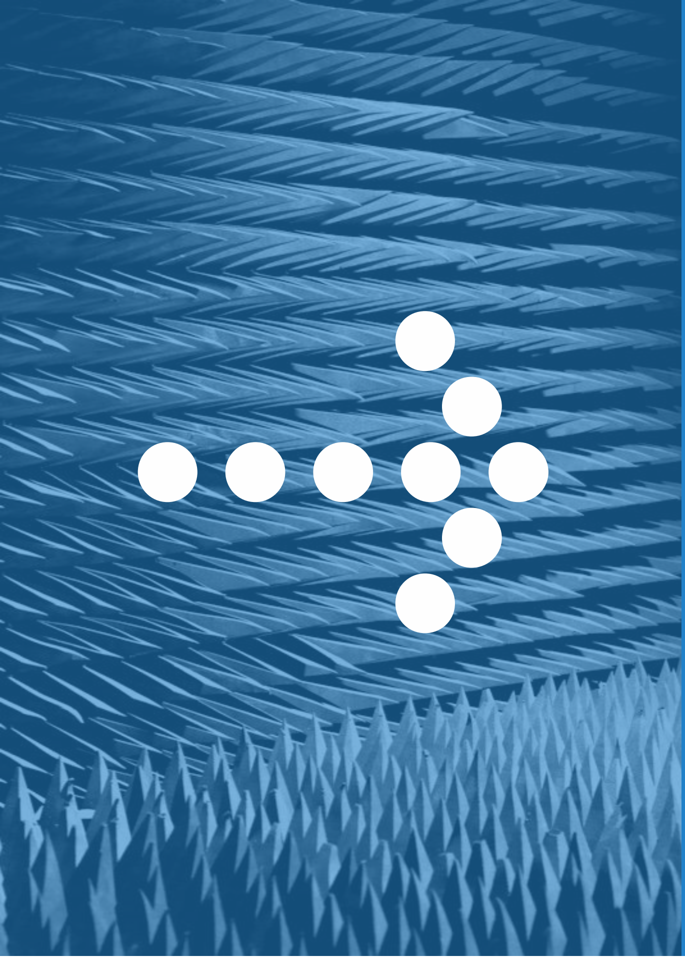

Internet of Things – EMC Challenges

Kia Wiklundh, Sara Linder Peter Stenumgaard

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IoT and EMC

- Internet of things (IoT)
  - internetworking of physical devices, vehicles buildings and other items - embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data
- Kevin Ashton, one of the founders of the original Auto-ID Center, is usually considered as the first to use "Internet of Things” in a wider sense in 1999.
- Goal of Electromagnetic Compatibility (EMC): correct operation of different equipment in a common electromagnetic environment
  - Immunity and emission requirements
- IoT → a massive increase of wireless technology → EMC challenges

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Connected devices….

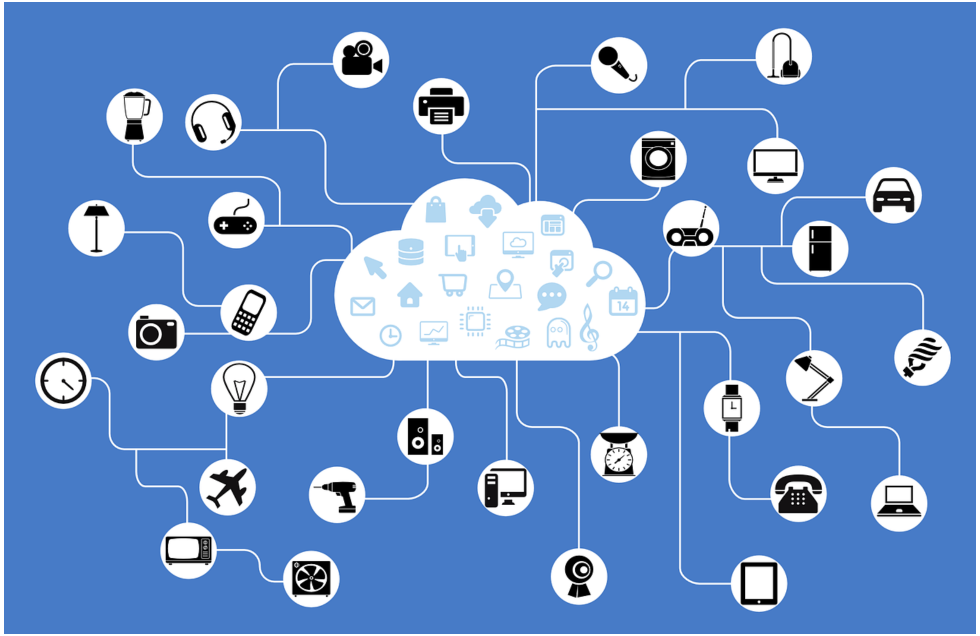
- Mix of concepts, actors, services

Cities
- Power meters
- Water meters
- Garbage weighting
- Alarms, home care alarms
- Parking

