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BUDVA, MONTENEGRO

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WIRELESS CONNECTIVITY TECHNOLOGIES EVOLUTION FOR INTERNET OF THINGS AND MACHINE TO MACHINE COMMUNICATION
KEY CHALLENGES FOR THE NETWORKED SOCIETY

Massive growth in
Connected Devices
Massive amount of communicating machines
“500 billion devices”

Massive growth in
Traffic Volume
Further expansion of mobile broadband
Additional users and increased usage
Additional traffic due to communicating machines
“>1000x”

Wide range of
Requirements & Characteristics
Multi-Gbps in specific scenarios
Hundreds of Mbps generally available
Ultra-low latency (~ms)
New requirements and characteristics due to communicating machines

Affordable and sustainable
THE INTERNET OF THINGS
TRANSFORMING THE WORLD WE LIVE IN
ACCELERATING INTERNET OF THINGS – IOT

26 BILLION
Connected devices in 2020

10 BILLION
Consumer electronics

9 BILLION
Mobile phones

7 BILLION
M2M devices

1.9 TRILLION
Predicted value-add of IoT across sectors in 2020

CONNECTIVITY IS KEY
IoT brings value across a range of industry sectors. Connectivity is the enabler for making the Internet of Things happen.
Wide Range of Requirements

Massive MTC
- Smart Building
- Logistics, Tracking and Fleet Management
- Smart Meter
- Smart Agriculture
- Capillary Networks

Critical MTC
- Remote Health Care
- Traffic Safety & Control
- Industrial Application & Control
- Remote Manufacturing, Training, Surgery

Low Cost, Low Energy
Small Data Volumes
Massive Numbers

Ultra Reliable
Very Low Latency
Very High Availability
WIDE VARIETY OF APPLICATIONS

<table>
<thead>
<tr>
<th>Category</th>
<th>Speed (MBPS)</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat-0</td>
<td>$5</td>
<td></td>
</tr>
<tr>
<td>Cat-1</td>
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</tr>
<tr>
<td>Cat-4</td>
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<tr>
<td>Cat-6</td>
<td>$20-$30</td>
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<tr>
<td>Cat-9</td>
<td>300</td>
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<tr>
<td>Cat-11</td>
<td>450</td>
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<tr>
<td>Cat-x</td>
<td>600</td>
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<tr>
<td>Cat-M</td>
<td>$2</td>
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<tr>
<td>LTE-Lite</td>
<td>$2</td>
<td></td>
</tr>
<tr>
<td>LTE</td>
<td>1000</td>
<td></td>
</tr>
</tbody>
</table>

- **ENHANCING EXISTING AND ENABLING NEW AND EMERGING APPLICATIONS**
- **INCREASING SUPPORT FOR A VARIETY OF SMARTPHONE APPS, VIDEO ON DEMAND AND ENTERPRISE CLOUD APPLICATIONS**
- **HIGH PRIORITY SERVICES IN COEXISTENCE WITH MOBILE BROADBAND**
- **SUPPORTING INTERNET OF THINGS AND LOW BIT RATE APPLICATIONS**

INCREASING SUPPORT FOR A VARIETY OF SMARTPHONE APPS, VIDEO ON DEMAND AND ENTERPRISE CLOUD APPLICATIONS

SUPPORTING INTERNET OF THINGS AND LOW BIT RATE APPLICATIONS

HIGH PRIORITY SERVICES IN COEXISTENCE WITH MOBILE BROADBAND

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SUPPORTING INTERNET OF THINGS AND LOW BIT RATE APPLICATIONS

HIGH PRIORITY SERVICES IN COEXISTENCE WITH MOBILE BROADBAND
MASSIVE MTC – TECHNOLOGY CHOICES

**Licensed Cellular IoT**
- **Licensed IMT spectrum**
- GSM, GSM evolution
- WCDMA/HSPA evolution for MTC
- *LTE evolution for MTC*
- Clean-slate narrowband (GERAN)

**Short-range radio**
- **License-exempt spectrum for local connectivity**
  - IEEE 802.15.4, ZigBee,
  - Bluetooth Low Energy,
  - IEEE 802.11ah,
  - Z-Wave, …
  - ...
- Backhaul *cellular* or fixed

**Unlicensed long range radio**
- **License-exempt spectrum for long range**
  - Weightless
  - Sigfox
  - OnRamp
  - LoRA
  - …
KEYS TO ACCELERATE IOT

