

Emerging Wireless Standards for Next Gen IoT Applications

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IoT Goals

Building & Home Automation

- Wireless environmental sensor
- Wireless lighting
- Connected appliances
- Control panels
- Gateway
- Light control
- Smart lock
- Smart thermostat
- Video doorbell



Smart Cities

- Wireless grid communication
- Surveillance cameras
- Smart combiner box
- Smart meters
- Smart street lights
- Energy harvesting
- Grid automation
- Protection relay
- Renewables
- Drones



Smart Manufacturing

- Industrial communication
- Communication module
- CPU (PLC controller)
- Hydraulic valves
- Industry 4.0
- Pneumatic valves
- Portable monitor
- Process analytics
- Field transmitter
- Robotics



Wearables & Health Care

- Augmented reality and entertainment
- Wearable fitness & activity monitor
- Telehealth gateway and aggregation
- Wireless patient monitor
- Location and tracking
- Smart watches
- Fitness



Automotive

- Level 1 & 2 EV charging station
- Level 3 EV charging station
- Engine management
- Wire replacement
- Infotainment



Precision agriculture

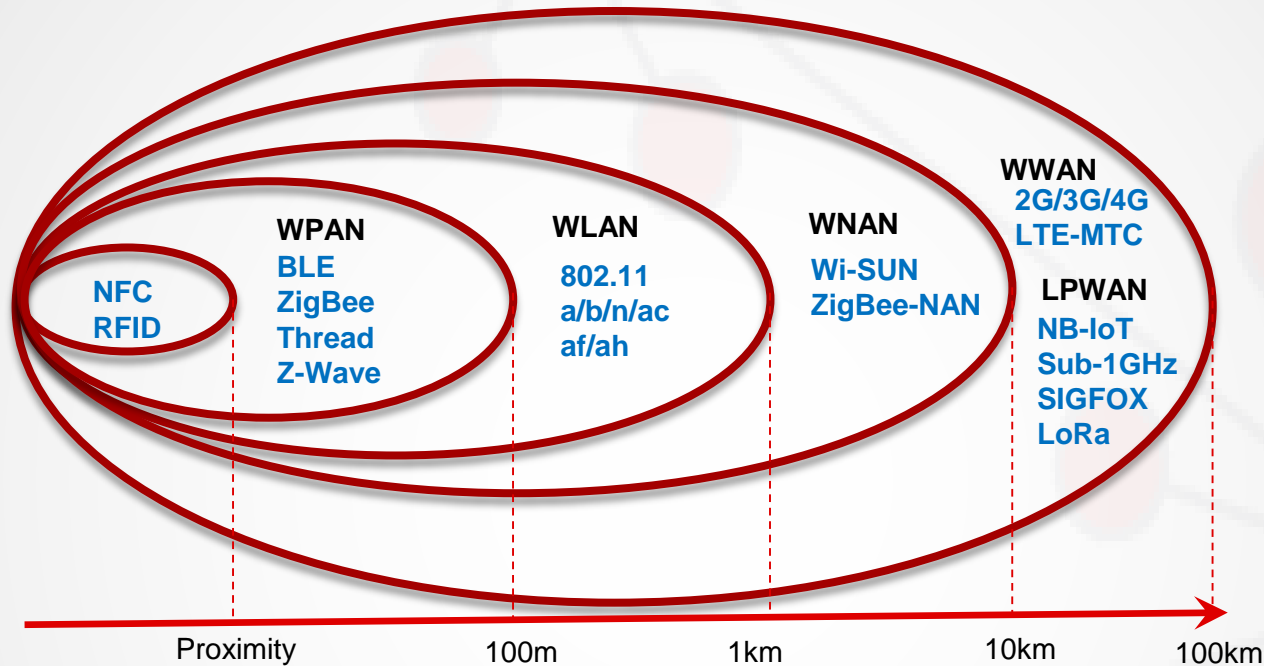
- Power converters & chargers for agricultural equipment
- Cold chain tracking for refrigerated transport
- Sensors for agricultural equipment
- Drones



IoT, How Hard Can It Be?