Home
- Home electronics
- Lamps
- Refridgerator
- Washing machine

Industry
- Connected mashines
- Control
- Logistics

Person
- Health status
- Tooth brush
- Scale



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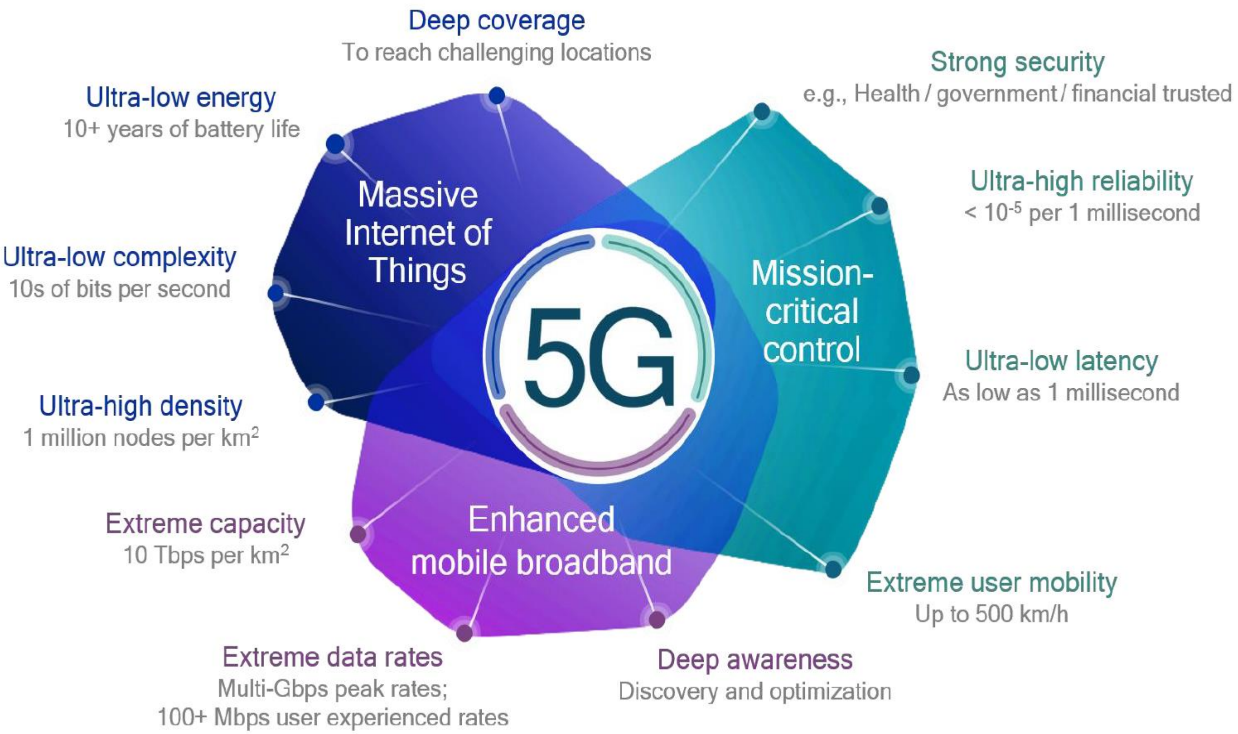
Internet of things

