Extra High Value Feature

NETWORK ENGINEERING

TDD Massive MIMO

LTE2666 Massive MIMO

LTE4566 TDD Massive MIMO 10MHz Support

Network Engineering Information

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TDD Massive MIMO
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Introduction

TDD Massive MIMO features structure (1/5 and still growing)

- **LTE2666 Massive MIMO** (subject of current NEI)

- **LTE3463** DL MU-MIMO for massive MIMO, up to 8 streams (webNEI)

- **LTE3469** AirScale site configuration for Massive MIMO (webNEI)

- **LTE3953** AirScale MAA 64T64R 128AE B38 80W AAHD
- **LTE3809** AirScale MAA 64T64R 128AE B40 80W AANA
- **LTE4084** AirScale MAA 64T64R 128AE B40 120W AANB
- **LTE3452** AirScale MAA 64T64R 128AE B41 120W AAHB
- **LTE3738** AirScale MAA 64T64R 128AE B41 120W AAHC

BASIC feature*

Basic Multi User in DL

Configuration

Hardware

TD-LTE18

*** each extension of BASIC LTE2666 feature applies to all mMIMO features**

T D D M a s s i v e M I M O

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Introduction

TDD Massive MIMO features structure (2/5 and still growing)

- **LTE4566 TDD Massive MIMO 10Mhz Support** (subject of current NEI)

Extension of BASIC LTE2666*

- **LTE4427** DL MU-MIMO for massive MIMO, up to 16 streams (webNEI)
- **LTE3464** UL MU-MIMO for massive MIMO, up to 8 streams (webNEI)
- **LTE3690** DL CA for massive MIMO (webNEI)
- **LTE3691** UL CA for massive MIMO (webNEI)

Extension of Multi User in DL, Multi User in UL & UL/DL CA

- **LTE4630** 10MHz configuration for TD-LTE mMIMO (webNEI)
- **LTE4298** 3 carrier or 3 sector configuration for mMIMO (webNEI)

Configuration

- **LTE4576** AirScale MAA 64T64R 128AE B41 120W AAHE
- **LTE4590** AirScale MAA 64T64R 128AE B43 200W AEQD
- **LTE4672** AirScale MAA 64T64R 128AE B41 120W AAHF

Hardware

* each extension of BASIC LTE2666 feature applies to all mMIMO features

TD-LTE18SP

T D D Massive MIMO

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Introduction

TDD Massive MIMO features structure (3/5 and still growing)

- **LTE4573** TDD massive MIMO DL 256QAM and UL64QAM (webNEI)

Extension of BASIC LTE2666*

TD-LTE18A mMP (commercial)

- **LTE4655** TDD 32TRX massive MIMO (webNEI)
- **LTE4557-A** TDD TM9 support for massive MIMO (webNEI)

LTERLCR-27092

- **LTE4659** 32Tx32Rx configuration with split mode for TDD mMIMO (webNEI)

Configuration

- **LTE4845** AirScale MAA 64T64R 128AE B41 120W AAHJ

Hardware

same branch as

TD-LTE18A

*** each extension of BASIC LTE2666 feature applies to all mMIMO features**

Introduction

TDD Massive MIMO features structure (4/5 and still growing)

- **LTE4567** TDD Massive MIMO Capacity boost (webNEI)
- **LTE4655** TDD 32TRX massive MIMO (webNEI)
- **LTE4557-B** TDD TM9 support for massive MIMO (webNEI)
- **LTE5107** TDD TM9 MU-MIMO support for massive MIMO (webNEI)

Extension of BASIC LTE2666*

Second 32TRx for LTE — LTERLCR-25482

TD-LTE19 PT1 — LTERLCR-27092

- **LTE4659** 32Tx32Rx configuration with split mode for TDD mMIMO (webNEI)

Second 32TRx for LTE — LTERLCR-25482

Configuration

TD-LTE19

* each extension of BASIC LTE2666 feature applies to all mMIMO features

T D D M a s s i v e M I M O

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Introduction

TDD Massive MIMO features structure (5/5 and still growing)

- **LTE4671** TDD massive MIMO on ABIC (webNEI)
- **LTE5116** TDD massive MIMO 32TRx on ABIC (webNEI)

Extension of BASIC LTE2666*

- LTE4759 HW activation (HWA) licenses for mMIMO (no webNEI)

****HWA License**

****HWA-Hardware Activation**

*** each extension of BASIC LTE2666 feature applies to all mMIMO features**

TD-LTE19A

T D D M a s s i v e M I M O

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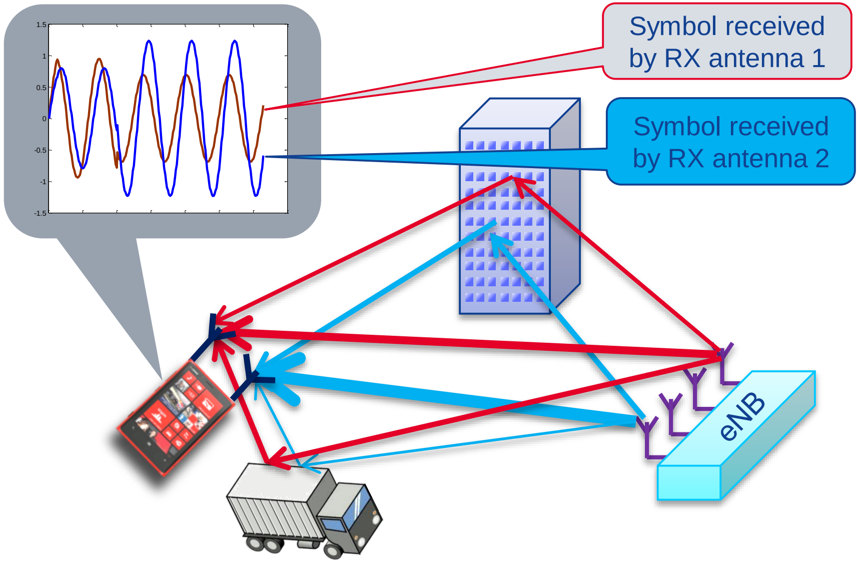
Introduction
Considered features in brief

THIS NEI complex covers following features:

- **LTE2666 Massive MIMO (TDD-LTE18)**
  basic feature introducing support for Single User (SU) Massive MIMO (mMIMO) for 20MHz deployment only

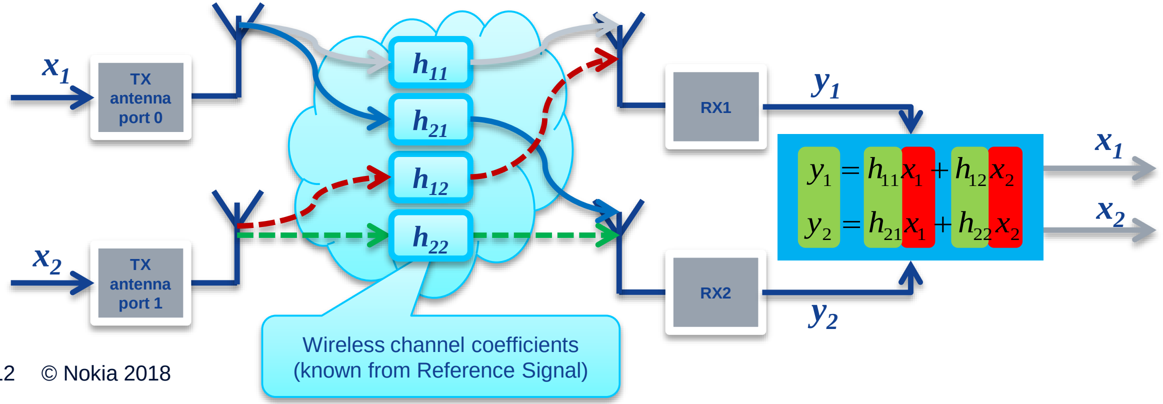
- **LTE4566 TDD Massive MIMO 10MHz Support (TDD-LTE18SP)**
  extension of mMIMO platform introducing support for 10MHz deployment

Introduction
MIMO Principle



MIMO = Multiple Input Multiple Output

- different symbols are sent by transmit antennas in the same time and frequency
- as symbols propagate over the wireless channel, their phase and amplitude changes according to the **channel coefficients**
- channel between each pair of the TX and RX antennas is different due to different propagation conditions



- channel coefficients are obtained from DL reference symbols (FDD) or uplink sounding in reciprocal channels (TDD)
- receiver needs to solve a set of linear equations to obtain the transmitted symbols

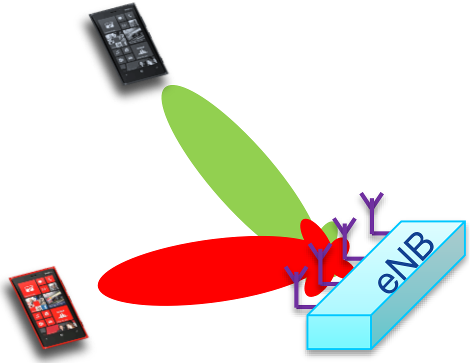
Introduction

Multiuser MIMO Principle

- in theory, maximum number of spatial multiplexing layers is defined by the smaller number of RX or TX antennas in the link:

$$MIMO\ order = \min(N_{tx}, N_{rx})$$

- in reality having large number of antennas on UE is not practical – increased cost of device, energy consumption, limited antenna packing space, favorable channel condition less frequent



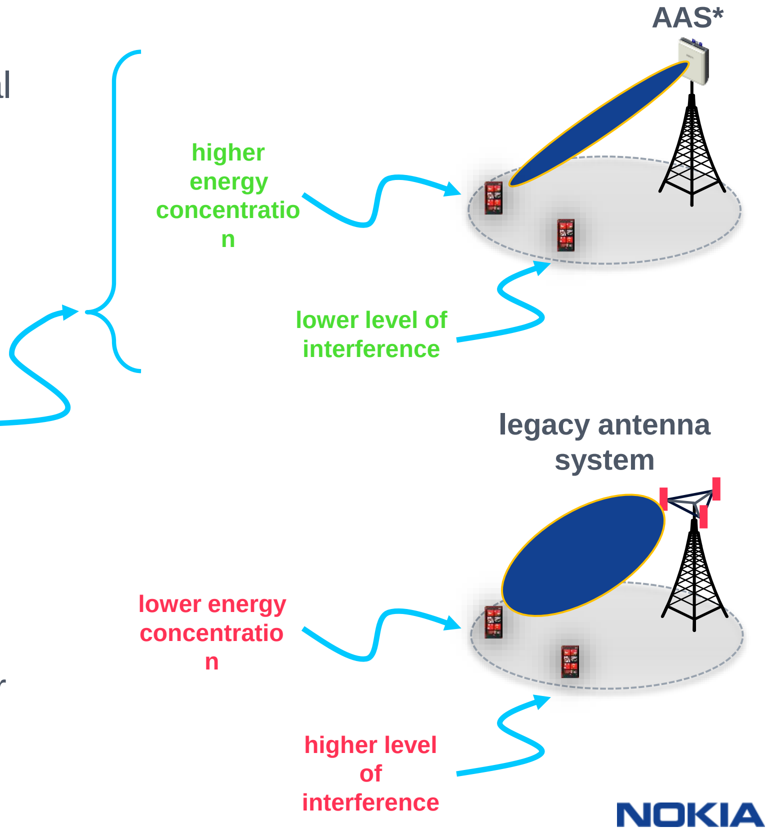
- multiuser MIMO (MU-MIMO) allows scheduling UEs on **same time and frequency** resources
- favorable channel conditions always met since close antenna packing is no longer an issue with multiple UEs
- better spectral efficiency (bit/s/Hz) than Single User MIMO (SU-MIMO)

Introduction
What is massive MIMO technology (1/2)?

