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Narrowband Internet of Things (NB-IoT)

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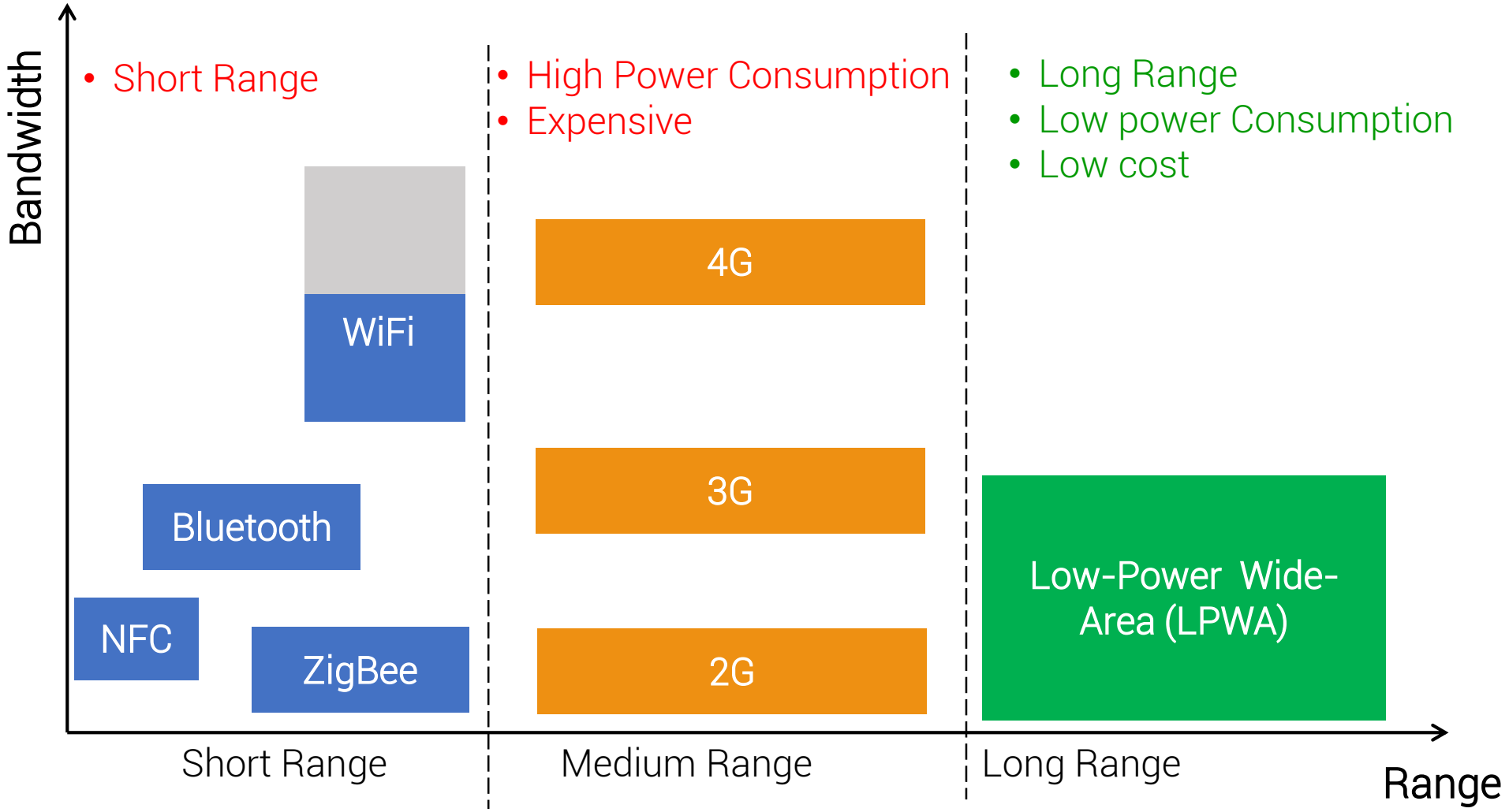
Agenda