- Deep coverage
- Ultra-low energy
- Ultra-low complexity
- Ultra-high density

- OBS: Contradictions between properties in Massive IoT and and eMBB and MCC



Qualcomm, Making 5G NR a reality, dec 2016

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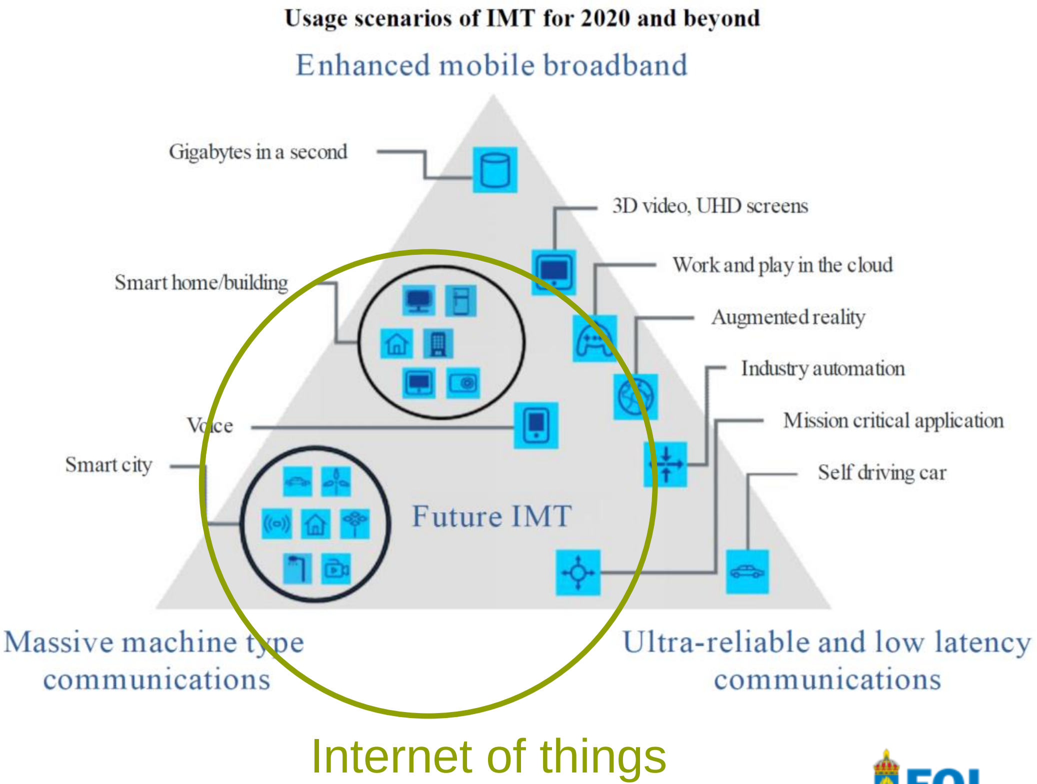
ITU

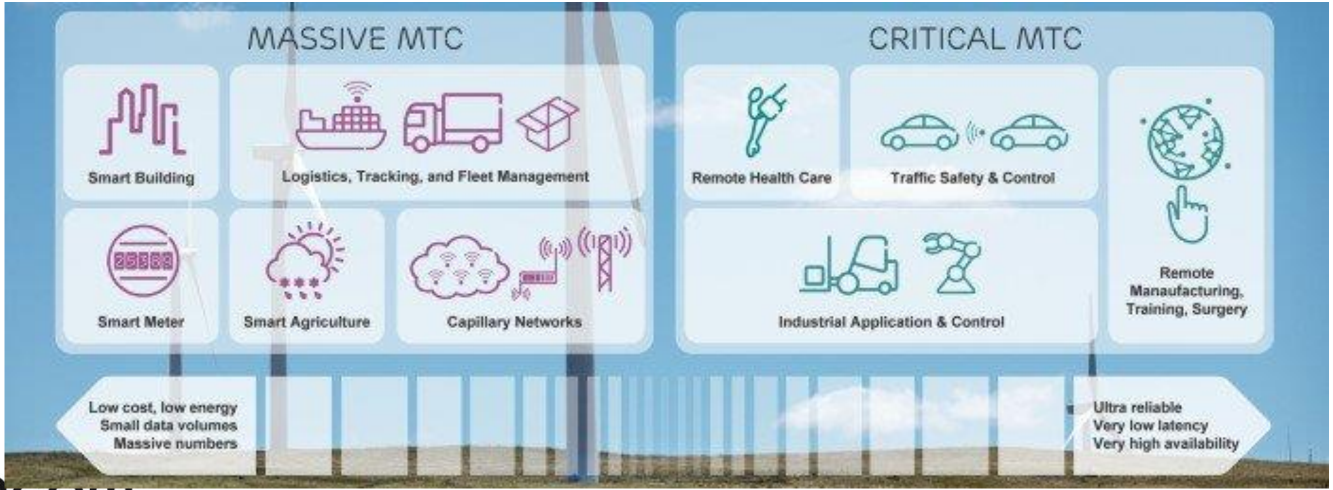
- The International Telecommunication Union (ITU) defined three representative service categories according to data rates, latency, and reliability:
  - The enhanced mobile broadband (eMBB),
  - the massive machine-type communication (mMTC), and
  - the ultra-reliable and low latency communication (uRRLC).