- **Massive MIMO (mMIMO)** is the extension of traditional MIMO technology to **antenna arrays** having a **large number (>>8)** of controllable antenna elements
- utilization of larger number of antenna elements for signal transmission toward only one UE enables high degree of energy concentration in space as narrower beam is possible to be created
- higher energy concentration (narrower beam) **brings SINR improvement** as:

  - increased signal strength is provided to the UE location

  - less power is spread in other directions causing lower level of interference

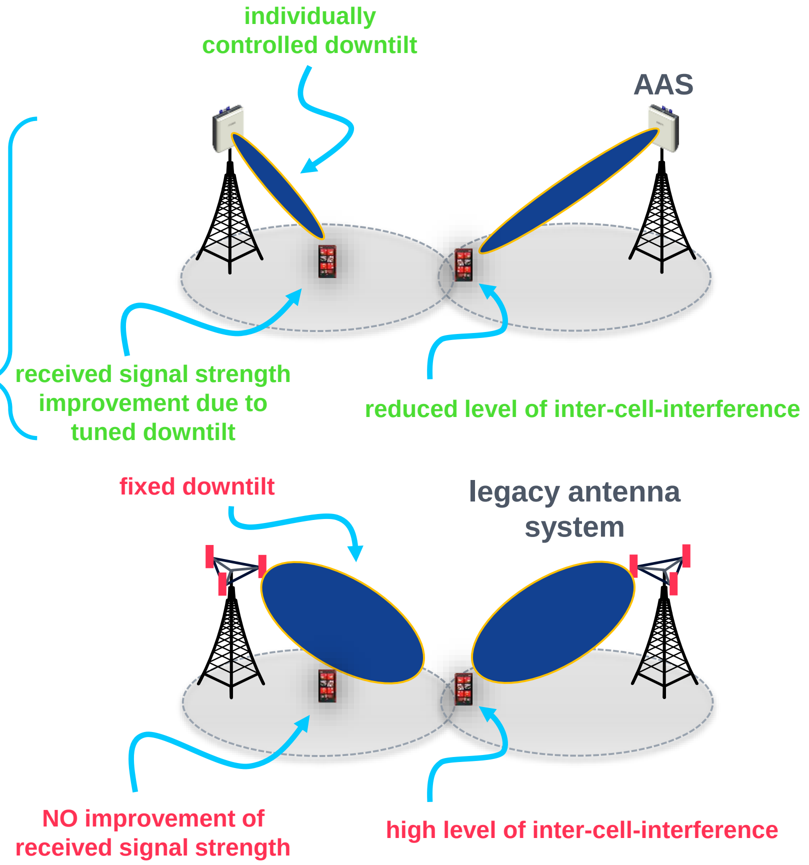


* Adaptive Antenna System

Introduction

What is massive MIMO technology (2/2)?

- moreover utilization of larger number of antenna elements for signal transmission toward only one UE enables beam's position to be controlled in 3D (**mMIMO enables 3D beamforming**)
- 3D beamforming enables downtilt of a beam to be controlled individually (no more fixed downtilts)
- individually controlled downtilt enables
  - **substantial reduction of inter-cell-interference**
  - **improvement of received signal strength**
- 3D beamforming is controlled through so called Beam Forming vector (BF vector)



Introduction

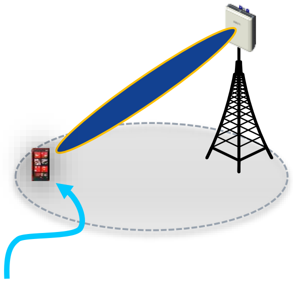
What is MU-MIMO for mMIMO technology (1/2)?

- **mMIMO antenna (MAA, AAS) is capable to produce more then just one narrow beam**
- moreover, each beam can be independently controlled in 3D (a dedicated Beam Forming vector is associated with each beam)
- as one beam can potentially serve one UE, that means more UEs can be simultaneously served by mMIMO antenna
- **the exact number of served UEs depends on:**

  - **the size of an AAS antenna array** (number of UEs should be smaller than number of elements in an antenna array – usually an order of magnitude)

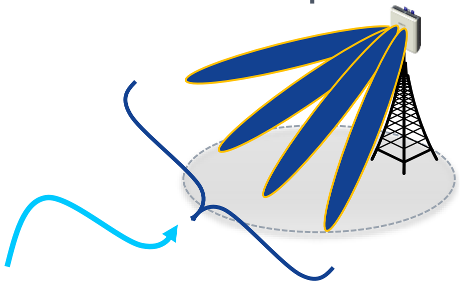
  - **the signal processing capabilities** of hardware just behind mMIMO antenna array

LTE2666



only one beam/UE is supported

AAS capabilities



mMIMO AAS is capable to produce more than just one beam each beam can potentially serve one UE

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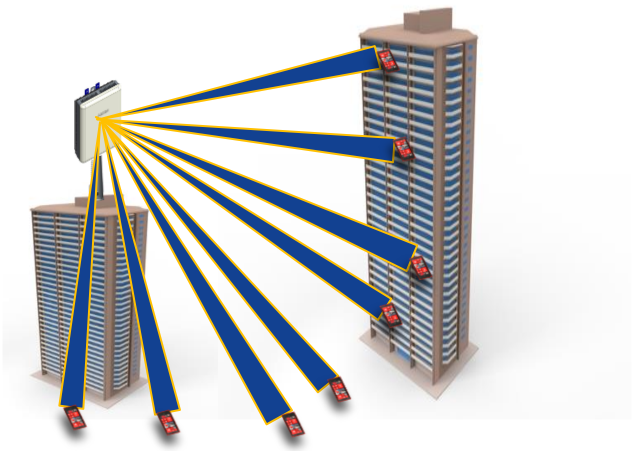
Introduction
What is MU-MIMO for mMIMO technology (2/2)?

- when all UEs are placed in distinct locations (are spatially separated) and each UE is served by dedicated narrow beam, AAS antenna array can distinguish them (UEs are considered to be spatially orthogonal)
- under such circumstances UEs no longer have to be allocated with different (orthogonal) time and frequency resources (PRBs), **UEs can reuse same PRBs**
- that in general means that PRBs are not distributed among UEs but simultaneously reused instead – as a result each UE can be (at least potentially) allocated with all available PRBs
- from that point of view number of available PRBs is multiplied by the number of UEs – this is how mMIMO can provide **Multiuser Gain**

MU-MIMO for mMIMO technology



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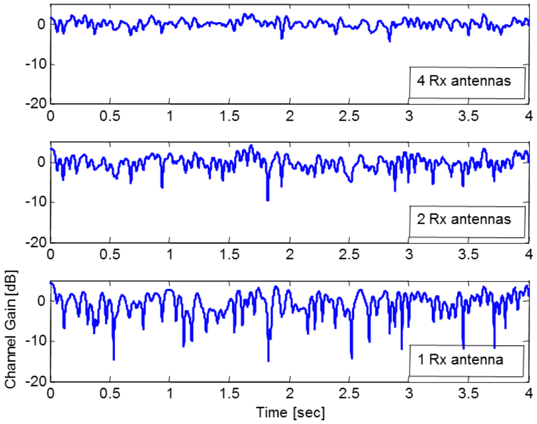
Introduction

Channel Hardening in Massive MIMO

Is Massive MIMO just MU-MIMO with extra antennas?

What is fundamentally different?

- with more transmit antennas, fast fading gradually disappears. This effect is called **channel hardening** in mMIMO literature
- this effect, plus **favorable propagation conditions** made available by massive antenna array take MU-MIMO to the **ultimate performance** level in practical radio conditions

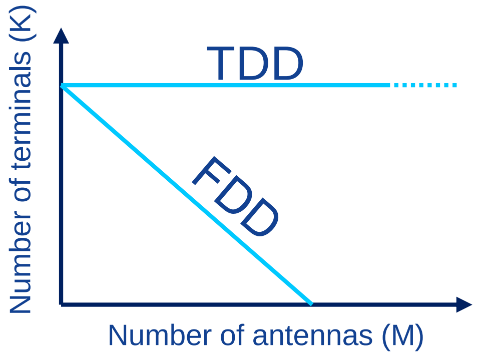


- radio channel becomes **flat in frequency domain** -> less gain from frequency scheduling
- system design *could be* simplified resulting in lower latencies

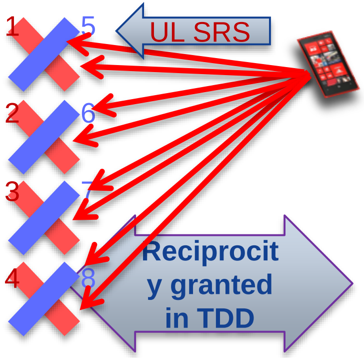
Introduction

TDD/FDD Aspects of Massive MIMO

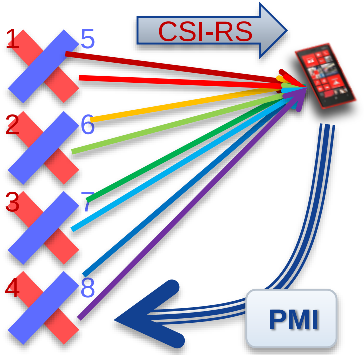
- **as in traditional closed loop MIMO, in mMIMO channel knowledge is needed at the transmitter as well:**
  - **TDD can use channel reciprocity**
  - **FDD uses improved 3GPP Release 13/14 feedback**
- **TDD is better suitable for Massive MIMO than FDD**



*Illustrative only.
*Assuming same % of pilot overhead.



In TDD, radio pilot overhead depends on the number of spatially multiplexed UEs. It does not depend on the number of the antennas.



In FDD overhead depends both on the number of the antennas and the number of spatially multiplexed UEs.

Therefore spectral efficiency of FDD mMIMO is limited compared to that of TDD.

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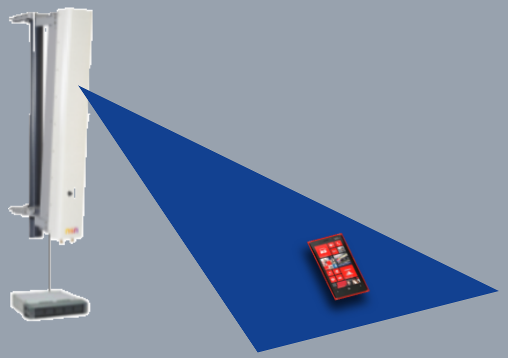
Introduction

Before & after LTE2666

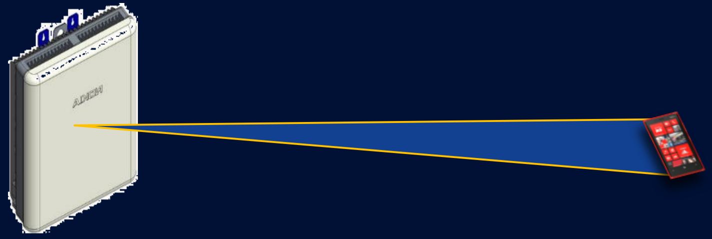
Before

- Network uses 8T8R beamforming in horizontal domain only



After

- mMIMO Active Antenna (AAS) in place
- Extended capacity and coverage due to 3D beamforming
- More mMIMO features possible with SW upgrade



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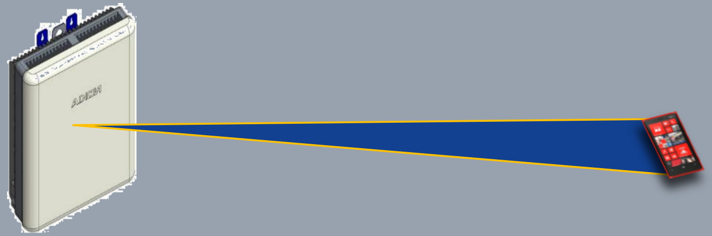
Introduction

Before & after LTE4566

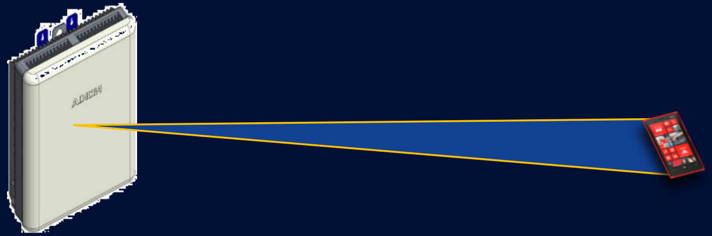
Before

- mMIMO Active Antenna (AAS) in place
- Extended capacity and coverage due to 3D beamforming
- More mMIMO features possible with SW upgrade
- **only 20MHz bandwidth supported by LTE2666**



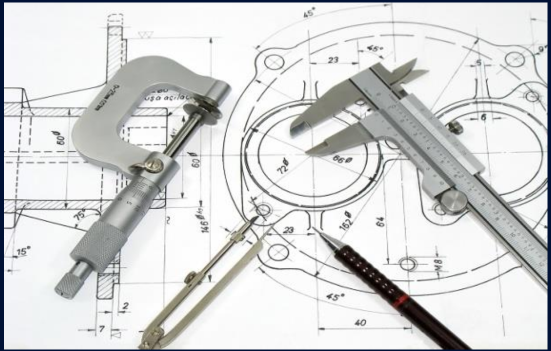
After

- mMIMO Active Antenna (AAS) in place
- Extended capacity and coverage due to 3D beamforming
- More mMIMO features possible with SW upgrade
- **10MHz bandwidth supported**