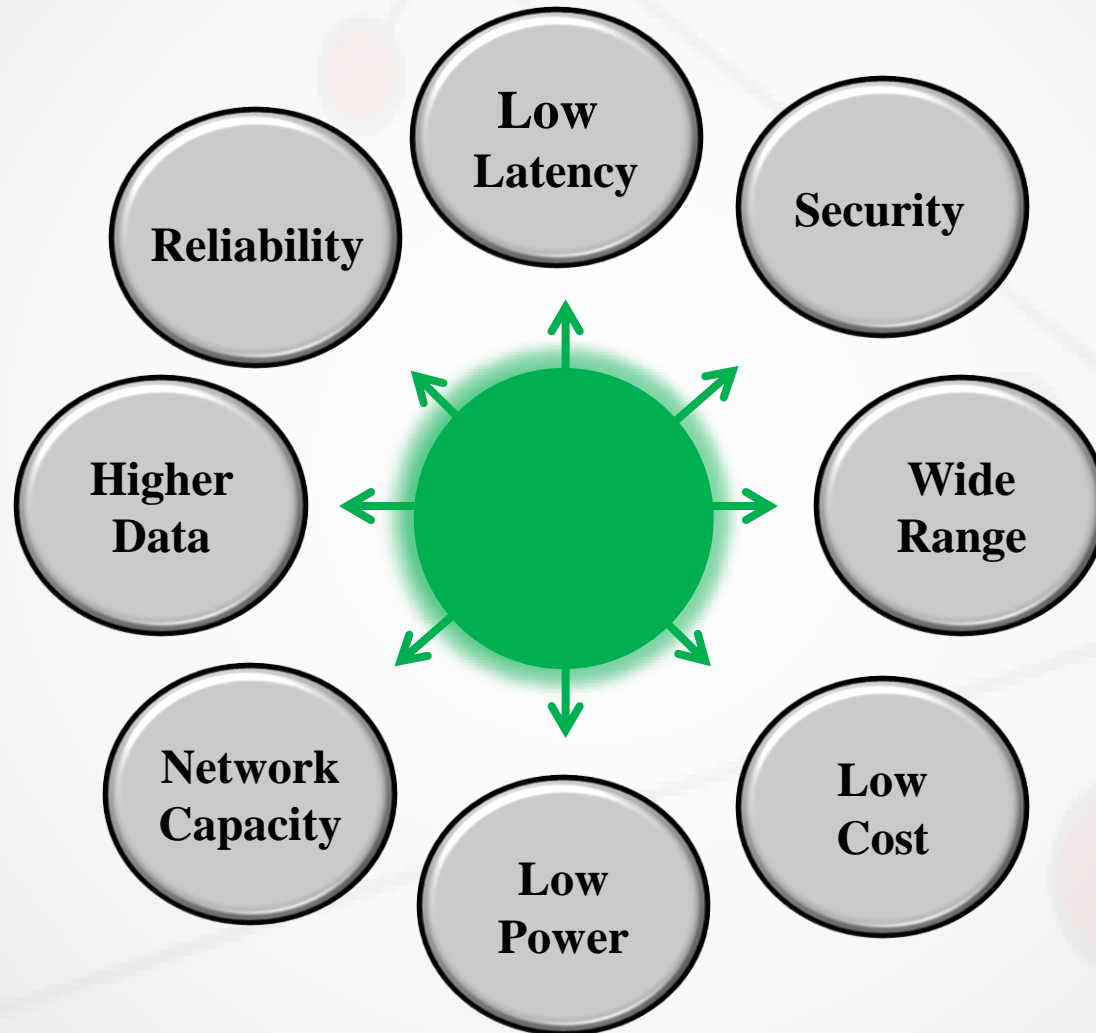


Wireless Communication for IoT



- ❑ Different wireless communication standards offer distinct specifications to meet varied IOT applications.
- ❑ These communication standards are rapidly evolving to enable future IOT solutions.