Ref: M. Series, "IMT vision–framework and overall objectives of the future development of IMT for 2020 and beyond," 2015.

IoT - use cases

- According to Ericsson, two evident classes of use case
  - Massive IoT: high numbers of connected devices
  - Critical IoT: high reliability and ultra-low latency



https://www.ericsson.com/en/networks/trending/hot-topics/iot-connectivity/iot-use-cases-and-requirements-on-technology

IoT - use cases

- The Low Power Wide Area (LPWA) applications for Massive IoT:
  - building automation, city parking, smart agriculture, smart grid, logistics, tracking and fleet management demand connectivity that is reliable and easy to scale.
  - The connectivity shall be able to provide extended coverage for low cost devices in remote locations and support long battery life time.

Low Power Wide Area Network (LPWAN): low power wireless telecommunication wide area network designed to allow long range communications at a low bit rate among things (connected objects).

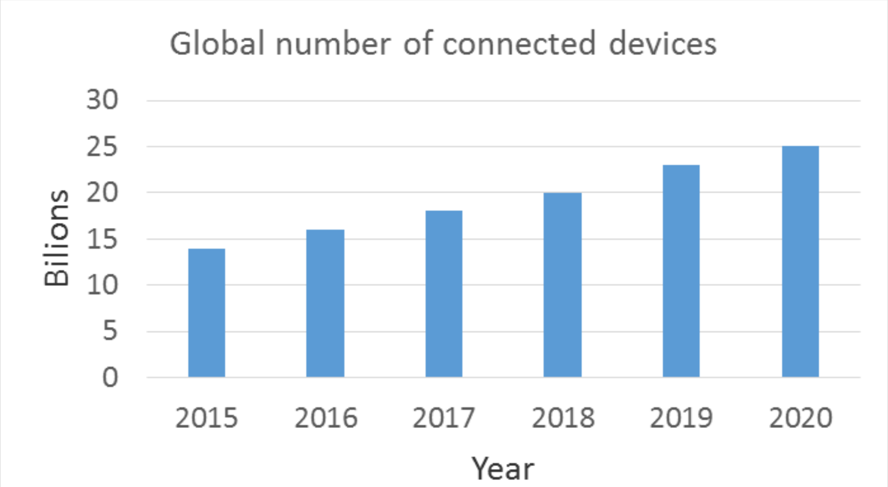
https://www.ericsson.com/en/networks/trending/hot-topics/iot-connectivity/iot-use-cases-and-requirements-on-technology

IoT - use cases

- The Critical IoT applications
  - Based on real-time communication and require connectivity that is highly reliable and available with ultra-low latency.
  - Safety and security are high – where trust in the system, including data, is essential and, in cases such as remote surgery and emergency rescue, potentially lifesaving.

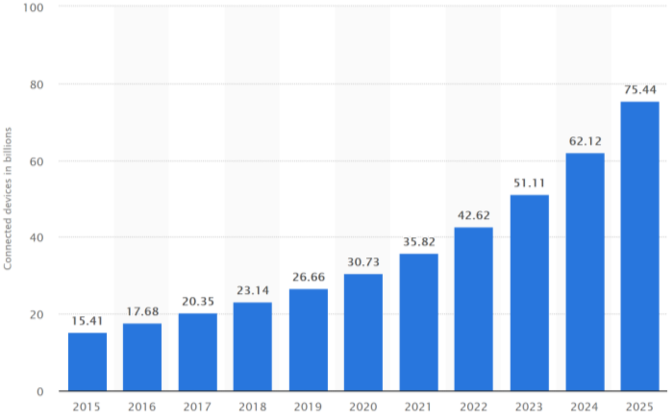
Internet of Things

- Increasing amount of connected devices, mainly due to IoT
- Forecasts
  - Previously often 50 Billion year 2020



From: Amy Nordrum, “Popular Internet of Things Forecast of 50 Billion Devices by 2020 Is Outdated”, IEEE Spectrum, Aug 2016

Forecast of total number of connected devices in the world
https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/



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Device densities

Estimated density of devices for massive IoT connected devices in smart cities

Device	Density [No of devices/km^2]
Water meters	10 000
Electricity meters	10 000
Gas meters	10 000
Vending machines	150
Bike fleet management	200
Pay-as-you-drive	2 250

From: “Ericsson Mobility Report”, November 2016.

