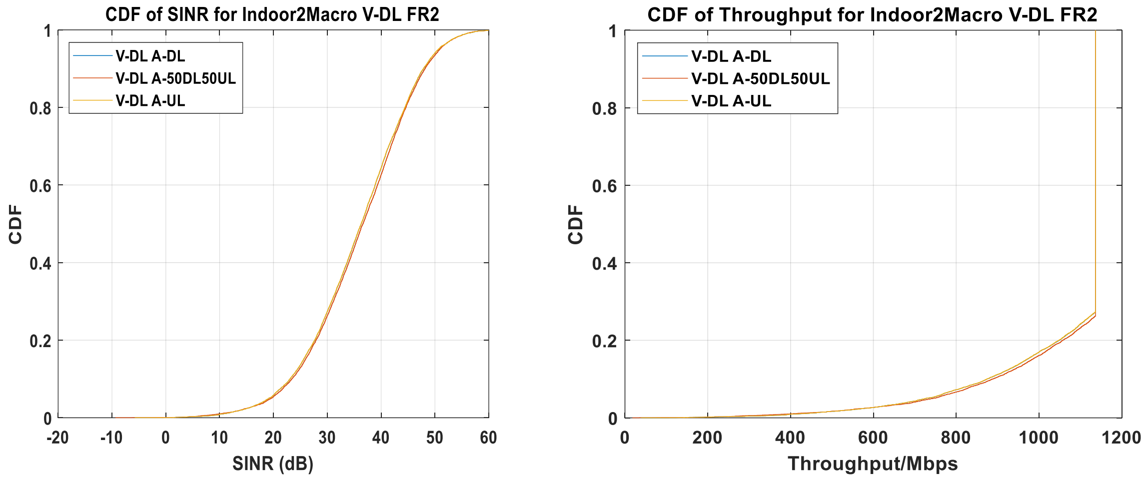


Figure A.2.6.1-1: CDF of DL SINR and throughput from Huawei

A.2.6.2 LGE

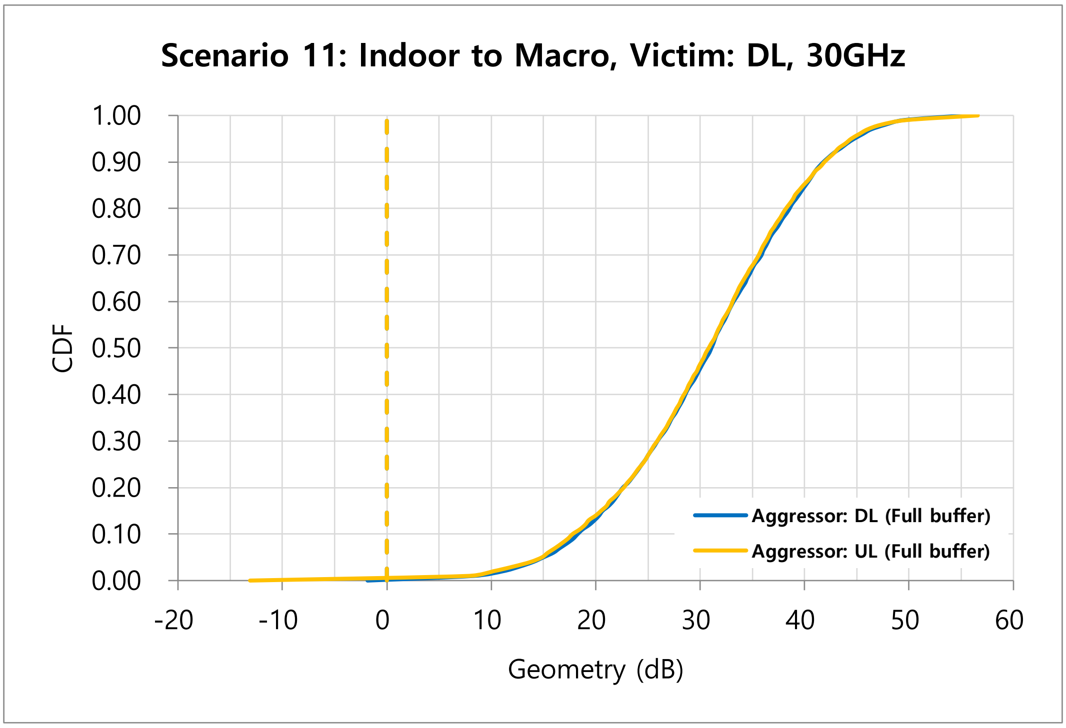


Figure A.2.6.2-1: Indoor-to-Macro SINR result (victim: DL)

A.2.7 Scenario 15: 30 GHz Indoor → Indoor (UL)

