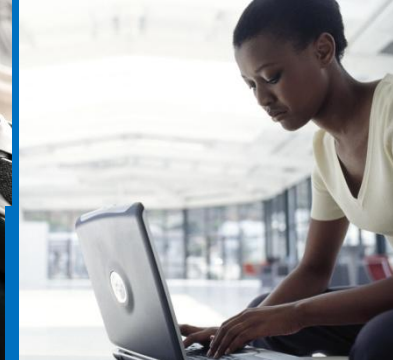




3GPP TSG RAN Workshop on Rel-12 and Onwards
Ljubljana, Slovenia, 11 – 12 June 2012

RWS-120046

Technologies for Rel-12 and Onwards

Samsung



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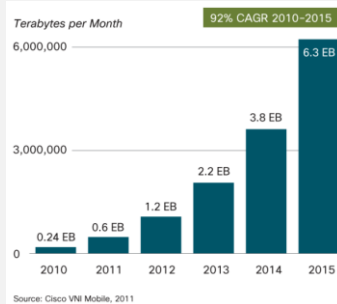


Requirement

Requirement of Beyond 4G Network

▪ Significant network capacity enhancement

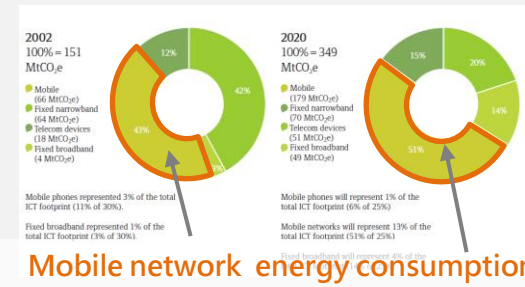
- Continued evolution of macro cell
- Enhancement for small cell, e.g., LTE or others



1000x traffic increase towards 2020

▪ Network energy efficiency improvement

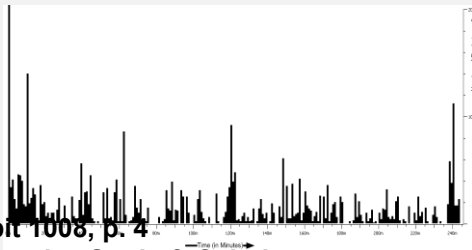
- Network capacity improvement without necessarily increasing energy consumption
- Energy efficiency improvement for both macro and small cells



Source: GeSI SMART2020 Report (2008)

▪ Enhanced network traffic control

- Efficient support of various traffic types



▪ Support of various types of LTE device

- Consider the market need for various device types, e.g., low cost LTE UEs





II

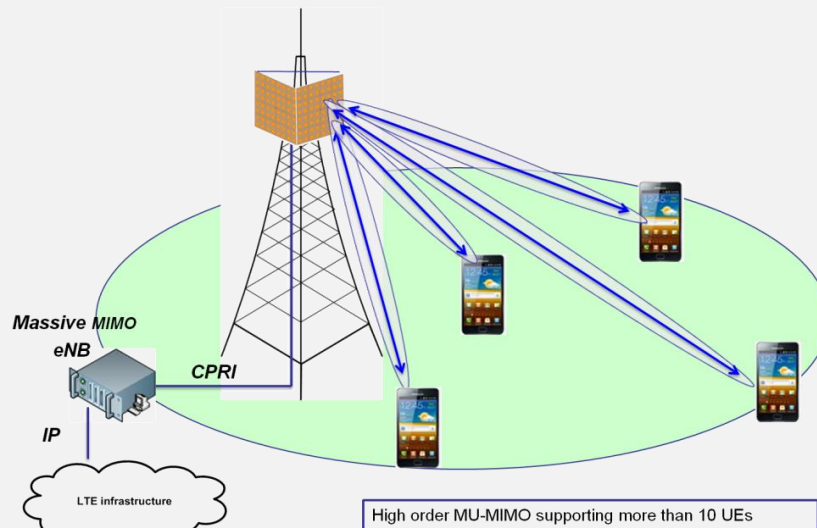
Technologies

- Full Dimension MIMO
- Inter-eNB Carrier Aggregation
- Control Plane Overhead Reduction
- Technologies for higher frequency
- Enhancement of Rel-11 Features

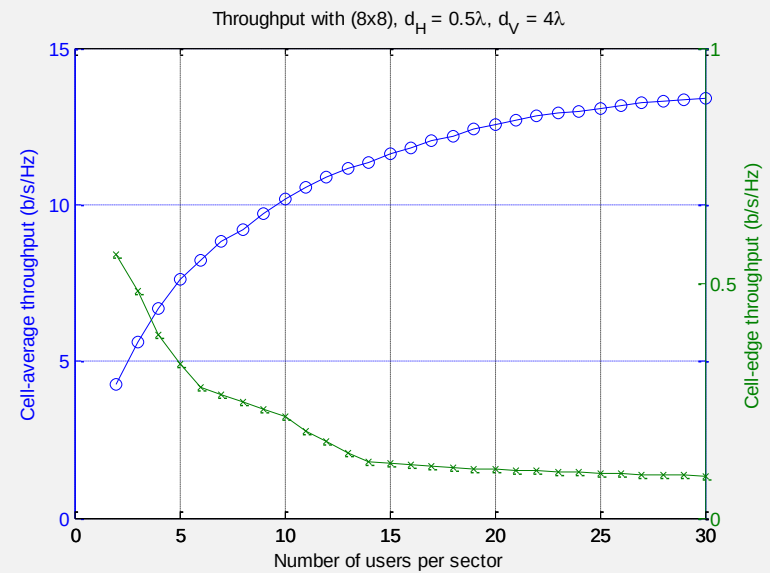
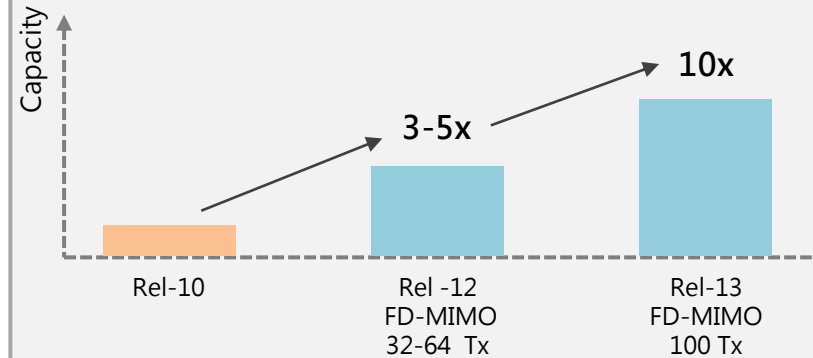
Full Dimension MIMO (FD-MIMO) System

Solution for capacity demand Full Dimension MIMO with 2D AAS (Active Antenna System)

- 1) MU-MIMO with 10s of UEs
- 2) 2D AAS array & 100 antennas
- 3) 3D-SCM channel

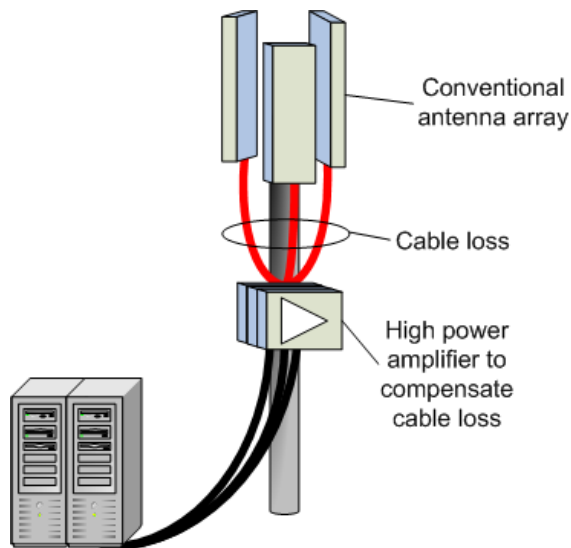


Benefit

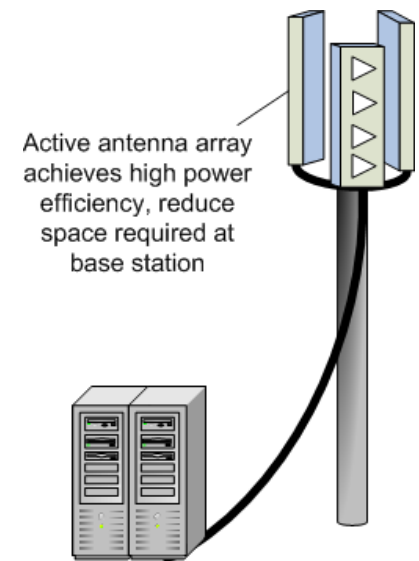


Active Antenna System – Road to FD-MIMO

- **Active antenna systems** – integrating RF components into antennas, allowing:
 - Improved energy efficiency
 - Improved beamforming capability (vertical and horizontal active beamforming)
 - Improved system capacity
 - Reduced cost of maintenance and site rental
- **3GPP RAN4: SI on RF and EMC requirements for AAS**
- **Important step toward realization of FD-MIMO**

