Expand the human possibilities of the connected world

Celtic-Plus Proposers Day
7 May, 2015, Oulu, Finland
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Technology disruption transforms business and lives

<table>
<thead>
<tr>
<th>Estimated 2025 Enterprise IT spend</th>
<th>Connected devices in 2025 45Bn of which are M2M</th>
<th>Compute power of Amazon’s cloud against 14 competitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated global spend in the Internet of Things</td>
<td>Estimated number of mobile devices held per person by 2025</td>
<td>Estimated mobile operator spend on Network and IT Infrastructure in 2025</td>
</tr>
<tr>
<td>3.8Tn EUR</td>
<td>2.3Tn EUR</td>
<td>5x</td>
</tr>
<tr>
<td>6+</td>
<td>31Bn</td>
<td></td>
</tr>
<tr>
<td>&gt;80%</td>
<td>244Bn EUR</td>
<td></td>
</tr>
</tbody>
</table>
In a business that requires a change

Our goal is to be a leader in technologies in a world where everybody and everything will be connected.
A change we embrace

Only opening up expands the business for all players

Agility
Openness
Innovation
Expertise
5G for people and things
Expanding the human possibilities of cellular technology

Critical machine type communication

Bomb of possibilities

HD Cams NW

Diagnosis

while traveling

Work & game

REVOLUTIONIZED

Massive machine

Massive machine

type communication

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Explosion of possibilities announcing new performance levels of people and things

Augmented

REDEDICATED

People & Things

Real world

automotive 4th industrial revolution

Virtual

High performance

Traffic Mgmt.

Traffic mngm.

Superefficient

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Augmented reality

VR glasses

Mobile living

Autonomous

Industry 4.0

Traffic Mgmt.

Safety & Security

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Your application environment following you anywhere

- **INTERCONNECTED**
  - Control
  - 4k Entertainment
  - eHealth
  - Fitness
  - Communication

- **AUTOMONOUS**
  - Wearables
  - "Enhancing my life" (US)
  - "Feel more informed" (UK & US)
  - "Feel more intelligent" (UK & US)

- **VIRTUAL**
- **TACTILE**
- **SUPEREFFICIENT**
- **REVOLUTIONIZED**

Enhancing perception of reality in real-time

- **INTERCONNECTED**
  - Car dashboard
  - Interact with real-word

- **AUTOMONOUS**
  - Object recognition
  - Task-specific assistance

- **VIRTUAL**
- **TACTILE**
- **SUPEREFFICIENT**
- **REVOLUTIONIZED**

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Virtually present at any place while interacting with real world

- Travel & commute
- Touch & steer
- Real-time remote avatar
- Real-time remote robot
- Real-time remote diagnosis
- Less medical costs with remote monitoring
- Doctors are missing in the US alone - virtual capabilities required

Rededicate commuting time for work & entertainment

- Widespread video calls
- Real-time working in the cloud
- 18% of tablet users demand connected car services
- 2020 UHD devices will be the norm
- 4K
- 100 commuters streaming ultra high definition content at the same time
- Freed time
- Autonomous cars turn into offices or living rooms

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Transforming urban space: autonomous vehicles

Transforming urban space: superefficient infrastructure
4th industrial revolution: create an "artificially intelligent" production system

<table>
<thead>
<tr>
<th>INTERCONNECTED</th>
<th>AUGMENTED</th>
<th>REDEDICATED</th>
<th>AUTONOMOUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperate in completely new ways</td>
<td>Manufacture a wide variety of products in small quantities</td>
<td>Zero-inventory production system; Minimized labor and energy costs</td>
<td>50% Improvement of manufacturing productivity in 10 years</td>
</tr>
<tr>
<td>Autonomous vehicles in warehouses move around at high speeds</td>
<td>Arrange themselves for optimal production efficiency</td>
<td>&quot;4th industrial revolution: Creating an artificially intelligent production system – drastically increase industrial competitiveness&quot;</td>
<td></td>
</tr>
<tr>
<td>Fleet of robots is supervised, updated and controlled by a cloud service</td>
<td>Remotely steer robots with integrated surveillance cameras</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Virtual | Tactile | SuperEfficient | Revolutionized

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Introducing extreme range of requirements

>10 Gbps peak data rates

10-100 x more devices

M2M ultra low cost

10 years on battery

Massive Broadband

100 Mbps whenever needed

10 000 x more traffic

Ultra reliability

<1 ms radio latency

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Networks to become much denser
5G flexibly integrates multiple air interfaces and layers

Perception of infinite capacity

Ultra-dense carrier bandwidth Dynamic TDD

Ultra-broadband
Low Rank MIMO & beamforming
High Rank MIMO & beamforming

mmWave

cmWave

< 6GHz

Ultra-dense

Dense

Macro

5G is to enable above 6 GHz access & optimize below 6 GHz access

mmWave

~1 GHz carrier bandwidth
Dynamic TDD

Several ~100 MHz
Dynamic TDD

Up to 100 MHz
carrier bandwidth
diverse spectrum, FDD and TDD

~ Ultra broadband

Enhanced urban

< 6GHz

Wide area

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Frequency-specific air interfaces managed as one system

A symbiotic integration of novel and existing access technologies
Nokia 5G system vision
What is needed to make 5G a true global success?
Growth and enabler of societal innovation

<table>
<thead>
<tr>
<th>Flagship of Digital Agenda</th>
<th>Cross region collaborative research and pre-consensus</th>
<th>Market driven competition and consolidation</th>
<th>Legislation on Net Neutrality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive global standardization</td>
<td>More globally harmonized spectrum (for LTE and 5G)</td>
<td>Data Protection for information centric networks</td>
<td>Fair rules for standard essential patents</td>
</tr>
</tbody>
</table>

Business models
- Connectivity
- Apps enabling & management
- Data brokerage & analytics will have to evolve

Connecting things is a different business

<table>
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<tr>
<th>Connecting people</th>
<th>Connecting things</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connection volumes 2020</td>
<td>Tens of billions</td>
</tr>
<tr>
<td>ARPC 2015</td>
<td>Low $3/month</td>
</tr>
<tr>
<td>Churn</td>
<td>Low -10% or less</td>
</tr>
<tr>
<td>Data pricing</td>
<td>Based on value of data</td>
</tr>
<tr>
<td>Connectivity</td>
<td>SLAs Reliability Criticality</td>
</tr>
<tr>
<td>Security</td>
<td>Important</td>
</tr>
</tbody>
</table>

- Based on volume of data
- Best effort, QoE mgmt.
5G as a platform for innovation

Platform which allows others to innovate and apply 5G to improve life, business and society

Useful for every industry, every vertical, every human, every machine and every thing

Finnish 5th Gear 5G test network project in Oulu
Imagine

Zero road fatalities?

• Zero fatalities = 1 million lives saved
• Annual economic cost of car crashes in U.S alone ~ $300 billion
• Autonomous cars could reduce annual CO2 emissions by as much as 300 million tons
Zero loss in water distribution?

20% water lost due to leakage today
= 71 billion gallons lost everyday
= Daily water usage in California, Texas and Ohio Combined

Always contain the spread of communicable diseases... never cross a boundary?
Give back 2hrs everyday... never be in a rush?

Always speak the local language ... never be lost in translation?
Always find home...
never be lost?

Always find the one...
never be alone?
Let’s live in the future, then build what’s missing.