A.2.7.1 Ericsson

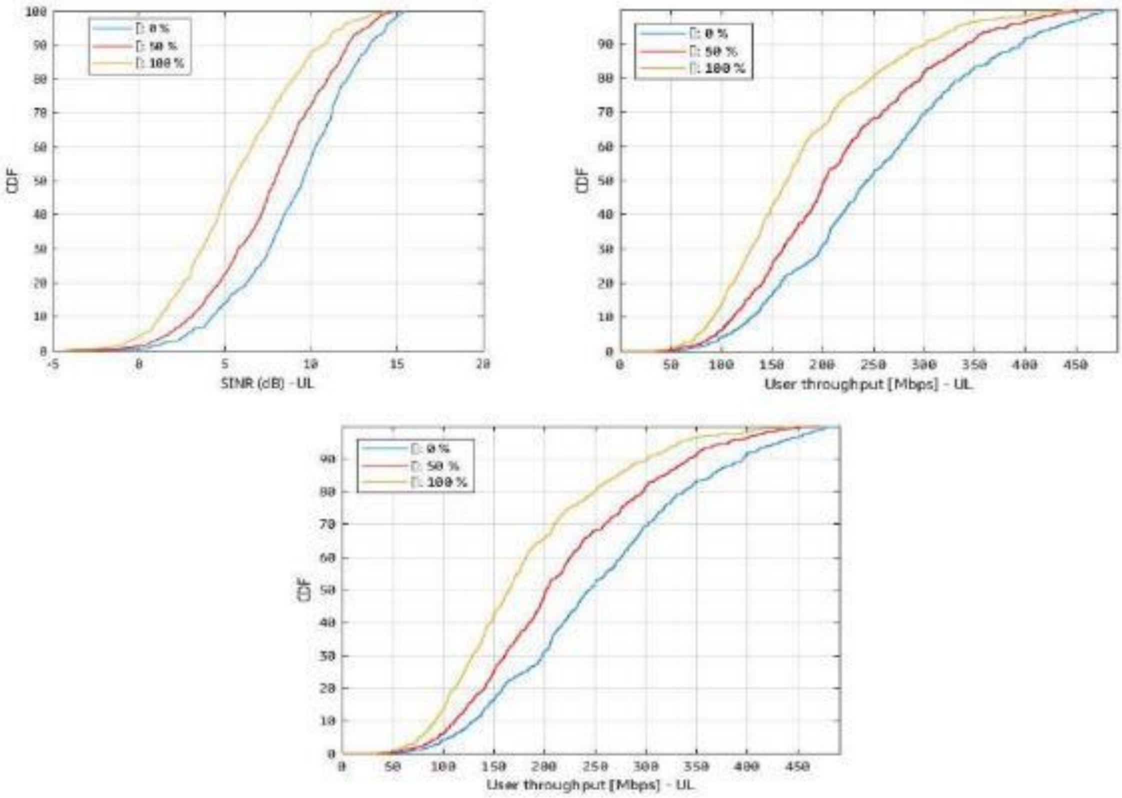


Figure A.2.7.1-1: CDF for the SINR and throughput for the UL victim.

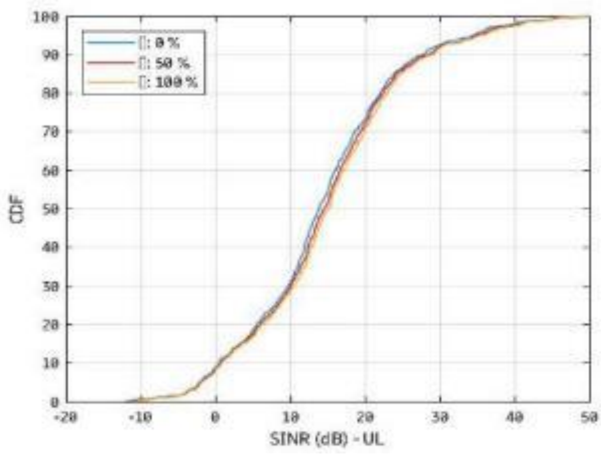


Figure A.2.7.1-2: CDF for the SINR for the UL victim, without UL power control.

