10 – 20 x Capacity with 5G

5x More Spectrum with 2 – 4x More Efficiency

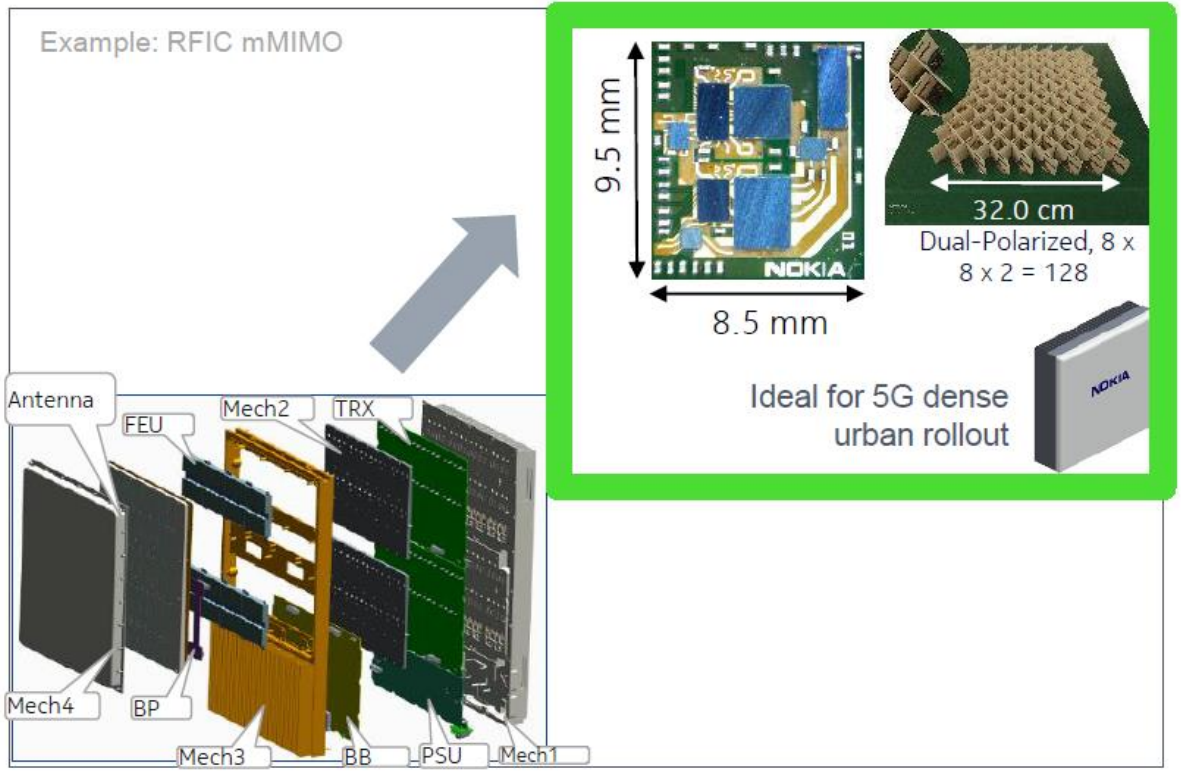
LTE1800
2x2 MIMO

1800 MHz	3.5 GHz
20 MHz	100 MHz
2 bps / Hz	4-8 bps / Hz
40 Mbps cell throughput	400-800 Mbps cell throughput

10-20 x

5G 3500 with
massive MIMO
beamforming

”Massive MIMO for Massive Deployment” requires higher integration/efficiency



Extreme Si integration

Combining RF + Filter + Power Amplifiers + TX/RX for > 40% lesser cost

Higher level of TRX chipset (FEM and Transceiver) integration for 50% power saving with mMIMO readiness

Extreme power efficiency

ETAdvanced technology for 30% lower RF lineup power consumption

Optimized algorithms such as Envelope tracking

Optimized HW/SW interaction, Highly optimized supply and frequency control

NOKIA

5G at 3.5 GHz Gives High Performance Broadband

Terabyte/Month with 5G

	LTE 3CA	VDSL2	5G @ 3500	Fiber
Typical use rate	20-100 Mbps	20-100 Mbps	100-1000 Mbps	100 Mbps to beyond 1 Gbps
Maximum capacity[1]	100 GB/month	>1 TB/month	1 TB/month	>1 TB/month
Deployment solution	Three-carrier aggregation	Copper <800 m to DSLAM	3.5 GHz mMIMO	Fiber installation

[1]Assumes 300 households per BTS site
LTE cell throughput 40 Mbps. 5G cell throughput 1000 Mbps. Busy hour load 75%. Busy hour share 10% of daily traffic.

