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What Does 5G Do for IoT and Wearable Devices?

Sensors Converge June 22, 2023

The Promise of 5G

- **Higher bandwidth, ultra-reliable, low-latency**
- **Addresses three key problems for the wireless infrastructure:**

Enhanced data throughput – astounding amount of data

Always on – ability for devices to always be connected

Reduced latency – enable additional types of solutions (i.e. healthcare, manufacturing and automotive applications)

But these are not important for most IoT applications.

5G Spectrum Within Three Key Frequency Bands

Similar to 4G Coverage and capacity

New with 5G

BELOW 1 GHZ

Low-band spectrum

- Will support widespread coverage across urban, suburban and rural areas
- Good in-building coverage
- Peak data speeds up to 100 Mbps
- Used by carriers in the U.S. for LTE
- Bandwidth is nearly depleted

1-6 GHZ

Mid-band spectrum

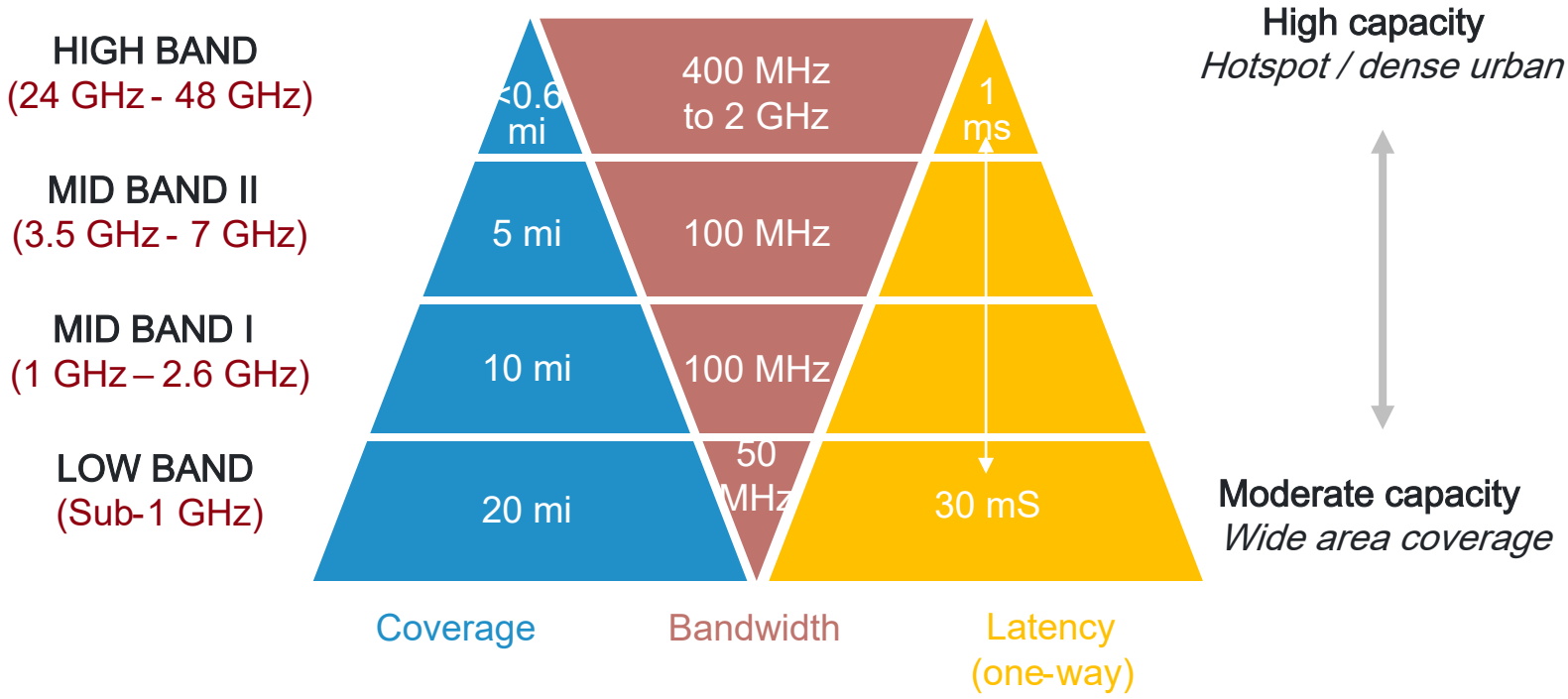
- Good mixture of coverage and capacity benefits.
- Peak data speeds reach as high as 400 Mbps
- Faster speeds and lower latency than lower band
- Does not penetrate buildings as well as low-band