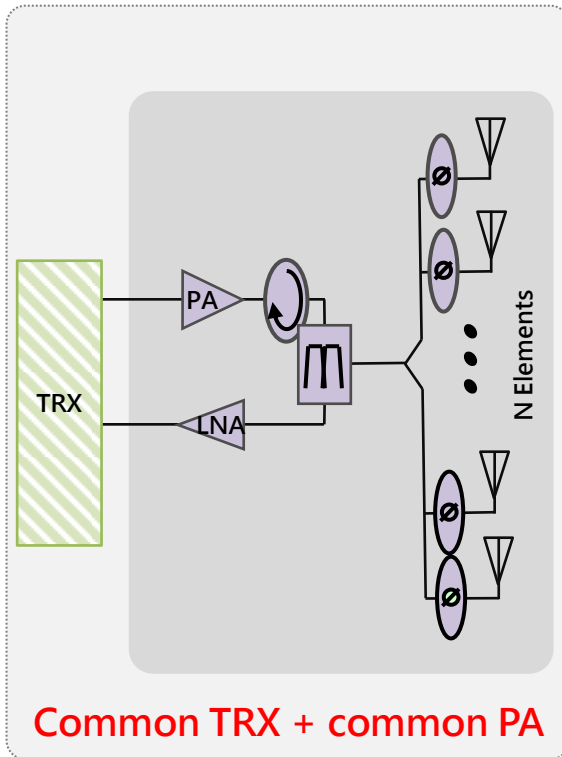


Base station evolution
with Active Antenna Systems

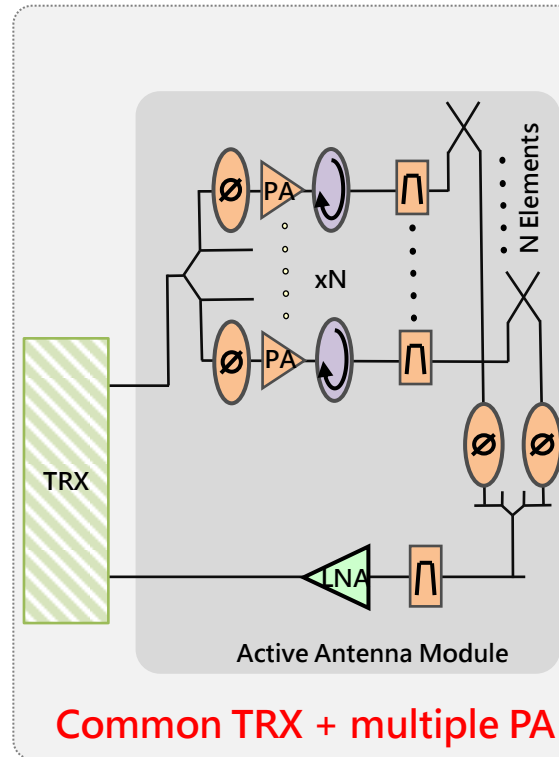


RF Transceiver Architecture for FD-MIMO

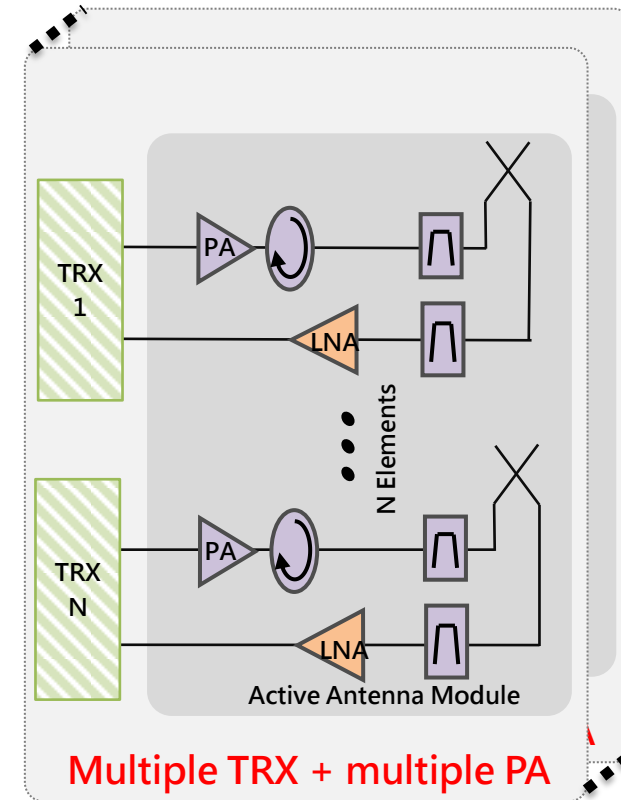
- Full digital control of individual active antenna in FD-MIMO allows
 - Easy adaptation to traffic and UE population change
 - Flexible partitioning of antenna resource for coverage and capacity



Current base station –
passive antennas



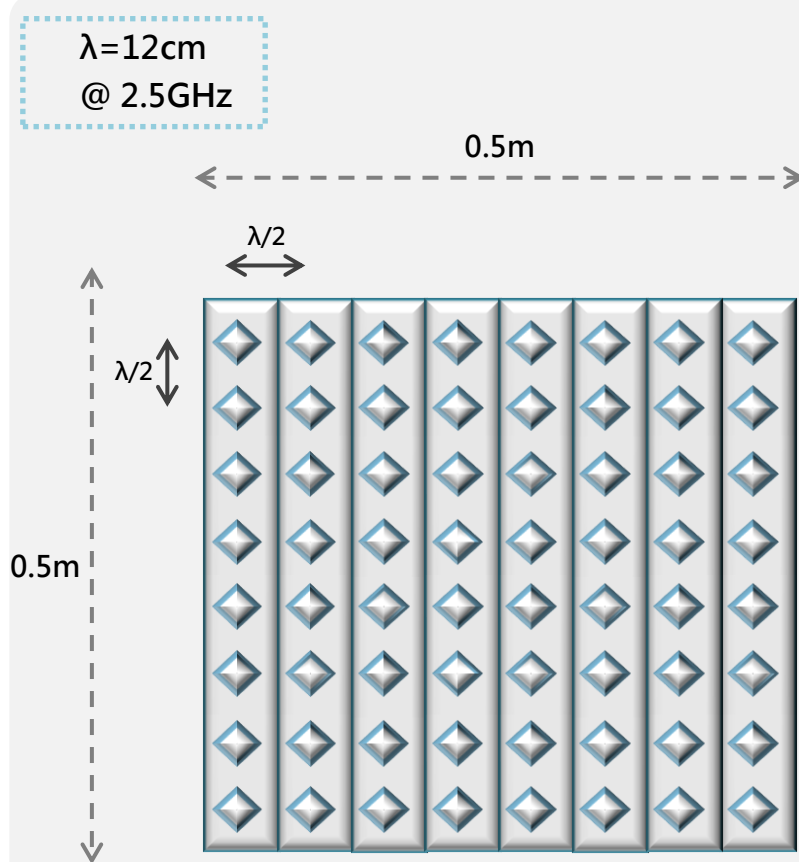
AAS solution in RAN4 SI



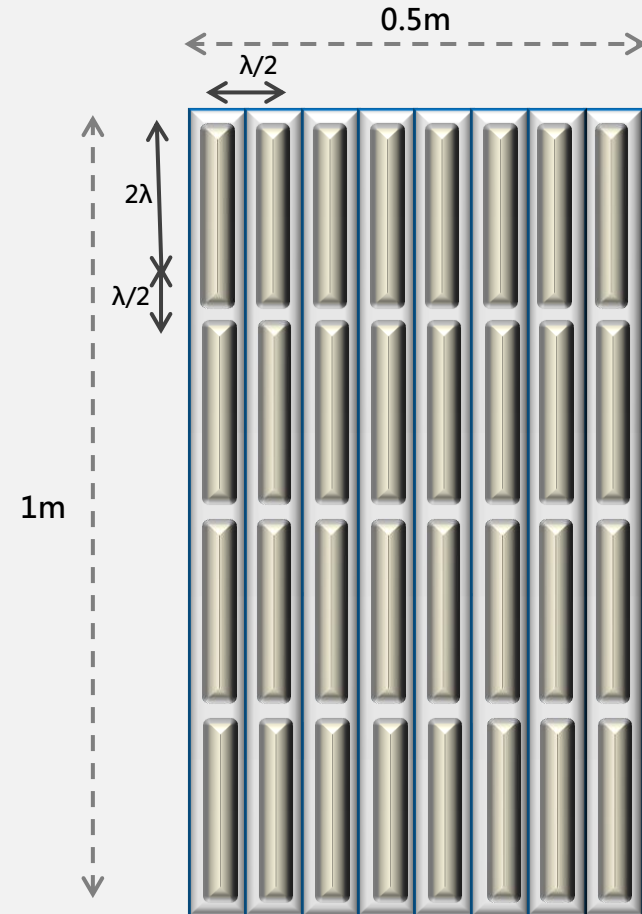
Smart 2D-AAS for
FD-MIMO

FD-MIMO 2D AAS Form Factor Examples

$\lambda = 12\text{cm}$
@ 2.5GHz



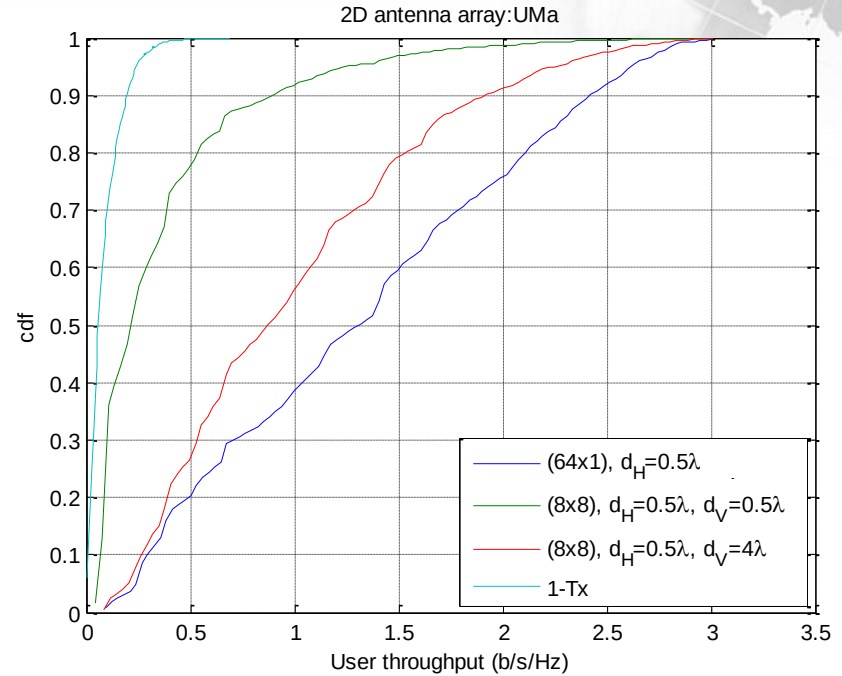
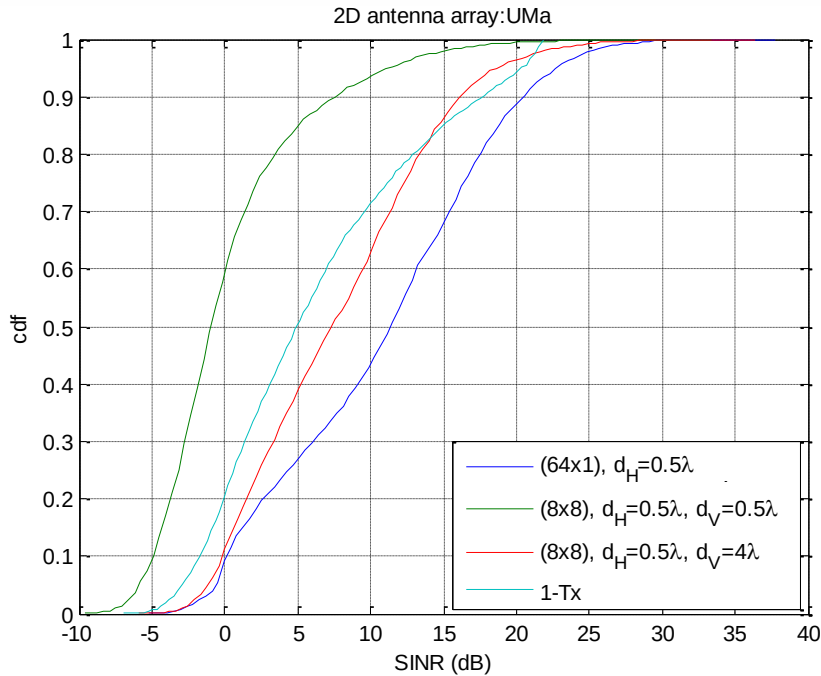
Example 1: 8x8 array with “uniform” elements
Full digital beamforming across 64 elements