5G Coverage Footprint – Combination of Low and High Bands

- High bands for capacity
- Low band for IoT and low latency critical communication

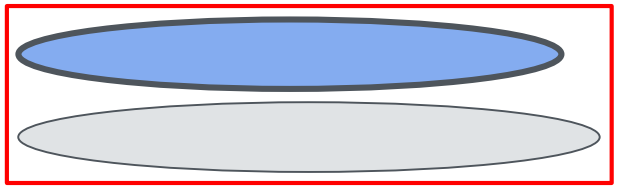
5G mm-waves

1000x local capacity

20 Gbps / 1000 MHz

5G 3500 mMIMO

LTE1800



10x capacity with LTE grid with massive MIMO

2 Gbps / 100 MHz

LTE800

5G700

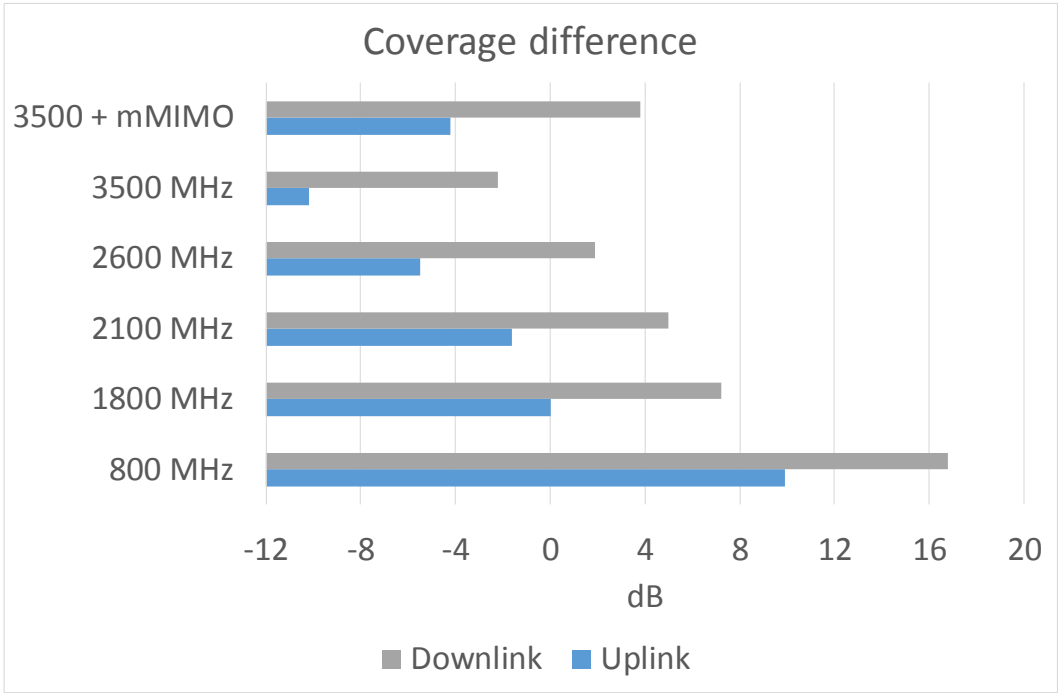
IoT and critical communication with full coverage

200 Mbps / 10 MHz

NOKIA

Coverage Comparison of 3500 MHz Macro Cells

Assumptions: Okumura-Hata model, downlink is +8 dB vs uplink and mMIMO gain 6 dB compared to 2x2MIMO



- 3500 MHz downlink with massive MIMO can exceed existing 1800 MHz outdoor coverage
- 3500 MHz downlink can match even 800 MHz with lower downlink data rate
- Indoor coverage still needs attention with low bands

5G Spectrum in USA – Focus Shifting to Low Bands, Mobility & Coverage

T-Mobile 5G at 600 MHz

Sprint plans to launch a 5G network by late 2019

by Chaim Gartenberg | @cgartenberg | May 10, 2017, 10:19am EDT

Sprint's announcement is *incredibly* lacking when it comes to details, however. Besides the "late 2019" date, the release notes that the carrier is looking to develop its 5G network in the 2.5GHz band of spectrum (E-UTRA LTE Band 41, to be precise), meaning that Sprint doesn't seem to be pursing millimeter wave for 5G at this time. But beyond that, there's virtually no