6 GHz – 86 GHz

High-band spectrum

- *Above 6 GHz needed for ultra-high broadband speeds. 28 GHz to 39 GHz bands identified in the USA*
- *Up to 2 Gbps*
- *Often referred to as mmWave*
- ***Major weaknesses:** low coverage area and poor building penetration*
- *Blocked by walls, windows, cars, trees, rain, or snow*

5G Coverage, Bandwidth, and Latency



Source: SCTE•ISBE and NCTA and others

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The 5G Service Classes

eMBB

Enhanced mobile broadband

Very high data rates
Very High traffic capacity

CHARACTERISTIC

High peak data rates | High speed mobility | down to 4 ms of air latency

USE CASES

Smart phones, tablets, home/enterprise/venues applications, UHD TV (4K and 8K) broadcast, and virtual reality/augmented reality

mMTC

Massive machine-type communications

Massive number of devices
Very low device cost
Very low energy consumption

CHARACTERISTIC

Will support massive IoT deployments

USE CASES

Smart buildings, logistics, tracking, fleet management, wearable devices, and smart meters

URLLC

Ultra-reliable and low-latency communications

Very low latency
Ultra high reliability and availability

CHARACTERISTIC

As low as 1 ms air latency

USE CASES

Traffic safety and control, remote surgery, and industrial control

Source: ITU-R SGO5

URLLC Service Class - Mostly On-Premise

Scenario	End-to-end latency	Reliability	User experienced data rate	Traffic density	Service area dimension
Discrete automation – motion control	1 ms	99.9999%	1 Mbps up to 10 Mbps	1 Tbps /km^2	100 x 100 x 30 m
Process automation – remote control	50 ms	99.9999%	1 Mbps up to 100 Mbps	100 Gbps /km^2	300 x 300 x 50 m
Electricity distribution – high voltage	5 ms	99.9999%	10 Mbps	100 Gbps /km^2	200 km along power line
Intelligent transport systems – infrastructure backhaul	10 ms	99.9999%	10 Mbps	10 Gbps /km^2	2 km along a road

Source: NOKIA 2018

URLLC Limitations

Mostly On-Premise uses

- No wide area coverage
- Equipment typically installed by the user
- Not for public service

Latency is one way from transmitter to receiver

- Local termination reduces network latency that is up to 100 mS in 4G
- Does not include the delay in the backbone of the network in latency figures

Highly reliable communication

- Much better than 4G

mMTC (IoT) Service Class

- Low-power Wide-area (LPWA)
- 160 bits/sec (up to 10 Kb/sec)
- 1 million devices / km^2
- Round trip latency of 10 seconds with 20-byte payload
- Low cost hardware
- Not available now in 5G

Current State of mMTC

- 5G mMTC standards are being worked on
- Current 5G not optimized for packet size, short sessions
- Inefficient control signaling – 100 bytes of signaling to send 10 bytes of data
- Present channel coding schemes are inefficient with small data packets
- 5G uses higher power than 4G
- LTE services have been adopted as part of 5G

Other Issues with 5G

mmWave signals are blocked by walls, windows, trees, cars, people, rain, or snow

mmWave signals don't transmit very far

- C-net Reported best coverage is line of sight 100 to 300 ft from base station

Phones use higher power for mmWave band

- Phone switches to lower band or 4G at high ambient temperature

Base stations use 3 times the power of LTE – not green

Concern about health effects of mmWave signals

Interference with weather satellites by mmWave frequencies

LTE (4G) is being expanded for IoT Services

NB-IoT and LTE-M (also called CAT-M)

- Coverage in the U.S. is good.
- 50,000 devices per cell
- NB-IoT and LTE-M will coexist with 5G for years into the future
- Now part of 5G mMTC spec
- NB-IoT not suitable for mobile – lack automatic zone switching