A.2.7.2 Huawei

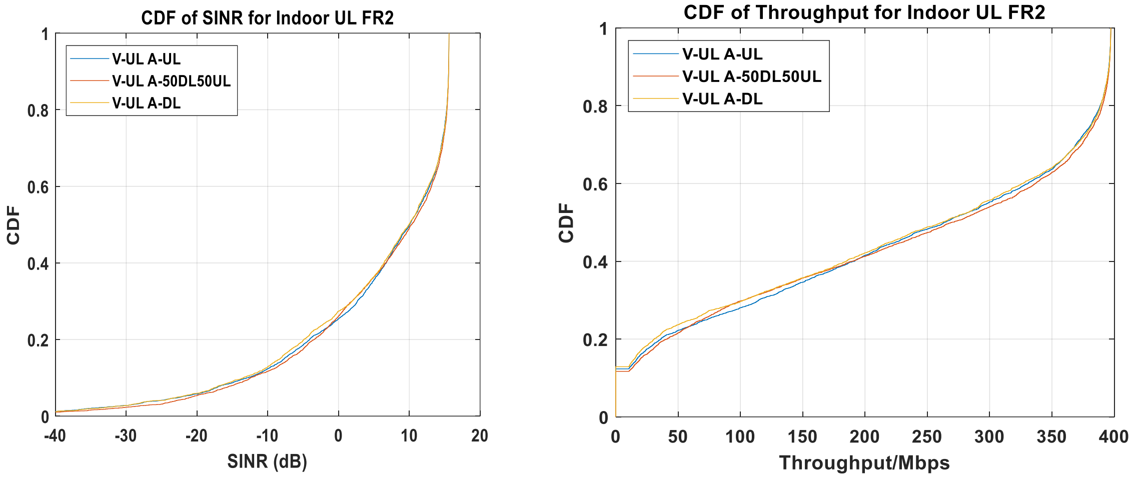


Figure A.2.7.2-1: CDF of UL SINR and throughput from Huawei

A.2.7.3 LGE

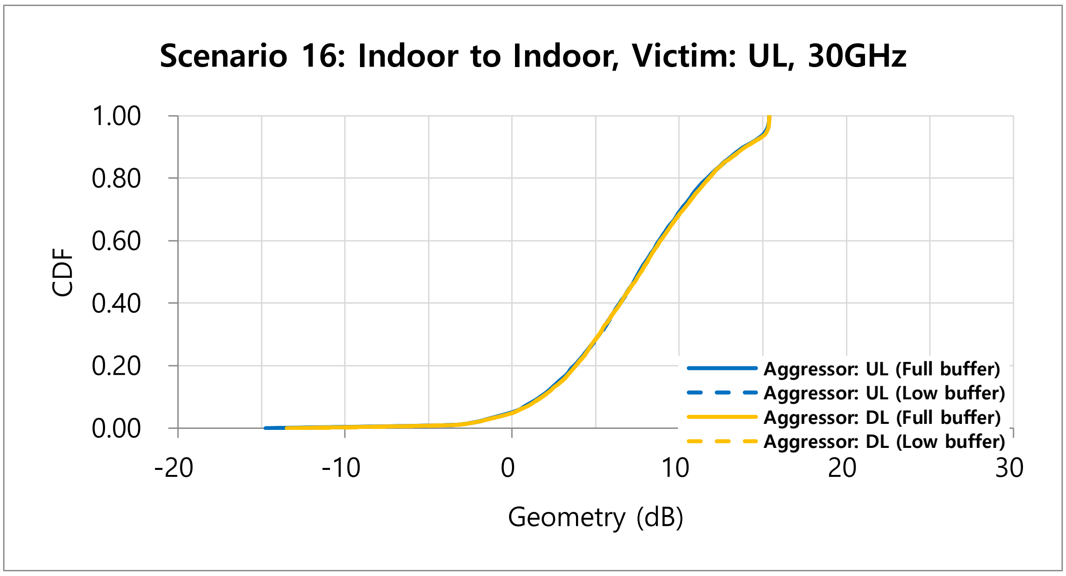


Figure A.2.7.3-1: Indoor-to-Indoor (victim: UL) SINR result

A.2.7.4 Nokia

A.2.7.4.1 Full buffer

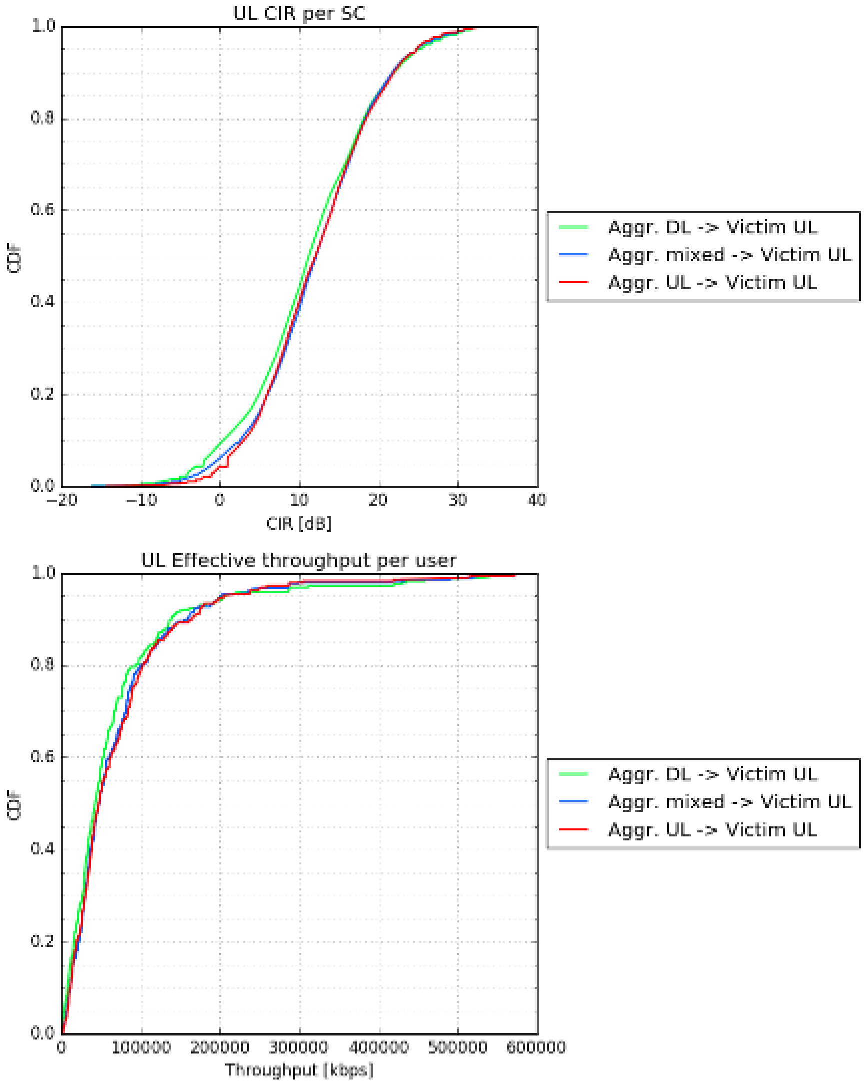