1. LPWA Technologies
2. NB-IoT Key Features
3. Use Cases for NB-IoT
4. NB-IoT Ecosystem
5. Conclusions

Wireless IoT Connectivity Landscape



LPWA Device Characteristics

Long Range Coverage

~5 km in dense urban areas &
~50 km in rural area

Good Penetration

In-building and in-ground (e.g., basement and underground car parks)

Low Power Consumption

Battery lasts for
~10 years

Low Cost

~2$ Chipset and
~5$ Module

Low Connection Cost

Few dollars
per year

Low to Moderate Data Rate

~100 bps
to ~ 1 Mbps

Transmission Latency

50 ms, 10s of sec, or
even couple minutes

Massive Connections

Tens of thousands of
devices per base station

Overview of LPWA Technologies

	sigfox	LoRa	eMTC Rel. 13	NB-IoT Rel. 13	EC-GSM-IoT Rel. 13
Carrier Frequency	Unlicensed ISM: < 1GHz	Unlicensed ISM: < 1GHz	Licensed LTE bands	Licensed LTE/ GSM bands	Licensed GSM bands
Node/Device Bandwidth	100/600 Hz	125/250/500 kHz	1.08 MHz	180 kHz	200 kHz
Max. Data Rate	600 bps	50 kbps	1 Mbps	250 kbps	240 kbps
Range	Many Km	Several Km	Several Km	Several+ Km	Several+ Km
Standardization/Driver	Proprietary / Sigfox	Proprietary / Semtech	3GPP Huawei, Ericsson, … Qualcomm, Mediatek,… u-Blox, Quectel,…	3GPP Huawei, Ericsson, … Qualcomm, Mediatek,… U-blox, Quectel,…	3GPP Huawei, Ericsson, … GCT, Qualcomm,… Quectel, …
Use Cases	Massive devices, small & infrequent data	Massive devices, moderate data rates	Critical (e.g., surveillance Cameras for public safety)	Massive devices, secure LTE commun.	Massive devices, secure GSM commun.

LPWA Forecast Figures for 2025

Very low ARPC, a real challenge to make a profit

NB-IoT is a good fit to address this challenge because:

- MNOs have already their own Networks
  - ✓ No need for a new network
- Most MNOs have good population coverage
  - ✓ Good coverage across the whole country
- MNOs can leverage their network resources to make profit
  - ✓ NB-IoT can be introduced via software upgrades and minor HW changes

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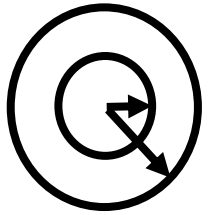
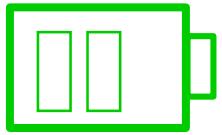
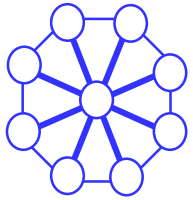
NB-IoT Key Features



Deep/Indoor Coverage (PSD boosting, Repetition)



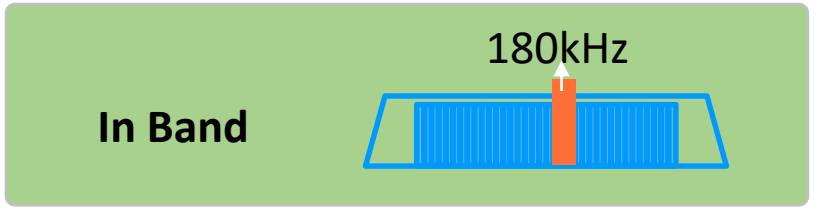
Low Power Consumption (PSM, eDRX)