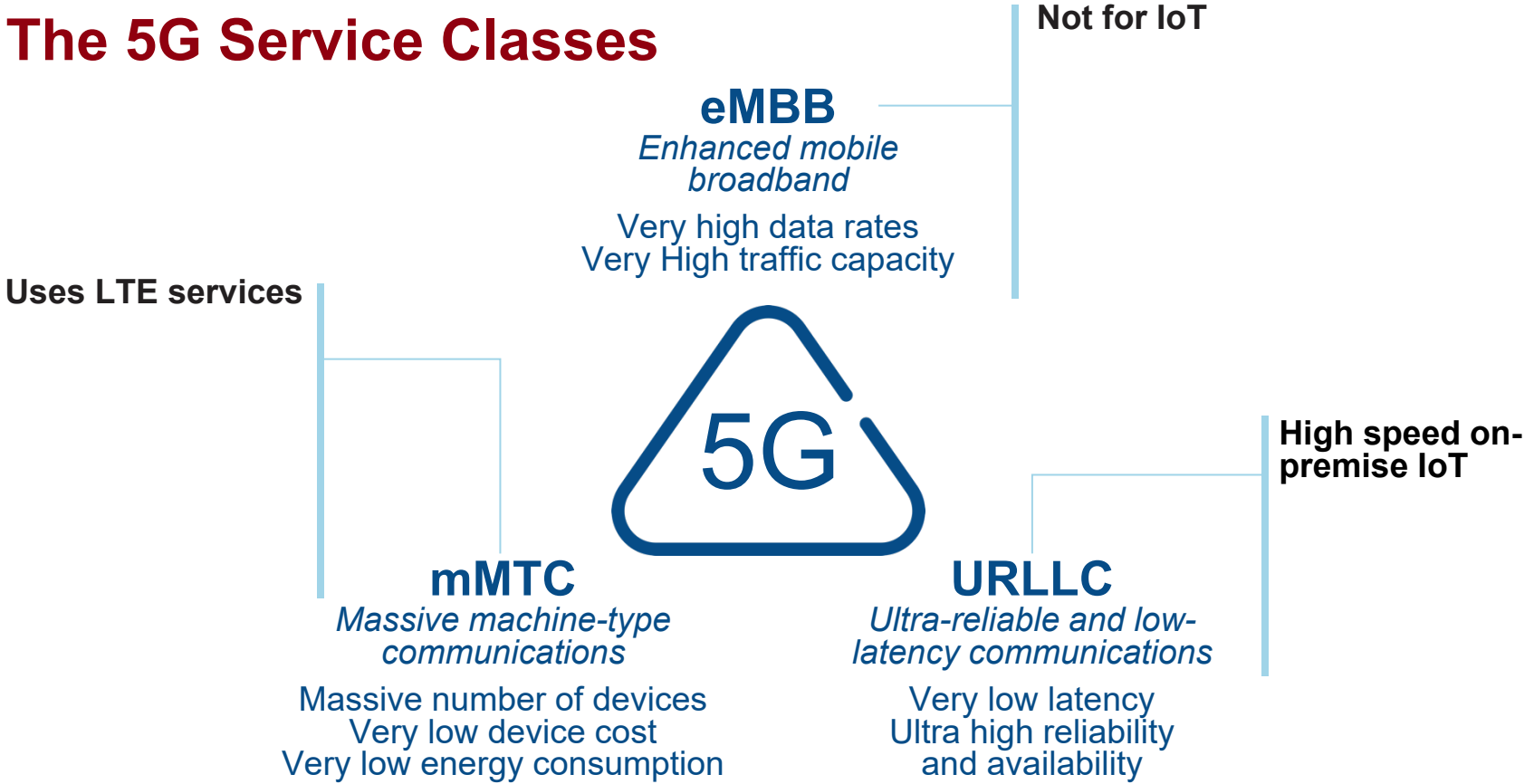
Non-cellular services are not included in 5G, but will still work

- LoRa, Sigfox and others
- Use unlicensed spectrum – lower cost air-time
- Not available most places