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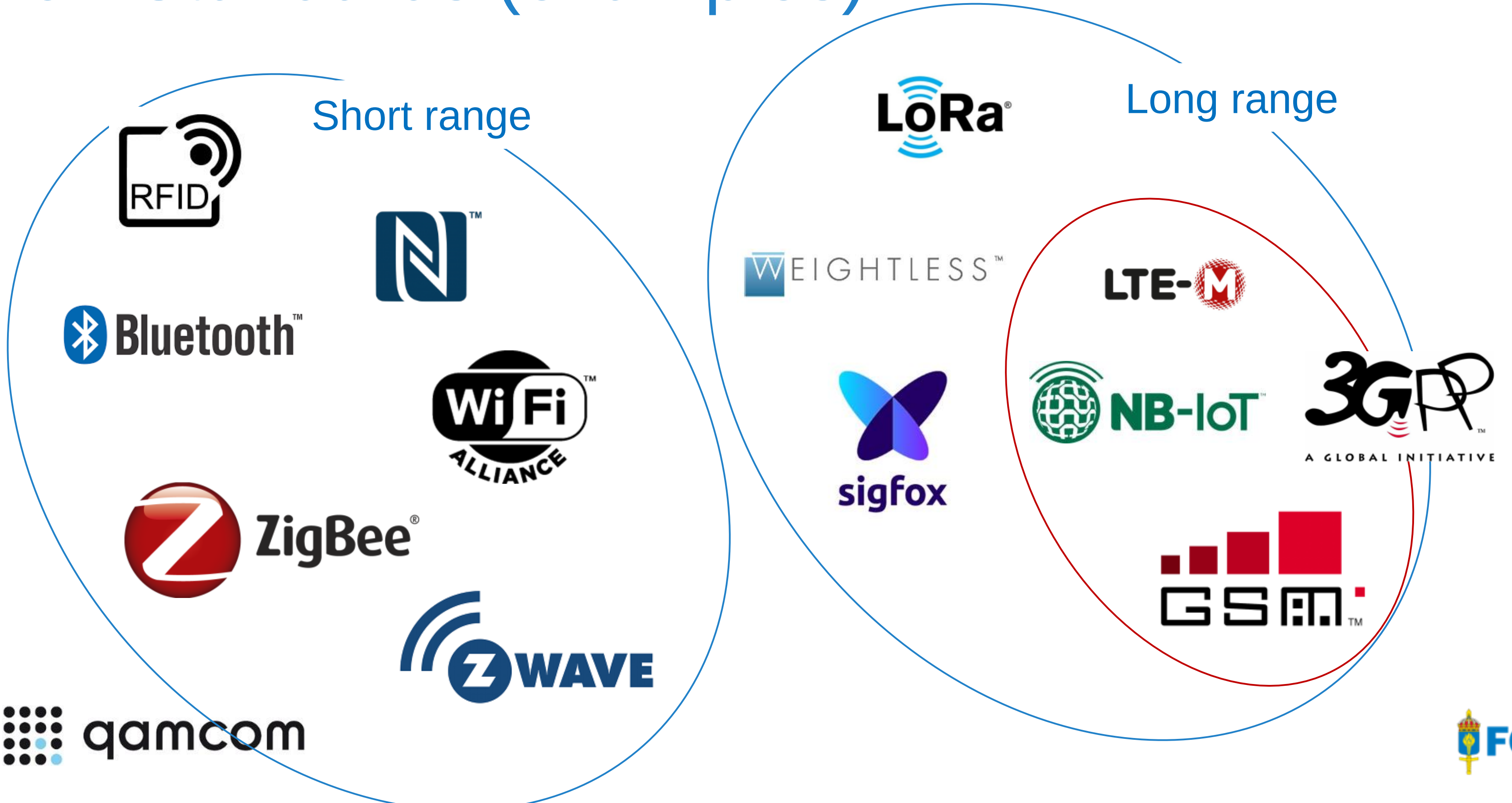
Examples of the variety of duty cycles in IoT products

Duty cycle	Application
0.0001	”Leaf nodes” (low power networks)
0.001	LPWAN in ISM networks
0.01	LPWAN in ISM networks
0.1	Routers (low power networks)
1	Cordless microphones, cordless phones

ISM - Industrial, scientific and medical

Low Power Wide Area Network (LPWAN): low power wireless telecommunication wide area network designed to allow long range communications at a low bit rate among things (connected objects).