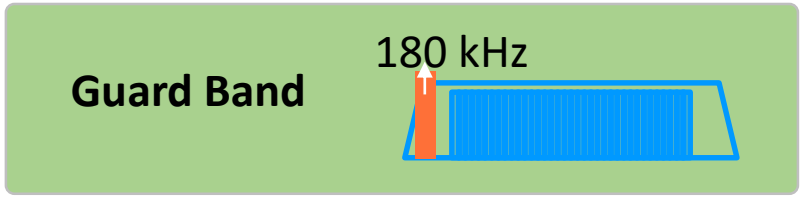
Massive Connections > 50K connections per cell

Low Device Cost (1~2$ Chipset /4~5$ Module)

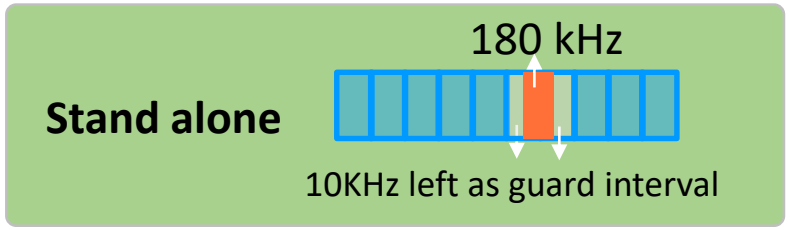
Deployment Scenarios



Utilizing resource blocks within an LTE carrier



Utilizing the unused resource blocks within an LTE carrier's guard-band

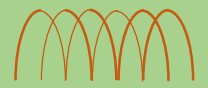


Dedicated spectrum (e.g.; re-farming GSM channels).

Note: GSM system uses 200 KHz BW for each carrier. Thus, here is still a guard interval of 10 kHz remaining on both sides of the spectrum

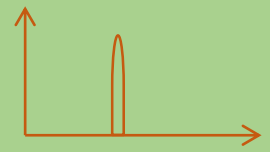
Physical Layer Design

- Device Bandwidth: 180 kHz
- **Downlink:** OFDMA

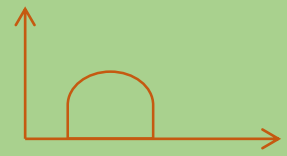


15kHz

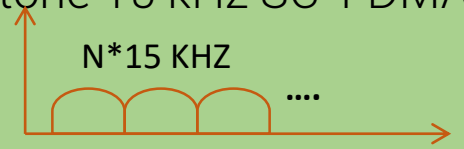
- **Uplink:**
  - single-tone 3.75 kHz SC-FDMA