Example 2: 8x4 array with “rectangular” elements
Each element is 4 antennas with analog beamforming

Petitioners' Exhibit 1008, p. 9 FD-MIMO antenna panel form factor is well within practical range

FD-MIMO with 1D/2D AAS Configurations

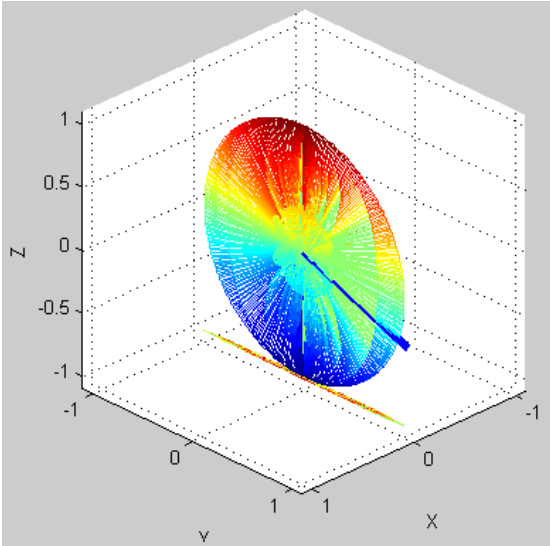


- 57 sectors, 10 UE/sector
- Long-term fading only
- Perfect AoD assumed at eNB
- SINR-throughput mapping using TU3 link results

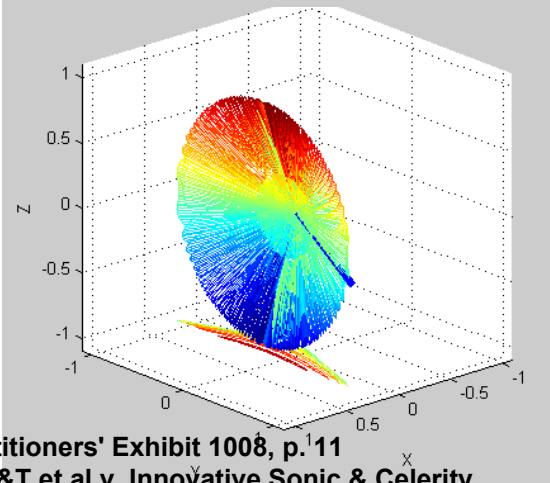
BS Antenna configuration	1Tx	(64Hx1V), $d_H=0.5\lambda$	(8Hx8V), $d_H=d_V=0.5\lambda$	(8Hx8V), $d_H=0.5\lambda$, $d_V=4\lambda$
Half power beamwidth (H, V)	(70, 10)	(90, 90)	(90, 90)	(90, 90)
Cell average throughput (bps/Hz)	0.880	13.539	3.814	9.960
Edge throughput (bps/Hz)	0.010	0.260	0.078	0.203

1D (64Hx1V): $d_H = 0.5\lambda$

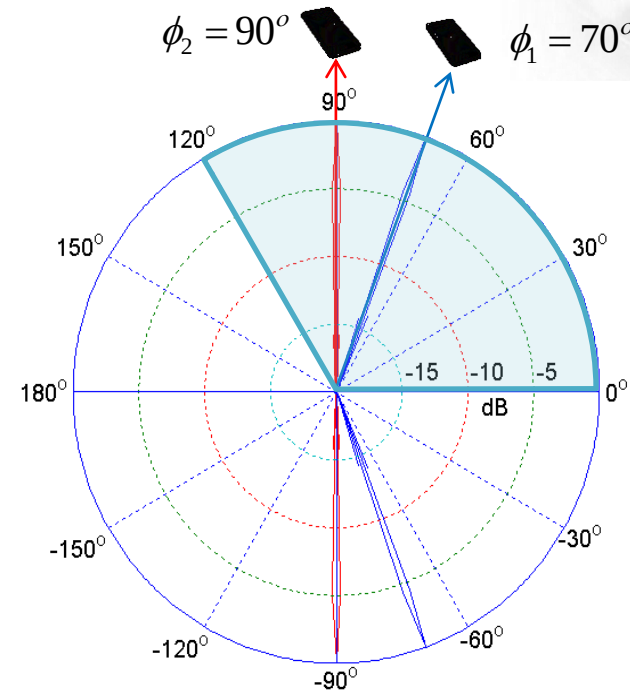
Full Dimension MIMO



$$\phi_2 = 90^\circ, \\ \theta_2 = 110^\circ$$

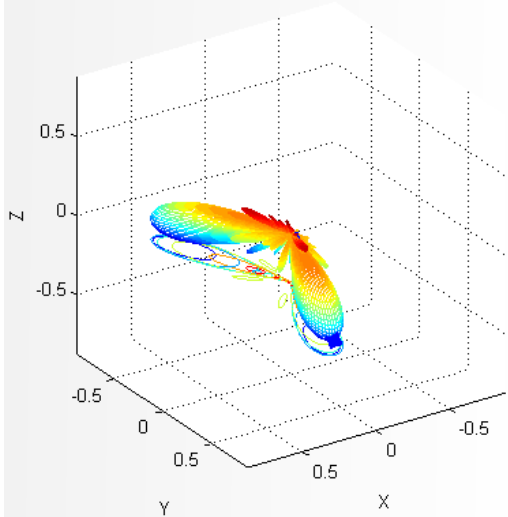


$$\phi_1 = 70^\circ, \\ \theta_1 = 100^\circ$$

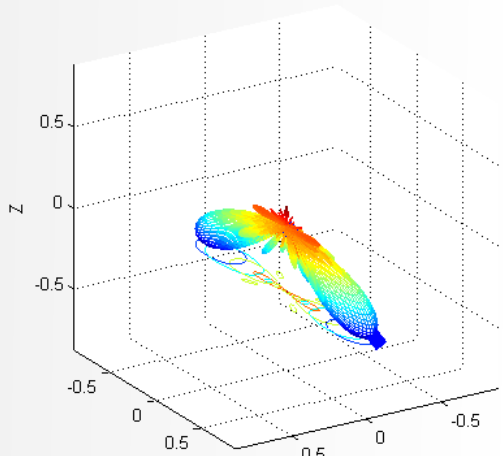


- MU Interference virtually non-existent using 64-antenna horizontal beamforming
- At 700MHz, 64 antennas with half lambda spacing is 15m long!

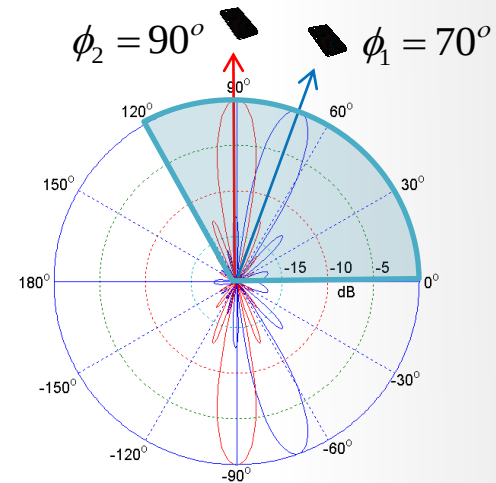
2D (8Hx8V): $d_H = 0.5\lambda$, $d_V = 0.5\lambda$



$\phi_1 = 70^\circ$,
 $\theta_1 = 100^\circ$

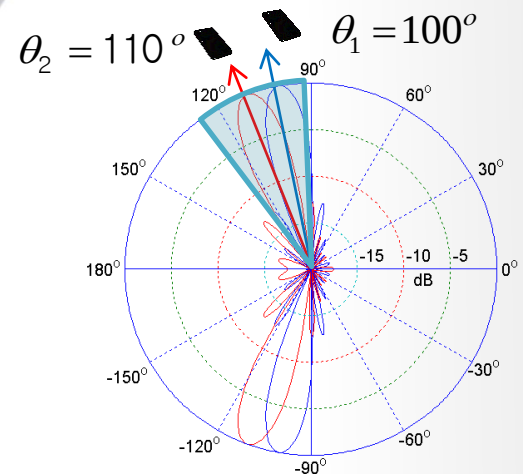


$\phi_2 = 90^\circ$,
 $\theta_2 = 110^\circ$



Azimuth

Low MU
Interference
from horizontal
beamforming

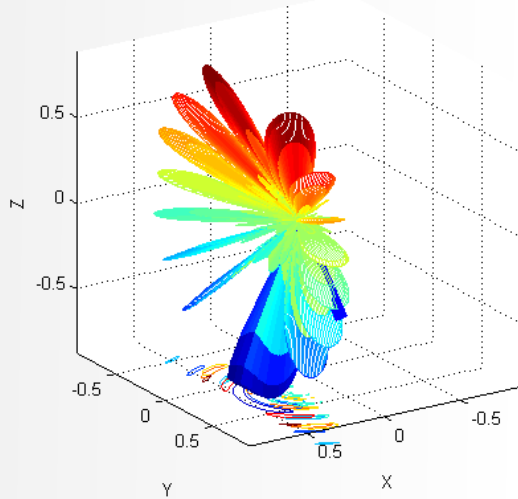


Elevation

High MU
Interference
from vertical
beamforming

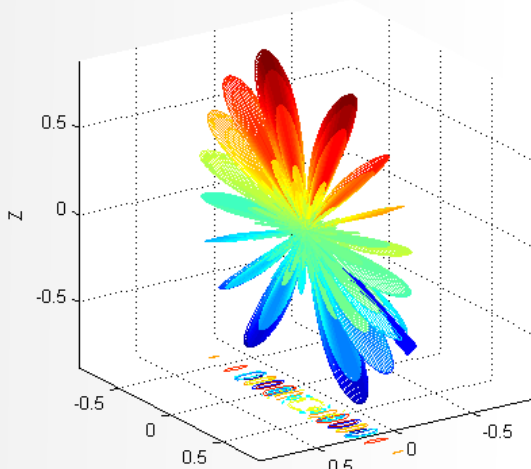
2D (8Hx8V): $d_H = 0.5\lambda$, $d_V = 4\lambda$