- COST
- BATTERY LIFE
- QUALITY OF SERVICE
- COVERAGE
EVOLUTION TOWARDS 2020

- Mobile Data Volumes: 1000x
- Connected Devices: 10x-100x
- Lower Latency: 10x
- End-user Data Rates: 10x-100x
- Battery Life for Low Power Devices: 10x

Source: METIS
5G IS DRIVEN BY THE APPLICATIONS

5G USE CASES

- Broadband Experience Everywhere, Anytime
- Media Everywhere
- Smart Vehicles, Transport & Infrastructure
- Critical Control of Remote Devices
- Interaction Human-IoT
Licence or unlicensed spectrum for IoT

**Dedicated spectrum**

- **Mobile networks**
  - e.g. GSM, LTE
- **Dedicated wide area IoT network**
  - e.g. SIGFOX, Weightless

**Shared spectrum**

- **Dedicated wide area IoT network**
  - e.g. ZigBee, WiFi (802.11 af, ah)
- **General local area network**
  - e.g. Bluetooth, WiFi (802.11n)

#### Coverage

- **Wide area coverage**
- **Short range, clustered connectivity**

#### QoS management

- **QoS management**
- **Best efforts QoS**

#### Other

- **Evolution of GSM & LTE**
  - e.g. LTE Cat 0
- **Optimised for long battery life**
- **Good in-building penetration/coverage**

#### Example bands

- **Example bands**
  - 800 MHz
  - 900 MHz
  - 400 MHz
  - 870-876 MHz
  - 915-921 MHz
  - 870-876 MHz
  - 915-921 MHz
  - 2.4 GHz
  - 5 GHz
**MARKET DYNAMICS**

**Cellular in Licensed Spectrum**
GSM, WCDMA, LTE
Telecom Grade MTC

**Unlicensed Long Range**
Weightless, Sigfox, OnRamp, LoRA, Iotera,…
Dedicated IoT Network

**Unlicensed Short Range**
ZigBee, Bluetooth, IEEE 802.ah, Z-Wave,…
5G RADIO AND SPECTRUM

Overall 5G solution

Evolution of LTE
Backwards compatible

Interworking

New radio-access technology

Existing spectrum

Gradual migration

New spectrum

Below 6 GHz
WRC-15
AI 1.1

Above 6 GHz
New spectrum below 6 GHz
WRC-15
AI 10
PRELIMINARY AGENDA FOR WRC-19 (AI 10)

Outdoor-to-indoor penetration

**BW**: min 350 MHz to 1 GHz

a few to several Gbps

80 – 200 MHz per operator

CA available, possibly also with bands below 6 GHz

Outdoor, hot-spot and indoor deployments

**BW**: ~1 GHz

several Gbps

> 300 MHz per operator

CA available, possibly also with bands below 20 GHz

Hot-spot and indoor deployments

**BW**: ~ 1 – 5 GHz

10 Gbps and above

many 100 MHz to 1 GHz per operator

CA available, possibly also with bands below 30 GHz

6 GHz 20 GHz 30 GHz 100 GHz

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UNLOCKS UNLICENSED SPECTRUM FOR INDOOR LTE APP COVERAGE

LTE-U

LTE-advanced on licensed & unlicensed spectrum

LTE-U unlicensed

LTE primary carrier
Licensed spectrum

LTE secondary carrier
Unlicensed spectrum

LTE MACRO

LTE licensed spectrum for performance

Carries additional data payload

4% of the 5 GHz band provides up to 150 Mbps speed increase

LTE efficiencies on unlicensed spectrum

LTE small cells

Evolving the Network | © Ericsson AB 2015 | 2015-09-09 | Page 18
CONCLUSIONS

› LTE already addressing requirements for M-MTC
  - 10 years battery life from Rel-12
  - 15 dB coverage enhancements in Rel-13
  - Device complexity reduced to 50% in Rel-12 and to 20-25% in Rel-13.
  - Capacity not a issue in wide system bandwidth.

› 5G is not a new RAT replacing everything but rather one network which can serve a very diverse set of use cases.
  - 5G is happening now.
  - Radio resources can be shared & no need to provision based on prediction.
    › Inclusive to any future extensions/alterations.
  - Already ubiquitous coverage due to existing deployment.