LTE2666 Massive MIMO, LTE4566 TDD Massive MIMO 10MHz support

Technical Details



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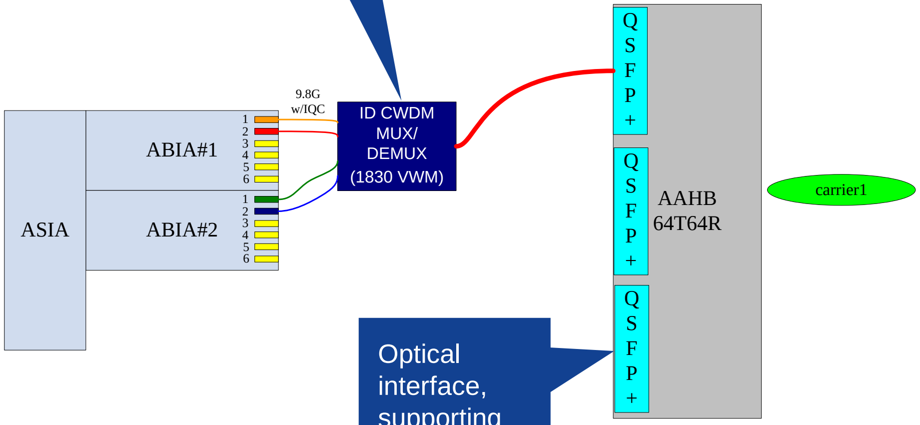
Technical Details
LTE2666 Massive MIMO Active Antenna Array

- **LTE2666** works with **Adaptive Antenna Systems (AAS)** provided in **Introduction** part
- first AAS supported by LTE2666 was **LTE3452 AirScale MAA 64T64R 128AE B41 120W AAHB**
- basic configuration is as per **LTE3469 AirScale site configuration for Massive MIMO**

- **LTE3452 features:**
  - Integrated antenna
  - 120W total output power at 2.6GHz Band (3GPP TDD B41)
  - 64 TRXs driving 128 antenna elements, transmitting 1.875W per TRX
  - Instantaneous bandwidth 60MHz at 2.6GHz Band (up to 3xLTE20)

- **LTE3469 features:**
  - **one 20 MHz carrier requires 2x ABIA cards**
  - 4 CPRI links required per carrier
  - physical layer from 64TXRX fully processed in baseband module

LTE2763 Fronthaul Passive



Optical interface, supporting 4x 9.8Gbps CPRI link

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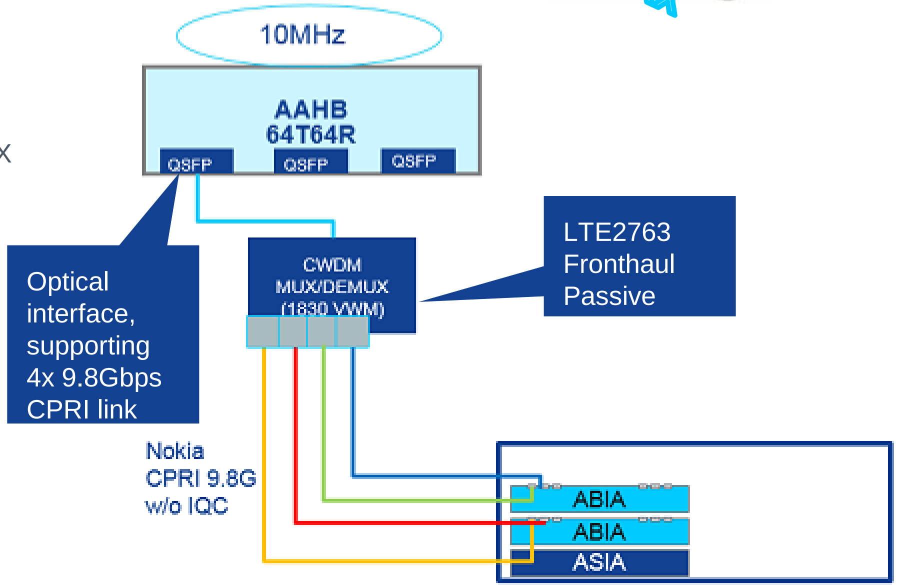
Technical Details
LTE4566 TDD Massive MIMO 10MHz Support

- **LTE4566** works with **Adaptive Antenna Systems (AAS)** provided in **Introduction** part
- first AAS supported by LTE4566 was **LTE3452 AirScale MAA 64T64R 128AE B41 120W AAHB**
- basic configuration is as per **LTE4630 10MHz configuration for TD-LTE mMIMO**

- **LTE3452 features:**
  - Integrated antenna
  - 120W total output power at 2.6GHz Band (3GPP TDD B41)
  - 64 TRXs driving 128 antenna elements, transmitting 1.875W per TRX
  - Instantaneous bandwidth 60MHz at 2.6GHz Band (up to 3xLTE20)

- **LTE4630 features:**
  - **one 10 MHz carrier requires 2x ABIA cards (same as for 20MHz)**
  - 4 CPRI links required per carrier
  - physical layer from 64TXRX fully processed in baseband module



Technical Details
LTE4566 TDD Massive MIMO 10MHz Support

- **in opposition to LTE2666, LTE4566 is supposed to covers not only SU-MIMO use cases, however…**
- LTE4566 deployment took place after deployment of features extending LTE2666 capabilities
- in fact LTE4566 is modification of basic LTE2666 feature only, however due to that has effect on each feature that bases on LTE2666
- to avoid necessity of updating a grate number of other mMIMO features, this update was included into the scope of LTE4566
- that is why MU-MIMO functionality is in the LTE4566 scope as well

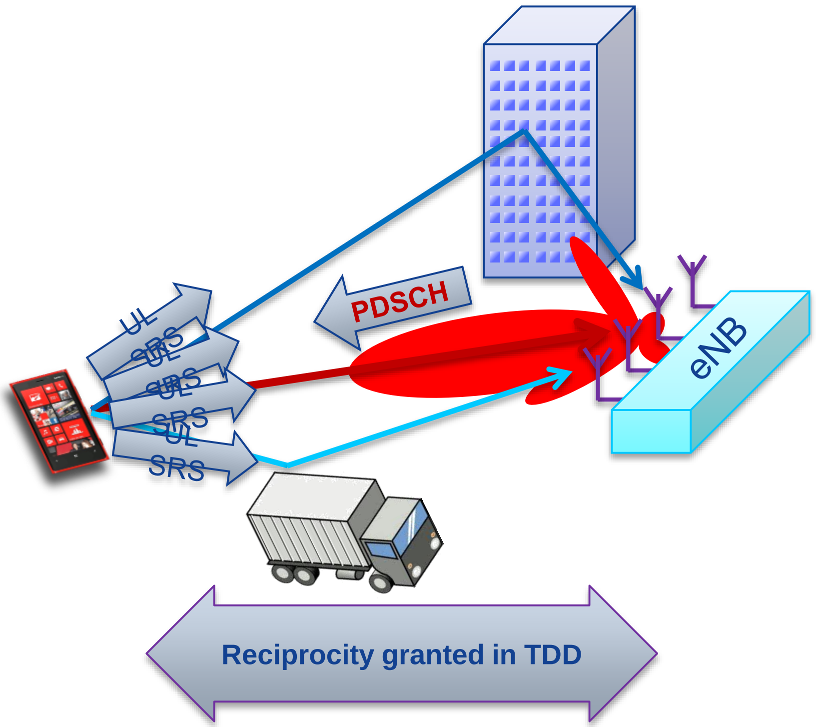
- that means LTE4566 covers:

  - **DL MU-MIMO for mMIMO** (LTE3463 in case of 20MHz bandwidth)
  - **DL MU-MIMO for mMIMO 16 layers** (LTE4427 in case of 20MHz bandwidth)
  - **UL MU-MIMO for mMIMO** (LTE3464 in case of 20MHz bandwidth)

- however, the range in which LTE4566 covers MU-MIMO functionality is limited only to the bandwidth
- that means that in order to activate any of MU-MIMO scenario in 10MHz network, relevant 20MHz feature has to be activated prior LTE4566 activation
- LTE4566 will only narrow the bandwidth to 10MHz

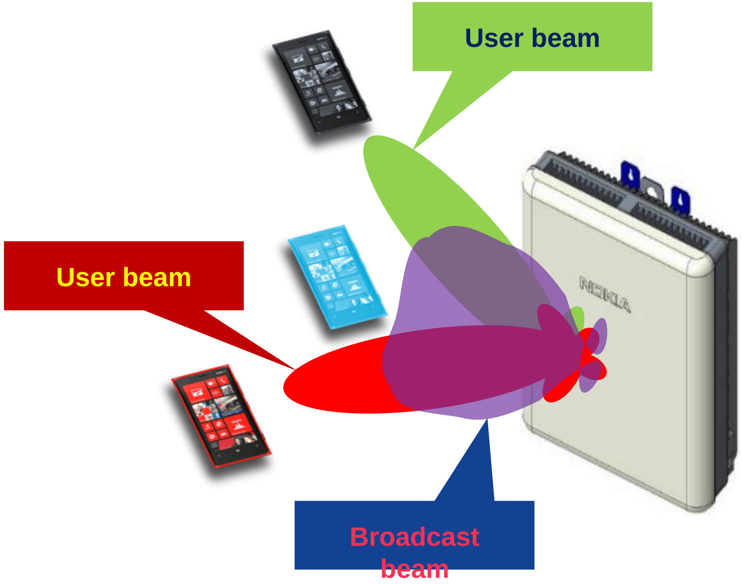
Technical Details
PDSCH beamforming

- LTE2666/LTE4566 is based on **Rel.9 UEs**. Transmission to the UE in the DL is done using 3GPP Transmission Mode 8 (**TM8**)
- long term beamforming weights per UE are calculated based on the Sounding Reference Signal (**SRS)** symbols sent by the UE periodically in the UL. They are then used to transmit up to 2 beamformed spatially multiplexed streams to the UE
- **broadcast and common control channels are not beamformed**
- LTE2666/LTE4566 bases on beamforming algorithm that was introduced by the legacy feature **LTE541 Dual Stream Beamforming (webNEI)**



Technical Details
Broadcast (sector) beam

- broadcast, common control channels and cell reference symbols are transmitted via **sector beam**. Sector beam radiation pattern is made wide enough (e.g.90^0 beam width) to provide coverage in the cell for the radio channels that cannot or must not be beamformed
- sector beam will also be used for non-beamformed UE dedicated PDSCH transmissions (e.g. TM2, TM3)
- sector beam weights are stored in the sector beamforming weight profiles, defined in both **vertical** and **horizontal** plane
- there are 20 predefined **beamforming profiles** defined for LTE2666/LTE4566
- in LTE2666/LTE4566 **electrical tilt** of the sector beam is realized also by means of beamforming profile selection



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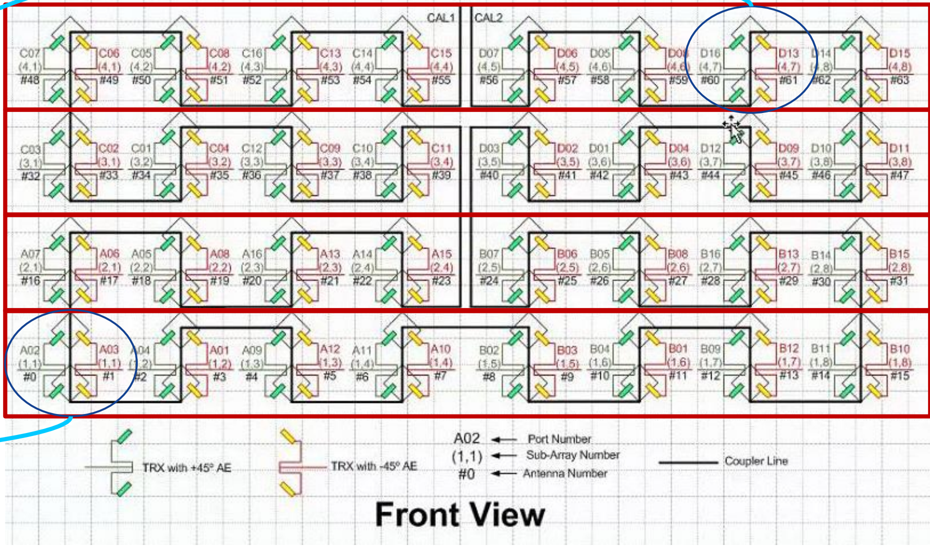
Technical Details

