Massive MIMO for the New Radio – Overview and Performance

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What is “Massive MIMO”

ANTENNA ARRAYS
large number (>>8) of controllable antennas

ANTENNA SIGNALS
adaptable by the physical layer

Not limited
to a particular implementation

Benefits

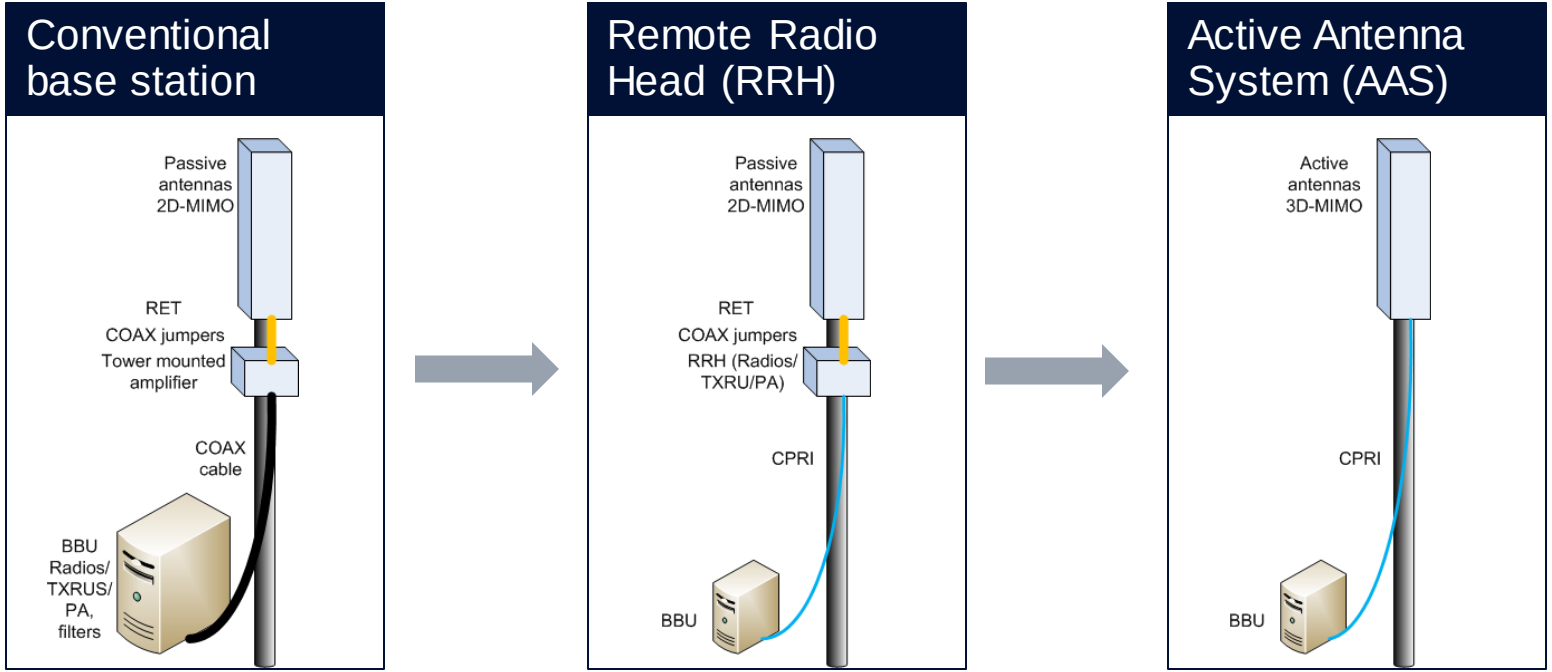
Enhance Coverage
High gain adaptive beamforming

Enhance Capacity
High order spatial multiplexing

Massive MIMO: Why now?