Sprint 5G at 2.5 GHz

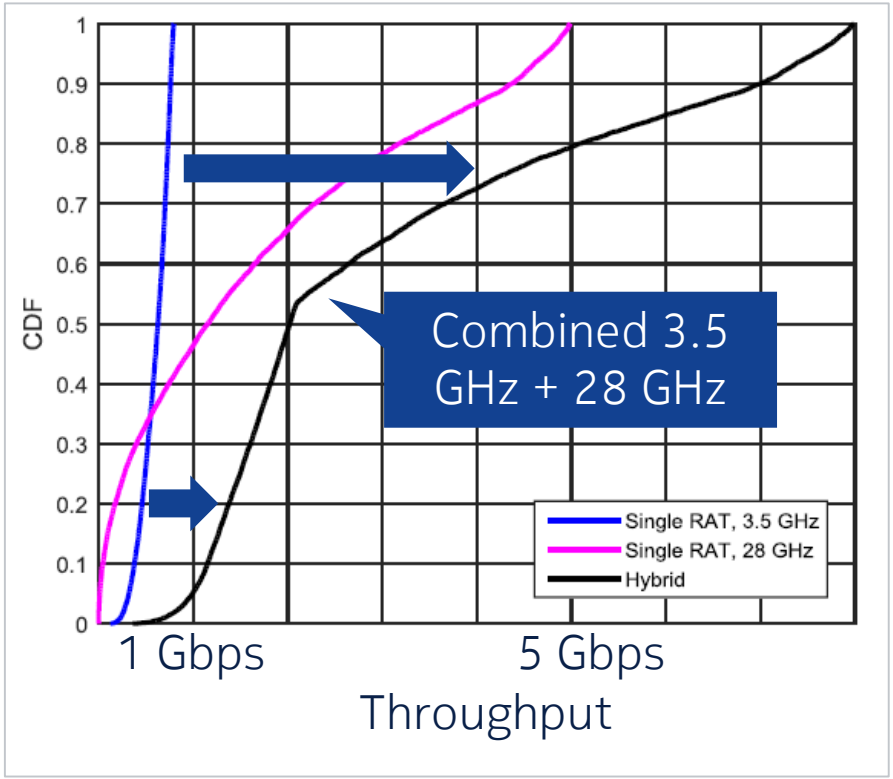
verizon

Verizon continues its march to 5G, with plans to deploy a prestandard fixed wireless solution in the first quarter of 2017, and it's seeking permission from the FCC to conduct market trials at 28 GHz in four states next year.

