5G Networks – Technologies, Capabilities and Deployments

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Harri Holma, Fellow

Nokia Bell Labs
From Vision to Reality – 1 GB per User per Day

Nokia vision from 2011 “1 GB per user per day in 2020”

1 GB per user per day in 2020: Do you need a small cell on every street corner?

By Ruth Liley on Thu 4 October 2012

Mobile data in Finland 1 GB per day by end-2017

4300 TB/day today with 5.4M population = 0.8 GB per user/day
Fast Growth in Global Mobile Data Usage – Great Starting Point for 5G

Mobile data usage per subscription per month

- Finland
- Latvia
- Korea
- Sweden, Austria
- USA, Japan
- UK
- France, Germany
LTE Data Rates in Drive Tests During 2016/2017 – Average Up to 80 Mbps

- Typical LTE networks show 60 Mbps in urban areas in P3 drive testing.
- Best performance by Telia in Sweden (with Nokia radio) average 81 Mbps.
- 1 Gbps LTE networks show 250 Mbps average data rates.
5G Enables New Capabilities Beyond Mobile Broadband

- "Unlimited experience":
  - >10 Gbps peak data rates
  - <1 ms radio latency
  - Ultra reliability

- "For everything":
  - 100 Mbps whenever needed
  - 10,000 x more traffic
  - 10-100 x more devices
  - M2M ultra low cost
  - 10 years on battery

- "Instant action":
  - Massive machine communication
  - Critical machine communication
  - Extreme Mobile Broadband
5G Coverage Footprint

• Extreme local capacity with mm waves
• Match LTE 2 GHz with 3.5 GHz massive MIMO
• Full coverage with 700 MHz or 900 MHz
10 – 20x Capacity with 5G
5x More Spectrum with 2 – 4x More Efficiency

5G 3500 with massive MIMO beamforming

LTE2600 with 2x2 MIMO

- 2.6 GHz
- 20 MHz
- 2 bps / Hz
- 40 Mbps cell throughput

5G 3500

- 3.5 GHz
- 100 MHz
- 4-8 bps / Hz
- 400-800 Mbps cell throughput

10-20 x
Latency Evolution – New Radio and New Architecture Required

- Strong evolution in latency with new radios
- HSPA latency 20 ms
- LTE latency 10 ms
- 5G latency 1 ms
- Low 5G latency requires new radio and also new architecture with local content
Architecture Evolution to Radio Cloud

Antenna site
- Antenna + RF
- Delay critical processing

Transport
- Ethernet transport

Local cloud
- Edge computing
- Non-delay critical processing
- Multiconnectivity
- Gateway functionality

Nokia AirScale base station
- Low latency
- Faster scalability

Nokia AirFrame
Flexible Radio Architecture in 5G
3.5 GHz, 3-sector, Massive MIMO

- Edge cloud
- Antenna site

**CPRI**
- Layer 3
- Layer 2
- Layer 1 high
- Layer 1 low
- RF

**Low layer split**
- Layer 3
- Layer 2
- Layer 1 high
- Layer 1 low
- RF
- 1 Tbps
- <0.3 ms

**High layer split**
- Layer 3
- Layer 2 high
- Layer 1 low
- Layer 1
- RF
- 1-5 Gbps
- 5 ms
Network Slicing – Different Architectures for Different Service Needs

- 5G network is designed to support very diverse and extreme requirements for latency, throughput, capacity, and availability.
- Network slicing offers a solution to meet the requirements of all use cases in a common network infrastructure.
5G Minimizes IoT Device Power Consumption

- Major potential in improving IoT device battery life time
- LTE connection duration >10 s today even for the small data transmission
- 5G solutions: RRC inactive state and contention based uplink
- Factor of 100x improvement potential
iPhone 7 Teardown

LTE modem is very small part of smartphone complexity and just 7% of direct cost.
• New operator (TPG) in Australia paid 890 MEUR for 2x10 MHz of 700 MHz spectrum in Australia in April 2017
• T-Mobile acquired lot of 600 MHz spectrum in USA
5G Spectrum – US Example

It’s no secret that Verizon is gearing up for pre-commercial fixed wireless 5G trials using 28 GHz spectrum, but it seems the carrier is seeking to supplement those 5G trials with a new series of tests.

In an application filed at the end last week, Verizon asked the FCC for permission to conduct tests in the 28 GHz band in Euless, Texas and South Plainfield, N.J. over the next six months. Verizon said the tests would utilize equipment from five different vendors, including Ericsson, Intel, Qualcomm, Samsung, and Nokia.

Sprint plans to launch a 5G network by late 2019

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

T-Mobile Announces Plans for Real Nationwide Mobile 5G

T-Mobile 5G at 600 MHz
5G Early Market Use Cases

- **Dedicated use cases**
  - Healthcare
  - Home
  - Industry
  - Events

- **Highway use cases**
  - Truck platooning

- **Public transport use cases**

- **Dense city area use cases**
  - 8K video streaming
  - Drones
  - VR/AR
  - Hotspots

- **Home Hotspots**

- **Event Industry**

**Structural 5G deployment area**

5G use case
## 5G Schedule in 3GPP

### 2017
- Q4: 5G radio study item
- Q2: 5G radio work item
- Q1: Core network study and work item

### 2018
- Q4: Non-standalone with EPC
- Q3: Standalone and non-standalone with 5G core
- Q1: Core network study and work item
- Q2: 5G radio work item

### Key:
- **A** = Content frozen
- **B** = ASN.1 backwards compatibility
5G Proceeding Rapidly

Telia 5G in Helsinki 2018

SONERA BRINGS 5G TO HELSINKI IN 2018

2016.11.29
Together with Nokia, Sonera will introduce 5G services in Helsinki in 2018. The partnership was announced at the ongoing Slush - Europe’s biggest startup event in Helsinki.

Vesku Laiti, CEO of Sonera, said: “We want to drive the industry change and be at the cutting edge of development. Together with Nokia we will ensure that Sonera’s customers in Finland will be able to have the best network and we will also be able to start early with our 5G partnerships to make tomorrow’s services come alive.”

“Be at the forefront!”
Tommi Lilje, Senior Vice President for Global Product labs at Nokia Mobile Networks, said: “Nokia has created the technology path to evolve operators smoothly towards SDN, NFV, 4G, 5G Pro and 4G 9G technologies will deliver the dramatic improvements in speeds, capacity and latency needed to meet the demand created by myriad connected devices and people. We are pleased to work with Sonera in the greater Helsinki region to be at the forefront of developing a truly connected 5G world.”

New opportunities
5G opens up completely new opportunities for mobile services. With superfast speeds, significantly lower latency and capability to support a vast amount of IoT devices, 5G will enable new customer behaviors, services and IoT applications, for example in the areas of virtual reality, connected cars and e-health.

5G trials in Italy 2017

Giacomelli: dal 2017 sperimentazione sul 5G in 3 città
Rinnovo frequenze in manovra dà certezze

L’Italia è profondamente convinta della bontà della tecnologia 5G, tanto che nel 2017 la sperimenteremo in tre città, una al Nord una al Centro e una al Sud, utilizzando parte dello spettro”. Lo ha annunciato il sottosegretario allo Sviluppo economico con delega alle
Balázs Bertényi of Nokia Corporation has been elected RAN Chairman this week, gaining the majority needed at the second round of membership voting. He succeeds Dino Flore of Qualcomm Inc., who has served the maximum number of two terms as the Chairman (note 1) of TSG RAN – which has responsibility for radio aspects, functions, requirements and interfaces for all 3GPP networks.