Broadcast beam: 64T64R antenna deployment

- according to the antenna deployment picture on the right, antenna Id #0 and #1 belong to a same sub-array and they will have a same Sector Beamforming Weight. Antenna IDs table is shown below:

48, 49	50, 51	52, 53	54, 55	56, 57	58, 59	60, 61	62, 63
32, 33	34, 35	36, 37	38, 39	40, 41	42, 43	44, 45	46, 47
16, 17	18, 19	20, 21	22, 23	24, 25	26, 27	28, 29	30, 31
0, 1	2, 3	4, 5	6, 7	8, 9	10, 11	12, 13	14, 15



- the two antennas that are in the same antenna group have different polarizations

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Technical Details

Broadcast beam: how sector beams are made

- sector beam weights are complex numbers, that are defined in terms of **modulus** and **phase** for each of **8 horizontal and 4 vertical antenna group**.
- individual antenna group weight is obtained by multiplying vertical and horizontal modules of an antenna element and adding their respective phases:

*modulusOfAntGrp**6H***
*phaseOfAntGrp**6H***

*modulusOfAntGrp**2V***
*phaseOfAntGrp**2V***

48, 49	50, 51	52, 53	54, 55	56, 57	58, 59	60, 61	62, 63
32, 33	34, 35	36, 37	38, 39	40, 41	42, 43	44, 45	46, 47
16, 17	18, 19	20, 21	22, 23	24, 25	26, 27	28, 29	30, 31
0, 1	2, 3	4, 5	6, 7	8, 9	10, 11	12, 13	14, 15

FinalModulusForAntGrp[i*8 + j] = ModulusOfVerticalForAntGrp[i] * ModulusOfHorizontalForAntGrp[j];

FinalPhaseForAntGrp[i*8 + j] = PhaseOfVerticalForAntGrp[i] + PhaseOfHorizontalForAntGrp[j];

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Technical Details

Broadcast beam: how to configure broadcast beam

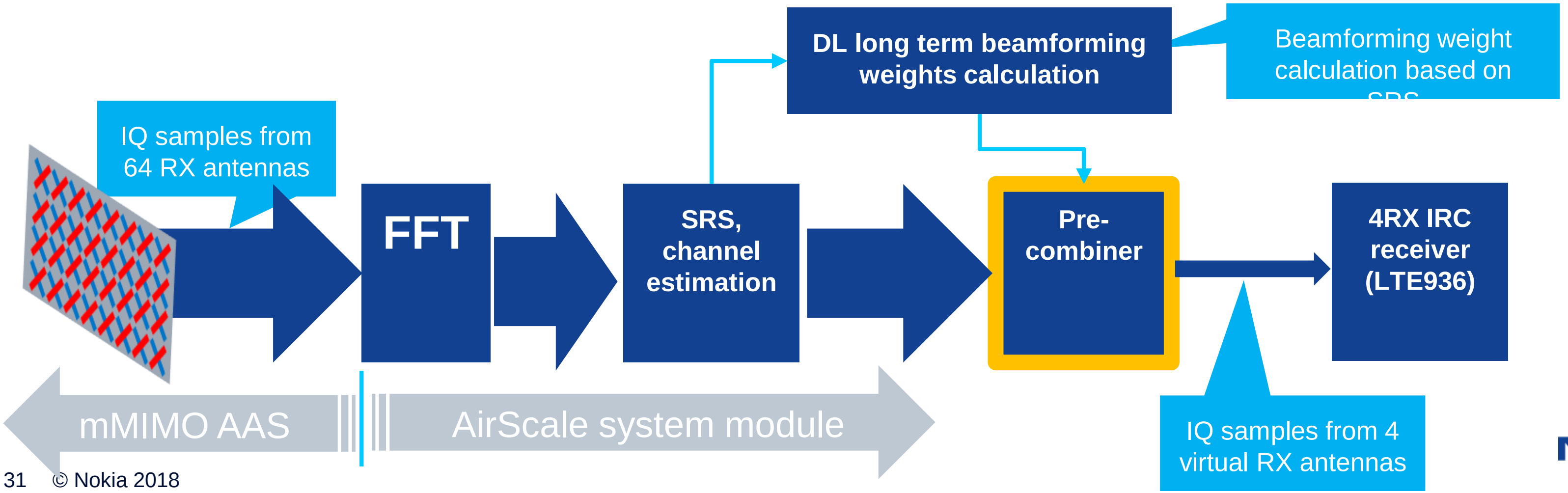
- sector beamforming profiles are either **predefined** or **customized**
- they are selected by setting *LNCEL_TDD:mMimoSectorBFProfName* parameter to a specific sector beam profile name
- vertical sector beam **tilt adjustment** is based on selecting one of the predefined profiles. In LTE2666 vertical tilt is processed by the baseband, there is no additional Remote Electrical Tilt (RET) function.
- additionally to the predefined profiles, customer can configure up to 20 additional sector beam profiles.

Predefined sector beam profiles:

Macro-0 Electrical Tilt-(0)
Macro-0 Electrical Tilt-(1)
Macro-0 Electrical Tilt-(2)
Macro-0 Electrical Tilt-(3)
Macro-0 Electrical Tilt-(4)
Macro-0 Electrical Tilt-(5)
Macro-0 Electrical Tilt-(6)
Macro-0 Electrical Tilt-(7)
Macro-0 Electrical Tilt-(8)
Macro-0 Electrical Tilt-(-1)
Macro-0 Electrical Tilt-(-2)
High Building-0

Technical Details
Uplink Receiver

- Uplink receiver structure is optimized for complexity caused by large scale of antennas
- Uplink PUSCH algorithm is based on **4RX IRC receiver** as specified in LTE936 considering balance between performance and complexity
- a large scale antenna data is split to 4 virtual antennas**. Pre-combined data** from these virtual antennas is the input of traditional type receiver
- **Pre-combining** is done based on the **long term beamforming** weights obtained from SRS



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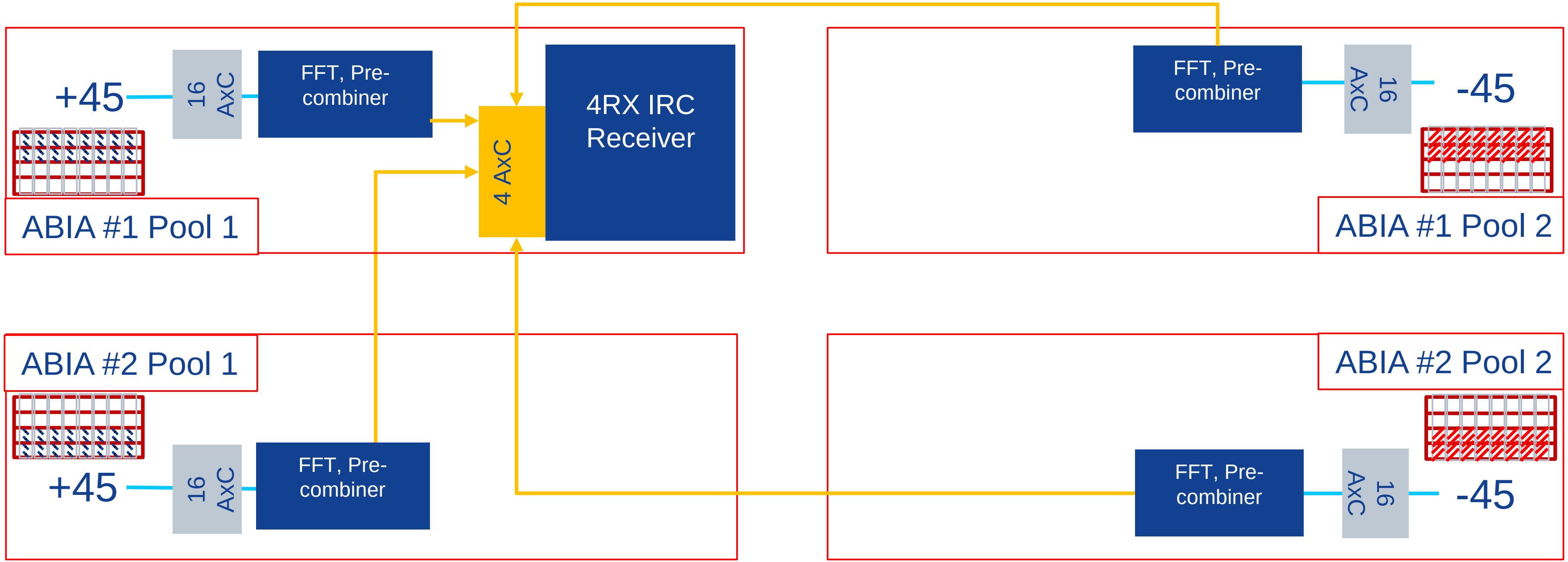
Technical Details
PUSCH Receiver: Internal Structure



- Get one 16x1 pre-coding vector in each DSP pool for each user based on covariance matrix
- 1 AxC output for each user from each pre-combiner
- Extra processing power will be used in later release for UL MU-MIMO for Massive MIMO (LTE3464)

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LTE2666 Massive MIMO, LTE4566 TDD Massive MIMO 10MHz support

Benefits and Gains

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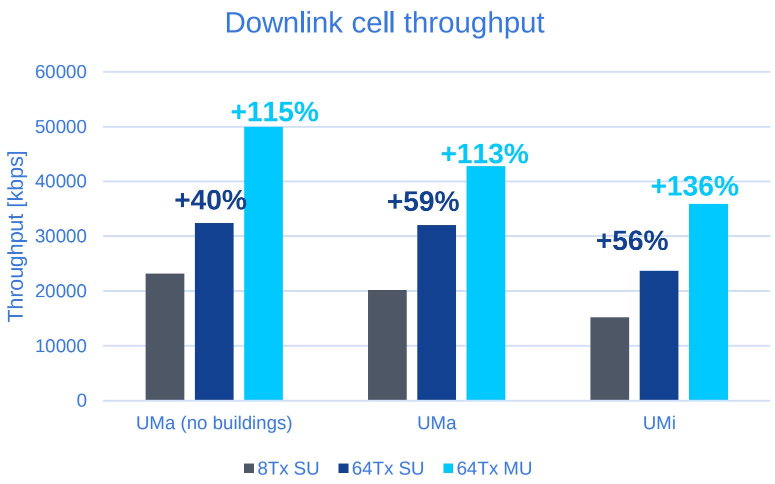
Benefits and Gains
LTE2666 System Level Simulations Single User DL MIMO

Mobile Users within 3D-UMa Cells (Macro scenario) with Buildings

- Full Buffer traffic
- TM8
- **SU-MIMO, MU-MIMO (8 users)**
- Reference scenario: 8TX

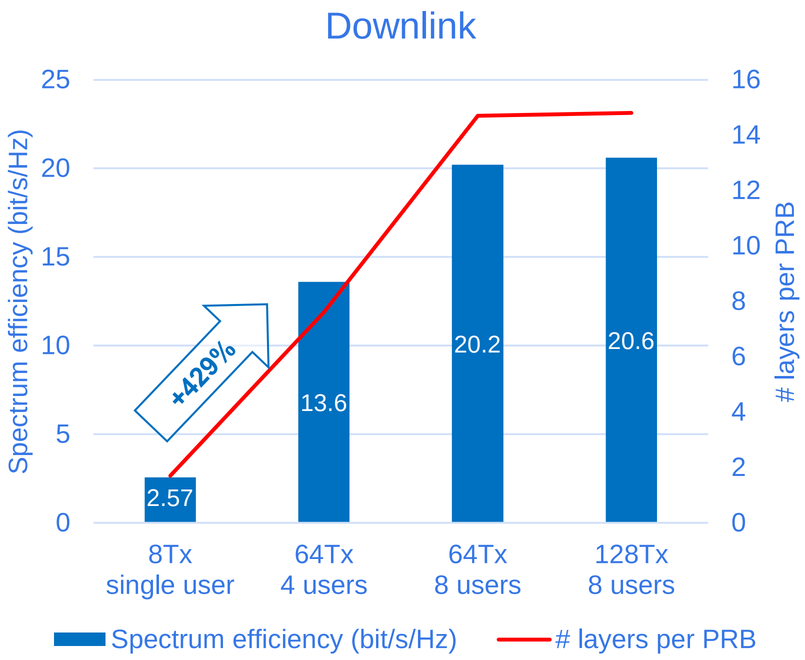
Source: Network Engineering system level simulations



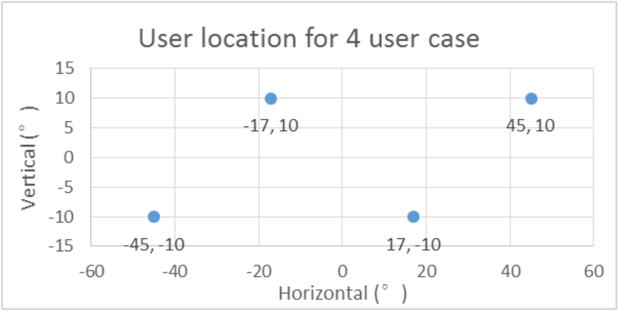
There is about 40% - 59% gain (depending on scenario) in downlink cell throughput after switching from 8Tx to 64Tx.

