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Enabling Technologies for Next Generation Wireless Systems

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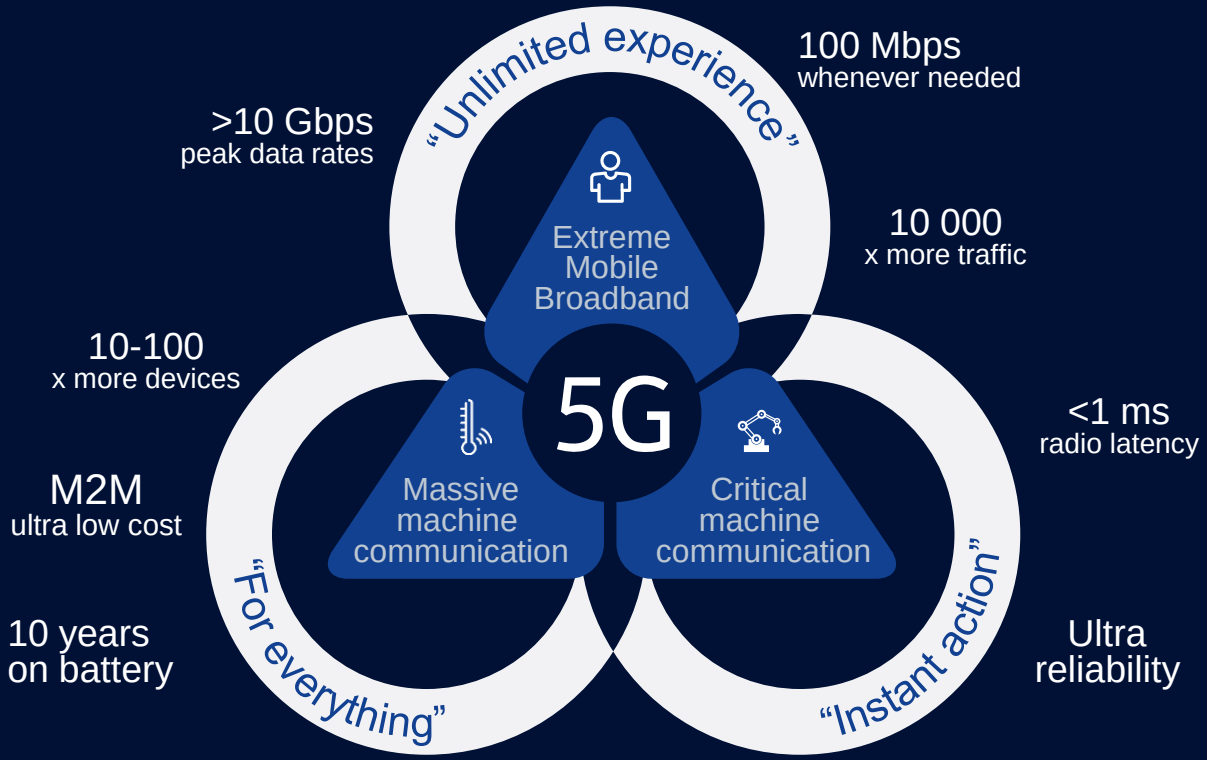
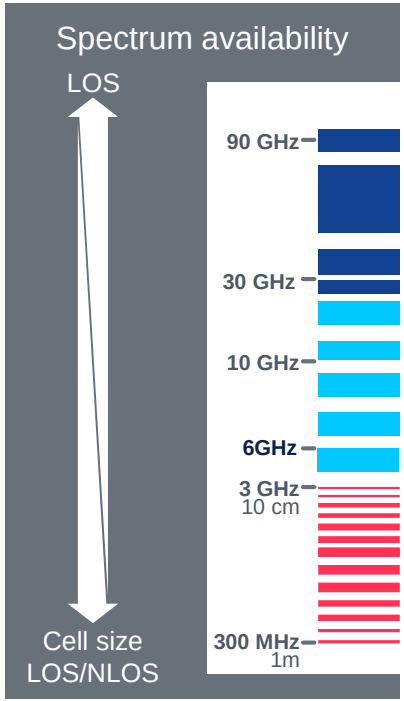
10th March, 2016