Full Dimension MIMO



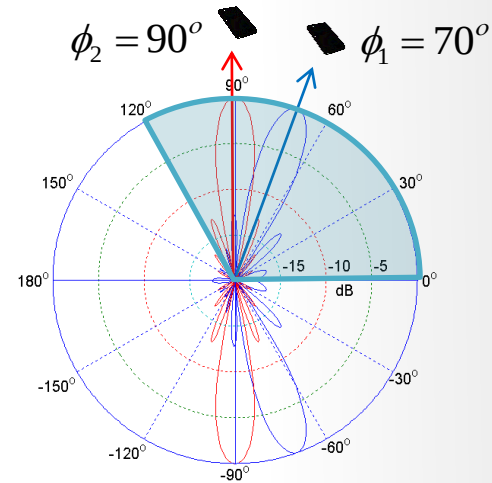
$$\phi_1 = 70^\circ,$$

$$\theta_1 = 100^\circ$$



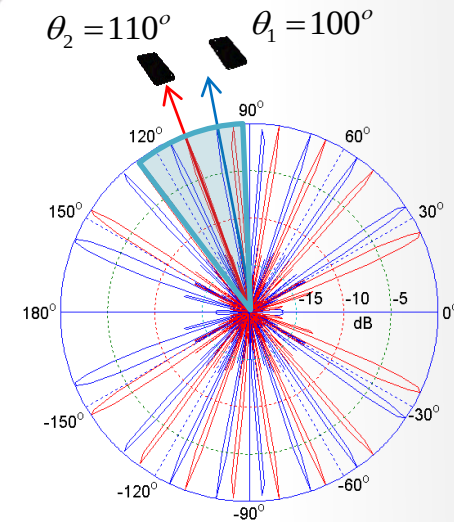
$$\phi_2 = 90^\circ,$$

$$\theta_2 = 110^\circ$$



Azimuth

Low MU
Interference
from horizontal
beamforming

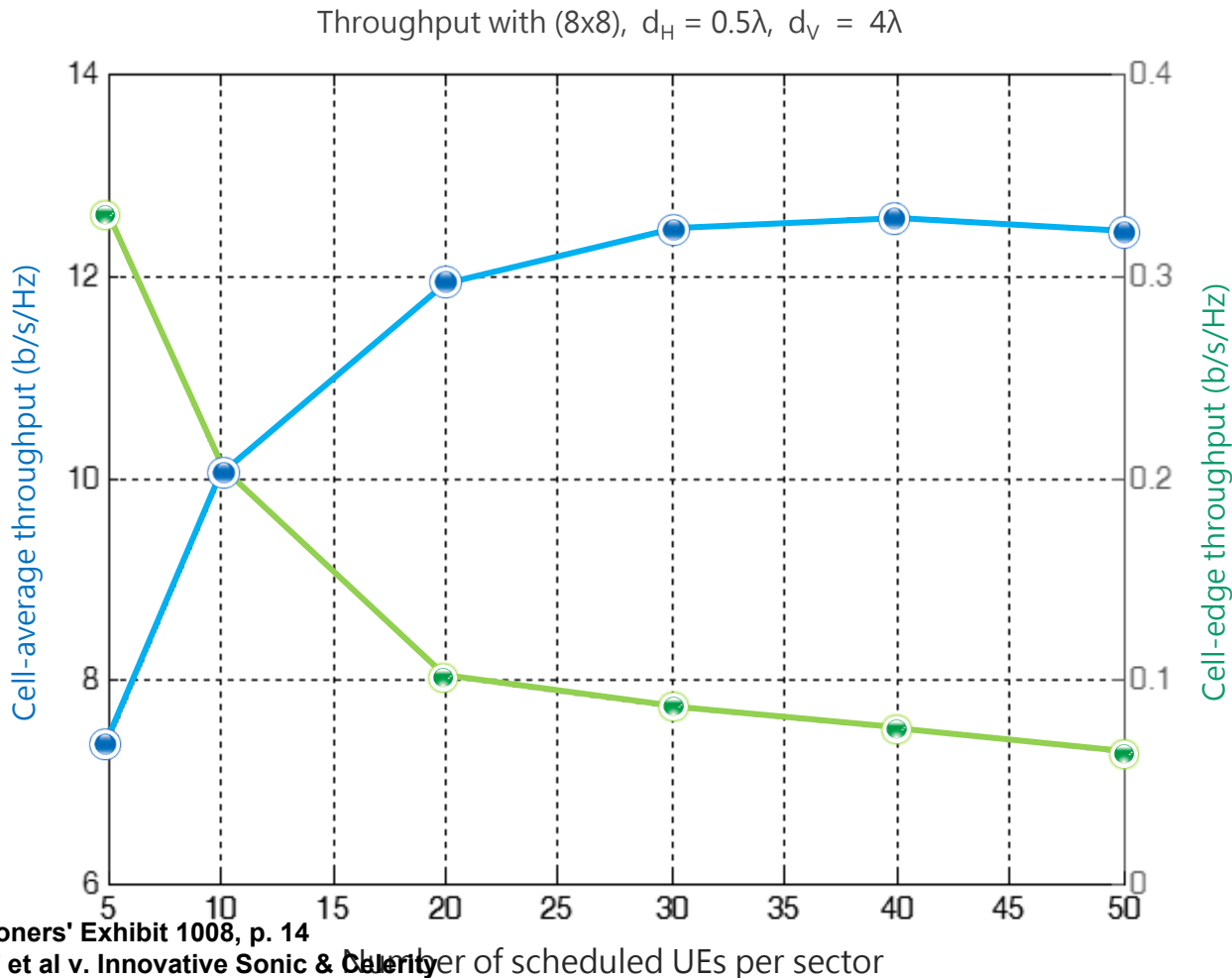


Elevation

Low MU
Interference
from vertical
beamforming

FD-MIMO Multi-user Dimensioning

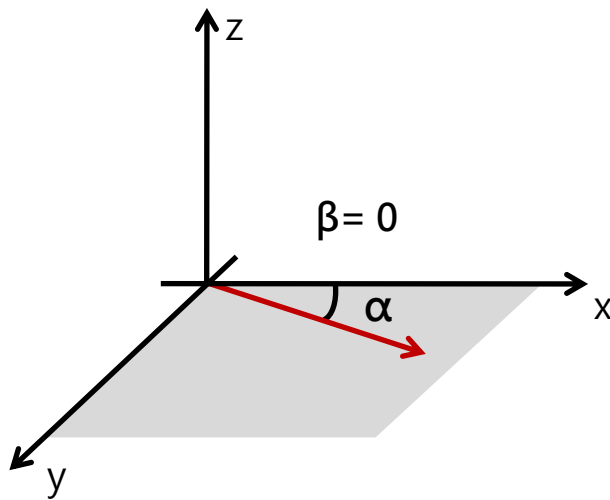
- Cell capacity increases until around 30 users/sector
- Cell-edge throughput drops but still better than the reference value of 0.01



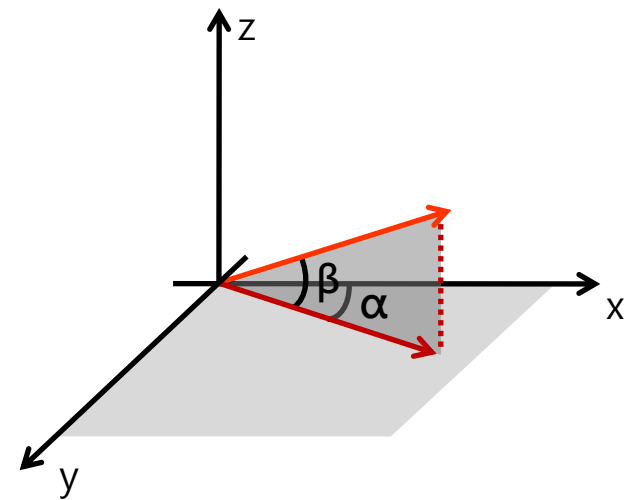
Case: UMa($d_V=4.0\lambda$)

3D-SCM Modeling Principles

- Associate elevation angles to paths generated by SCM
- Correlate elevation statistics with other large-scale fading parameters
- Reuse the mechanism and procedure in SCM



SCM



3D SCM

α : azimuth angle

β : elevation angle

3D-SCM Block Diagram



Choose scenario

Suburban macro

Urban macro

Urban micro



Determine user parameters

Azimuth spread at departure (ASD)

Elevation spread at departure (ESD)

Lognormal shadowing (SF)

Delay spread (DS)

Orientation, speed vector

Antenna gains

Azimuth angle of departure (A-AoD)

Subpath offset of A-AoD 1

Elevation angle of departure (E-AoD)

Subpath offset of E-AoD

Path delays

Average path powers

Azimuth angle of arrival (A-AoA)

Subpath offset of A-AoA

Elevation angle of arrival (E-AoA)

Subpath offset of E-AoA

Generate channel coefficients

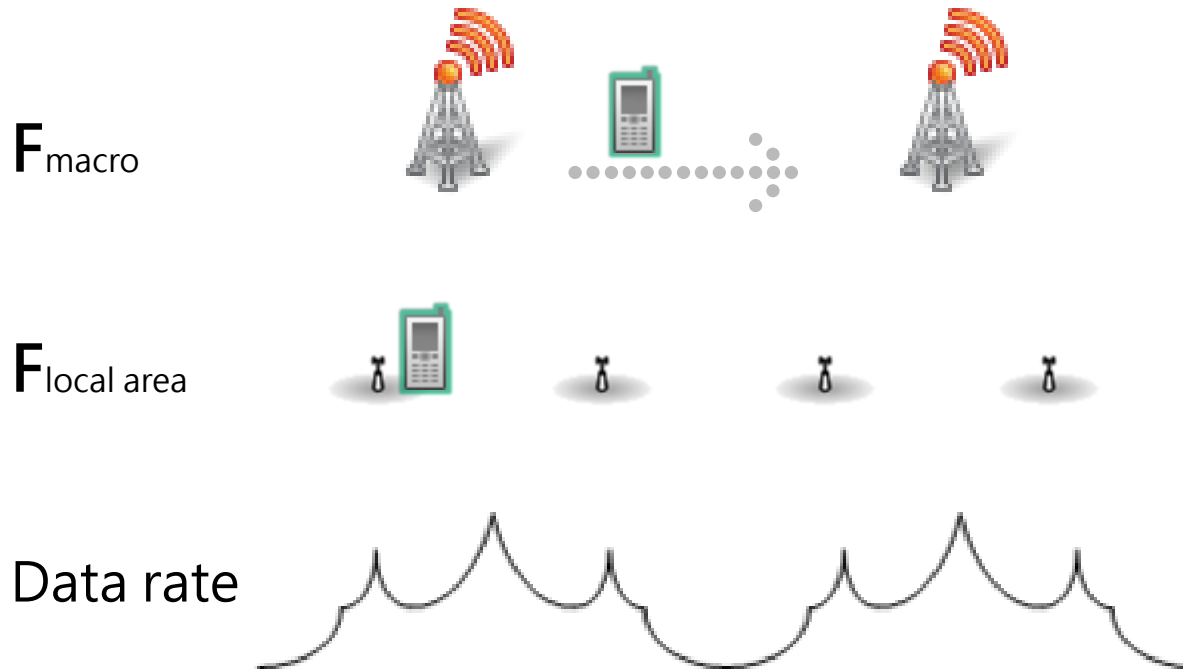
Initial Evaluation Results with 3D-SCM

BS antenna configuration (H x V)	UE Rx	Avg. throughput (bps/Hz) / gain	Edge throughput (bps/Hz) / gain
2Hx1V, (0.5 λ)	2	1.51	0.029
64Hx1V, (0.5 λ)	1	9.43 / x6.2	0.446 / x15
32Hx1V, (0.5 λ)	1	6.27 / x4.2	0.252 / x8.7
8Hx8V, (0.5 λ , 0.5 λ)	1	5.24 / x3.5	0.219 / x7.6
8Hx4V, (0.5 λ , 0.5 λ)	1	3.53 / x2.3	0.076 / x2.6
8Hx4V, (0.5 λ , 2 λ) Electrical down tilt = 15°	1	5.81 / x3.8	0.144 / x5