Figure A.2.7.4.1-1: SINR (top) and throughput (bottom) degradation for Indoor aggressor Indoor UL victim, full buffer traffic

A.2.7.4.2 FTP3 with 10% load

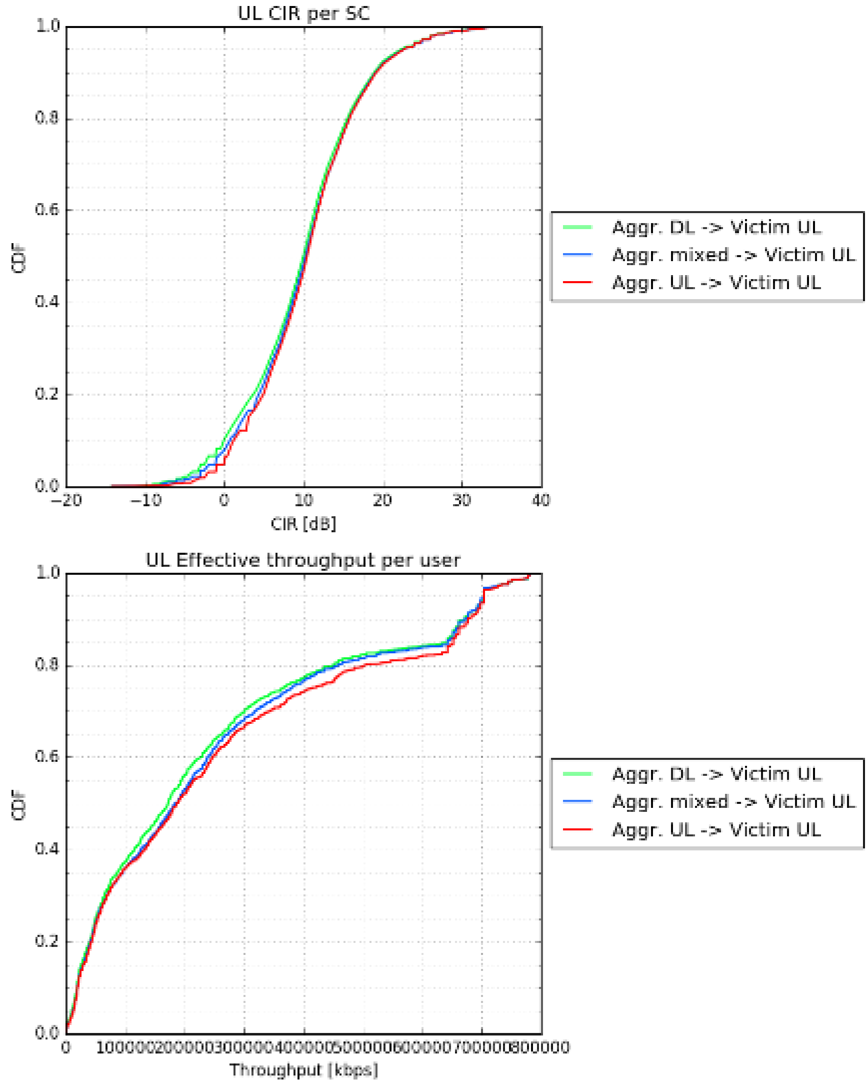


Figure A.2.7.4.2-1: SINR (top) and throughput (bottom) degradation for Indoor aggressor Indoor UL victim, 10% traffic