  - single-tone 15 kHz SC-FDMA



  - multi-tone 15 kHz SC-FDMA

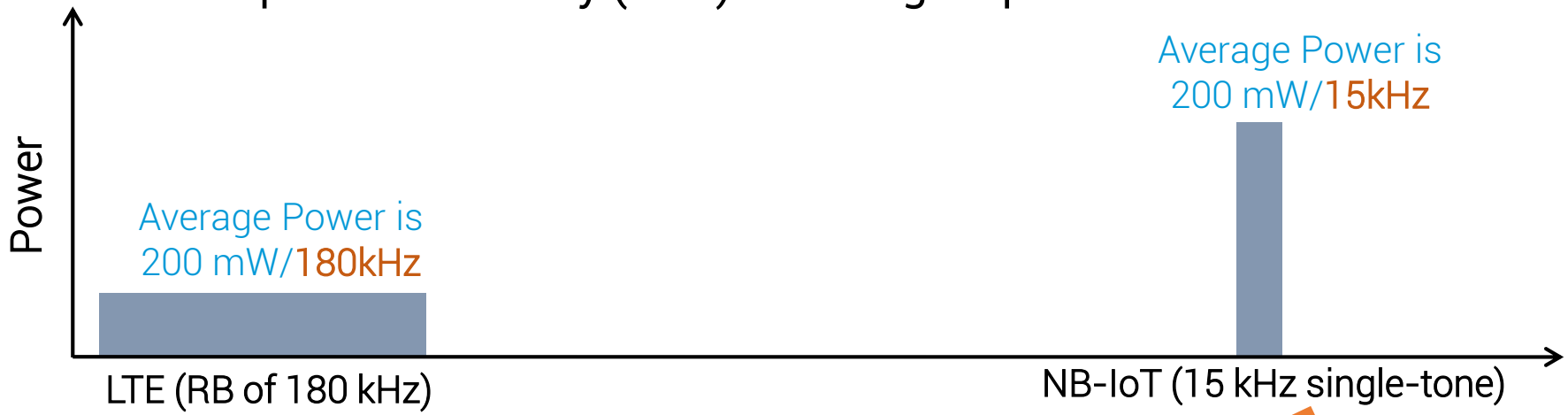


Data Transmission Options

- CP（Control plane based solution）：Data over non-access stratum (DoNAS) , No need for Data Radio Bearers (DRB)
- UP（User Plane based solution ）：Similar to legacy LTE system

Coverage: 20 dB Coverage Extension

- Power Spectrum Density (PSD) Boosting - Uplink



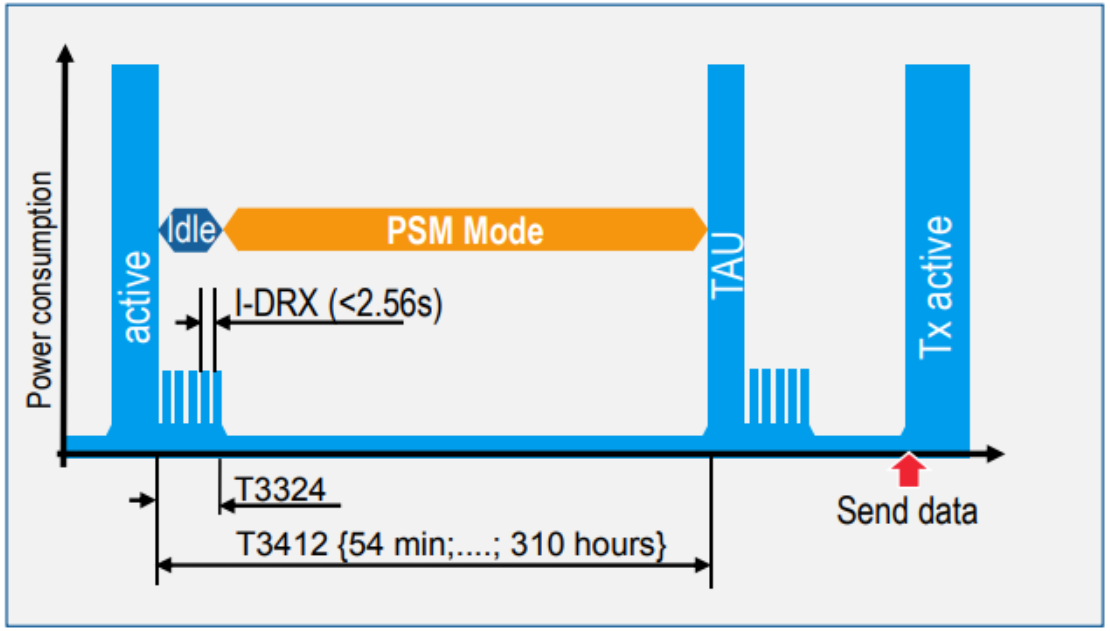
12 times power per Hz
10 log10(12) = ~11 dB

- Repetition
  - Max for uplink: 128 repetitions
  - Max for downlink: 2048 repetitions