IoT Standards (examples)



Wireless candidates - properties

- Fixed and short range
  - RFID
  - Bluetooth
  - Zigbee
  - WiFi

Unlicensed bands

Licensed bands

- Long range
  - Non 3GPP
    - LORA
    - SIGFOX
    - Weightless
  - 3GPP
    - LTE-M
    - EC-GSM
    - NB-IOT
    - 5G

Properties

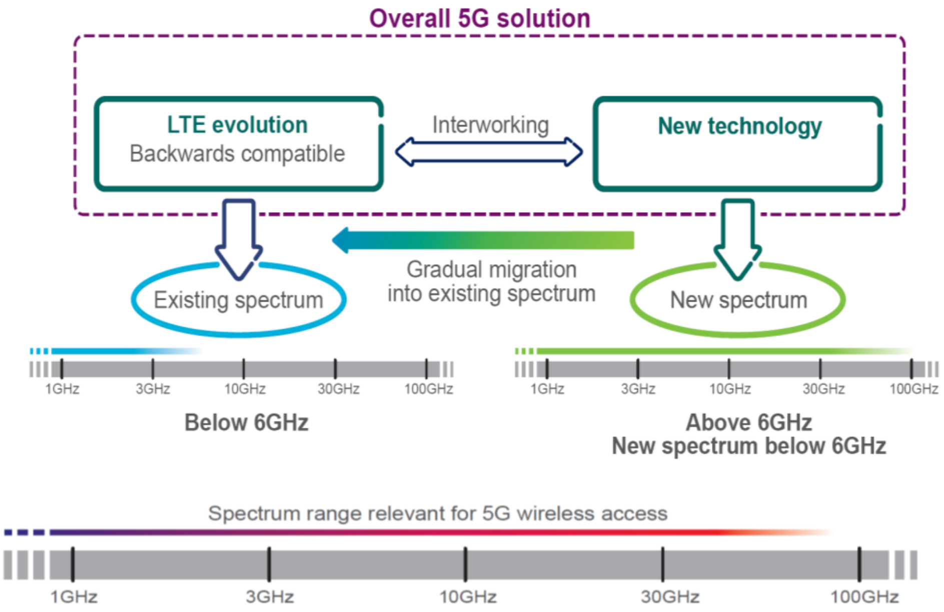
- In licenced vs licenced-free bands
- Proprietary vs non-proprietary systems
- Bandwidth
- Battery life

Frequency bands

Standard	Frequency band
Bluetooth	2.4
Zigbee	2.4 GHz, 868, 915 MHz
WiFi	2.4/5/5.8 GHz
LORA	868, 915 MHz
SIGFOX	868, 915 MHz
LTE-M	In-band LTE
EC-GSM	In-band GSM
NB-IOT	In-band LTE, guard band LTE

EMC Challenges

- Considerably Higher Frequencies
  - Planned to use considerably higher frequencies than standard EMC emission and immunity testing is performed for today
  - Outdoor environments: frequencies up to about 30 GHz
  - Indoor: up to about 90 GHz



https://www.ericsson.com/assets/local/publications/white-papers/wp-5g.pdf.

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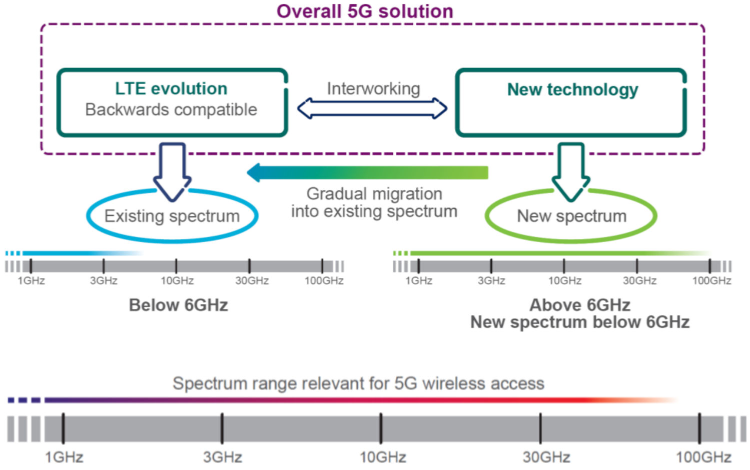
EMC Challenges

- Larger bandwidths
- One of the main objectives of 5G: increase the data rate to several Gigabits per second.
- Accomplished by using higher frequencies (above 6 GHz), where wide and contiguous blocks of spectrum are available and larger bandwidths can be allocated.
- Larger bandwidths in the order of a GHz → Much larger than today → several magnitudes larger than present resolution bandwidths in EMC standards and therefore requires new EMC test methods with larger bandwidths have to be developed.



https://www.ericsson.com/assets/local/publications/white-papers/wp-5g.pdf.