Benefits and Gains

LTE2666 Static User Locations within 3D-UMi-LoS (microcell, line of sight)



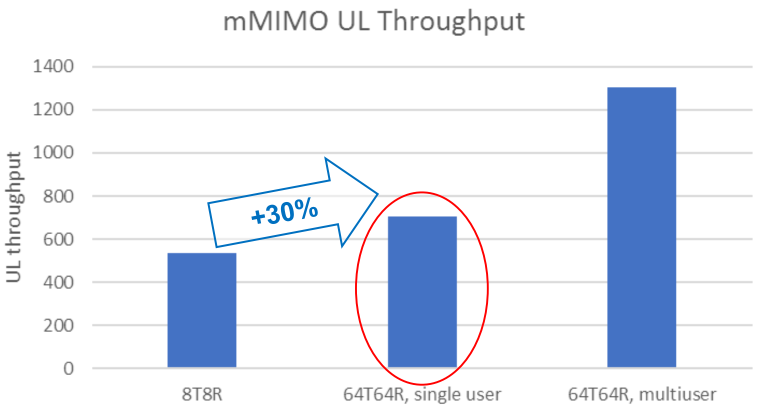
- stationary users experience more stable channel and therefore channel estimates are more reliable. This is reflected in spectral efficiency gain, and eventually to higher DL cell throughput
- please note, that simulations shown here are for massive MU-MIMO case, gain for single user is not shown, however similar quantitative impact is expected also for SU-MIMO case



Source: https://sharenet-ims.int.net.nokia.com/livelink/livelink/overview/D550070418

Benefits and Gains

LTE2666 Mobile Users, uplink



- single user UL throughput gain is about 30% compared to 8T8R.
- in case of 8T8R the receiver is 8RX IRC, which should outperform 4RX IRC used by LTE2666, all other things considered equal. However in case of 8T8R there are only 8 active antenna elements. In case of 64T64R pre-combining over four groups of 16 antennas in the mMIMO AAS is able to compensate for lower IRC receiver complexity, and bring an additional gain.
- please see Technical Details section for more information on the uplink receiver in LTE2666.

Source: https://sharenet-ims.int.net.nokia.com/Overview/D551644206

Benefits and Gains

Peak cell throughput comparison for 10MHz and 20MHz massive MIMO

Feature	Uplink peak L1 target	Downlink peak L1 target
LTE2666	9.996 Mbps	92.0 Mbps
LTE4566	4.680 Mbps	46.13 Mbps

UL settings
transmission mode – TM1
MCS - MCS24
SSF config – any
Frame Config – 2
Rank – 1

DL settings
transmission mode - TM8
MCS - MCS28
SSF config – 7
Frame Config – 2
Rank – 2
Layer – 1

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Interdependencies

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Interdependencies

prerequisites

Following features are prerequisites for LTE2666 and LTE4566

- LTE3452 AAU TD-LTE massive MIMO AAS 64T64R B41 120W AAHB
- LTE3469 AirScale TDD-LTE site configuration for Massive MIMO
  These features cover 64T64R Massive MIMO AAS and baseband configuration
- LTE541 Dual Stream Beamforming
  LTE2666 bases on the hybrid DL beamforming algorithm introduced by LTE541

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Interdependencies

limitations

Following features are not supported with LTE2666 and LTE4566

- LTE1089: Downlink carrier aggregation - 20 MHz
- LTE1103: Load based Power Saving for multi-layer networks
- LTE1130: Dynamic PUCCH allocation
- LTE1203: Load based Power Saving with Tx path switching off
- LTE1709: Liquid Cell
- LTE1987: Downlink Adaptive Closed Loop SU MIMO (4x4)
- LTE2733: Baseband pooling
- LTE48: Support of High Speed Users
- LTE495: OTDOA
- LTE73: UL MU MIMO 4RX
- LTE993: Cell Combination (Super cell)

Interdependencies

limitations

Following functionalities are not supported with LTE2666 and LTE4566

- LTE2479 256 QAM in downlink
- LTE1691 UL CoMP for 4RX
- LTE2462 Coordinate Scheduling for Beamforming Interference Avoidance
- LTE1929 UL SPS Scheduler
- LTE1117 LTE eMBMS
- LTE1113 eICIC
- LTE180 Large cell radius
- PRACH format 4

Interdependencies

extensions

Following functionalities extends capabilities of LTE2666 and LTE4566

- LTE3463 DL MU-MIMO for Massive MIMO
- LTE3464 UL MU-MIMO for Massive MIMO (in TL18SP)
  These features introduce multiuser MIMO functionalities for LTE2666 and LTE4566

- LTE1013 Dynamic transmission Mode Switch
  This feature allows for switching between transmission modes resulting in higher peak and average throughput

Configuration Management

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Configuration Management

Definition of terms and rules for parameter classification*

The **'Basic Parameters'** category contains primary parameters which should be considered during cell deployment and must be adjusted to a particular scenario:

- Network Element (NE) identifiers
- Planning parameters, e.g. neighbour definitions, frequency, scrambling codes, PCI, RA preambles
- Parameters that are the outcome from dimensioning, i.e. basic parameters defining amount of resources
- Basic parameters activating basic functionalities, e.g. power control, admission control, handovers
- Parameters defining operators' strategy, e.g. traffic steering, thresholds for power control, handovers, cell reselections, basic parameters defining feature behaviour

The **'Advanced Parameters'** category contains the parameters for network optimisation and fine tuning:

- Decent network performance should be achieved without tuning these parameters
- Universal defaults ensuring decent network performance need to be defined for all parameters of this category. If this is not possible for a given parameter it must be put to the 'Basic Parameters' category
- Parameters requiring detailed system knowledge and broad experience unless rules for the 'Basic Parameters' category are violated
- All parameters (even without defaults, e.g. optional structures) related to advanced and very complex features

The **'Obsolete parameters'** category is intended for parameters that are candidates to be removed from the product in a future release:

- Parameters always used with default value
- Parameters that are not used by operators
- Parameters that are not relevant anymore

* **<u>- purpose:</u>** Categories of parameters have been defined to simplify network parametrization. Parameterization effort shall be focused mainly on Basic ones. Categorization is reflected in a 'view' definition in NetAct CM Editor.

Configuration Management

New parameters LTE2666 Massive MIMO

	Abbreviated name	Full name	PKDB link
	LNCEL_TDD:actMMimo	Massive MIMO activation (read only)	https://mint.emea.nsn-net.net/data/gui/3.0/parameters/eNB/LNCEL_TDD/actMMimo!details,TD-LTE18
	LNCEL_TDD:mMimoSectorBFProfName	Massive MIMO profile name	https://mint.emea.nsn-net.net/data/gui/3.0/parameters/eNB/LNCEL_TDD/mMimoSectorBFProfName!details,TD-LTE18
	LNBTS:MMIMOCPR:mMimoDlSBFWeightProfName	Massive MIMO DL sector beamforming weight profile name	https://mint.emea.nsn-net.net/data/gui/3.0/parameters/eNB/MMIMOCPR/mMimoDlSBFWeightProfName!details,TD-LTE18
	MMIMOCPR:modulusOfAntGrp0H.. modulusOfAntGrp7H	Modulus of weight for horizontal antenna group 0..7	https://mint.emea.nsn-net.net/data/gui/3.0/parameters/eNB/MMIMOCPR/modulusOfAntGrp0H!details,TD-LTE18
	MMIMOCPR:modulusOfAntGrp0V.. modulusOfAntGrp3V	Modulus of weight for vertical antenna group 0..3	https://mint.emea.nsn-net.net/data/gui/3.0/parameters/eNB/MMIMOCPR/modulusOfAntGrp0V!details,TD-LTE18

REQUIRES BTS RESTART   REQUIRES CELL LOCKING   ONLINE MODIFIABLE

Configuration Management

New parameters LTE2666 Massive MIMO

	Abbreviated name	Full name	PKDB link
	MMIMOCPR:phaseOfAntGrp0H.. phaseOfAntGrp7H	Phase of weight for horizontal antenna group 0..7	https://mint.emea.nsn-net.net/data/gui/3.0/parameters/eNB/MMIMOCPR/phaseOfAntGrp0H!details,TD-LTE18
	MMIMOCPR:phaseOfAntGrp0V.. phaseOfAntGrp3V	Phase of weight for vertical antenna group 0..3	https://mint.emea.nsn-net.net/data/gui/3.0/parameters/eNB/MMIMOCPR/phaseOfAntGrp0V!details,TD-LTE18

New parameters LTE4566 TDD Massive MIMO 10Mhz Support

- **LTE4566 reuses all LTE2666 parameters and does not introduce any new parameters**

REQUIRES BTS RESTART REQUIRES CELL LOCKING ONLINE MODIFIABLE

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Deployment Aspects

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Deployment Aspects

LTE2666 Massive MIMO, LTE4566 TDD Massive MIMO 10MHz support

- Based on LTERLCR-25434

- TDD mMIMO originally restricted the cell maximum total power to 40W per 20MHz for 64TRX due to radio emission performance limitation
- after HW internal test it is confirmed that the performance of 60W shall be acceptable for AAHC
- as all TDD mMIMO official AASs 64TRX in TD-LTE18A or earlier release follow the same platform, it is reasonable to believe more radios shall follow the new limitation

- **after this CR Nokia support cell maximum total power as below for designated TDD mMIMO official AASs 64TRX in TD-LTE18A or earlier release (B41,B40,B38):**
  - **20MHz 64TRX 60W**
  - **10MHz 64TRX 40W (legacy rule)**

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Deployment Aspects
LTE2666 Massive MIMO, LTE4566 TDD Massive MIMO 10MHz support

- Based on LTERLCR-25434
- for special areas there may be specific governance rules, e.x. U.S.A FCC
- this CR does not cover these specific market radios (AAHJ, AAHE)
- for these specific markets eNB will check:
  - maximum power limitation per carrier (20MHz or 10MHz)
  - total AAS maximum power limitation (this CR has no intention to increase total AAS power)

- **NOTE:** AAS requires multi-carrier flat power spectrum density(20MHz+10MHz configuration example: 20MHz 60W, then 10MHz 30W), operators should follow this rule for configuration
- **NOTE:** the same family AASs beyond TD-LTE18A shall follow the same limitation
- **NOTE:** 32TRx split mode maximum cell power is defined in TD-LTE18A **LTE4655 TDD 32TRX massive MIMO** (WebNEI) and shall follow the similar principle (e.x. half cell maximum total power of 64TRx)

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Deployment Aspects
LTE2666 Massive MIMO, LTE4566 TDD Massive MIMO 10MHz support

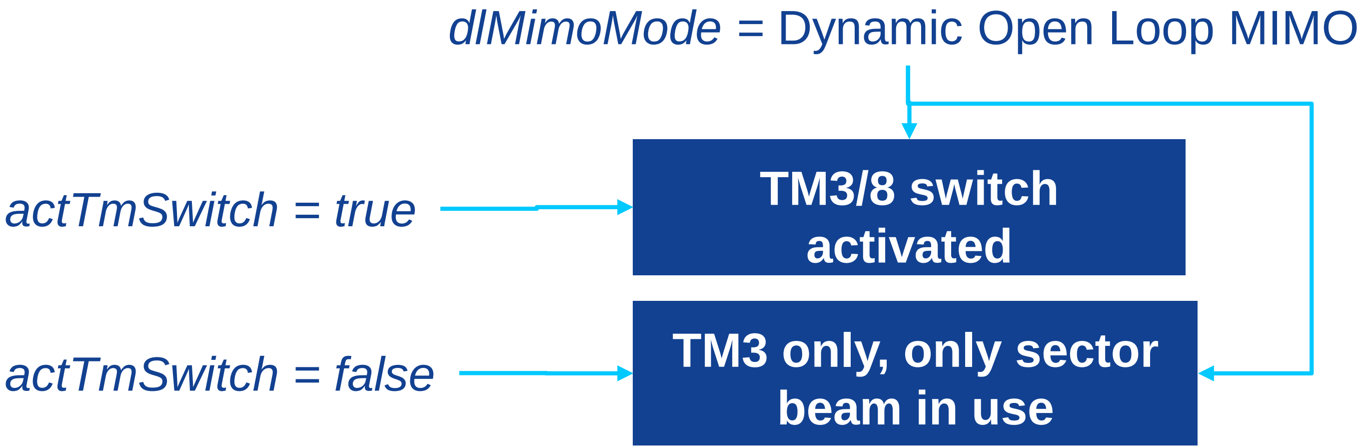
- due to improved antenna gain and capability of vertical beamforming **DL coverage and capacity** is increased as well when compared to the legacy 8-column beamforming antennas.
- another purpose of the feature is to increase site capacity in dense urban environments with **high rise buildings** owing to 3D beamforming.

