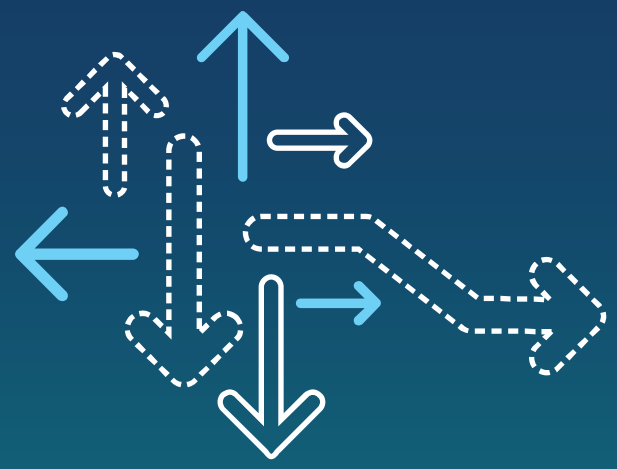
3GPP RAN #75
Dubrovnik, March 6-9, 2017
Agenda Item 9.1

RP-170758



Uplink Coverage Analysis of LTE and NR

Qualcomm

Overview

- Observation
  - Operating at higher carrier frequency can have larger propagation loss
    - E.g., 1.8GHz versus 3.5GHz has ~6dB propagation difference
- Solution 1
  - Larger antenna arrays at higher carrier frequencies can offset propagation differences
  - Performance gains from larger arrays can be observed even after channel estimation
- Solution 2
  - NR UL long burst and slot-aggregation transmissions can provide link budget gain

Antenna array considerations

- Antenna assumptions under RAN1 agreements suggest larger arrays can potentially compensate for losses at higher carrier frequency
  - Improved array gain at 3.5GHz below can largely offset 6dB propagation losses

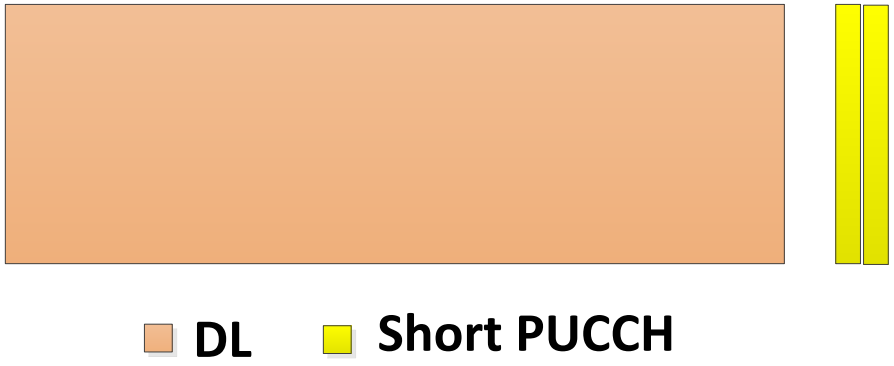
Carrier frequency GHz	# of Ants	Array gain (dBi)	Antenna Element Gain (dBi)	Total Ant Gain (dBi)
1.8	2	3.0	17*	**20.0**
3.5	64 X-pol**	21.1	8**	**29.1**

*Based on 36.873 for panel antenna at macro site
**Assuming 64 X-pol (i.e., 128 element), and gain based on 36.814
Note: for ITU evaluation, 128-cross pol was assumed.

Conclusion: 9dB improved margin from antennas at higher carrier frequency

Link level performance analysis

- Performance for uplink channels with appropriate channel estimation can leverage larger antenna arrays to operate at lower SNRs
  - Simulation considers 10-bit NR-PUCCH on short uplink burst with 2 short symbols, including RS for demodulation
- Net effect is less than 1dB loss compared to ideal antenna array gain
  - + Larger frequency diversity
  - + Larger antenna diversity
  - - Channel estimation loss (due to lower operating point)

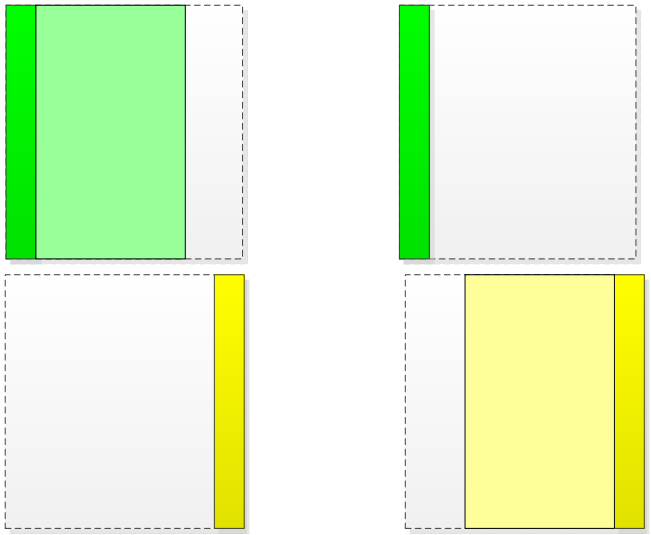


Comparison 24 vs 4 receive antennas at gNB

	Ideal antenna gain	Link-level SNR gain modeling impairments
10 bits NR-PUCCH	7.7dB (6x)	7 dB

