High mm-Wave Bands for 5G and Beyond Systems

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High mm-Wave Bands for 5G and Beyond Systems

Outline

- Background
- Use cases and scenarios
- Design requirements
- Performance study and results
- Summary and conclusions

High mm-Wave Bands for 5G and Beyond Systems

Background

- 3GPP Rel-15 New Radio supports bands from below 1 GHz up to 52.6 GHz
- Wide bandwidths are available beyond 52.6 GHz, e.g. 60 GHz unlicensed, E-band and W-band
- 3GPP Release 16 Plenary level study on NR beyond 52.6 GHz (up to 114.25 GHz), to be completed during 2019. Expected to lead study item and work item in the following Releases (years 2020-2022)

3GPP TR 38.807 V0.0.4 (2018-09)

Technical Report

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
Study on requirements for NR beyond 52.6 GHz
(Release 16)

A GLOBAL INITIATIVE

1. *Identify target spectrum ranges*
2. *Identify potential use cases and deployment scenarios*
3. *Identify NR design requirements and considerations on top of regulatory requirements*

3GPP Release 16 RAN pre-study on NR beyond 52.6 GHz ongoing

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Use cases and scenarios

Use Case	Description	Scenario
Private Networks	Enable easy and cost-effective deployment of industrial private networks including non-public and closed group access	Indoor hotpots, dense urban, fixed access, mobile hotspots
Time Sensitive Networks	High resolution time synchronization, low delay jitter, guaranteed delay constraints	Indoor hotspots, dense urban, fixed access
High Accuracy Positioning	Indoor spaces and dense deployments will benefit from greater spatial resolution allowing operators and private networks to offer new targeted services and solutions	Indoor hotpots, dense urban
Environmental Sensing	Support for radar applications identifying objects in the environment and their respective motion	Indoor hotpots, dense urban
Audio-visual interaction (AR/VR)	Augmented reality relies on substantial sensor information to process and resolve the environment. The higher bandwidths may improve both sensor resolution and reduce latency	Indoor hotpots, dense urban, fixed access, mobile hotspots

[3GPP TSG RAN Meeting #83, RP-190492, Shenzhen, China, March 18-21, 2019, Agenda item: 9.3.12, Nokia, Nokia Shanghai Bell, NR beyond 52.6GHz – Potential use cases and deployment scenarios]

New spectrum and wider bandwidths for 5G New Radio will enable higher data-rates and new use cases

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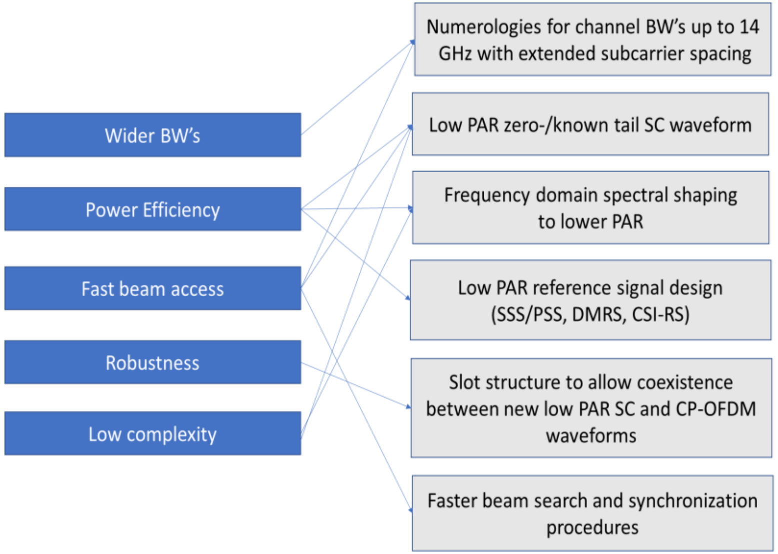
Design requirements

- **Larger carrier bandwidth** - component carriers > 400 MHz
- **Waveform design** – relevant considerations: power efficiency, demodulation complexity and numerology
- **Enhanced beam management** – methods for managing narrower beams and greater number of beams should be studied
- **Enhanced path diversity** – methods for improving path diversity and increasing the probability of LoS paths should be studied



Specific enhancements to NR must be considered to operate effectively at higher band

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Link level performance study - parameters

- Link-level performance between 28 GHz (NR Rel'15) and 73 GHz carriers (NR beyond 52.6 GHz) is compared by:
  a) assuming constant antenna aperture
  b) constant number of antenna elements (physical array size at 73 GHz will be less than ¼ the size of the array at 28 GHz)
- 28 GHz with 400 MHz bandwidth and 73 GHz with 2 GHz bandwidth
- Fixed PA power

Parameters	Value	Value
Carrier Frequency	73 GHz	28 GHz
FFT size	4096	4096
Subcarrier spacing	960 kHz	120 kHz
Channel Model	CDL-E 10ns	CDL-E 10ns
K-factor	15 dB	15 dB
Number of PRB's	180	268
Number of SCSs	2160	3216
Total bandwidth	2 GHz	400 MHz
CP	73 ns (288 samples)	586 ns (288 samples)
BS antenna config	8x16x2 (x-pol), half wavelength spacing	8x16x2/4x8x2 (x-pol), half wavelength spacing
UE antenna config	4x4x2 (x-pol), half wavelength spacing	4x4x2/2x2x2 (x-pol), half wavelength spacing
Number of layers	2	2
Number of symbols per slot	14	14
Channel estimation	Real	Real
Waveform	Single-carrier	CP-OFDM

Detailed link level performance study to compare NR Rel'15 @ 28 GHz and NR beyond 52.6 GHz @ 73 GHz