A.2.8 Scenario 16: 30 GHz Indoor → Indoor (DL)

A.2.8.1 Ericsson

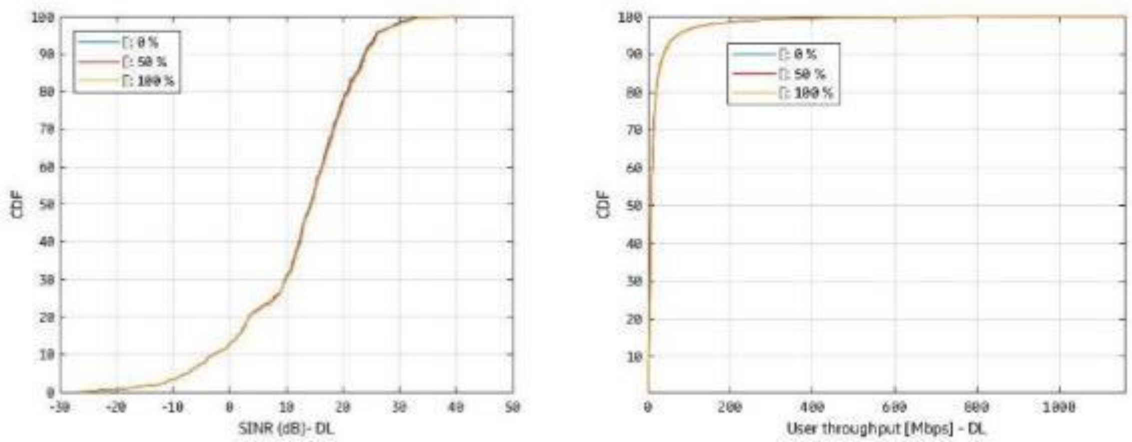


Figure A.2.8.1-1: CDF for the SINR and throughput for the DL victim.