- ESD = 1.7 assumed, indicating channel with limited v-domain diversity
- Further gain expected with 2 Rx UE, larger ESD and better scheduler

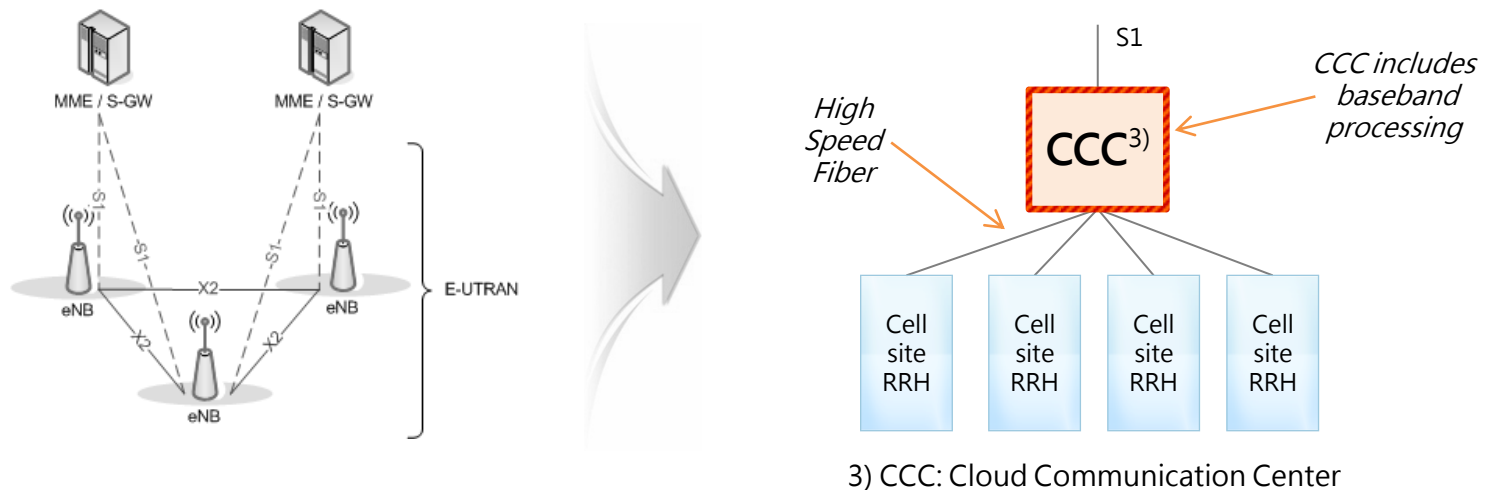
Small Cell Enhancement in Rel-12

- Increasing need for throughput boost in areas with high user traffic
- Rel-12 focus for small cell: capacity without mobility headaches, plug and play



Cloud-RAN: Benefits and Drawbacks

- Cloud control center controls and coordinates large number of RRHs
- Supports COMP, ICIC and other multi-point transmission and coordination schemes

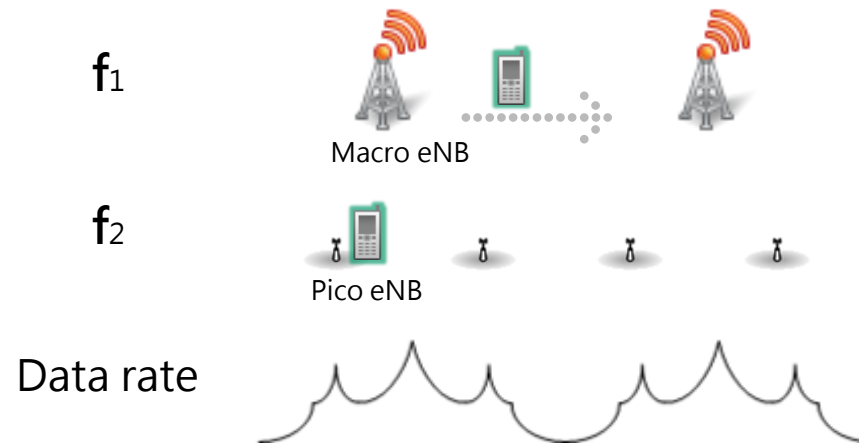


E.g. KT/Samsung/Intel: CCC-servers used to cover Seoul (up to 144 eNB' s per CCC-server)

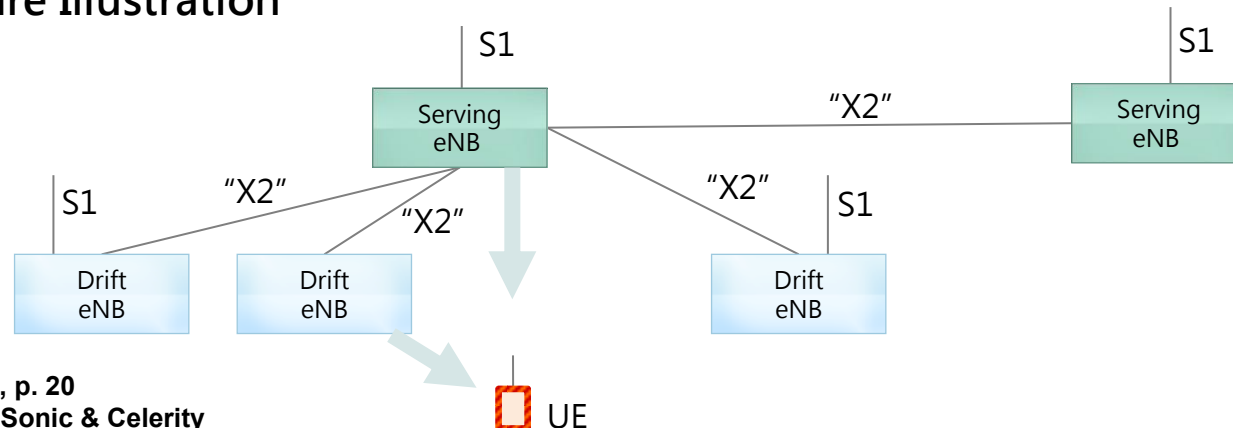
+	-
Sharing of BB processing capacity	Gbps transport
Easily enables advanced radio concepts (e.g. CA, COMP)	

Inter-eNB Carrier Aggregation: Architecture

- Inter-eNB Carrier Aggregation is an alternative to fiber based cloud-RAN
 - Lower cost and backhaul requirement, easy to deploy in many scenarios
 - E.g., Macro-cell layer f_1 for mobility robustness, pico cells in f_2 for throughput boost



Architecture Illustration



Inter-eNB CA: Potential Specification Impact

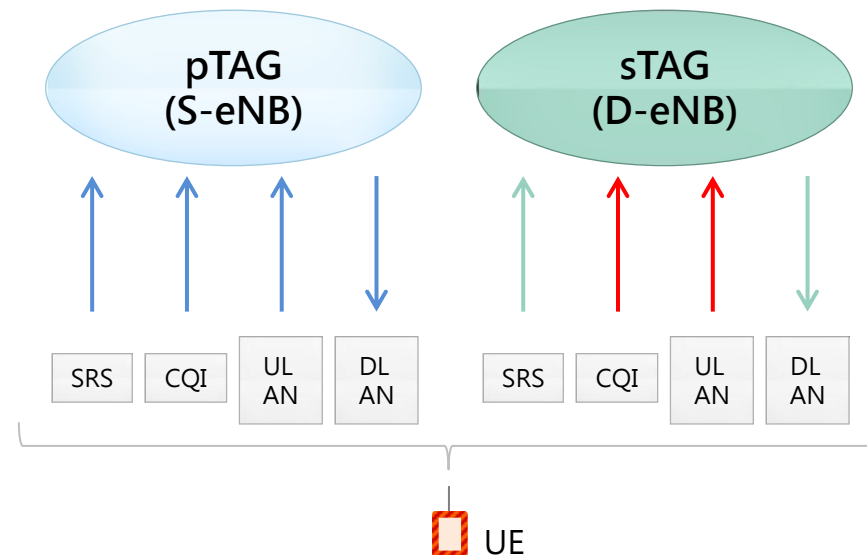
▪ Main architectural considerations:

- Traffic splitting (for SeNB/DeNB) in CN or DeNB ?
- If splitting in RAN, how to transport user data over "X2"
- "X2" a new interface or update of existing interface?
 - The more asymmetric the SeNB<->DeNB relation, more need for new interface

▪ RAN1/2 enhancement needed in order to enable "self-operating D-eNBs" :