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EMC Challenges

- Unlicensed Versus Licensed Frequency Bands
  - Licensed frequency bands: a licensing fee for the exclusive right to transmit on assigned channels within that band in a given geographic area
  - Unlicensed frequency bands: no permission to use, only requirement is to meet rules associated with the particular frequency band. Typically, the maximum transmission power is regulated
  - Unlicensed frequency bands: challenge from an EMC point of view, especially for applications and services with requirements on availability and non-disruptiveness

  - High densities
  - IoT will use both licensed frequency bands and unlicensed frequency bands
  - → crowded unlicensed bands

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EMC Challenges

- Short Range - versus Wide Area Networks
  - A large number of devices per area unit will give a higher level of the total electromagnetic environment
  - Power restrictions on unlicensed bands
  - Low-power devices will have a lower signal-to-noise ratio (SNR) for the wireless connections. This means larger sensitivity to electromagnetic interference.

EMC Challenges

- Increased interference level
  - A large number of devices per area unit will give a higher level of the total electromagnetic
  - Depend on transmit power, frequency use, duty cycle and density

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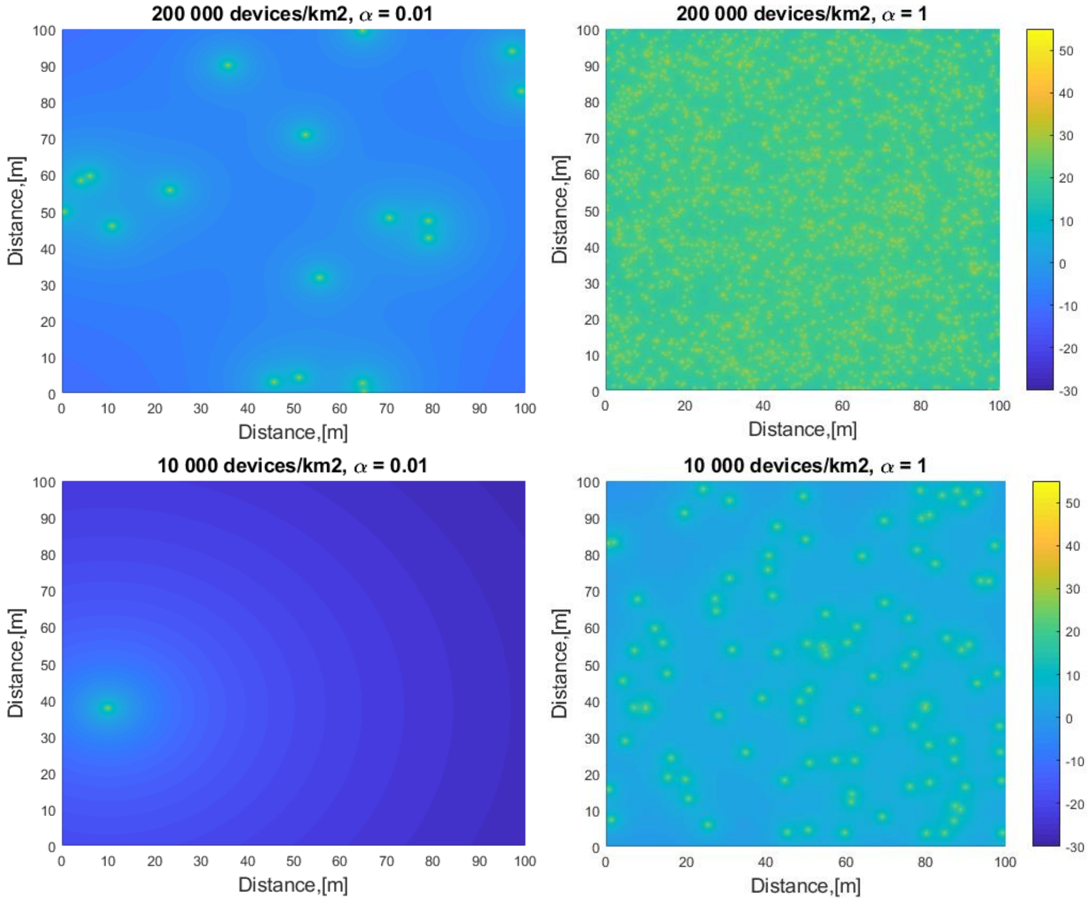
Increased EM Interference Levels