Capacity requirements	Coverage requirements	Technology capability	3GPP spec support
Most macro networks will become congested	Below 6GHz: Deploy LTE/NR on site grids sized for lower carrier frequencies	Active Antennas are becoming technically and commercially feasible	3GPP: LTE: Rel-13/14 NR: Rel-15
Spectrum < 3GHz and base sites will run out of capacity by 2020	Above 6GHz Large bandwidths but poor path loss conditions	Massive MIMO requires Active Antenna technology	3GPP-New-Radio will be a “beam-based” air interface

Evolution to Active Antenna Systems



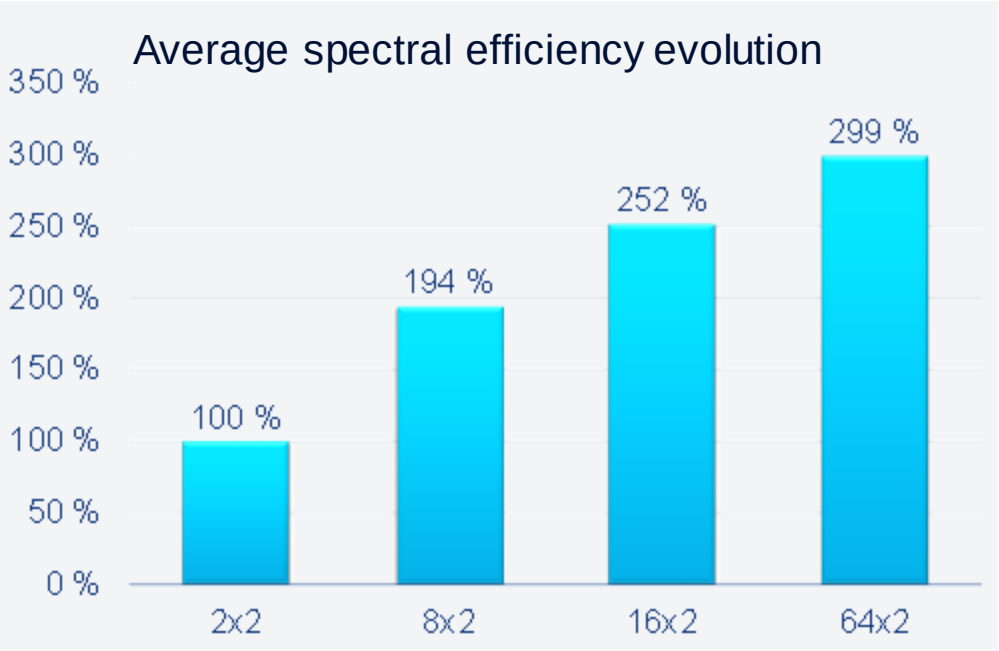
Reduced footprint and more efficient delivery of power

MIMO in 3GPP

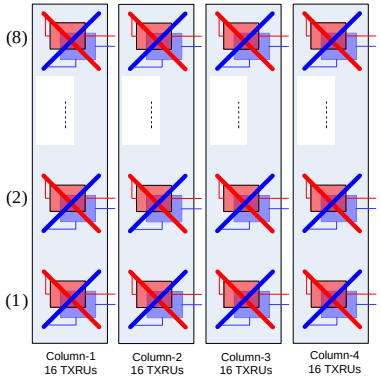
Release 8	Release 9	Release 10	Release 11
• 4x4MIMO • 4x2MIMO • 8RX uplink • Uplink CRAN	• 8TX TM8	• 8TX TM9	• Downlink CoMP (TM10)

Release 12	Release 13	Release 14	Release 15+
• Downlink eCoMP • New 4TX codebook	• Massive MIMO 16TX	• Massive MIMO 32TX	• 5G massive MIMO 64TX+

Higher efficiency with Massive MIMO (full dimension MIMO / 3D MIMO)