A.2.8.2 Huawei

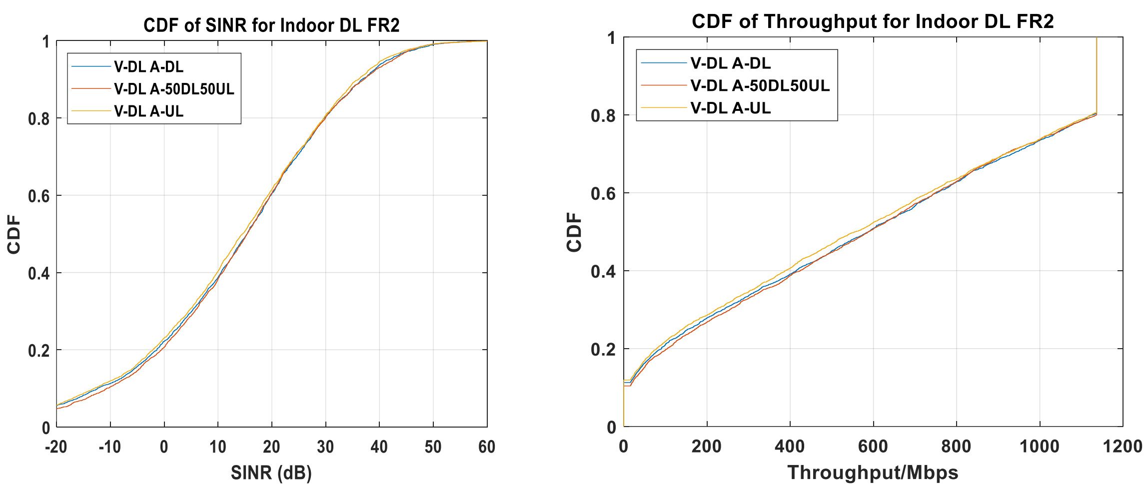


Figure A.2.8.2-1: CDF of DL SINR and throughput from Huawei

A.2.8.3 LGE

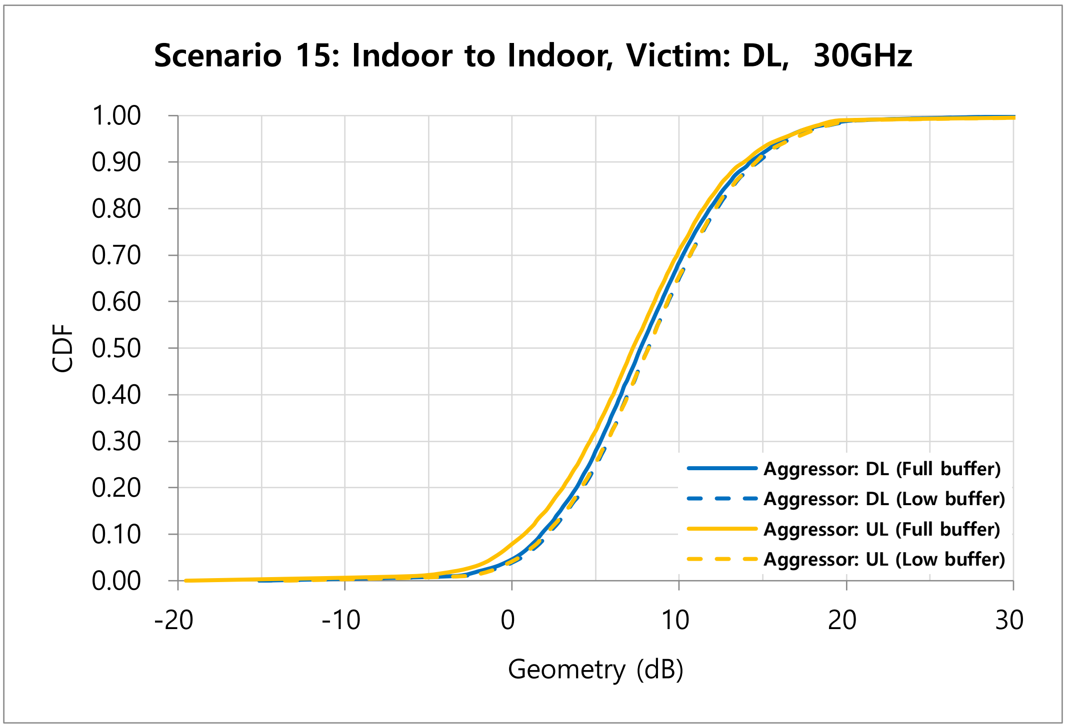


Figure A.2.8.3-1: Indoor-to-Indoor (victim: DL) SINR result

A.2.8.4 Nokia

A.2.8.4.1 Full buffer

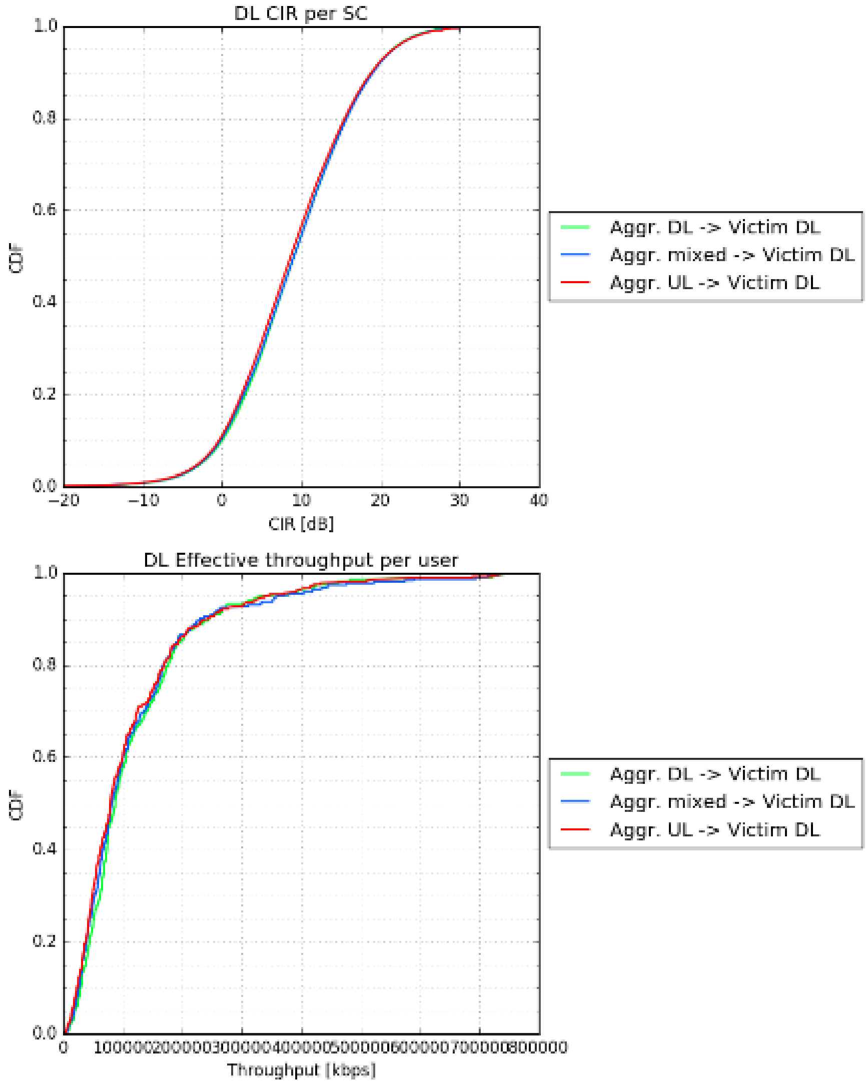


