LPWAN Protocols

Embedded Interface Design

with **Bruce Montgomery**

Learning Objectives

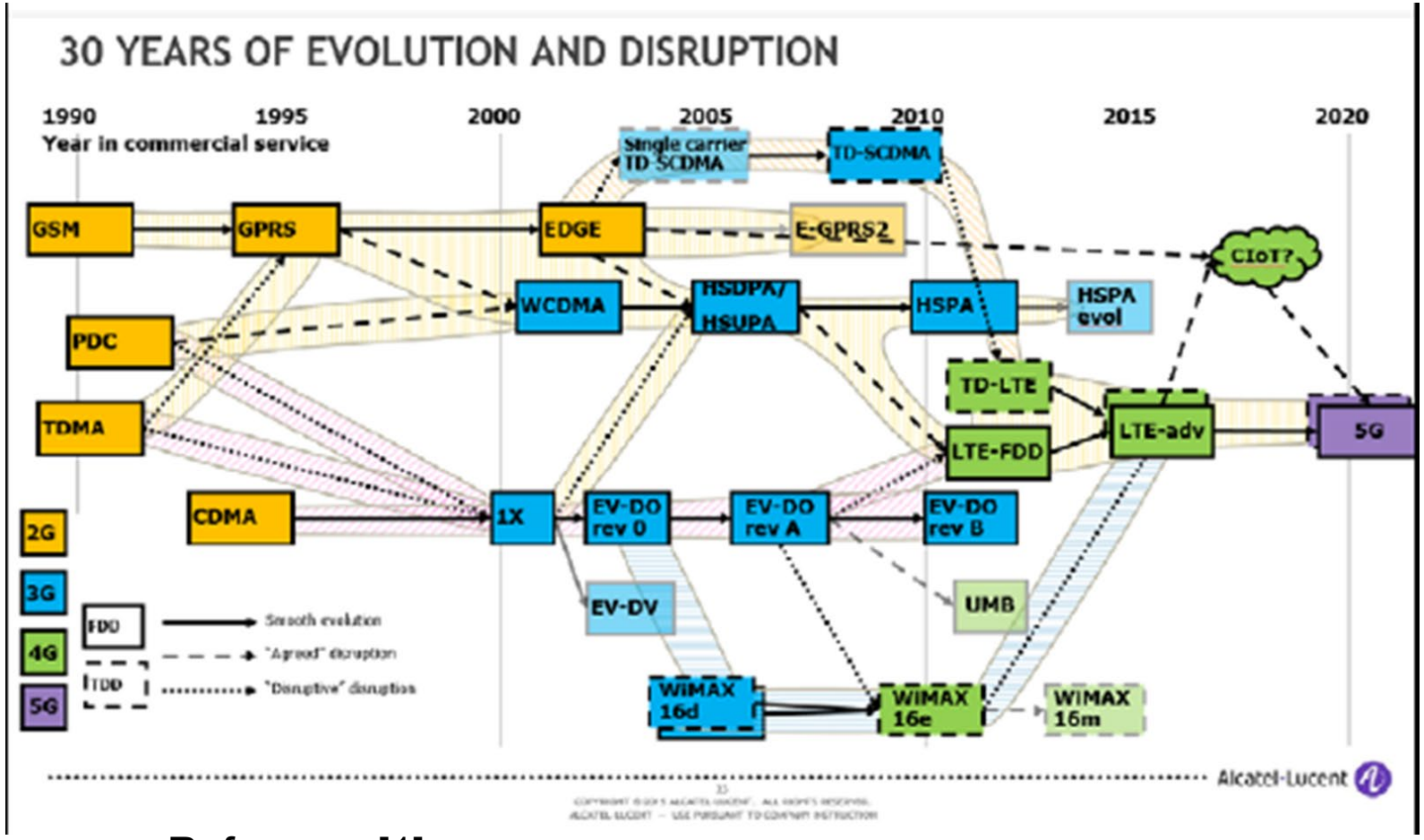
- Students will be able to…
  - Recognize and compare LPWAN protocols and characteristics

LPWANs for IoT

- Low Power Wide Area Networks (LPWANs)
  - Cellular (LTE-M, NB-IoT)
  - LoRaWAN
  - SigFox

Cellular Protocols

- A mix of rapidly changing technologies and approaches
- Rapid change due to demand for performance, search for competitive advantage, and widespread use



Reference [1]

Primary Cellular Protocols

- 1G
  - Spotty coverage, analog systems
  - FDMA – Frequency Division Multiple Access (each user gets a private frequency)
- 2G
  - Digital systems/data, improved voice, higher data rates (up to 144 kbps)
  - TDMA – Time Division Multiple Access (each user gets a time slot on a private frequency) = GSM (Global System for Mobile comms)
  - CDMA – Code Division Multiple Access (users get a private code and shift times and frequencies)
    - Primary champion, Verizon – still supported
  - CDMA has 4-5 times the capacity of a GSM/TDMA system with a fixed capacity limit
- 3G
  - Data rates up over 2 Mbps, moving from circuit switched to packet switched
  - UMTS – Universal Mobile Telecommunications System
    - Wideband CDMA
    - EV-DO – Evolution Data Optimized
  - EDGE – Enhanced Data rates for GSM Evolution