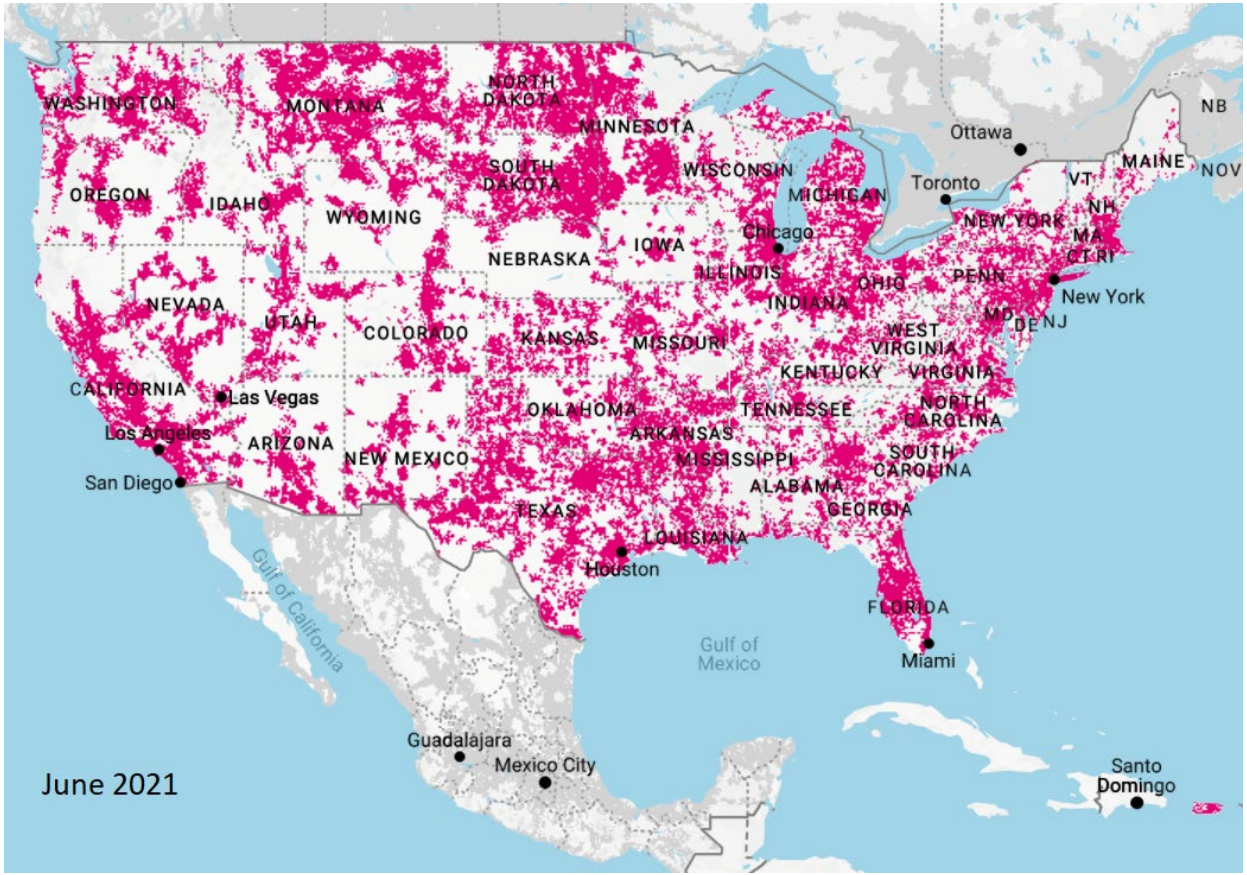
Comparison of Existing IoT Wireless Standards

	NB-IoT NB1	NB-IoT NB2	CAT-M1 LTE-M	CAT-M2 LTE-M	LoRa	Sigfox
Range	1-50 km	1-50 km	1-50 km	1-50 km	2-50 km	10-50 km
Data rate	26-66 Kbits/s	120-150 Kbits/s	1 Mbits/s	4-7 Mbit/s	200-50K bits/s	300 bits/s
Supports Voice	No	No	Yes	Yes	No	No
Network	Public	Public	Public	Public	Public or Private	Public
Available	Good coverage	Good coverage	Good coverage	Good coverage	Yes Limited public	30% of US population