Heterogeneous use cases – diverse requirements



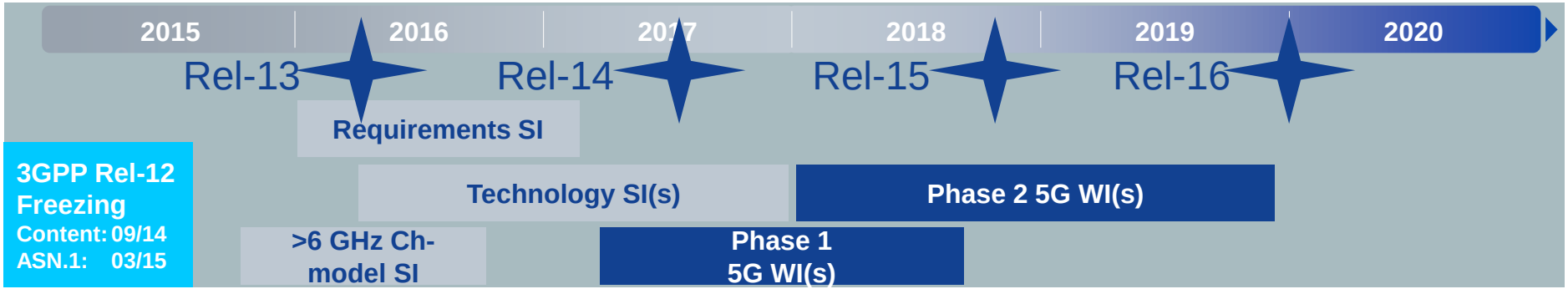
5G Scalable air interface design across frequency bands

Expanding the spectrum assets to deliver capacity and experience



Spectrum	Antenna size	Network layer
~Nx1GHz carrier bandwidth Dynamic TDD	**Very small** Low rank MIMO and beamforming	Ultra high capacity and data rates
~Nx100 MHz carrier bandwidth Dynamic TDD	**Small** High Rank MIMO and beamforming	Boosting capacity and data rates
~Nx10 MHz carrier bandwidth FDD and TDD	**Medium - large** High Rank MIMO and beamforming	Providing base coverage and capacity

3GPP release schedule and 5G work phasing plan in RAN



RAN workshop on 5G: Chairman Summary

Dino Flore

Chairman of 3GPP RAN

RAN workshop on 5G, Sep. 2015

- Emerging consensus that there should be two phases for the normative work
  - Phase 1 to be completed by H2 2018 to address a more urgent subset of the commercial needs (to be agreed)
  - Phase 2 to be completed by Dec 2019 for the IMT 2020 submission and to address all identified usecases & requirements

http://www.3gpp.org/ftp/workshop/2015-09-17_18_RAN_5G/Docs/RWS-150073.zip

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5G Technical Solutions – Summary of Ten Potential Technologies

Solution	Benefit
Usage of cm and mm waves	10x..100x more capacity
UE agnostic MIMO and beamforming	Network based massive MIMO evolution
Lean carrier design	Low power consumption, less interference
Flexible frame structure	Low latency, high efficiency
Dynamic TDD	Improved performance

Solution	Benefit
Enhanced interference coordination	Higher efficiency
Aggregation of LTE + 5G carriers	Higher data rate with smooth migration
Wireless backhaul with full Duplex	Improved performance
Flexible connectivity, mobility and sessions	Optimized end-to-end for any services
New waveforms	Multiservice flexibility

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5G mmWave Challenges & Proof Points

- Unique difficulties that a mmWave system must overcome
  - Increase path loss which is overcome by large arrays (e.g., 4x4 or 8x8)
  - Narrow beamwidths, provided by these high dimension arrays
  - High penetration loss and diminished diffraction
- Two of the main difficulties are:
  - Acquiring and tracking user devices within the coverage area of base station using a narrow beam antenna
  - Mitigating shadowing with base station diversity and rapidly rerouting around obstacles when user device is shadowed by an opaque obstacle in its path
- Other 5G aspects a mmWave system will need to address:
  - High peak rates and cell edge rates (up to 10 Gbps peak, 100 Mbps cell edge)
  - Low-latency (< 1ms)

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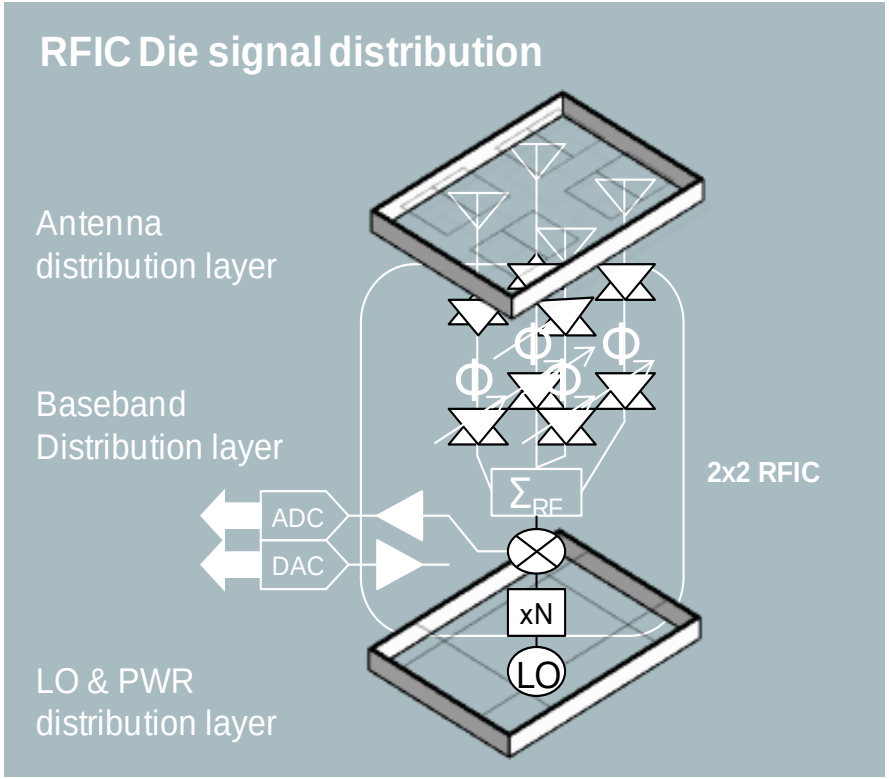
mmWave Massive MIMO/Beamforming Solution