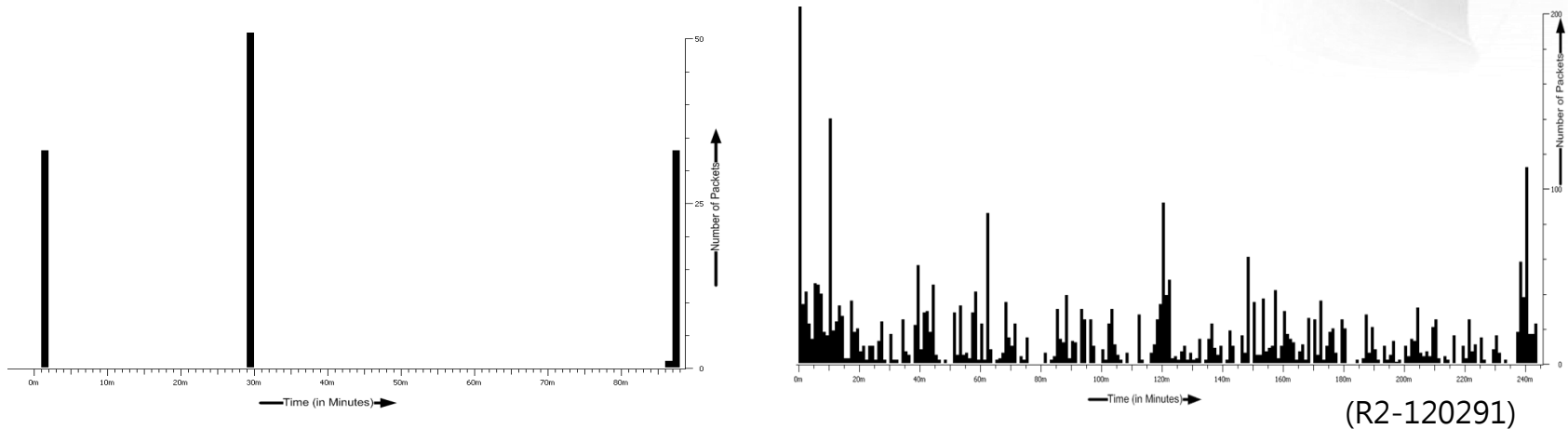
- D-eNB UL Control Info handling
- RACH Msg2 from D-eNB

▪ Need to consider feasibility, market need and specification impact



Control Plane Overhead Reduction

- Many applications generate “small data transmission” like background traffic



Facebook

Skype

- Overview on Uu CP overhead for different applications and network configurations

	Data (B in 5hrs)	Connection release Timer	#Connections	#HOs	CP Overhead
Skype	406000	10 Sec	375	280	24.1%
	406000	60 Sec	80	700	20.9%
gTalk	233000	10 Sec	311	190	33.0%
	233000	60 Sec	124	710	40.4%

- UE speed: 30Kmh

- CP Overhead:

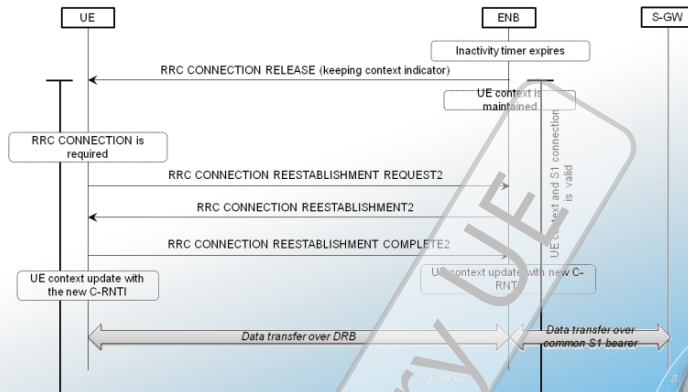
- Handover: 100B

Petitioners' Exhibit 100B p. 22
 AT&T et al v. Innovative Sonic & Celerity
 IPR2024-00991

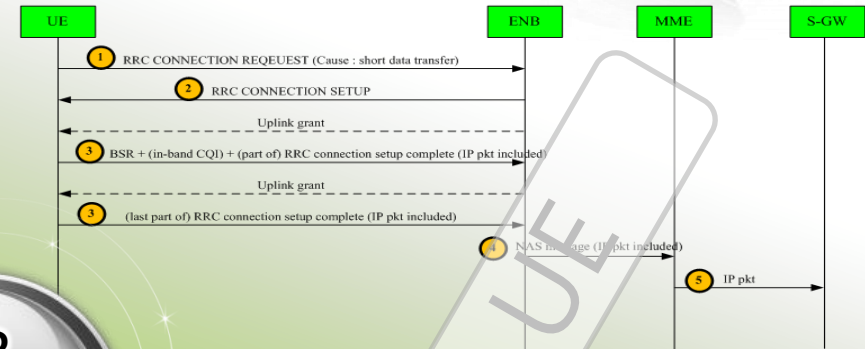
186B (Table 5.2.1-1 TR36.822 v0.4.0)