IoT Wireless Technology Drivers



Emerging Wireless Standards in IoT communication

❑ 802.11 ba

❑ 802.11 ax

❑ Bluetooth 5

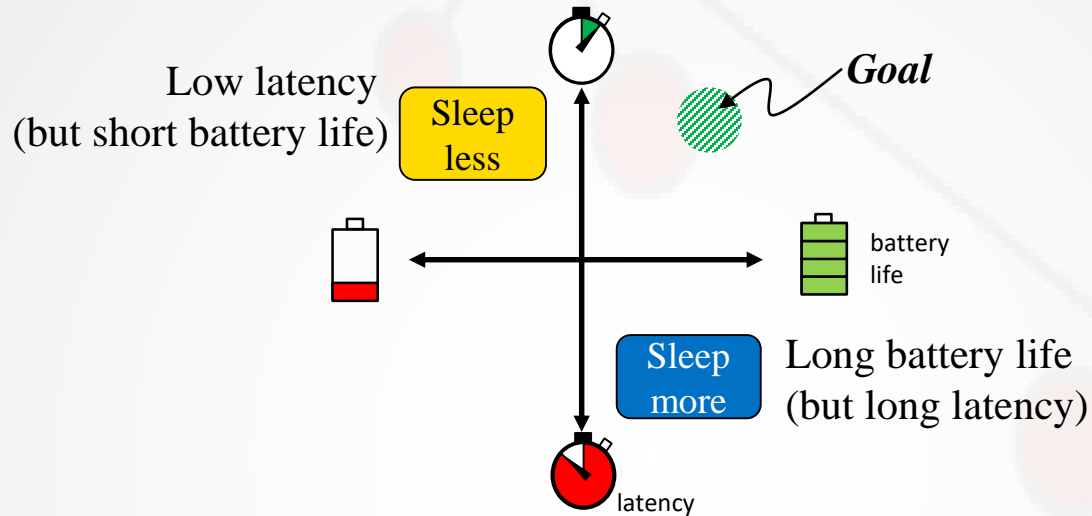
❑ SUB-1GHz

❑ NB-IoT

802.11ba Wake-up Receiver

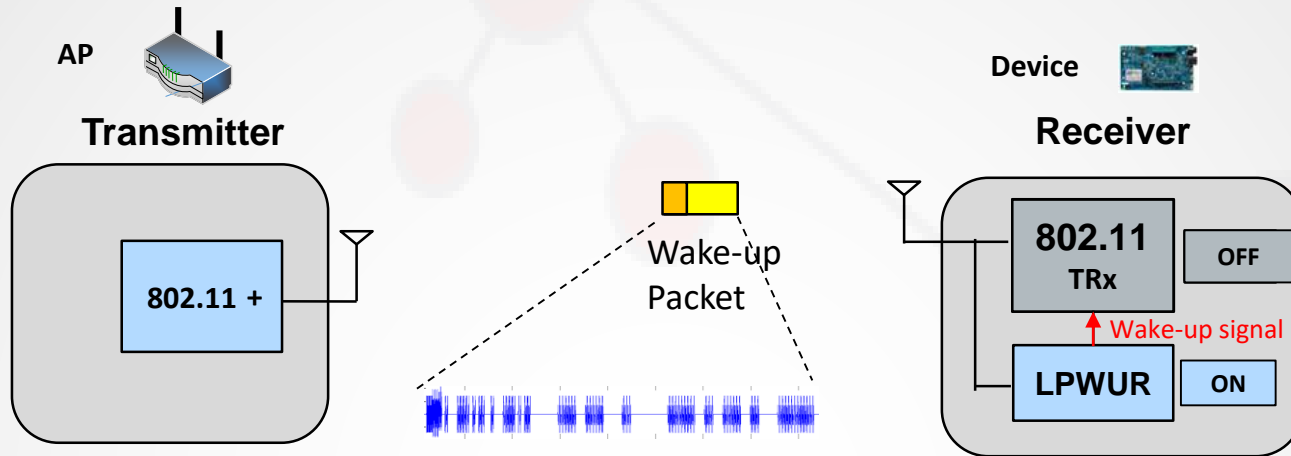


IoT market Drivers for 802.11ba



- ❑ With duty-cycled operation, low power and low latency are conflicting goals.
- ❑ To increase battery life, a device needs to sleep more → increased latency.
- ❑ To receive data with low latency, a device needs to sleep less → shorter battery life

Wake up Receiver 802.11ba

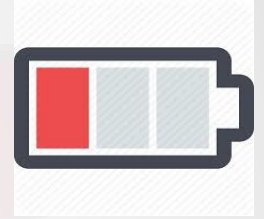


- ❑ One use case for LPWUR is video surveillance which needs low latency as well as low power and high data rate.
- ❑ The AP transmits a wakeup packet to wakeup the main WLAN transceiver (TRx).
- ❑ The Wakeup packet is coded with ON-OFF Keying (OOK).
- ❑ The Low Power Wakeup Receiver (LPWUR) is a simple OOK demodulator, its sole function is to decode the wakeup packet and turn on the main transceiver.
- ❑ The Wake-up packet has a preamble followed by the data field.
- ❑ The data field can have a sensor identification code to selectively wake up sensors.