Coverage improvement with UL Centric Slots

- Further coverage improvement can be enabled with long uplink bursts
- RAN1 agreements allow both long and short PUCCH
  - Long PUCCH may span longer duration of slot
  - Usage with DFT-s-OFDM can allow NR to maintain same link budget with LTE
  - Even longer transmission supported through slot aggregation



System level performance analysis

4GHz carrier frequency at 1.732 km ISD

	Downlink-centric Slot Full Buffer	Uplink-centric Slot Full Buffer
50% UE Throughput (Mbps)	33.4	27.3
5% UE Throughput (Mbps)	11.2	3.9
1% UE Throughput (Mbps)	7.5	1.4

- **Observation 1:** Massive MIMO improves both the DL and UL coverage for high frequency band deployment.
- **Conclusion 1:** No specific link imbalance between uplink and downlink due to higher carrier frequency itself
- **Conclusion 2:** LTE edge rate is designed for 384kbps, NR edge rate shown to exceed LTE

R1-166390, “Updated Sub6 DL Full-buffer KPI evaluation for eMBB”, Qualcomm Incorporated, 3GPP TSG-RAN WG1 NR #86, August 22nd - 26th, 2016, Gothenburg, Sweden

R1-166391, “Updated Sub6 UL Full-buffer KPI evaluation for eMBB”, Qualcomm Incorporated, 3GPP TSG-RAN WG1 NR #86, August 22nd - 26th, 2016, Gothenburg, Sweden

System level evaluation assumptions

Parameters	Dense urban	Rural
Layout	Single layer - Macro layer: Hex. Grid	Single layer - Macro layer: Hex. Grid
Inter-BS distance	Macro layer: 200m	1732m
Carrier frequency	Macro layer: 4 GHz	4GHz
Aggregated system bandwidth	200MHz (DL+UL)	80 (DL+UL)
Simulation bandwidth	20MHz per CC below 6GHz Note: UE TX power scaling will impact final results	
Channel model	3D UMa	3D-UMa
Tx power	BS: 44 dBm PA scaled with simulation BW UE: 23dBm	BS: 49 dBm PA scaled with simulation BW UE: 23dBm
BS antenna configuration	256 Tx /Rx antenna elements (X-pol)	
BS antenna pattern	Follow the modeling of TR36.873	
BS antenna height	25 m	35 m
BS antenna element gain + connector loss	8 dBi	
BS receiver noise figure	5 dB	
UE antenna elements	4 Tx /Rx antenna elements	
UE antenna height	Proposal: Follow TR36.873	
UE antenna gain	Proposal: Follow the modeling of TR36.873	
UE receiver noise figure	9 dB	
Traffic model	full buffer	
Traffic load (Resource utilization)	100%	
UE distribution	80% indoor (3km/h), 20% outdoor (30km/h) Uniform/macro TRP ([10] users per TRP for full buffer traffic)	50% outdoor vehicles (120km/h) and 50% indoor (3km/h) 10 users per TRP for full buffer traffic User distribution: Uniform
UE receiver	MMSE-IRC as the baseline receiver	
Feedback assumption	Realistic	
Channel estimation	Realistic	

- DL imperfection modeling
  - Channel estimation loss for reciprocity based channel (SRS) sounding
  - gNB side calibration error
  - Demod loss due to the channel estimation error
  - Noise covariance Rnn estimation error
- UL imperfection modeling
  - Channel estimation loss for reciprocity based channel (SRS) sounding
  - Demod loss due to the channel estimation error
  - Noise covariance Rnn estimation error
- The simulation also captures the overhead associated with both the DL and UL TDD operations, including DL control, UL control, DL/UL DMRS, UL SRS and DL/UL gap, etc.

Conclusions

- Link level performance analysis
  - Larger antenna arrays at higher carrier frequencies can offset propagation differences
  - Performance gains from larger arrays can be observed even after channel estimation
- System level performance analysis
  - No specific link imbalance between uplink and downlink due to higher carrier frequency itself
  - LTE edge rate is designed for 384kbps, NR edge rate shown to exceed LTE
- Additional techniques to improve uplink link budget
  - NR UL long burst and slot-aggregation transmissions can provide link budget gain

Thank you

Follow us on:

For more information, visit us at:
www.qualcomm.com & www.qualcomm.com/blog

©2013-2015 Qualcomm Technologies, Inc. and/or its affiliated companies. All Rights Reserved.

Qualcomm is a trademark of Qualcomm Incorporated, registered in the United States and other countries. All trademarks of Qualcomm Incorporated are used with permission. Other products and brand names may be trademarks or registered trademarks of their respective owners.

References in this presentation to "Qualcomm" may mean Qualcomm Incorporated, Qualcomm Technologies, Inc., and/or other subsidiaries or business units within the Qualcomm corporate structure, as appli

.

Qualcomm Incorporated includes Qualcomm's licensing business, QTL, and the vast majority of its patent portfolio. Qualcomm Technologies, Inc., a wholly-owned subsidiary of Qualcomm Incorporated, operates, along with its subsidiaries, substantially all of Qualcomm's engineering, research and development functions, and substantially all of its product and services businesses, including its semiconductor business.