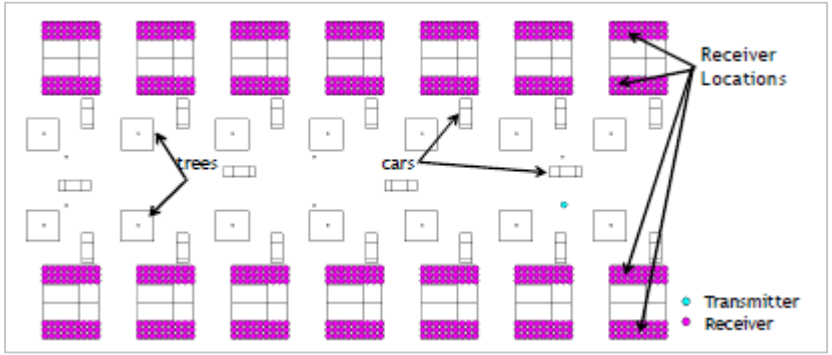
Verizon 5G at 28/39 GHz

NOKIA

28 GHz Band Works also for Mobile Use Cases

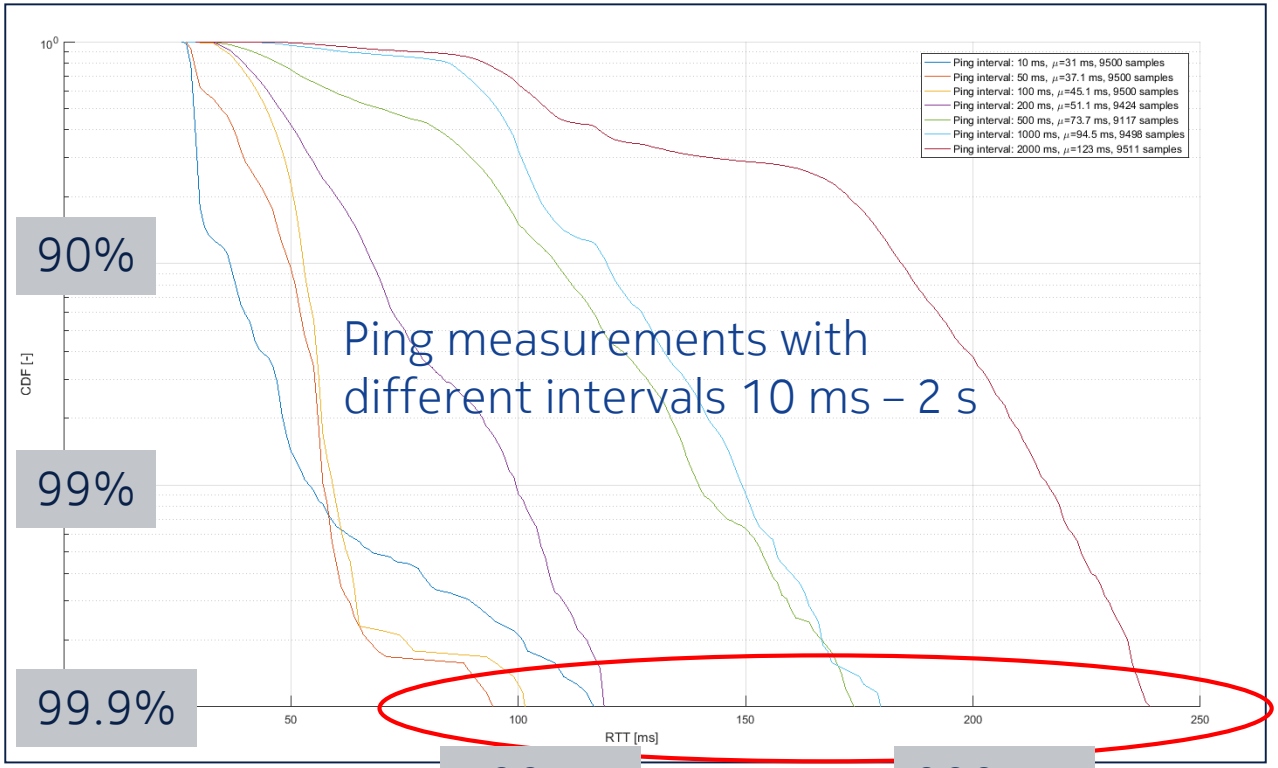


- 95% of indoor users get >100 Mbps
- 2/3 of users get 28 GHz and 1/3 get 3.5 GHz
- 3-5x higher data rate than 3.5 GHz alone
- Inter-site distance 230 m in suburban area
- 3.5 GHz: 40 MHz bandwidth, 19 dBi
- 28 GHz: 250 MHz bandwidth, 25 dBi



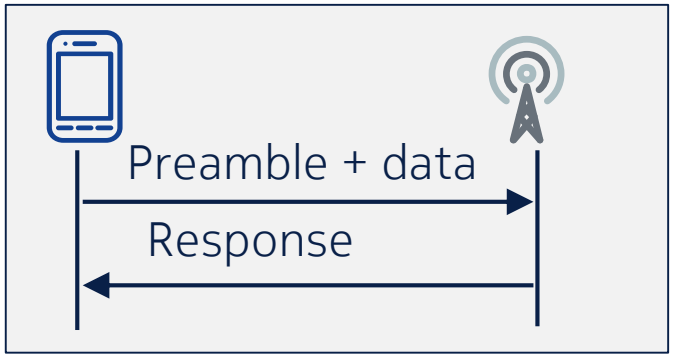
LTE Latency Measurements Show 100-250 ms with 99.9% Probability

5G Target 100x More Aggressive



- LTE 99.9% latency 100-250 ms depending on ping interval
- 5G target 100x higher reliability and 100x lower latency