Potential Solutions

1. Preserve UE ctxt in eNB in IDLE

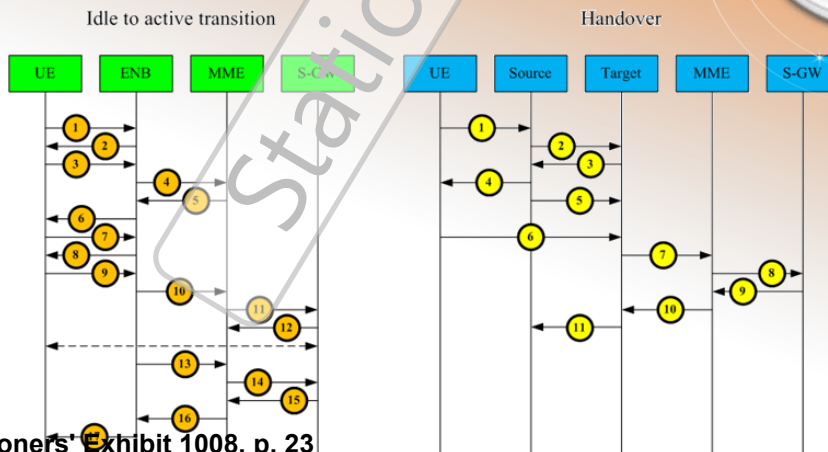


2. Transport over NAS

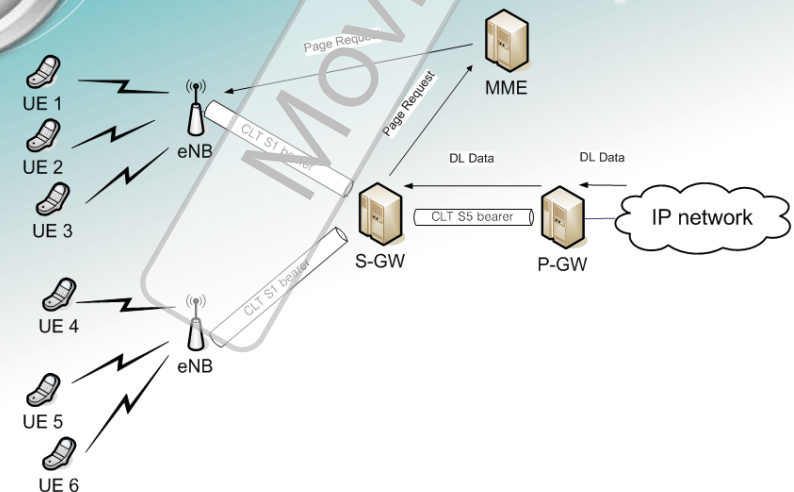


CP
Overhead
Reduction

3. Keeping UE longer in CONN

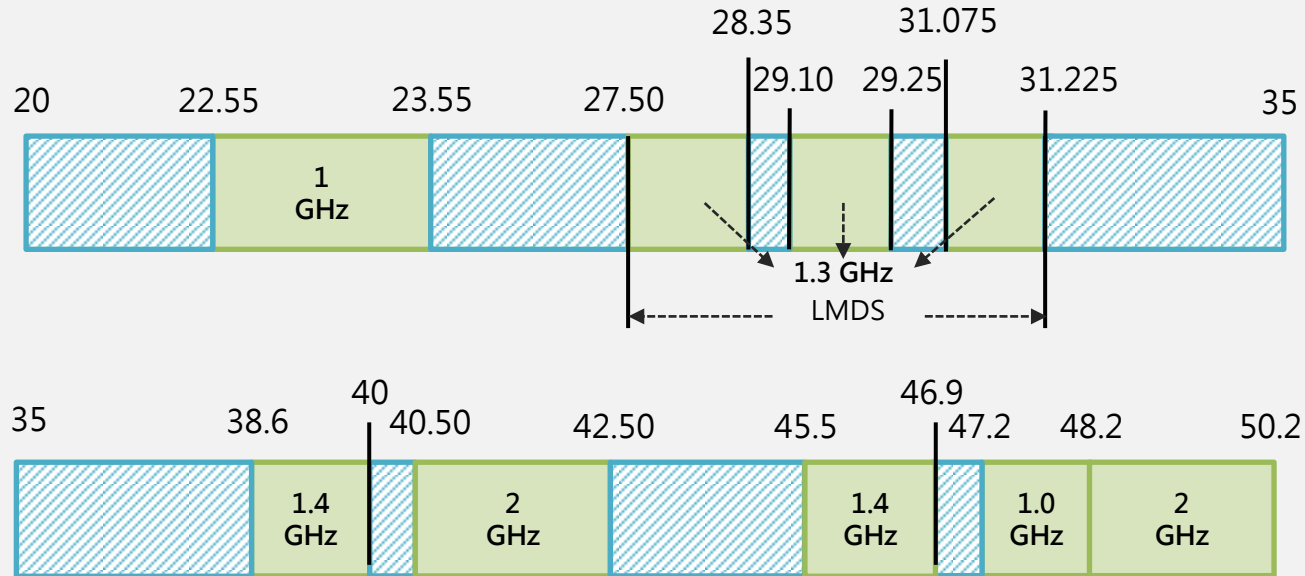


4. Connectionless transport



New Spectrum for Mobile Broadband Access

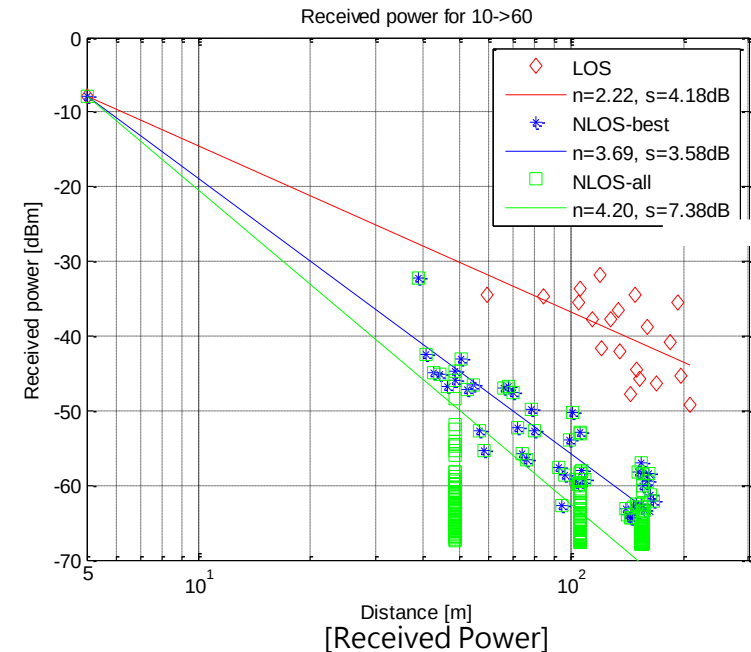
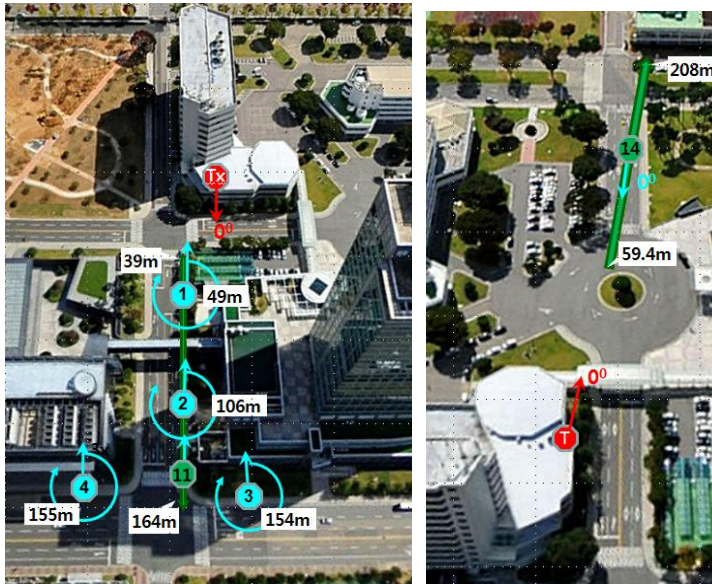
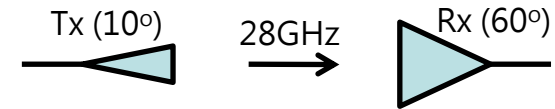
- Possibility of large chunks of contiguous spectrum
 - 23, 28(LMDS band), 38, 40, 46, 47, 49GHz
- Time to start considering these bands for mobile broadband usage
 - These bands are being used for fixed applications in backhaul of mobile in US and EU



Radio Propagation (1/2)

- Channel measurement results at 28GHz exhibits similar path loss exponent but much less delay spread compared to the current cellular bands
 - Tx beamwidth $10^\circ \rightarrow$ Rx beamwidth 60°

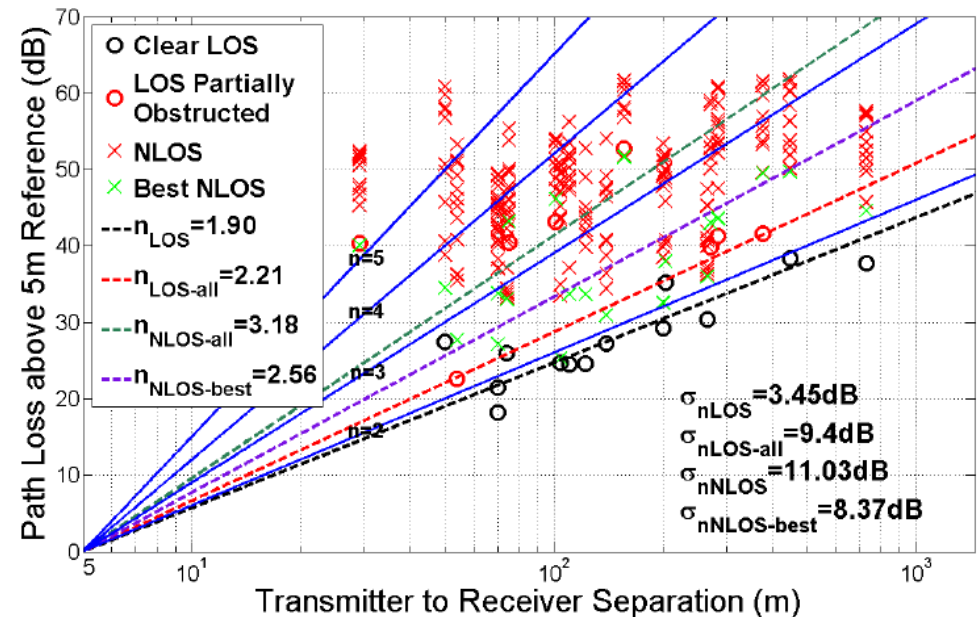
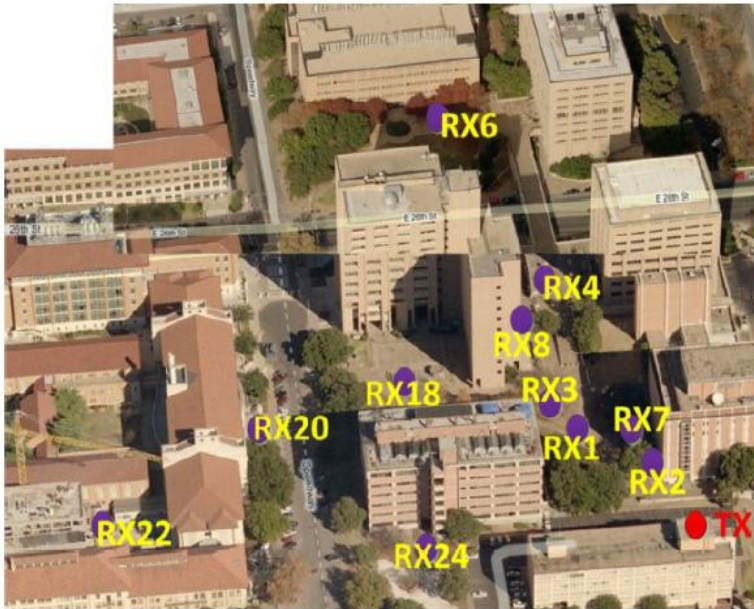
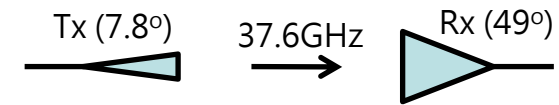
		LOS	NLOS
Path Loss Exponent		2.22	3.69
RMS Delay Spread [ns]	Median	4.0	34.2
	99%	11.4	168.7



Radio Propagation (2/2)

- Even at 37.6GHz radio characteristics are similar to one observed at 28GHz
 - Tx beamwidth $7.8^\circ \rightarrow$ Rx beamwidth 49°

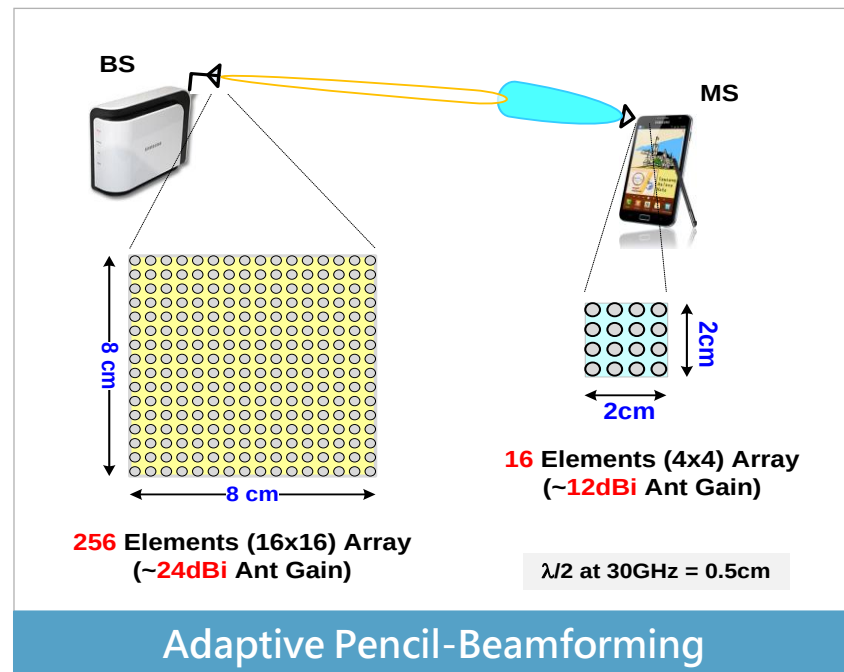
		LOS	NLOS
Path Loss Exponent		2.21	3.18
RMS Delay Spread [ns]	Median	1.9	15.5
	99%	13.7	166



Enabling Technologies for New Spectrum

- **A New Numerology adequate for higher frequencies**
 - Shorter CP size, Wider subcarrier spacing, Shorter frame size, etc.
- **Adaptive Pencil-Beamforming**
 - Huge beamforming gain with compact-sized antenna at both BS and MS (suitable for the small cell deployment)
- **Dynamic Virtual Cells**
 - High link reliability and uniform QoE through user-centric virtual cells consisting of cooperating BSs interconnected by wireless links
- **Observation:**
 - Markedly different radio propagation conditions (new numerology) along with essential technologies for effective operation in these new higher frequencies

may require a new RAT design



Enhancement of Rel-11 Features (1/2)

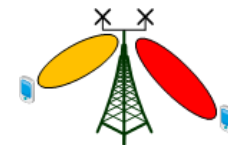
CoMP enhancement

- Inter-eNB CoMP with non-ideal backhaul based on X2 interface
- Enhanced feedback mechanism, e.g., inter-TP phase, aggregated CQI, etc.

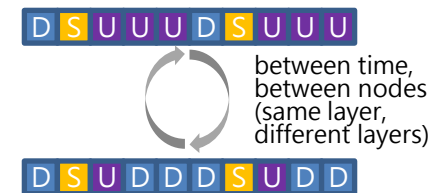


Further enhanced DL MIMO

- Codebook, MU-MIMO enhancement, sub-band CQI/PMI

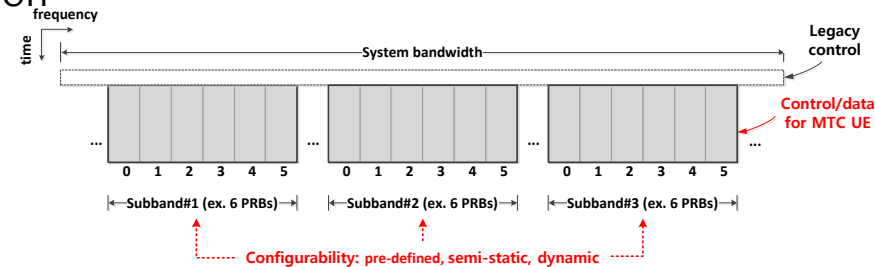


LTE TDD interference management & traffic adaptation



Low cost MTC UE

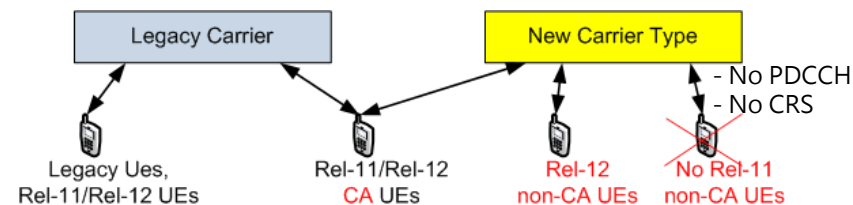
- Reduced bandwidth most helpful for cost reduction
- Peak rate reduction, half duplex, etc.
- Any interest from market on low cost VoLTE UE?