802.11ba an IoT enabler

Low Power – Battery life increased by 10X

Wake up receiver consumes less than 10% of power compared to the primary WLAN receiver.



Low Latency – Response time few milliseconds

Wake up receiver can be continuously ON or be duty cycled.



Always Connected – For Sensors on the move

AP transmits periodic wakeup packets, enabling quick detection if sensor moves out of coverage



Future advances for 802.11ba

Low Power Indoor Location Scan

Wake up receiver can provide ultra low power indoor Location Scan using Wakeup packets from neighboring APs.



Low Power Roaming Scan

WLAN receivers scan for available networks when link quality degrades, this consumes lot of power. Wakeup receiver can facilitate low power scans.



Wi-Fi 6[®]

802.11ax

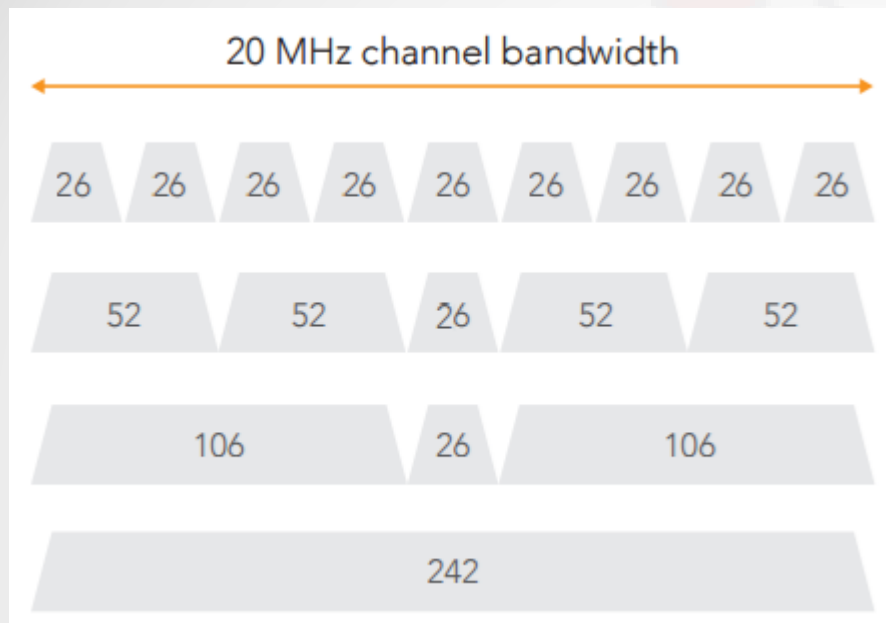


Comparison Between 802.11ac and 802.11ax

	802.11ac	802.11ax
Spectrum	5GHz	2.4 & 5GHz
Technology	OFDM	OFDMA
Bandwidth	20/40/80/80+80/160 MHz	20/40/80/80+80/160 MHz
Highest Modulation	256 QAM	1024 QAM
Subcarrier Spacing	312.5 KHz	78.125 KHz
Symbol length	3.2 μ s	12.8 μ s
Guard Interval	0.4/0.8 μ s	0.8/1.6/3.2 μ s
MU-MIMO	4 (DL)	8 (UL & DL)
Spatial Streams	8	8
Data Rates	433 Mbps (80MHz 1SS)	600.4 Mbps (80MHz 1SS)
Spectral Efficiency	42.5 bps/Hz	62.5 bps/Hz

- ☐ Aim is to improve average performance in real world conditions.
- ☐ And improve network efficiency, capacity and reliability in dense networks.