- please keep in mind that LTE2666 will usually not be deployed “as is” but also with combination of other features, especially LTE3463 DL MU-MIMO for Massive MIMO. Therefore feature potential of increasing the capacity should be considered in the first place.

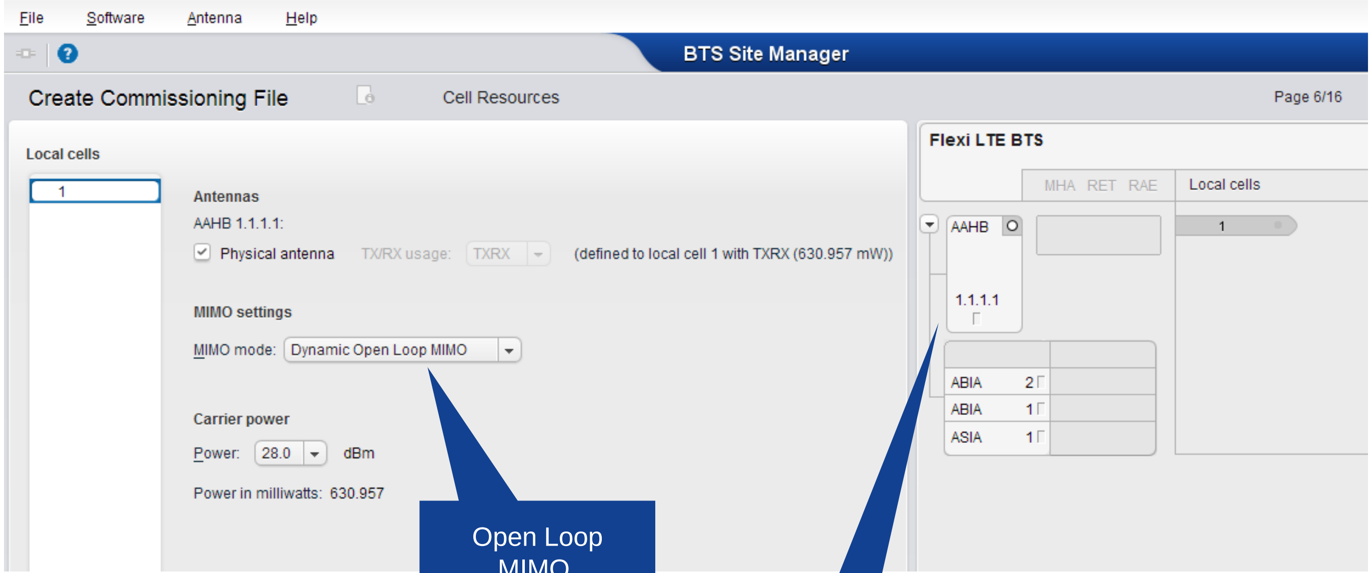
- **as supported bandwidth is the main and only factor by which LTE4566 differ from LTE2666, same conclusion apply for LTE4566.**

Deployment Aspects
LTE2666 Feature activation/deactivation (1/3)

- feature activation flag (***LNCEL_TDD:actMMimo***) is a read-only parameter. It is automatically set to true whenever a 64T64R radio is commissioned.
- it is possible to force feature to work in a sector beam mode, when user beamforming will be deactivated. This can be used to show the true benefits of the feature in field trial conditions.
- use combination of ***LNCEL_TDD:dlMimoMode*** and ***LNCEL_TDD:actTmSwitch*** for the desired effect.



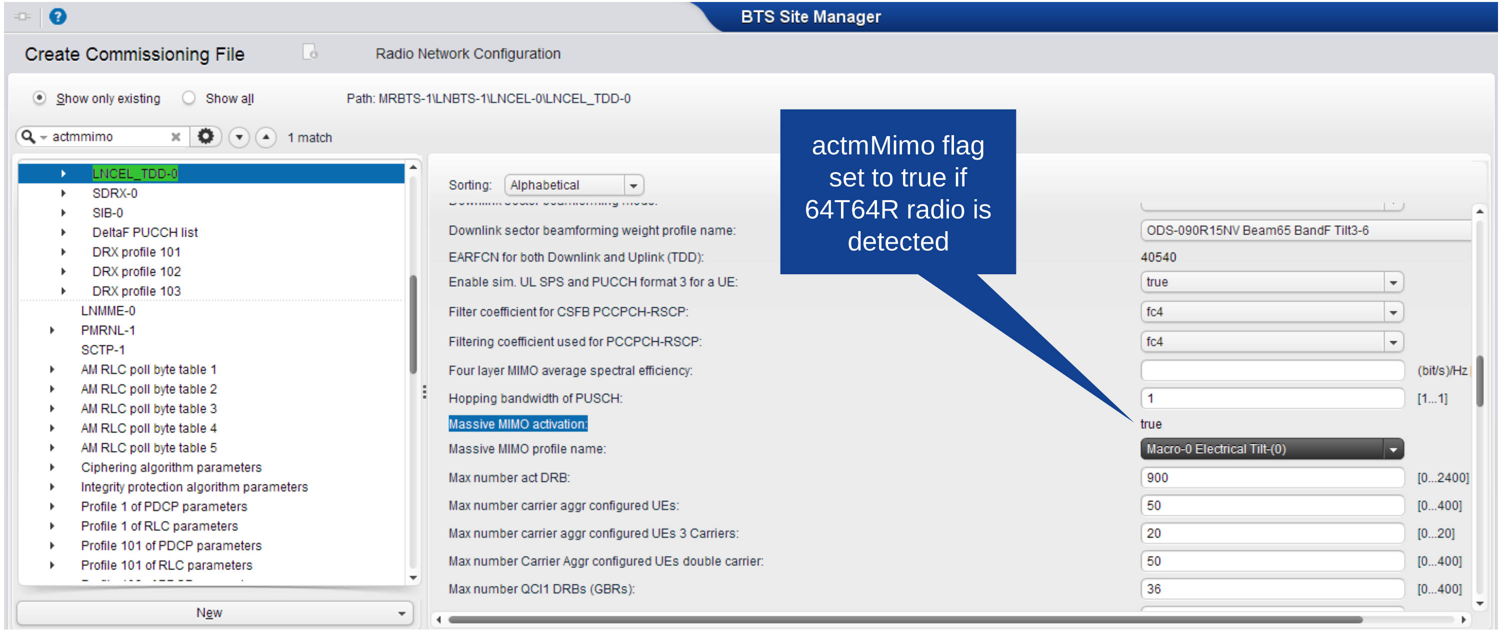
Deployment Aspects
LTE2666 Feature activation/deactivation (2/3)



Open Loop MIMO. Interworking with TM switching is supported.

AAHB and 2 ABIAs are configured

Deployment Aspects
LTE2666 Feature activation/deactivation (3/3)



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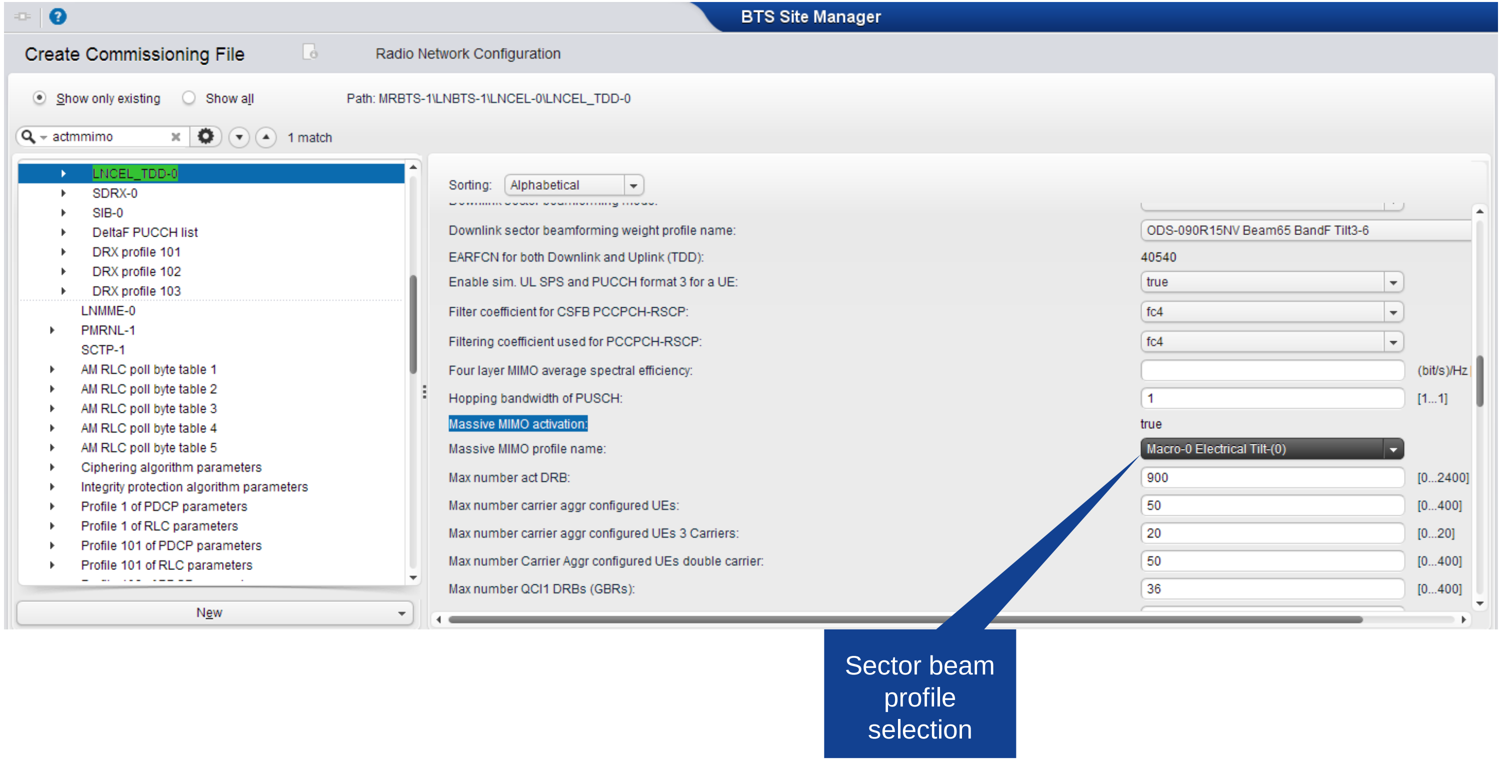
Deployment Aspects

LTE2666 Sector Beam Configuration (1/3)

