5G – Remarkable enabler of Smart Cities

HiDATA Event: SMART CITIES

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4\textsuperscript{th} Industrial Revolution Powered by 5G

Social & human impact
Economic flexibility & social mobility
Industrial change

Industrial change

1\textsuperscript{st} Industrial revolution
Mechanization
Steam
1770

2\textsuperscript{nd} Industrial revolution
Mass production
Electricity
1870

3\textsuperscript{rd} Industrial revolution
PCs, automation
IT
1970

4\textsuperscript{th} “Industrial” revolution
Artificial intelligence, cloud, robotics, VR
5G
2020

People & Things

Driver
Enabler
Cities and Digitalization

- **IoT** Data Collection (Sensors, cameras, detectors...)
- **5G, 4G, 2/3G, WiFi, Bluetooth, LAN...** Wireless / Wired connectivity
- **AI/ML** Artificial Intelligence and Machine learning/data analytics will together change many things.

Cities need to understand the change and prepare to use the digitalization to:
- **Make citizens life better**
- **Optimize** everything (including transport, energy,..)
- Keep the **privacy** and ensure **security**
- Meet the **UN** (United Nations) **Sustainable Development Goals**

**Need**

Our modern society and growing cities face great **challenges** nowadays, e.g. to improve:
- **safety**
- **energy efficiency**
- **air quality**
- **effectivity of transportation**
- **general quality of living**
Global View

Smart cities require a new service infrastructure and a truly digital ecosystem enabling:

- Services
- High data capacity
- Business opportunities for companies

**Big Data for local use** of city, citizens and companies to help:

- Privacy and Security
- Sustainable growth
  - to meet UN SDG’s
  - to prevent climate change

**Common understanding:**

Climate change need to be minimized

- 70% of global population lives in cities by 2050
- 76% of global energy use and carbon emissions from cities

UN SDG’s

“EU SDG’s”

We need revolution for cites to save the Planet
5G – Three Main Segments

**Enhanced Mobile Broadband (eMBB)**
- >10 Gbps peak data rates
- <4 ms radio latency
- 100 Mbps whenever needed
- 10,000 x more traffic
- Unlimited experience

**Massive machine type communication (mMTC)**
- 1,000,000 devices per km²
- Range 164 dB MCL (Maximum Coupling Loss)
- >15 years on battery
- mMTC ultra low cost
- For everything

**Ultra Reliable Low Latency communication (URLLC)**
- <1 ms radio latency
- Ultra Reliable < 10⁻⁵ outage
- Zero mobility interruption
- Instant action
The quest for **new value**

The legacy problem!

Some growth, but not all for Telcos

New DSP markets offer growth

New industrial, infra & enterprise value

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* Western Europe, Canada, USA, Japan, South Korea, Singapore, Australia, and NZ. Source: Gartner

Most consumer focused operators facing long term stagnation – enterprise becomes a key focus
5G Radio Spectrum – enables many type of Smart City connections

High data rates up to 20 Gbps require bandwidth up to 1 GHz which is available at higher frequency bands. 5G is the first radio technology that is designed to operate on any frequency bands between 450 MHz and 90 GHz.

RSPG “PIONEER” BANDS
RSPG = Radio Spectrum Policy Group

3.5GHz auction results in Finland (130 MHz/MNO):
- Telia: 3,410-3,540 GHz
- Elisa: 3,540-3,670 GHz
- DNA: 3,670-3,800 GHz

World Radio Conference 2019

Capacity
Coverage

- 4G + WiFi
- 4G Radio
- 5G Radi0
- 5G mm wave
- 5G cm wave
- LTE Advanced/LAA LTE

- 1 GHz
- 2 GHz
- 3 GHz
- 6 GHz
- 10 GHz
- 20 GHz
- 60 GHz
- 100 GHz

Log Scale

Stretching urban mobile data speeds

- 3.4 – 3.8 GHz

Stretching Hot Spot data speeds

- 26 GHz
  - eg 10 Gb/s at railway stations, airports, sporting events, Factories etc “hot spots”

Stretching urban mobile data speeds

- 3.6 GHz
  - eg 1-3 Gb/s over all towns and cities (mobile Gb/s society)

Stretching reliable coverage (rural)

- 700 MHz
  - eg 100% coverage of roads
5G Boosts Cell Capacity by 20x with 3.5 GHz Band
4x More Spectrum and 5x More Efficiency

<table>
<thead>
<tr>
<th>LTE</th>
<th>5G</th>
</tr>
</thead>
<tbody>
<tr>
<td>1800 MHz</td>
<td>Frequency</td>
</tr>
<tr>
<td>20 MHz</td>
<td>Bandwidth</td>
</tr>
<tr>
<td>2 bps / Hz</td>
<td>Spectrum Efficiency</td>
</tr>
<tr>
<td>40 Mbps</td>
<td>Capacity: 20 x</td>
</tr>
<tr>
<td>40 Mbps cell throughput</td>
<td>800 Mbps cell throughput</td>
</tr>
</tbody>
</table>

- LTE1800 2x2 MIMO
- 5G 3500 with massive MIMO beamforming

180% is downlink
Innovations for Low Latency Radio Transmission – 1 millisecond in 5G

- **Minimum transmission time**
  - **3G HSPA**: 2 ms
  - **4G LTE**: 1 ms
  - **5G**: 0.125 ms

- **Round trip time**
  - **3G HSPA**: 10-15 ms
  - **4G LTE**: 20-30 ms
  - **5G**: 1 ms
Speed of Light is the Limit – Content Must be Close to the Radio

- 5G target is 1 ms round trip time
- 100 km two-way propagation delay in optical fiber is to 1 ms
- 10 km propagation delay to 0.1 ms

Content must be close to the radio (within a few 10 km) to get full benefit from the 1-ms round trip time in the radio ⇒ Multi access Edge Computing (MEC/vMEC) and Local break out will be needed.
LuxTurrim5G – Solution for Smart Cities

LuxTurrim5G develops and pilots concrete technology enablers and service concepts for open Smart City Digital Ecosystem

Indoor/Outdoor connections
Signal propagation through construction materials
- RF permeable windows: Lammin Windows

5G network
High capacity, low latency
Small cells -> many sites
5G network: Nokia Bell Labs
Light pole: Exel Composites

City Infrastructure
Light pole infra, power, data transport
Infra planning: Sitewise

Operators
Business models for:
- Existing ones
- New ones?

Smart city services on top of a common platform
Examples:
- Video surveillance, public safety, infotainment screens: Teleste
- Air quality, weather: Vaisala
- Location, navigation: Indagon
- Lighting/charging: Ensto
- Drones: Rumble Tools

Public partners contributing in each research area:
VTT, Aalto, TUT

City Infrastructure: Sitewise

Transportation

Citizens

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Digital Smart City: LuxTurrim5G
5G mmW access points in every light pole

Integrated in to Light pole or other “box”

- Sensors
- Cameras
- 5G mmW Access Point
- μMEC AI

Local AI services:
- sensor fusion
- video analytics
- autonomous traffic
- RN optimization
- ...

Nokia HQ
Espoo campus

On 73 GHz frequency, 15 Gbps per sector, four sectors
On 26 GHz frequency, 5 Gbps per sector, four sectors

Fiber
Neutral Host Pilot - Approach

City wide network with open interfaces for service creation

Users: Citizens Companies City

Application layer
Applications / use cases

Data platform
Collect, store, manage, share, AI/ML, secure

Connectivity platform
LuxTurrim5G (and other technologies)

Sensors Cameras Screens Terminals

Neutral Host Pilot company

Only one 5GmmW network feasible, shared with operators and the city