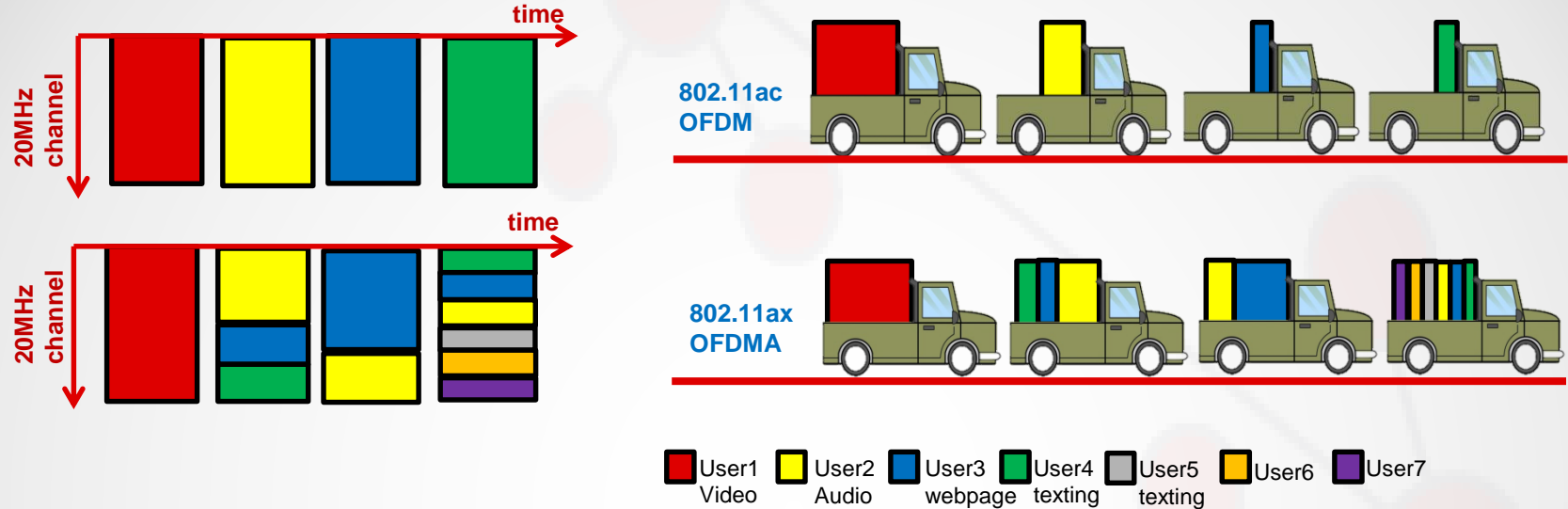
Multi User OFDMA



RU size	Number of RUs within BW
26 sub-carriers	9
52 sub-carriers	4
106 sub-carriers	2
242 sub-carriers	1

- ❑ 11ac has 52 subcarriers in 20MHz band with subcarrier spacing of 312.5KHz.
- ❑ With 78KHz spacing, 11ax has 242 data subcarriers in the same 20MHz band.
- ❑ Each 20MHz Wi-Fi channel is divided into 9 resource units (RUs).
- ❑ The smallest RU has 26 subcarriers ~2MHz wide.
- ❑ In overcrowded networks the same 20MHz channel can be shared among multiple devices at the same time.

OFDMA – Orthogonal Frequency Division Multiple Access

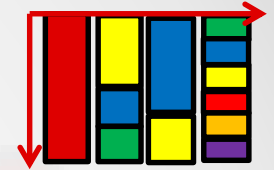


- ❑ Different users demanding different data speeds can be served using the same 20MHz channel at the same time.
- ❑ Efficient use of spectrum and improves overall efficiency.
- ❑ For a fixed data transfer the system can save power by transmitting all data together enabling longer sleep time.
- ❑ Supports 9 times more users or devices than 11ac.

802.11ax Features

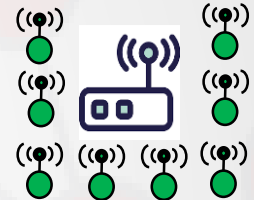
OFDMA DL/UL

Improves Spectrum efficiency and network capacity.



8X8 MU-MIMO DL/UL

Increases data throughput for both DL and UL.