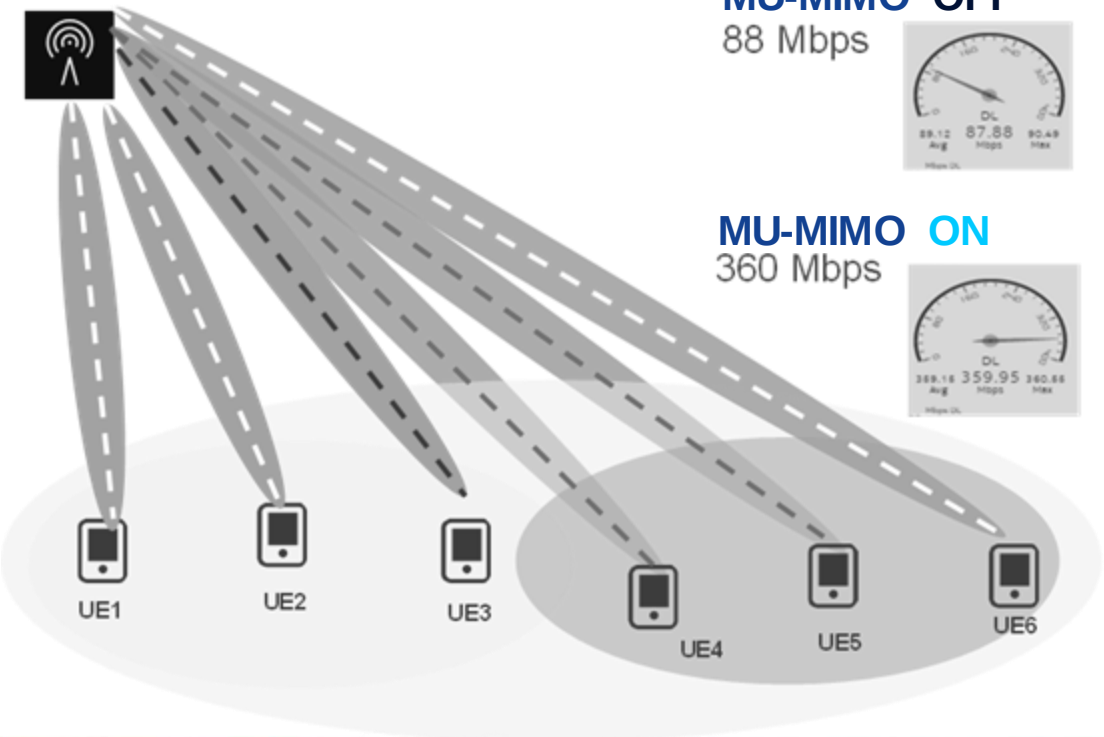


16x2 → 2.5x gain over 2x2
64x2 → 3.0x gain over 2x2
64x2 → +50% gain over 8x2

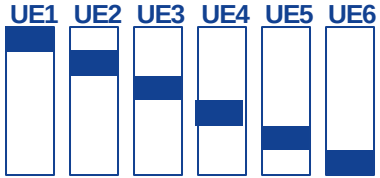


4 columns of XPOL antennas for 8TX - 64TX

Massive MIMO field performance: TD-LTE 2600



MU-MIMO OFF
88 Mbps



PRB Utilization (SU)

MU-MIMO ON
360 Mbps

PRB Utilization (MU)

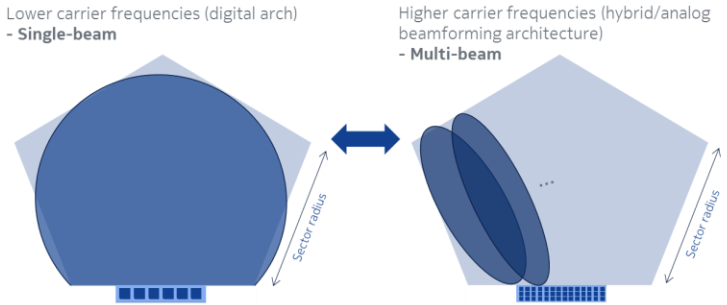
High-order multi-user spatial multiplexing

Massive MIMO at Higher Carrier Frequencies (>>6 GHz)

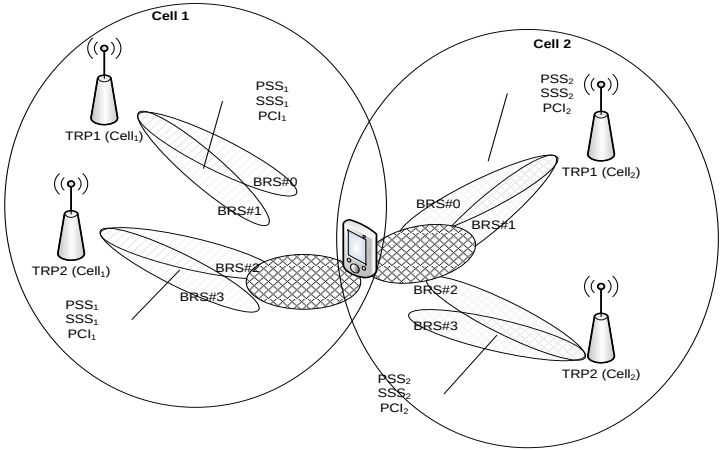
Poor path loss conditions	Cost & power consumption	Antenna array implementation	Beam based air interface
Large number of antennas needed to overcome poor path loss Obtaining channel knowledge per element is difficult	Full digital solutions require transceiver units behind all elements Wide bandwidths: A/D and D/A converters are very power hungry	Smaller form factors Distributed PA solutions → Hybrid arrays Beamforming at RF with baseband digital Precoding	Single sector-wide beam may not provide adequate coverage → Beamform all channels!