Just 8 times repetition → **10 log10(8) = 9 dB**

11 + 9 dB = 20 dB
→ Maximum Coupling Loss is: 144+20 = 164 dB

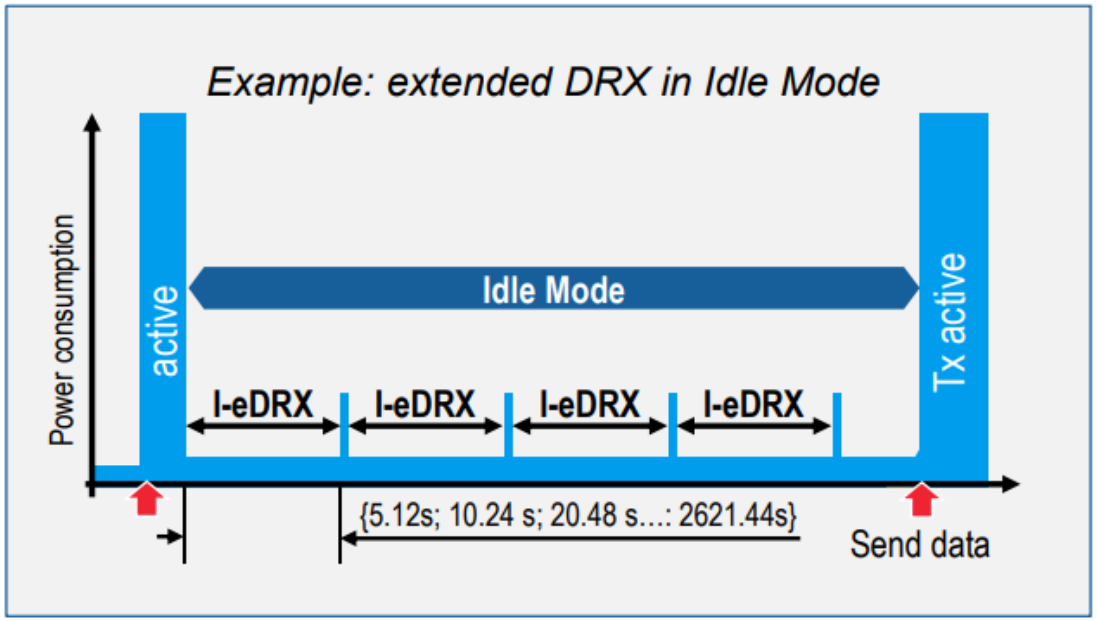
Power-Saving Mode (PSM)



- The Device requests the PSM simply by including a timer (T3324) with the desired value in the attach, tracking area update (TAU) or routing area update (RAU)
- The T3324 is the time the device monitors paging before entering PSM
- Device reachable only during T3324 only via paging. During PSM, the device is not reachable
- Device exits PSM when T3412 expires or devices wants to send data
- Device remains registered with the network. No need to re-attach or re-establish PDN Connections

PSM is suitable for device-originated or scheduled applications (e.g.; smart metering and environmental monitoring)

Extended Discontinuous Reception (eDRx)



- Extending the sleeping cycle in idle mode
- In LTE, the interval for the Idle DRX timer is up to 2.56 seconds
- With eDRX, the I-eDRX is up to 40+ minutes

eDRX is suitable for device-terminated applications (e.g.; object tracking and smart grid)