Latency with LTE and 5G

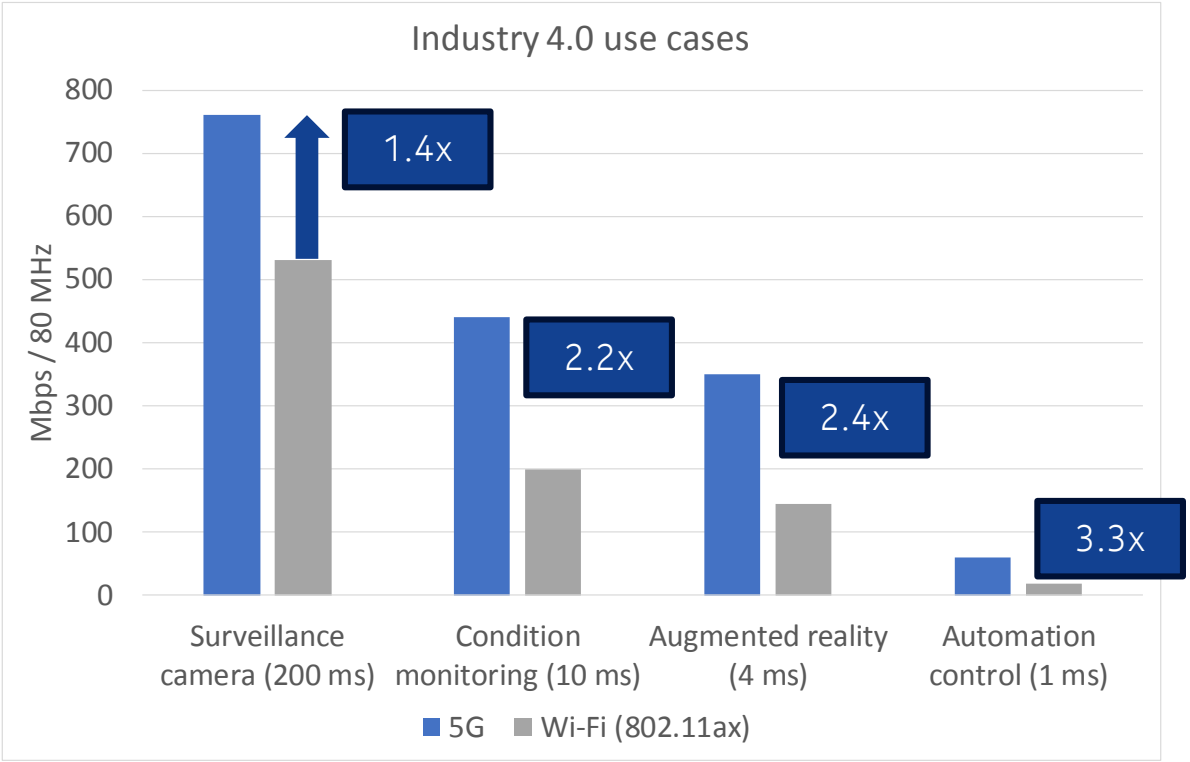


	4G	4.9G	5G target
Connected with uplink resources	10 ms	2 ms	1 ms
Connected without uplink resources	30 ms	<10 ms	1 ms
Idle	100 ms	<50 ms	1 ms

5G solutions for low latency

- Connected inactive state
- Contention based uplink

Benchmarking of 5G and WiFi in Industry Environment



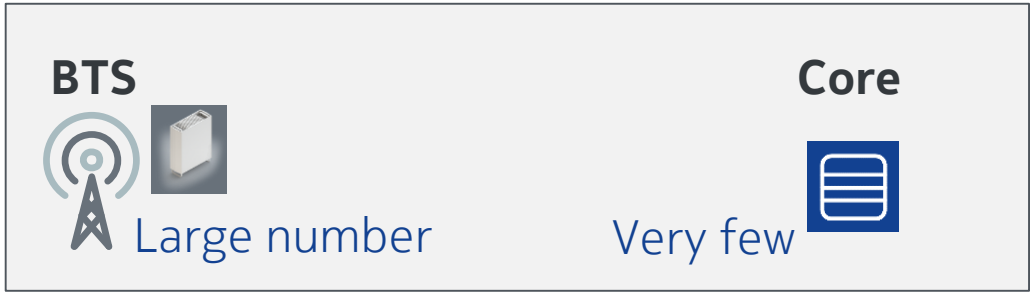
- 5G gives 1.4 – 3.3x higher efficiency than WiFi 802.11ax for Industry 4.0 use cases
- 5G benefit is largest compared to 802.11ax when the delay requirement gets tough (10 ms or less)