The 5G Service Classes



NB-IoT Coverage by T-Mobile, June 2021



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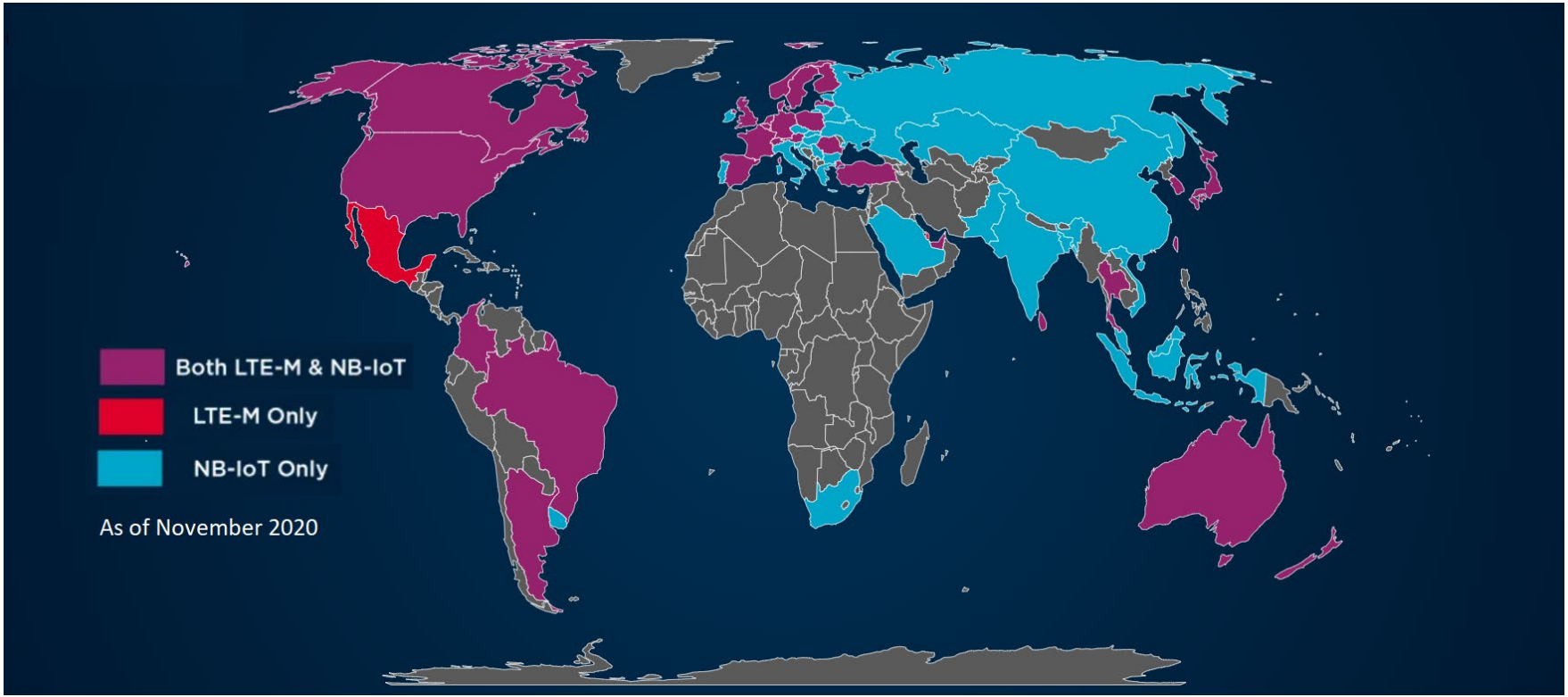
NB-IoT and LTE-M Deployment



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LPWAN (IoT) Compared to Others
Power – How much? How far?

	100 bps		10K bps		40K bps	
1 m	BLE4/Zigbee	0.15	BLE4/Zigbee	7.5	Zigbee	30
	BLE Mesh	0.15	BLE Mesh	7.5	LoRa	20
	LoRa	0.5	LoRa	10	NB-IoT	50
	Sigfox	0.5	NB-IoT	20	CAT-M1	50
	NB-IoT	0.5	CAT-M1	20		
	CAT-M1	0.5				
50 m	Zigbee	20	Zigbee	30	NB-IoT	100
	LoRa	0.5	LoRa	20	CAT-M1	100
	Sigfox	0.5	NB-IoT	30		
	NB-IoT	1.0	CAT-M1	30		
	CAT-M1	1.0				
1 km	LoRa	20	NB-IoT	100	NB-IoT	500
	Sigfox	20	CAT-M1	100	CAT-M1	500
	NB-IoT	20				
	CAT-M1	20				

Units: mW

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What should be considered for tradeoffs?

- Data rate
- Transmission distance
- Power Consumption
- Cost
- Licensed vs unlicensed spectrum
- Carrier deployed vs customer deployed
- Availability of technology
- Density of end devices
- Where it gets deployed
- Firmware updates
- Drivers for your OS
- Component/ module selection
- Antennas

Let Voler Help You Succeed!

Voler designs IoT and wearable devices with expertise in wireless communication and sensors

Walt Maclay, Voler Systems

Walt@volersystems.com

408-245-9844 ext 101

Quality Electronic Design & Software

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Slides will be at www.volersystems.com

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