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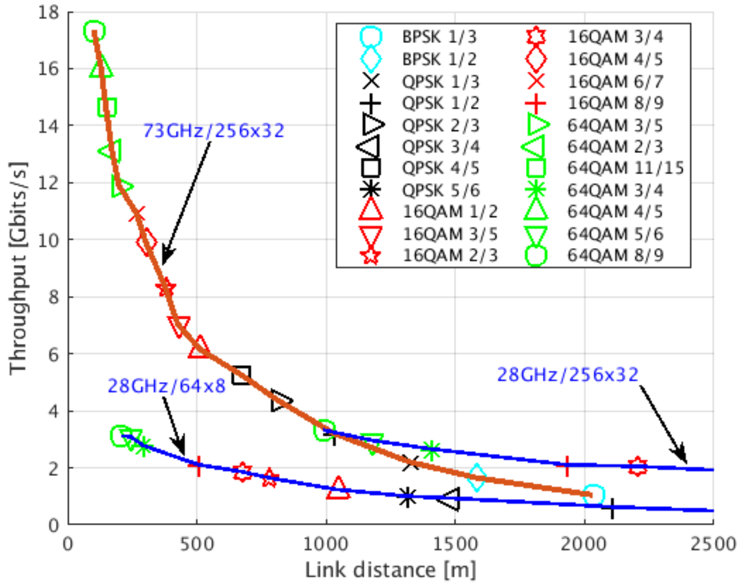
Link level performance study – 28 GHz and 73 GHz LoS channel

- For 73GHz, single-carrier (DFT-s-OFDM) is used to compensate the PA efficiency reduction at higher frequency
- 73GHz has significantly better link performance when aperture size is kept the same
- With constant number of antenna elements, similar coverage for multi-Gbps data-rates
- For 3Gbps datarate, 256x32@73GHz achieves 4x coverage increase vs. 64x8@28GHz



Wide bandwidths at high mm-wave will facilitate multi-Gbps link rates for NR evolution

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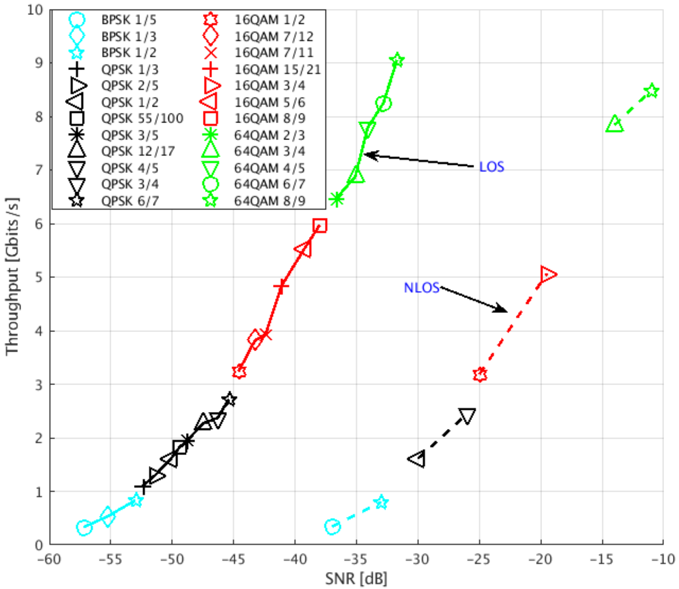
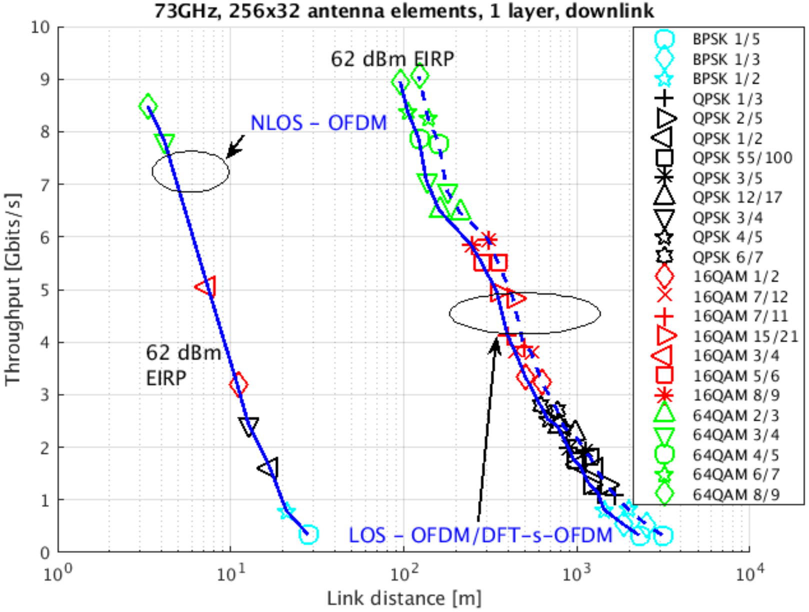
Link level performance study – NLoS vs. LOS performance



(Note, SNR values w/o antenna gain)



Mm-wave link performance on NLoS is limited -> methods for increasing the probability of LoS paths needed

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Summary and conclusions

- NR operation on high mm-wave bands requires new technology components because system have to cope with wider bandwidths, increased path loss, larger arrays and less efficient RF components
  - Low PAPR modulation
  - RFIC with large number of antenna elements
- Our performance study showed that
  - wider bandwidths available at high mm-wave bands will facilitate multi-Gbps link rates in LoS paths
  - performance on NLoS channel is limited -> methods for increasing probability of LoS paths needed
- 3GPP NR pre-study ongoing for bands 52.6 GHz - 114.25 GHz
- Future work to explore whether we can extend the technology beyond 115 GHz

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Questions?

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