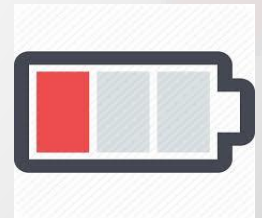
Long OFDM Symbol duration

4X longer symbol improves robustness to multipath in outdoor environment.



Power Save Modes

Allows for longer sleep intervals and scheduled wake times with TWT.



Future IoT Use Cases – Smart Buildings/Hospitals/Offices



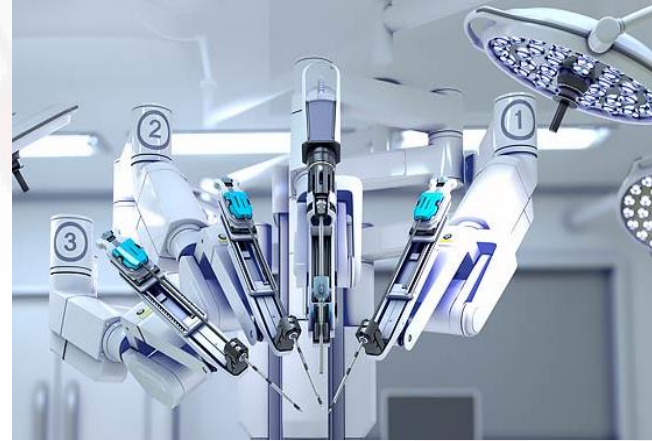
Use Cases

- ☐ HVAC and energy Monitoring
- ☐ Video Surveillance
- ☐ Remote Diagnostics
- ☐ Disaster Management
- ☐ Access Control & Security
- ☐ Switches/Motor Control
- ☐ Indoor GPS Positioning

IoT Enabler

- ☐ Low Power
- ☐ Large Range
- ☐ Low latency
- ☐ Network Capacity
- ☐ Security

Future IoT Use Cases – Augmented and Virtual Reality



Use Cases

- ☐ Virtual Training or Collaboration
- ☐ Virtual Diagnostics/Expert
- ☐ Robotic Surgery
- ☐ Augmented Reality Tourism
- ☐ Retail Visualizer

IoT Enablers

- ☐ High Data rate
- ☐ Low Latency
- ☐ Security

Bluetooth 5

New *Bluetooth* 5 features

Longer Range – 4X range for low data rates

Achieved through FEC without increase in power for low data rates.

Faster Data – Max Data rate 2Mbps

Achieved by doubling the symbol rate.

Advertising Extension – 8X more advertising data

Transmit more intelligent data over a beacon with increased broadcasting capacity, enable rich location/navigation applications

Bluetooth End Equipment

Health & Fitness



- Heart rate monitor
- Treadmill
- Smart band
- Sports equipment

Wireless Audio



- Sound bar
- Speaker
- Headset

Remote Control



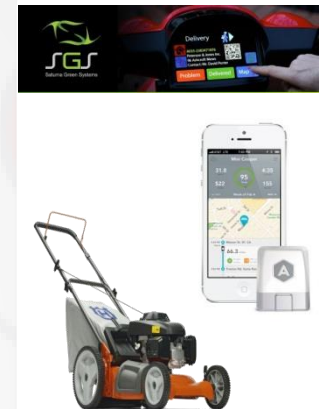
- Voice activated remote control
- HID (keyboard, mouse, etc.)

Retail



- Location based adds.
- Remote control toys
- Audio streaming

Automotive & Industrial



- On-board diagnostics
- After market hands free, audio streaming

SUB-1GHz

Sub-1 GHz

Better range, Lower power, More robust, Diverse Applications.