Massive MIMO in 3GPP New Radio – beam based air interface

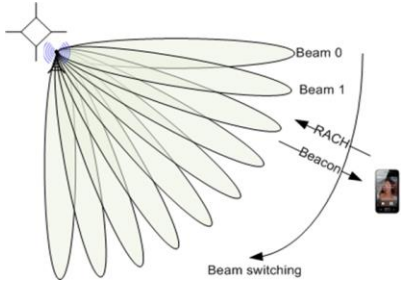
Beamformed control channels



Beam management



Beam scanning

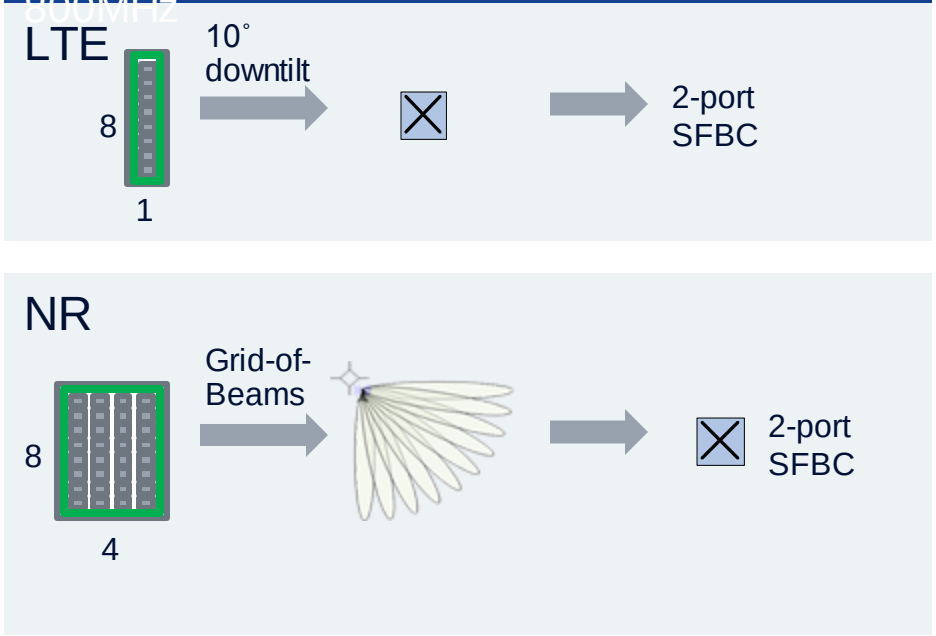


Acquisition and maintenance of a set of beams for TX and RX at base and UE

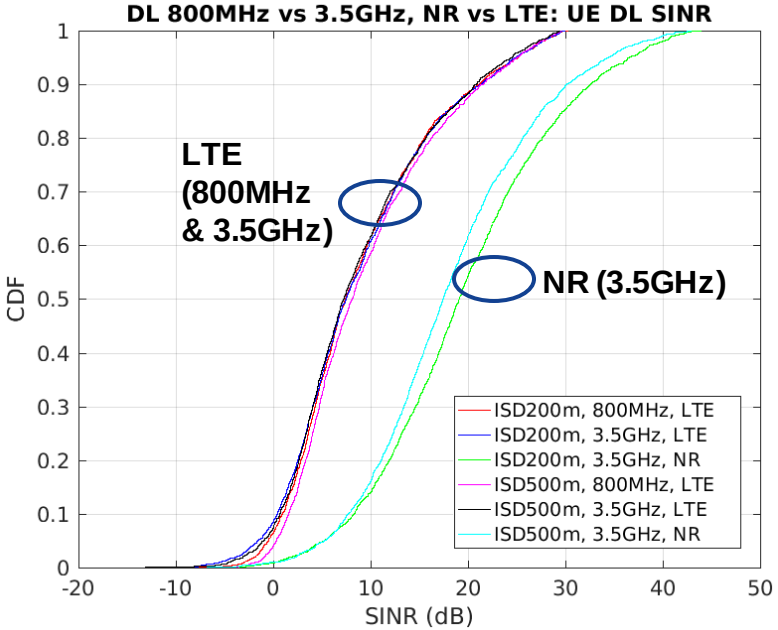
CoMP is built in

Control Channel Coverage – LTE vs NR

Coverage performance when deploying a 3.5GHz system on a site grid sized for 800MHz