Assumptions:80 MHz, TDD, 4x4 SU-MIMO, 2 streams, 1024QAM in Wi-Fi, 256QAM in 5G

NOKIA

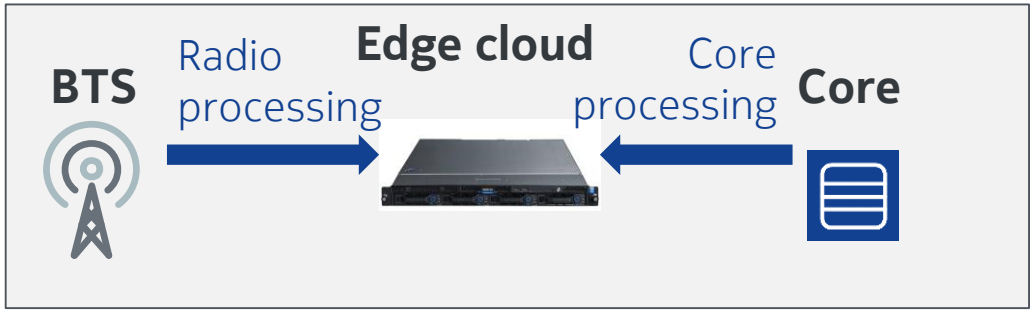
Network Architecture Evolution Towards 5G

Today



- Current radio is distributed
- Current core is centralized

Target



- Radio more centralized for faster scalability
- Core more distributed for low latency