Long range



- 20Km Range
- Full house coverage
- Choice of long range modulations

Ultra-Low Power



- Multi-years on coin cell battery
- Lower power vs. other technologies for the same range

Robust



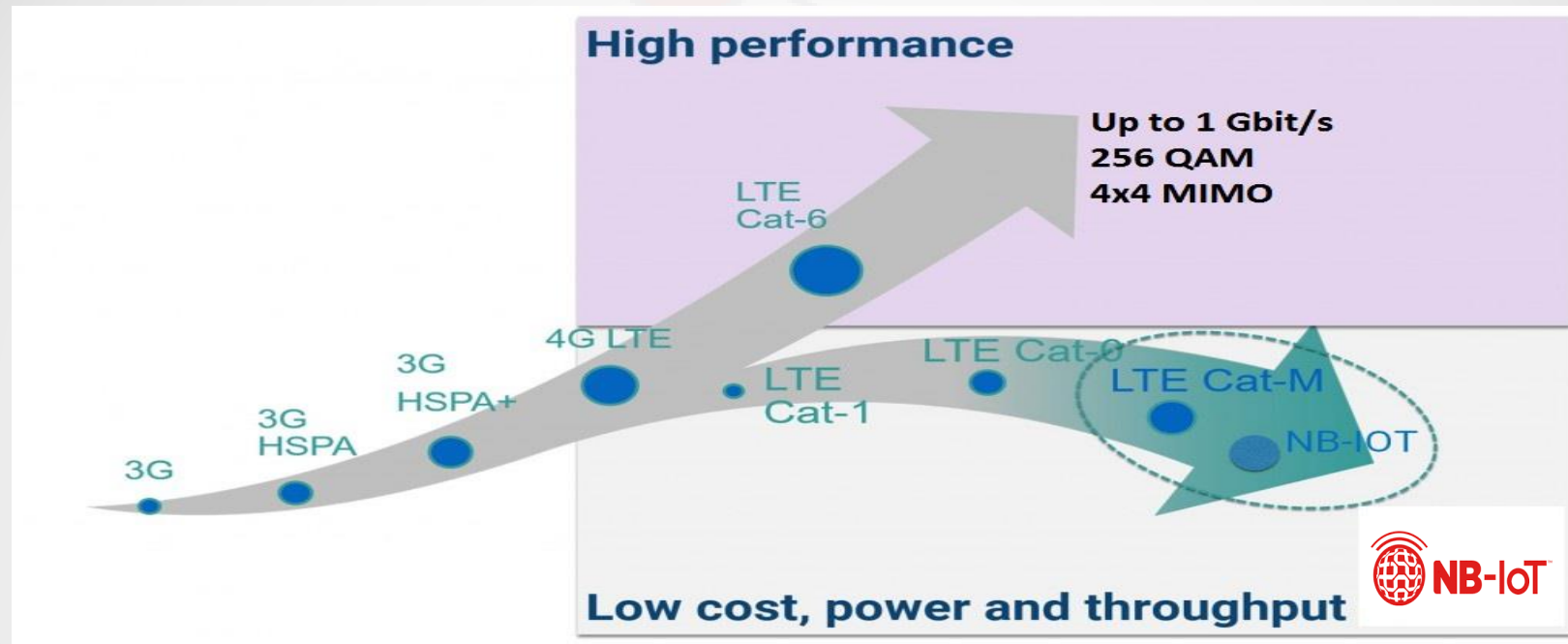
- Frequency hopping
- Less susceptible to interference
- Avoid the crowded 2.4 GHz

Automation	Smart Grid	Alarm & Security	Retail	Logistics	Factory Automation	Agriculture	Other
							
Lighting Control Door Locks Heat Control	Flow Meters E-Meters Heat cost allocators	Security Alarms Smoke/CO2 alarms Security Sensors	ESL/Price Tags Locationing Cold Chain Mgmt	Tollroad Tags Asset Tracking	Monitoring sensors Cable Replacement	Irrigation systems Rodent traps Animal tracking	Rescue tracking RC toys