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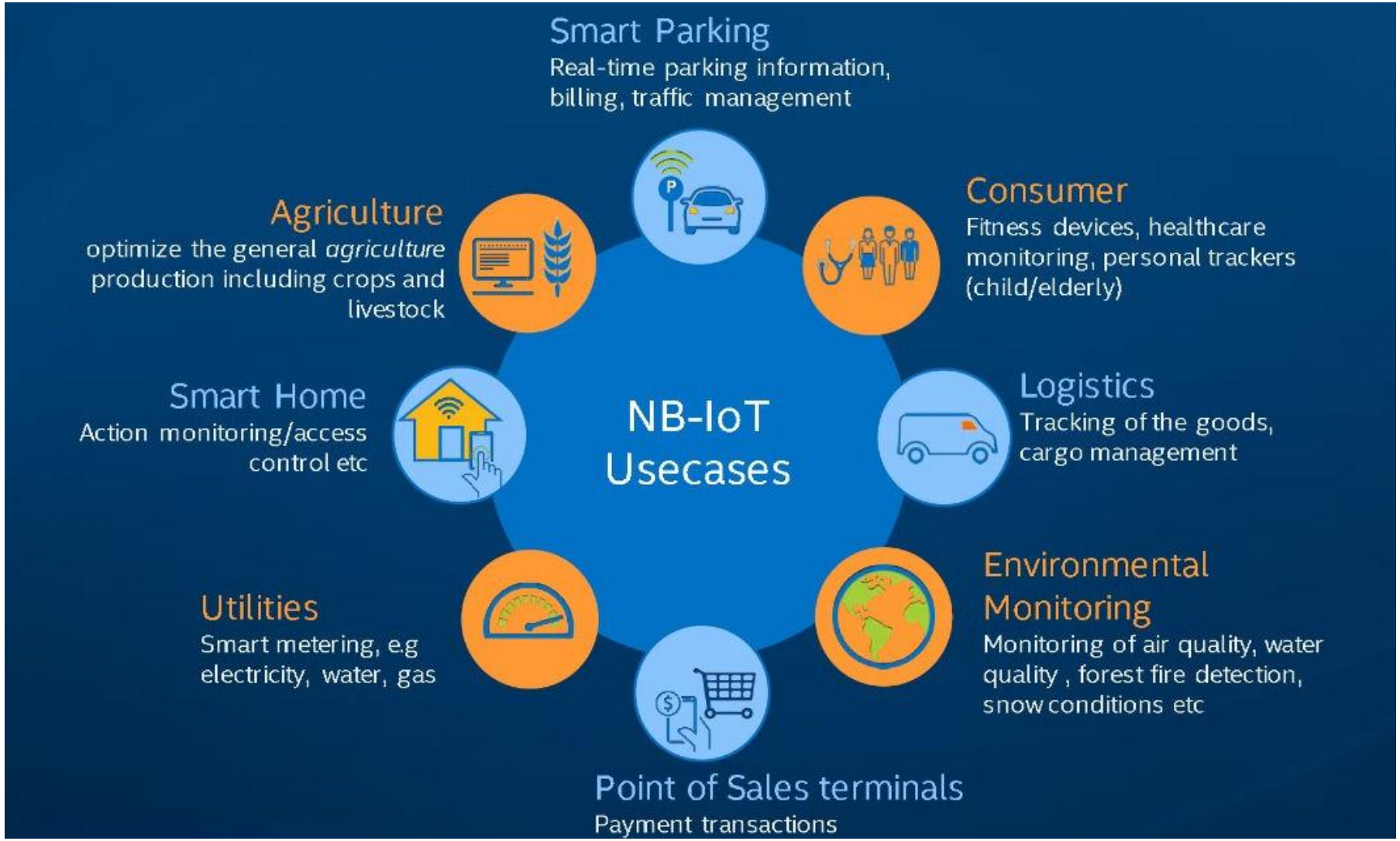
Use Cases for NB-IoT