- Massive MIMO AAS that is used with LTE2666 does not provide a remote electrical tilt (RET) function. Instead, vertical sector beam tilt is controlled entirely by the baseband and is selected from **12 predefined sector beamforming profiles.** The tilts of the predefined profiles range from +8 to -2 degrees, and are indicated in the profile name.
- in addition to the tilted profiles, there is an additional predefined sector beam profile for the **high rise building** use case.
- operator may define **additional 20 customized** sector beam profiles in MMIMOCPR managed object class.
- sector beam profile selection is done by setting parameter *LNCEL_TDD:mMimoSectorBFProfName* to a corresponding predefined or customized profile name
- **selection of the sector beam should be done following radio network planning, as it involves deployment of a new antenna system with new radiation pattern.**

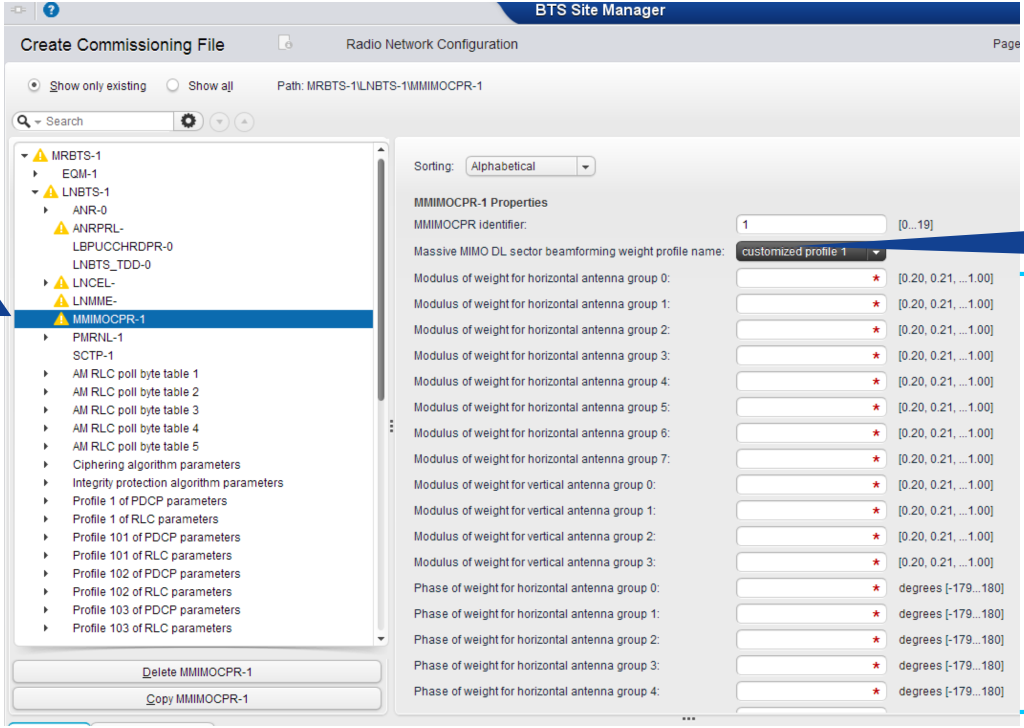
Macro-0 Electrical Tilt-(0)
Macro-0 Electrical Tilt-(1)
Macro-0 Electrical Tilt-(2)
Macro-0 Electrical Tilt-(3)
Macro-0 Electrical Tilt-(4)
Macro-0 Electrical Tilt-(5)
Macro-0 Electrical Tilt-(6)
Macro-0 Electrical Tilt-(7)
Macro-0 Electrical Tilt-(8)
Macro-0 Electrical Tilt-(-1)
Macro-0 Electrical Tilt-(-2)
High Building-0
customized profile 1
customized profile 2
customized profile 3
customized profile 4
customized profile 5
customized profile 6
customized profile 7
customized profile 8
customized profile 9
customized profile 10
customized profile 11
customized profile 12
customized profile 13
customized profile 14
customized profile 15
customized profile 16
customized profile 17
customized profile 18
customized profile 19
customized profile 20

Deployment Aspects
LTE2666 Sector Beam Configuration (2/3)



Deployment Aspects
LTE2666 Sector Beam Configuration (3/3)

Customized sector beamforming profile may be added in MMIMOCPR. MMIMOCPR object can be created in LNBTS



Sector beam profile selection

Horizontal and vertical beamforming weights to be defined in customized profile

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Deployment Aspects
LTE2666 Massive MIMO

Additional parameters, recommended/required settings

Parameter name	Abbreviation	Description	Range and Step	Required/ recommended value	MOC
Channel bandwidth TDD	chBw	Channel Bandwidth defines the Downlink and Uplink bandwidth for the eNode-B transmission.	10 MHz (100), 15 MHz (150), 20 MHz (200)	20MHz (200)	LNCEL_TDD
TDD subframe configuration	tddFrameConf	Indicates the uplink-downlink subframe configuration in TDD.	1...2, step 1	2	LNCEL_TDD
TDD special subframe configuration	tddSpecSubfConf	The TDD Special Subframe Configuration parameter is used for the configuration of DwPTS, GP and UpPTS in the special subframe	0...9, step 1	7	LNCEL_TDD
Activate modulation scheme DL	actModulationSchemeDl	Selects the highest modulation scheme for link adaptation use in PDSCH	QPSK (0), 16QAM (1), 64QAM (2), 256QAM (3)	64QAM (2)	LNCEL

NOKIA

Deployment Aspects

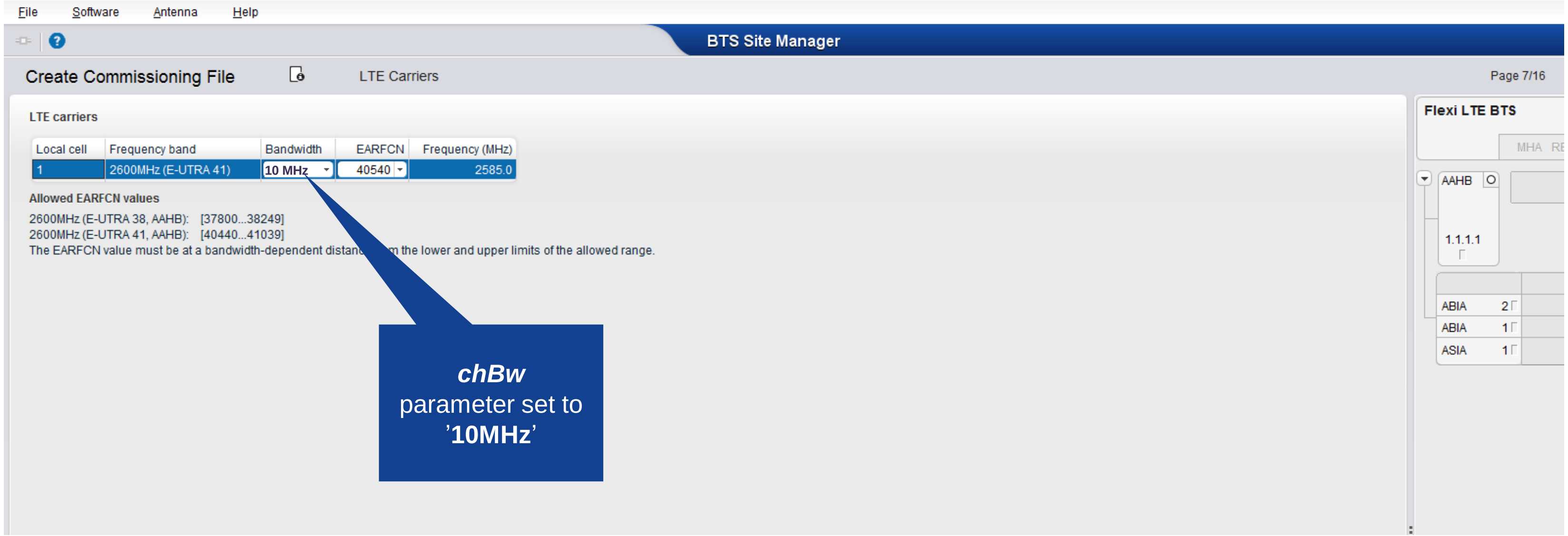
LTE2666 Massive MIMO

Additional parameters, recommended/required settings

Parameter name	Abbreviation	Description	Range and Step	Required/ recommended value	MOC
Active transmission mode switch	actTmSwitch	Activate or deactivate the dynamic transmission mode switch function	True, false	True/false	LNCEL_TDD
Prohibit timer for dynamic TM mode switch	prohibitTimerTmSwitch	Defines the period of time between to transmission mode switches for the same UE	infinite (0), 100ms (1), 200ms (2), 400ms (3), 800ms (4), 1200ms (5), 1600ms (6), 2000ms (7)	1200ms (5)	LNCEL_TDD

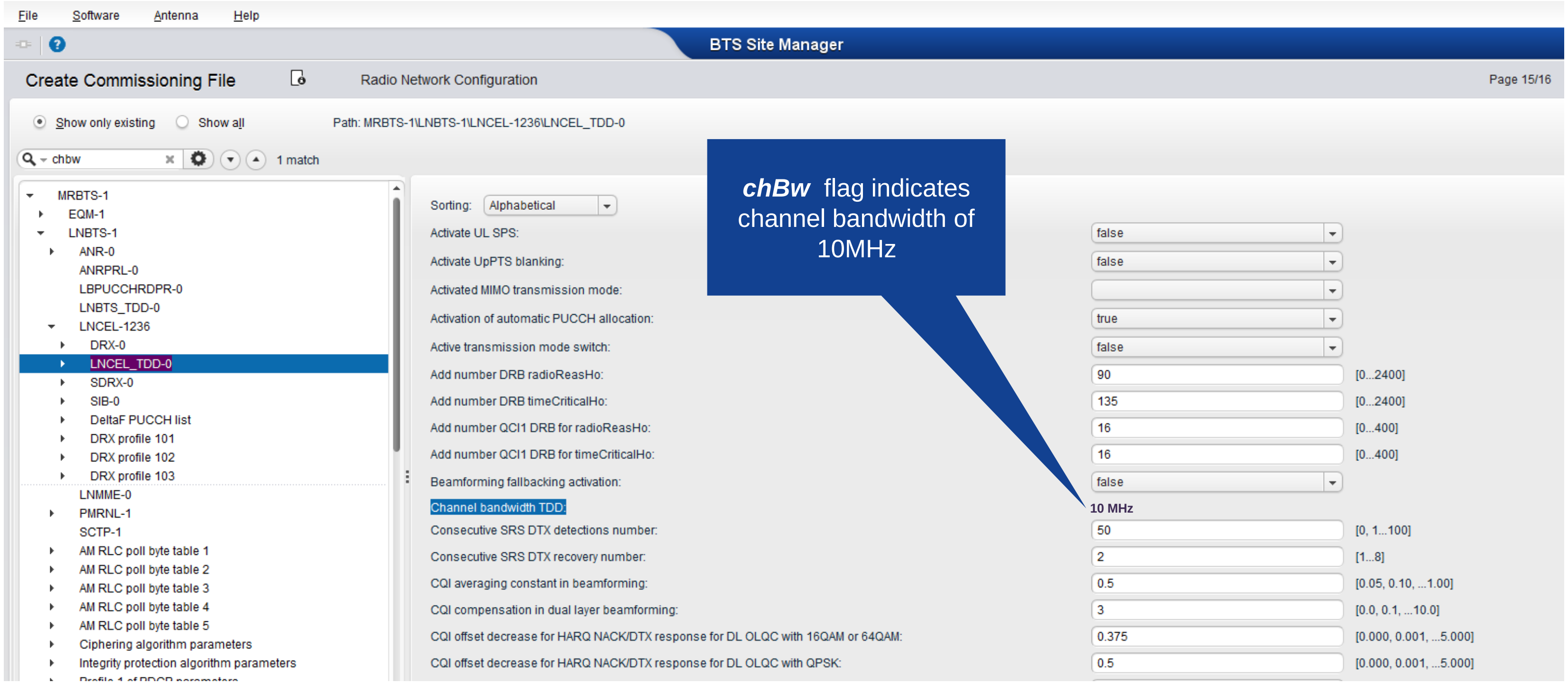
Deployment Aspects
LTE4566 Feature activation/deactivation

LTE4566 TDD massive MIMO 10MHz support is activated in the same way as LTE2666. The main and only difference is the cell bandwidth which in the case of LTE4566 needs to be set to 10MHz.