CDF of downlink control channel SINR



Massive MIMO in 3GPP New Radio - advanced CSI

Type II Linear Combination Codebooks in NR promise to provide significant gains over the Rel-14 LTE codebooks for the same array size

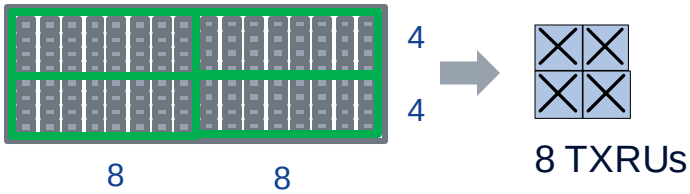
Performance of NR CB over LTE Rel-14 CB *	Gain in mean UE throughput	Gain in cell edge throughput
Full buffer traffic	18%	15%
Bursty traffic	33%	65%

* LTE: Rel-14, 16-port CB with 2 beams per polarization
NR: Candidate Type II 16-port CB with 4 beams per polarization and sub-band scaling

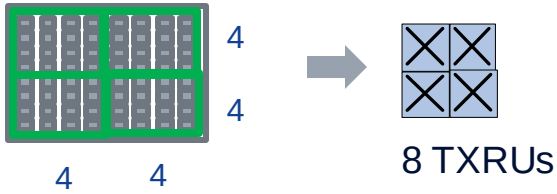
3GPP New Radio at mmWave

Large spatial multiplexing gains at 30GHz with multi-panel hybrid arrays

Four-panel TRP: 256 elements



Four-panel UE: 128 elements



SU-MIMO

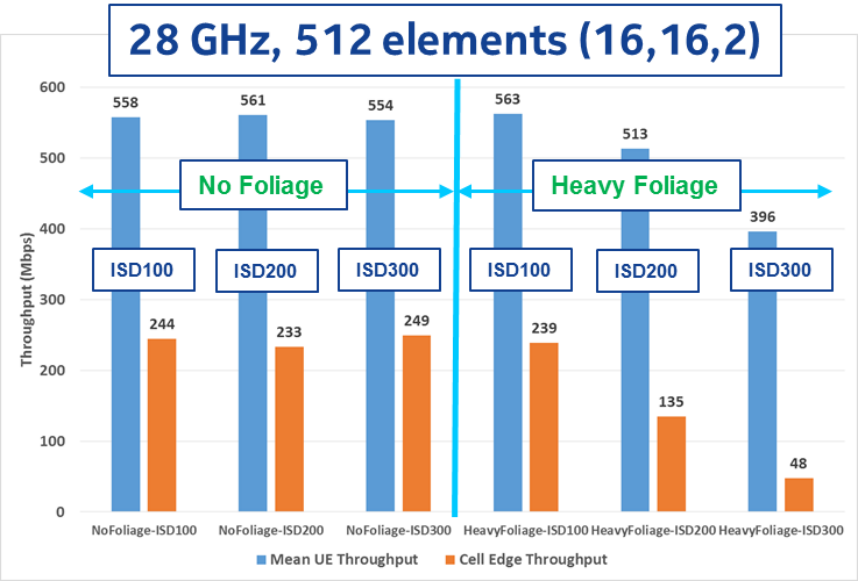
➔ ~60% from leveraging high-rank single-user MIMO transmission

MU-MIMO

➔~20%-50% from multi-user MIMO transmission

Early 5G use case: Extreme broadband to the home

The last 200m



Massive MIMO for the new radio

Summary

Massive MIMO is being deployed today

Massive MIMO will improve coverage and capacity
in current LTE bands and also in newly-allocated sub-6GHz, cmWave, and mmWave bands

Massive MIMO in 3GPP New Radio promises large gains
over massive MIMO in LTE

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