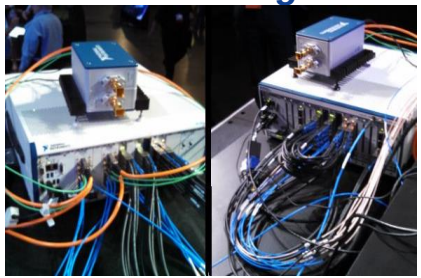
- Power consumption is one critical aspect for mmWave deployments
  - ADCs capable of sampling a 2 GHz BW signal will be a major factor in power consumption
  - Full digital baseband transceiver behind each element would consume an unacceptable amount of power
  - Analog (aka RF-radio frequency) beamforming techniques will be employed to steer the array elements on the panel
- The antenna panel would host a highly integrated mmWave circuit
  - Array of patch antenna elements bonded to an antenna distribution layer with power amplifiers, low noise amplifiers and phase shifters
  - Signal summed and down converted on the die and mixed down to where it could be generated or sampled by DAC and ADC
  - A separate antenna panel would be used for each orthogonal polarization

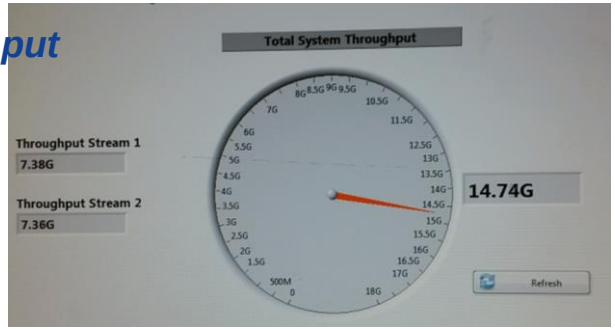


MWC -2016 demos at NTT DOCOMO and Nokia Booth

mmWave PoC System @ 74 GHz and 2GHz BW supporting 14.7 Gbps Peak rate

Nokia Booth: High Throughput

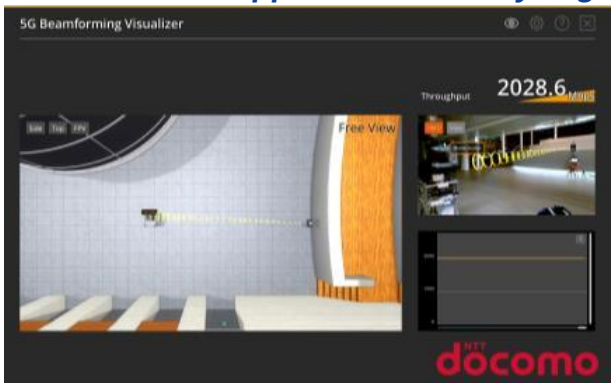




Parameters	Value
Operating Frequency	74GHz
Bandwidth	2 GHz
Antenna	Horn Antenna
Throughput	14.7 Gbps

mmWave PoC System @ 73 GHz and 1 GHz BW with Beamsteering and Low Latency

DOCOMO Booth: AR Beam Visualization and Low Application Latency Gigi-bit speeds



Parameters	Value
Operating Frequency	73.5 GHz
Bandwidth	1 GHz
Antenna	Lens w/Beamsteering
One way Latency	<1 msec

Addressing Security in 5G

- Variety of new devices and applications, including traditional cellular services, M2M and Internet of Things (IoT) applications, and mission critical and public safety services
  - Requires us to better understand the security of future mmW band networks in order to promote public safety through communications networks
- In general, the security measures envisaged for 5G are expected to be related more to the use cases enabled by the use of mmWave bands and not coupled with the radio characteristics of any particular frequency band.
- Nokia is conducting research in 5G security aspects
  - Reference: “Towards 5G Security” (Paper presented at the 14th IEEE International Conference on Trust, Security and Privacy in Computing and Communications (IEEE TrustCom-15), Helsinki, Finland, 20-22 August, 2015)
  - We can build on the protocols in 4G security. But we envisage adding security features to provide more flexibility and additional security services, depending on the need of the use case.
  - Different services may have different security requirements, and different approaches (e.g., whether they rely on security offered by the network or application layer security instead). We therefore believe the 5G security architecture must be flexible to support these different requirements in an optimal manner.

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