Deployment Aspects

LTE4566 Feature activation/deactivation



Deployment Aspects
LTE4566 TDD Massive MIMO 10MHz support

Additional parameters, recommended/required settings

Parameter name	Abbreviation	Description	Range and Step	Required/ recommended value	MOC
Channel bandwidth TDD	chBw	Channel Bandwidth defines the Downlink and Uplink bandwidth for the eNode-B transmission.	10 MHz (100), 15 MHz (150), 20 MHz (200)	**10MHz (100)**	LNCEL_TDD

chBw
parameter set to
’**10MHz**’

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Deployment Aspects
Where to deploy the feature?

- please keep in mind that LTE2666/LTE4566 will usually not be deployed “as is” but also with combination of other features, especially LTE3463 DL MU-MIMO for Massive MIMO. Therefore feature potential of increasing the capacity should be considered in the first place.
- feature should be activated in clusters with **high number of UEs** and **high average DL throughput**.
- one of the use cases of the feature is providing indoor coverage for the **high-rise buildings**.

Other factors to consider:

- UE support
  - Feature should be deployed in clusters with high penetration of 3GPP Rel.9 compliant UEs supporting TM8
- Low to moderate mobility
  - Feature does not support High Speed receiver, moreover simulations predict much more significant gains for stationary UEs
- Subframe configuration and cell BW
  - LTE2666/LTE4566 supports only TDD 7/2 configuration and 20MHz bandwidth

Please refer to the Interdependencies section for other limiting features.

To monitor number of active UEs, LTE_1734a **Effective connected users ratio** can be used

To monitor average DL throughput, LTE_5292d **E-UTRAN average PDCP Layer Active Cell Throughput DL** can be used

To monitor penetration of 3GPP Rel.9 compliant UEs , LTE_6093a **UEs Supporting Rel 9 Access Stratum Release Distribution Ratio** can be used

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Deployment Aspects
How to verify if the feature works

LTE2666/LTE4566 does not introduce any new counters or KPIs. Feature activation should bring benefit in terms of the increased DL and UL cell throughput.

KPI ID	KPI Name	Description / Role in evaluating LTE2666/LTE4566
LTE_5292d	E-UTRAN average PDCP Layer Active Cell Throughput DL	This KPI shows the active average PDCP layer throughput per cell in a downlink direction.
LTE_5289d	E-UTRAN average PDCP Layer Active Cell Throughput UL	This KPI shows the active average PDCP layer throughput per cell in an uplink direction.

Drive test, or stationary test before and after feature activation can also be used to prove that the feature is working.

Deployment Aspects

Alarms
Faults
&
Malfunctions
Management

Deployment Aspects
How to verify if the feature works

S1: TX/RX path failure handling

Purpose: This scenario describes mMIMO cell service handling after failure of TX/RX paths(s)

Actors
NetAct, BTSSM/WebEM
BTS

Precondition
BTS has established connection to NetAct and/or Element Manager (BTSSM or WebEM)
64T64R antenna is connected to BTS
TDD mMIMO cell is configured and working (enabled) OR antenna carrier activation is just progressing during cell setup of TDD mMIMO cell

Trigger
BTS detects TX/RX path failure in the "OnAir" cell
OR
BTS detects TX/RX path failure during carrier activation in Cell Setup

Description
BTS detects that the state of one or more TX/RX channel out of commisioined 64TX or 64 RX for TDD mMIMO cell has been changed to Faulty.
BTS checks that value of txPathFailureMode = keepCellInService OR disableCell
BTS sets the cell state to disabled and failed
BTS deactivates related TX/RX carrier on radio module
BTS notifies NetAct and/ or EM about cell state changes via appropriate notification mechanism
BTS raises CELL FAULTY alarm toward NetAct and/ or EM

Postcondition
TDD mMIMO cell is deactivated
TDD mMIMO cell state changes are visible in NetAct and/or EM
CELL FAULTY alarmis visible in NetAct and/ or EM for that cell

Exception(s)
1. All TX/RX channels are "Online". Cell is operational. Use case ends

Deployment Aspects
How to verify if the feature works

US2: Recovery of faulty TDD mMIMO cell upon appearance of the failed TX/RX path(s)

Purpose: To describe the way the faulty TDD mMIMO cell recovers and becomes fully operational. The cell became faulty upon one or more TX/RX paths failed when the TDD mMIMO cell was fully operational or during carrier activation procedure (the last phase of the cell setup)
Actors
NetAct, BTSSM/WebEM
BTS

Precondition
The TDD mMIMO cell was activated but became faulty (due to failure of one or more TXes/RXes out of commisioined 64TX or 64 RX. The radio module is still working (degraded)
Alarm(s) related to the TDD mMIMO cell are visible in NetAct/BTSSM/WebEM

Trigger
BTS detects that the state of TX/RX channel(s) for given cell has been changed to Online/Degraded

Description
BTS checks the number of working (Online/Degraded) TX/RX channels equals to the number of commissioned TXes
BTS sets the cell state to Online and activates all channel(s).
BTS notifies NetAct and/ or EM about cell state changes via appropriate notification mechanism
BTS cancels CELL FAULTY alarm toward NetAct and/ or EM

Postcondition
TDD mMIMO cell is fully operational
no alarms visible in NetAct and/ or EM for that cell

Exception(s)
1. Number of working (Online/Degraded) TX/RX channels is still less than the commissioned 64 TXes or 64 RXes for the cell.
- BTS keeps the cell Failed state.
- CELL FAULTY alarm is still visible in NetAct/BTSSM/WebEM

Acceptance Critetia:

Dimensioning Aspects

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Dimensioning Aspects
LTE2666 Massive MIMO, LTE4566 TDD Massive MIMO 10MHz support

- Massive MIMO functionality is not available in RAN Dim tool, however it can be easily modeled using certain workaround:
  1. Activate **Dual Stream BF (TM8)** feature on ***Features configuration*** tab and make sure corresponding **Antenna configuration** and **Tx/Rx Algorithm at eNB** on ***Coverage calculation*** tab are set:
     - **8Tx-8Rx SS-HBF** in DL
     - **1Tx-8Rx** in UL
  2. Tune DL **Antenna gain [dB]** parameter to **15.0 dB** to compensate for performance of 64Tx-64Rx mMIMO antenna and channel model difference.
  3. Perform all calculations as usual tuning other parameters like output power cell edge user throughput, propagation environment specifics, etc. according to the scenario requirements

Configure Dual Stream BF (TM8) feature

DL Adaptive CL MIMO (4Tx)	☐
DL Adaptive CL MIMO 4x4 (TM4)	☐
Single Stream BF (TM7)	☐
Dual Stream BF (TM8)	☑
Single User MIMO 8x2 (TM9)	☐
Single User MIMO 8x4 (TM9)	☐
IRC	☐

Channel	DL	UL
Channel Model	SCME Suburban Macro NLOS	
Antenna configuration	8Tx-2Rx	1Tx-8Rx
Tx/Rx Algorithm at eNB	SS-HBF	MRC
Frequency scheduler	Channel aware	Channel aware
PDSCH power adjustment due to DL RS Power Boost [dB]	0.00	-
Number of users per TTI	1	6
Frequency scheduling gain [dB]	0.90	2.00

Tune DL Antenna gain to model 64Tx-64Rx antenna

Transmitting end	DL	UL
Output power	20W	
UE Power Class	UE Power Class 3	
Tx Antenna Power [dBm]	43.0	24.0
Antenna gain [dBi]	15.0	0.0
Feeder loss [dB]	0.40	-
Body loss [dB]	-	0.0

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Dimensioning Aspects

LTE2666 Massive MIMO, LTE4566 TDD Massive MIMO 10MHz support

4. Provide additional gain introduced by mMIMO solution using **Additional gains [dB]** parameter on ***Coverage calculation*** tab
   - **8.44 dB** in DL
   - **8.30 dB** in UL
5. Finally, calculated cell range will reflect usage of mMIMO solution

- introduction of the mMIMO functionality significantly improves network coverage in both DL and UL direction

Model mMIMO impact using additional gain values

Receiving end	DL	UL
Feeder loss [dB]	-	0.40
Body loss [dB]	0.0	-
Antenna gain [dBi]	0.0	21.0
Noise figure [dB]	7.0	3.0
Additional gains [dB]	8.44	8.30

	mMIMO		Legacy 8Tx-8Rx	
Site Count	DL	UL	DL	UL
Cell Range [km]	1.593	0.528	1.358	0.467

Visible coverage improvement in both DL and UL

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Dimensioning Aspects
LTE2666 Massive MIMO

- impact of LTE2666 massive MIMO solution on the average cell capacity calculations can be modeled using **Additional capacity gain [%]** parameter on ***Air Interface Capacity*** tab
  - There should be provided gain value corresponding to the required mMIMO deployment:

20MHz	mMIMO Single User (SU)	mMIMO Multi User (MU)
Downlink	59%	125%
Uplink	31%	99%

LTE2666

Model mMIMO impact using additional gain values

Capacity network configuration	DL	UL
Macro Layer		
Inter Site Distance [km]	1.085	
Cyclic prefix	Normal	
Channel model	SCME Urban Macro NLOS	
Cell load [%]	50.00%	50.00%
MIMO Settings	8x2 DS-HBF Mode 8	8Rx MRC
Frequency scheduler	Channel aware	Channel aware
Victim Cell Fully Loaded	☑	
DL-to-UL configuration	DL-to-UL Conf 1	
Special Subframe Format	"S" Subframe Format 7	
DL/UL Ratio [%]	54.29%	40.00%
Almost Blank Subframe Ratio [%]	0.00%	0.00%
MBSFN Subframes Ratio [%]	0.00%	-
Additional capacity gain [%]	125.00%	99.00%
Method for Number of sites (Capacity)	Traffic-based estimation	
Number of sites (Capacity) [User defined]	-	
Cell capacity [kbps]	54651.91	34103.41
Site capacity [Mbps]	163.96	102.31

Dimensioning Aspects
LTE4566 TDD Massive MIMO 10MHz support

- impact of LTE4566 Massive MIMO 10MHz support solution on the average cell capacity calculations can be modeled using **Additional capacity gain [%]** parameter on ***Air Interface Capacity*** tab

  - There should be provided gain value corresponding to the required mMIMO deployment:

10MHz	mMIMO Single User (SU)	mMIMO Multi User (MU)
Downlink	30%	63%
Uplink	15%	50%

LTE4566

Model mMIMO impact using additional gain values

Capacity network configuration	DL	UL
Macro Layer		
Inter Site Distance [km]	1.085	
Cyclic prefix	Normal	
Channel model	SCME Urban Macro NLOS	
Cell load [%]	50.00%	50.00%
MIMO Settings	8x2 DS-HBF Mode 8	8Rx MRC
Frequency scheduler	Channel aware	Channel aware
Victim Cell Fully Loaded	☑	
DL-to-UL configuration	DL-to-UL Conf 1	
Special Subframe Format	"S" Subframe Format 7	
DL/UL Ratio [%]	54.29%	40.00%
Almost Blank Subframe Ratio [%]	0.00%	0.00%
MBSFN Subframes Ratio [%]	0.00%	-
Additional capacity gain [%]	30%	15%
Method for Number of sites (Capacity)	Traffic-based estimation	
Number of sites (Capacity) [User defined]	-	
Cell capacity [kbps]	54651.91	34103.41
Site capacity [Mbps]	163.96	102.31

in opposition to LTE2666, LTE4566 is supposed to cover MU-MIMO features as well (already discussed)

LTE2666 Massive MIMO, LTE4566 TDD Massive MIMO 10MHz support

Performance Aspects

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Performance Aspects

Feature impact

- LTE2666/LTE4566 Does not introduce any new performance measurement counters nor KPIs. Feature impact can be measured using the existing counters (shown on next slides).

Performance Aspects
Feature impact

Feature impact	How to measure?
Downlink throughput Downlink cell throughput should increase for UEs scheduled with TM8. Therefore it is important to activate feature with adequate Rel.9 compliant UE penetration	**KPIs:** - DL RLC PDU volume transmitted (LTE_284a) - Average PDCP Layer Active Cell Throughput DL (LTE_5292b) **Counters:** RLC_PDU_VOL_TRANSMITTED (M8012C18) PDCP_DATA_RATE_MEAN_DL (M8012C26)
MCS distribution DL MCS will increase due to improved DL conditions	**Counters:** - PDSCH_TRANS_USING_MCS0 (M8001C45)… - PDSCH_TRANS_USING_MCS28 (M8001C73)