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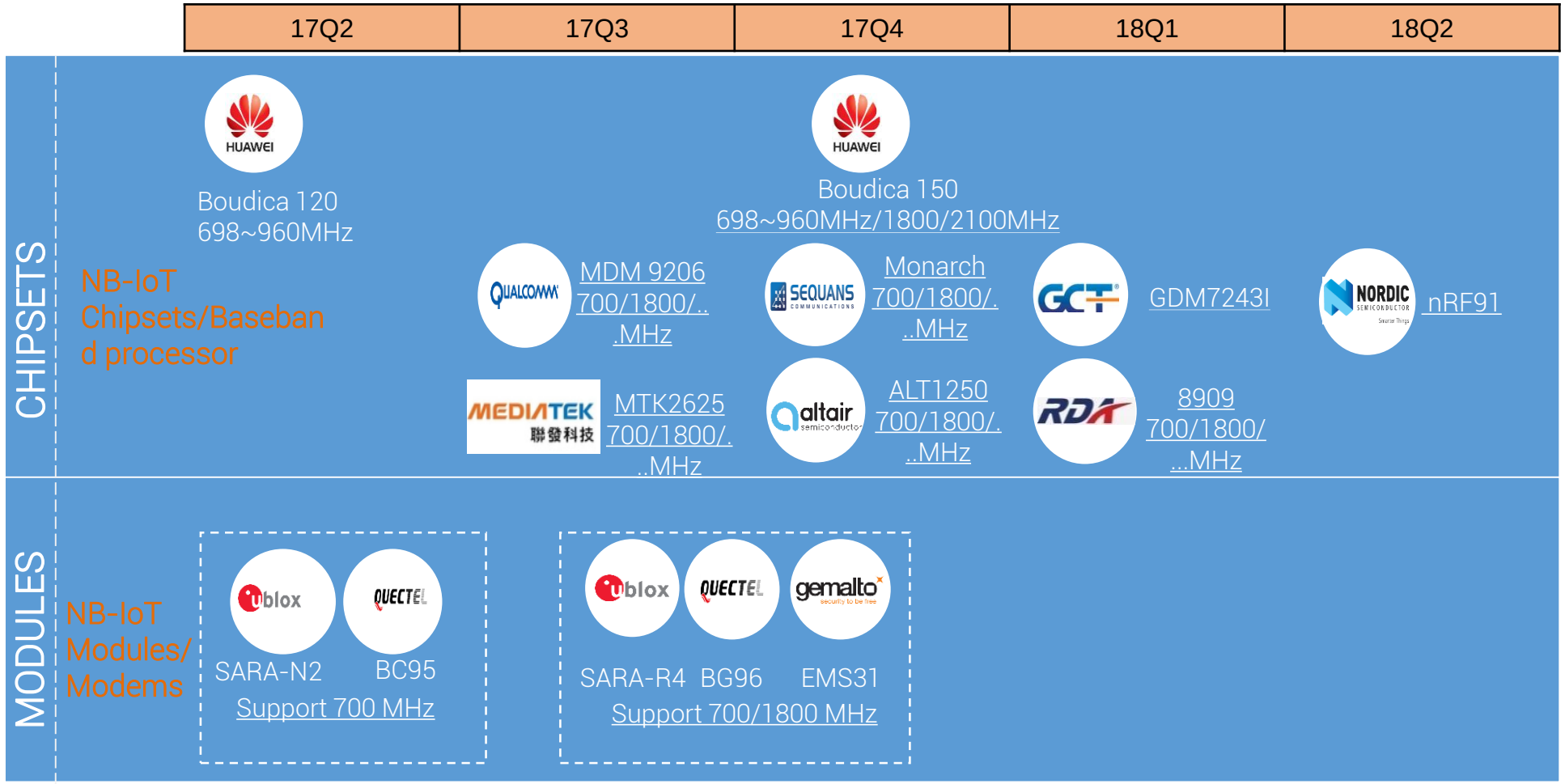
Leading Chipset & Module Vendors Support NB-IoT Ecosystem



- The chipsets and modules of 700MHz are more mature than that of 1800Mhz
- Most chipsets and modules vendors will support both 700MHz and 1800MHz by the end of 2017

Spectrum Selection of NB-IoT Operators

APT 700 MHz	Telefónica, STC
800 MHz	vodafone, Telefónica, T-Mobile
850 MHz	Unicom, China Telecom, TELUS, Bell, KDDI
900MHz	T-Mobile, Telefónica, 中国移动 China Mobile, China unicom中国联通, SoftBank, kt, etisalat, AIS, true move
1800 MHz	China unicom中国联通, STC

Most of leading operators deploy NB-IoT in low bands

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Conclusions

- ✓ NB-IoT is a new technology standardized by 3GPP in Rel. 13
- ✓ It is to connect a large number of IoT-Devices in a secure, reliable, and efficient manner
- ✓ Beneficial for MNOs, Businesses, and Consumers
- ✓ The ecosystem is ready
- ✓ MNOs are increasingly deploying NB-IoT


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