NOKIA

Agenda

1

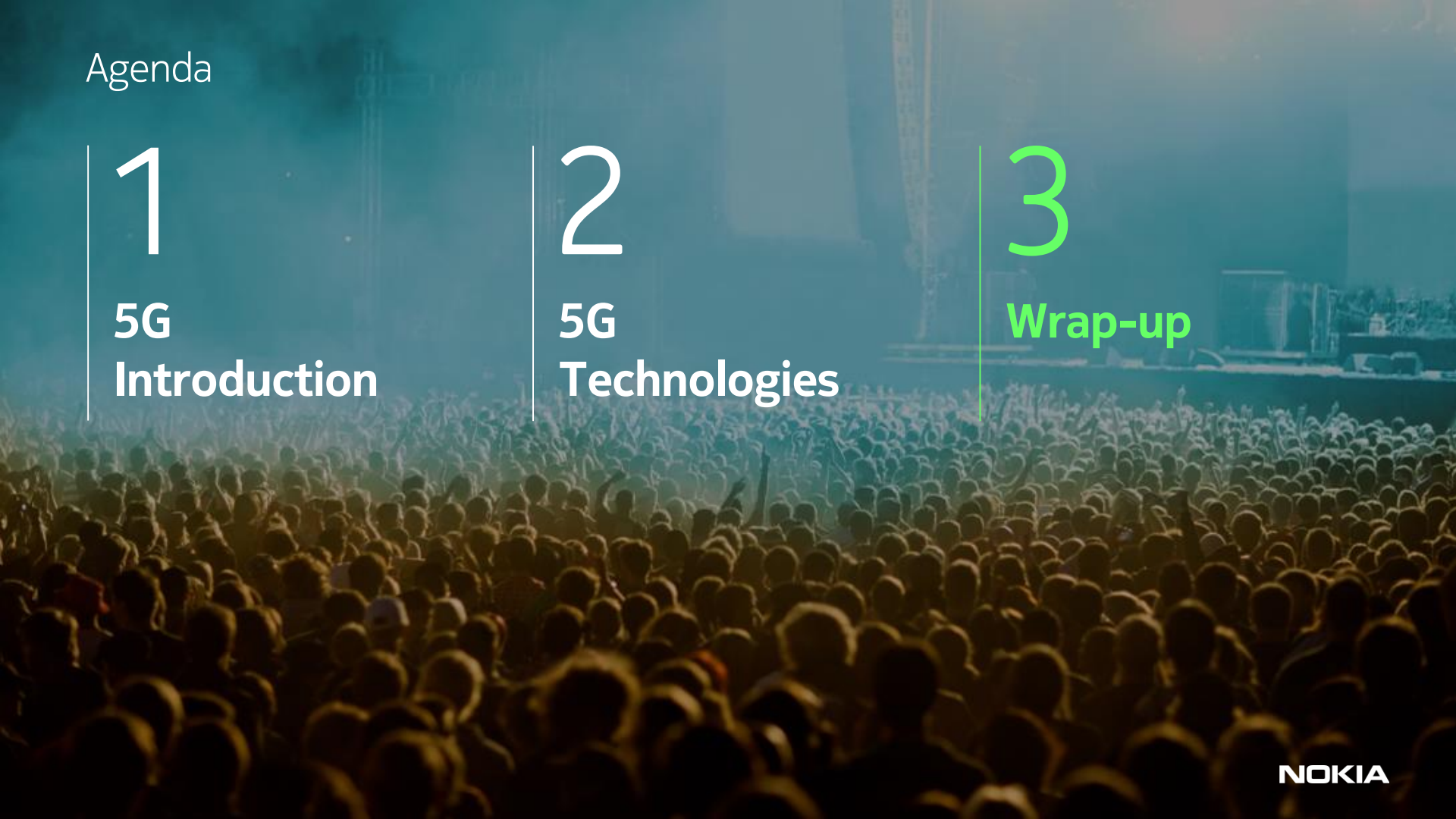
5G Introduction

2

5G Technologies

3

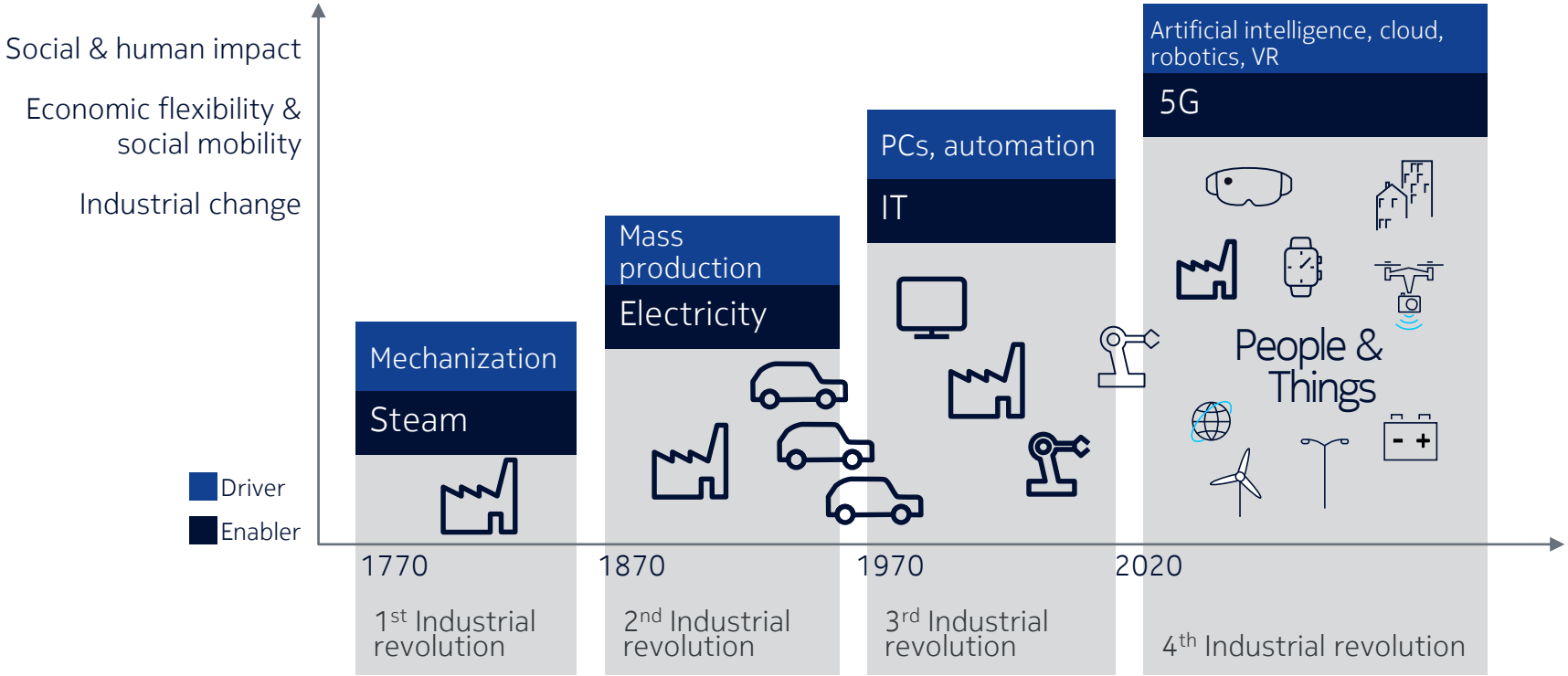
Wrap-up



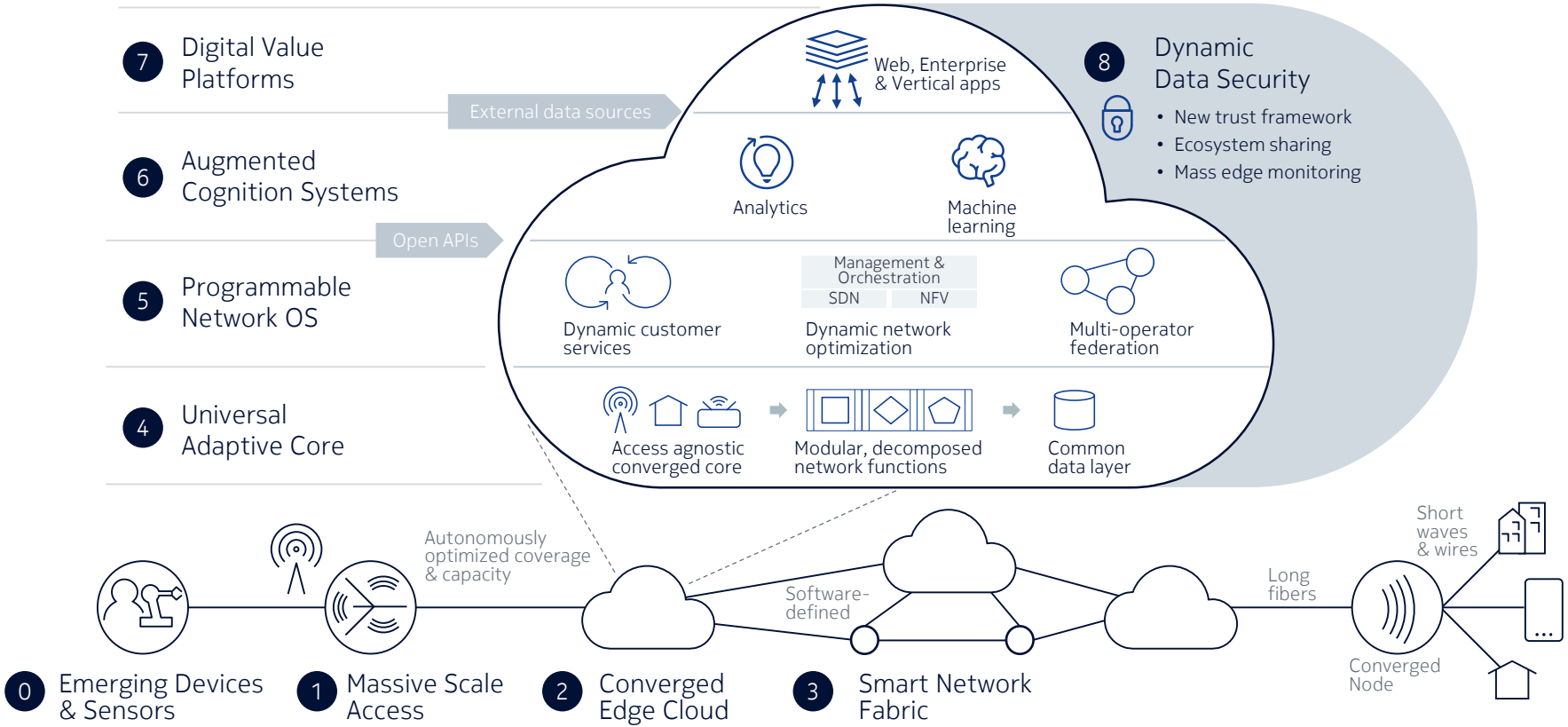
NOKIA

Convergence of megatrends creates a perfect storm for the need of 5G

4th Industrial revolution powered by 5G



End to end 5G capability based on Future X architecture



Thank you

5G – Drinking and Autonomous Driving