Figure A.2.8.4.1-1: SINR (top) and throughput (bottom) degradation for Indoor aggressor Indoor DL victim, full buffer traffic

A.2.8.4.2 FTP3 with 10% load

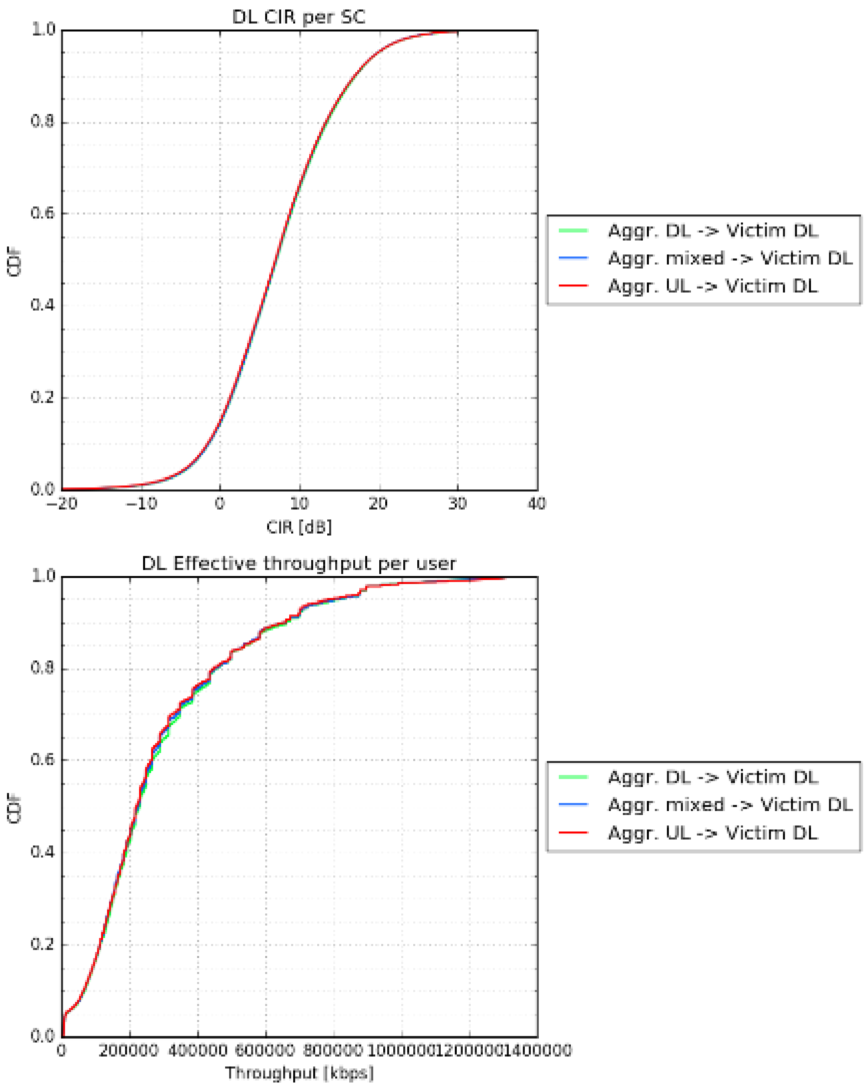


Figure A.2.8.4.2-1: SINR (top) and throughput (bottom) degradation for Indoor aggressor Indoor DL victim, 10% traffic