LTE coverage enhancement

Stand-alone New Carrier Type in Rel-12?

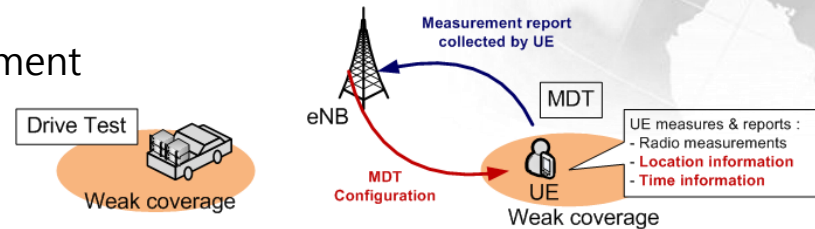
- Helpful to reduce network energy consumption
 - TX off when no data to transmit
- Carefully decide whether/when to introduce



Enhancement of Rel-11 Features (2/2)

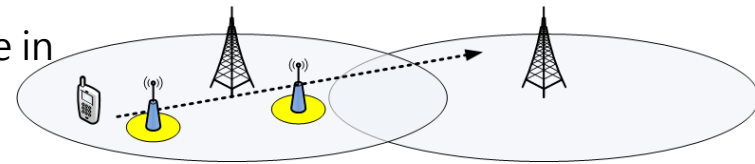
Further enhancements to MDT

- MDT is turning into an area of continuous improvement
- Potential improvement in Rel-12



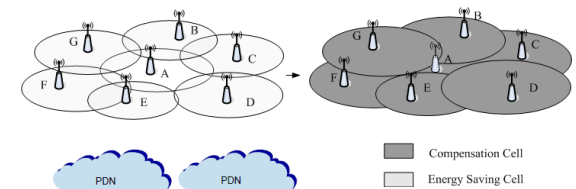
HetNet mobility enhancement

- No major issues identified in Rel-11 SI
- Could consider implement some of the proposals made in SI-phase (e.g. inter-freq pico cell detection)



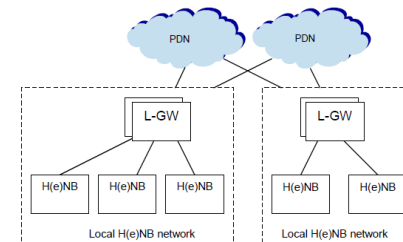
Network energy saving

- Energy saving in various scenarios besides HCS, e.g., in non-overlapping eNBs scenario, energy saving in HetNet.



LIPA/SIPTO

- LIPA and SIPTO mobility support

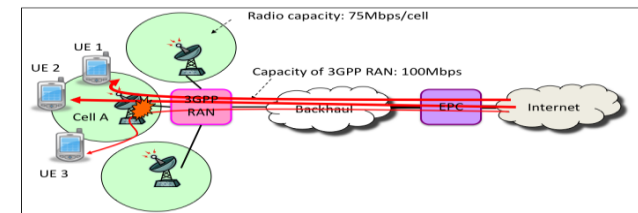


Mobile relay

- Continue the mobile relay based on alternative 1

UP-CON

- Handling user plane traffic when RAN congestion occurs.
- Many issues has RAN impact, e.g., mechanism to detect the RAN congestion / congestion removal





Roadmap

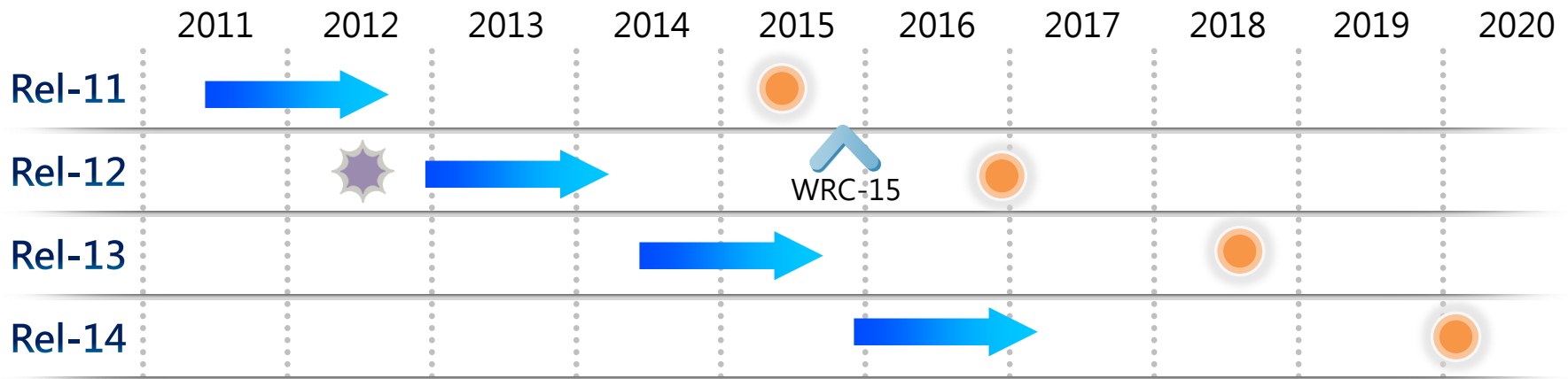
3GPP Release Roadmap

▪ Rel-12

- Full Dimension MIMO
- Inter-eNB carrier aggregation
- Control plane overhead reduction
- Enhancement of Rel-11 features

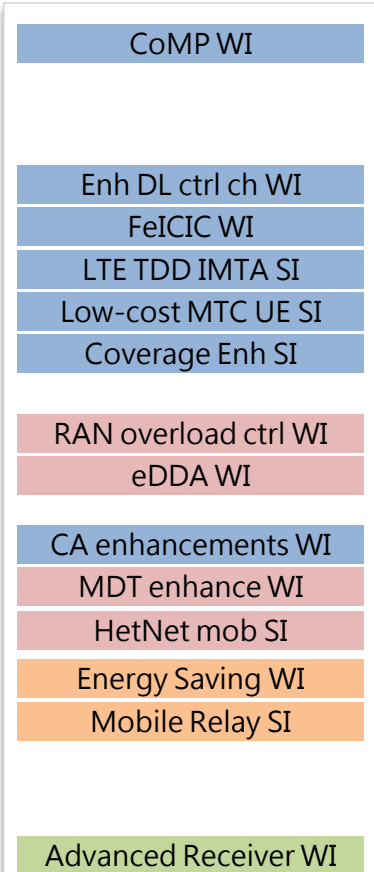
▪ Rel-13

- Enhancement on FD-MIMO, inter-eNB carrier aggregation, and CP overhead reduction
- Technologies for higher frequency

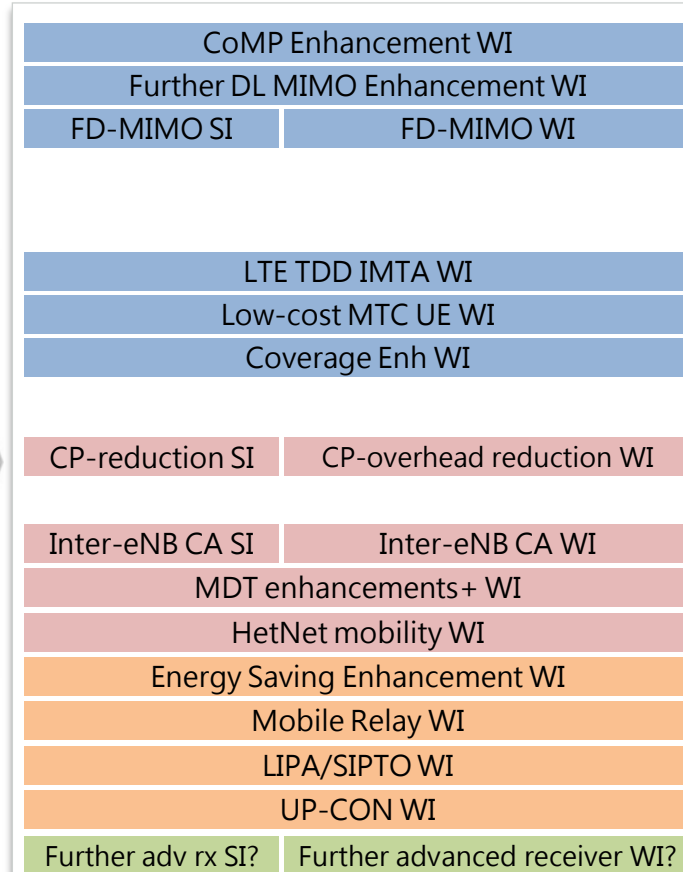


Technology Roadmap

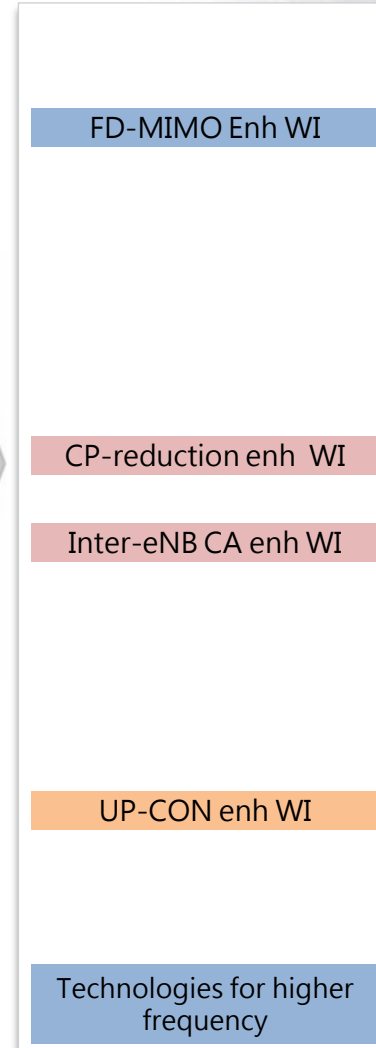
Rel-11



Rel-12



Rel-13



RAN1

RAN2

RAN3

RAN4