- Example:
  - 10 000 and 200 000 devices per square kilometer
  - Received interference power in dBµW over an area of 100 m x 100 m
  - Introduces an increase of the background-noise level

Frequency	Transmit power
868 MHz	25 mW (44 dBµW)
5.8 GHz	200 mW (53 dBµW)
30 GHz	10 mW (40 dBµW)

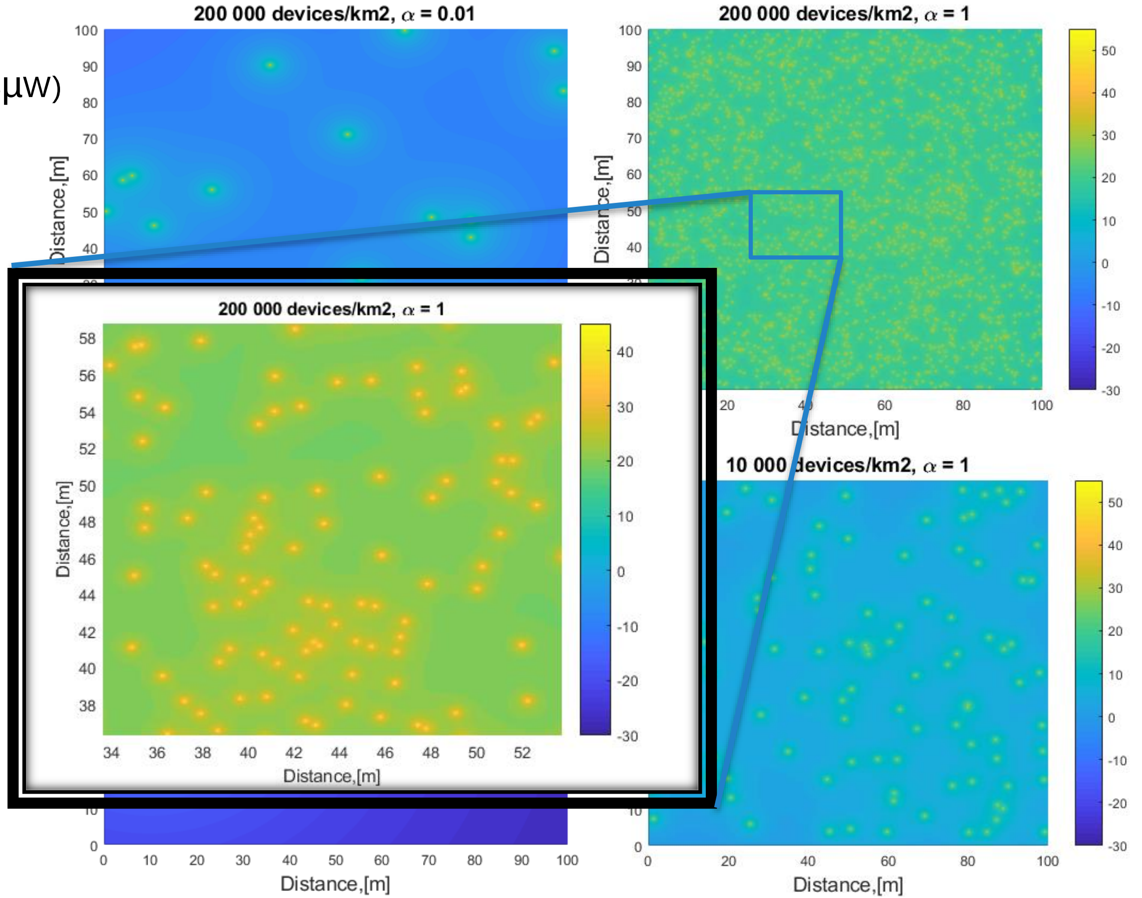
Interference level

Transmitter power: 25 mW (44 dBμW)
Frequency: 868 MHz



Interference level

Transmitter power: 25 mW (44 dBµW)
Frequency: 868 MHz



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Conclusions

- In summary, the following challenges may be the largest for the EMC area:
  - The mass increase of low-power wireless networks means larger vulnerability to electromagnetic interference and higher interference levels due to larger concentration of co-located devices.
  - The considerable extension of frequency regions up to several tenths of GHz requires further development of methodology and equipment for standard EMC emission- and immunity testing.
  - The mass-increase of wirelessly products will make the unlicensed frequency bands occupied to a considerably larger extent than today.
  - The co-location scenarios will be characterized by being highly dynamic, flexible and non-predictable. Therefore consumer habits will to a larger extent have impact on the possibility of achieving EMC.

Questions?