NB-IOT

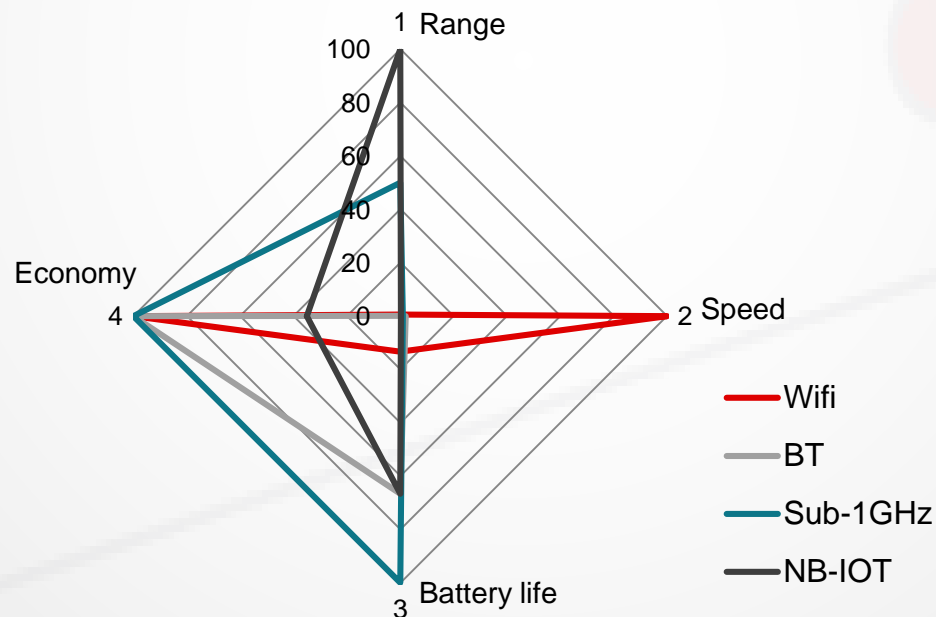
Narrow Band IOT



- ❑ NB-IOT is the lowest data rate LTE version.
- ❑ Focus is on low power and long range.
- ❑ Data Speeds of upto 250Kbps and range upto 20Km
- ❑ NB-IoT can support ~5000 connections per cell.
- ❑ Use cases include Healthcare, Safety and Security, Asset management, Agriculture, Retail.
- ❑ Eg. health monitors, meter tracking, warehouse automation etc.

Comparison of the wireless standards for IOT

Technology	Range (m)	Speed (Mbps)	Battery Life (years)	Cost * (Rs)
WiFi	100	1000	2	350
BT	10	2	10	350
Sub-1GHz	10000	0.25	15	300
NB-IOT	20000	0.25	10	1000





TI's Wireless Connectivity Portfolio

The Widest in the Industry

More than 15 years of Wireless Expertise

1+

BILLION UNITS

Wireless connectivity
products shipped

5k+

ACTIVE CUSTOMERS



14+

**Wireless
Technologies**

The industry's
broadest portfolio

15+

YEARS

Shipping
Connectivity
solutions

130+

PRODUCTS

Products currently
shipping

260+

END EQUIPMENTS

Products with
wireless connectivity

TI broad portfolio: A solution for each industry challenge

Wireless Connectivity Portfolio

Proximity

Personal area networks

Local area networks

Wide area networks

cm

Up to 100m

Range

km

**NFC
RFID**

Identification



**Bluetooth®
Bluetooth® LE**

Connection to
smart devices



**Proprietary
2.4GHz**
Customizable



**ZigBee®, RF4CE,
Thread**
Mesh



Wi-Fi®
Universal –
Cloud
connection



6LoWPAN
IP Mesh



Sub-1 GHz
Long range



Key Differences

Throughput:

✓ Data up to
848 Kbps

Power needed:
No battery or
coin cell



Throughput:

✓ Data or voice
up to 3 Mbps

Power Needed:
Coin cell or AAA



Throughput:

✓ Data up to 1
Mbps

Power Needed:
Coin cell



Throughput:

✓ Data up to
256 Kbps

Power Needed:
Energy harvesting
or AAA



Throughput:

✓ Voice/video
10-100 mbps

Power Needed:
AA or Lithium
Ion



Throughput:

✓ Data up to
256 Kbps

Power Needed:
Energy harvesting
or AAA



Throughput:

✓ Data up to 1
Mbps

Power Needed:
Coin cell



Key Attributes

- Passive operation & data storage
- Dedicated multi-tag read zone
- In Portable devices

- Interoperable with other Bluetooth devices
- Large install base
- Ultra Low Power

- Customizable to application
- Robust RF

- Standards based
- Self-healing mesh
- Ultra Low power
- Large area coverage

- Existing infrastructure
- Power Optimized
- Built-in security
- Wi-Fi Certified
- Connection to the cloud

- IPv6 stack
- Ultra low power
- IoT platform

- Longest range
- Ultra low power
- Customizable to application
- Robust RF²⁹