A.2.8.5 Qualcomm

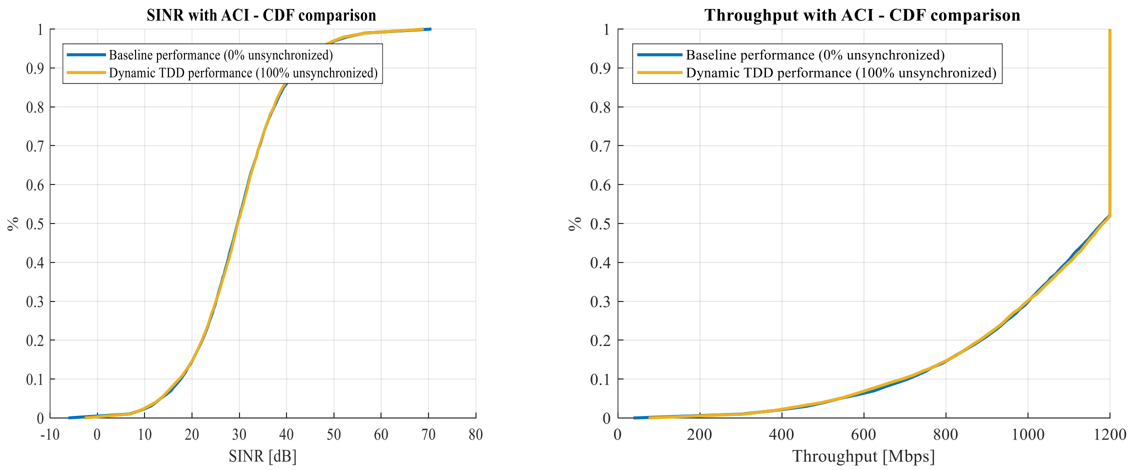


Figure A.2.8.5-1: Comparison of SINR and throughput performance with ACI in InH-to-InH scenario

Annex B: Detailed analysis for zero grid shift

This annex provides analysis of the inter-BS interference effects when there is zero grid shift (i.e. co-located aggressor and victim base stations). The interference between the base stations may be calculated analytically by considering the aggressor TX power, and the isolation between co-located base stations.

FR1:

For FR1, a typical assumption for the isolation between co-located base stations is 30dB. The 30dB assumption is the basis of the transmitter intermodulation and co-location blocking requirements for the FR1 specifications. A typical TRP transmit power as assumed for this study is 24-49dB, dependent on scenario (see section 5.3.1).

The power arriving into the receiver of a co-located victim is the aggressor TX power – isolation = 24 to 49dBm – 30dB = -6 to 19dBm. The FR1 receiver blocking requirement is -43dBm, so the interference from the aggressor to the victim will block the RF receiver and prevent uplink reception at the victim.

FR2:

For FR2, during the development of the 38.104 RF requirements in RAN4, around 50 to 70dB isolation between co-located BS was assumed. The total radiated power assumed for an FR2 BS in this study is 23 to 33 dBm, depending on scenario (see section 5.3.2). The range of interference power levels arriving at the receiver of a co-located receiver would be equal to TX power – isolation = (23 to 33dBm) – (50 to 70dB) = -17 to -47dBm. The FR2 blocking requirement is equal to the reference sensitivity + 33dB. The highest FR2 blocking level is -50dBm (for other sensitivity levels, the FR2 blocking requirement will be lower). Thus, power levels in the range arising for co-location scenarios will lead to receiver blocking in all circumstances.

Annex C: Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2019-04	RAN4 #90BIS	R4-1905090				TR skeleton for Co-existence study of Cross-Link Interference (CLI)	0.0.1
						Approved TPs in RAN4#90BIS **R4-1905091**, “TP to TR 38.828: Background” **R4-1905210**, “TP on CLI scenarios and system level simulation assumption” **R4-1905093**, “TP to TR 38.828: Inter-Operator interference mechanisms for unsynchronized TDD” **R4-1905094**, “TP to TR 38.828: Inter operator interference for co-located BS”	
2019-05	RAN4#91	R4-1906044				TR 38.828 v0.1.0 for Co-existence study of Cross-Link Interference (CLI)	0.1.0
						Approved TPs in RAN4#91 **R4-1907605**, “TP on summary and recommendations of co-existence evaluation of CLI” **R4-1907603**, “TP on simulation results and AnnexA_Detailed simulation results for non zero grid shift” **R4-1907600**, “TP to TR 38.828: Addition of missing antenna configurations to simulation assumptions” **R4-1907599**, “TP to TR 38.828 – clean up”	
2019-05	RAN4#91	R4-1906094				TR 38.828 v0.2.0 for Co-existence study of Cross-Link Interference (CLI)	0.2.0
2019-06	RAN#84	RP-191357				TR 38.828 1.0.0 is submitted for 1 step approval	1.0.0
2019-06	RAN#84					Approved by plenary – Rel-15 spec under change control	16.0.0
2019-09	RAN#85	RP-192024	0001	1	F	CR to TR 38.828 - abbreviations clean up	16.1.0
2019-09	RAN#85	RP-192024	0002	1	F	CR to TR 38.828 - references clean up	16.1.0