Primary Cellular Protocols

- 4G/LTE
  - Higher data rates for multimedia and video applications, fully IPv6-based VoIP
  - LTE – Long Term Evolution – 300 Mbps
  - WiMAX – Worldwide Interoperability for Microwave Access – up to 1 Gbps
- Pre-5G
  - Incremental advances in LTE to 1 Gbps or more
- 5G
  - Higher data rates, lower latency than 4G
  - Support for data-intensive VR and other applications
  - First official 5G launches in early 2020 – beta tests now
  - Qualcomm's 5G modem family, Snapdragon, will support 5G in 2019/2020
  - Maintains ioT Protocols within 5G like LTE-M or NB-IoT

Primary LTE-based IoT Protocols

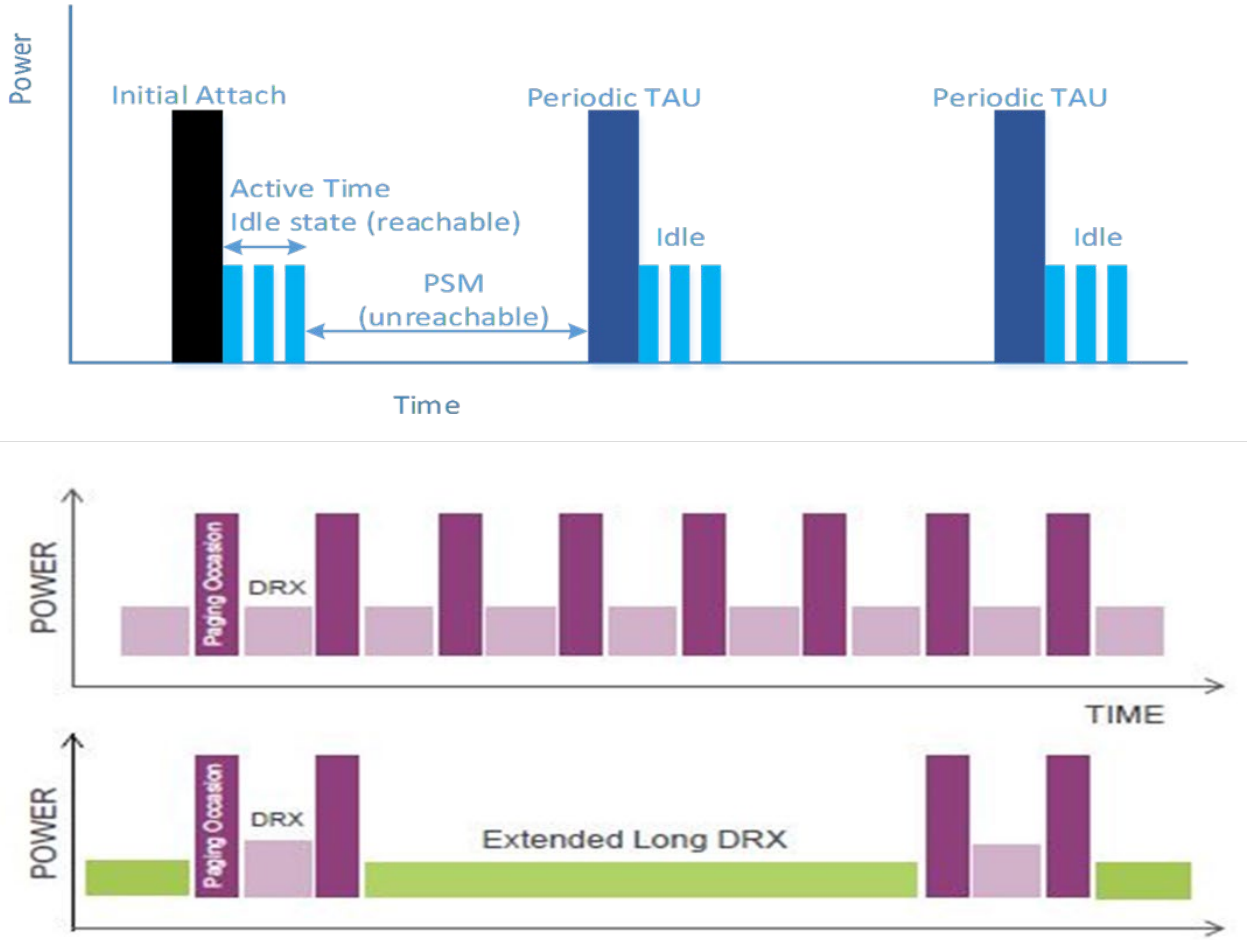
LTE-M	NB-IoT
AT&T LTE Bands 2, 4, 12 utilizing a 1.4 MHz channel	AT&T LTE Bands 2, 4, 12 utilizing a 200KHz channel
Up to 15dB coverage gain extension (+5dB at initial deployment)	Up to 20dB coverage gain extension
Message repetition	Message repetition & control channel optimization
Single Tx/Rx antenna	Single Tx/Rx antenna
Half duplex transmission	Half duplex transmission
Commercial module availability Q2 2017	Commercial module availability for AT&T Q4 2018
Managed thru AT&T Control Center and EOD	Managed thru AT&T Control Center

Reference [2]

LTE-M Feature: Long Battery Life

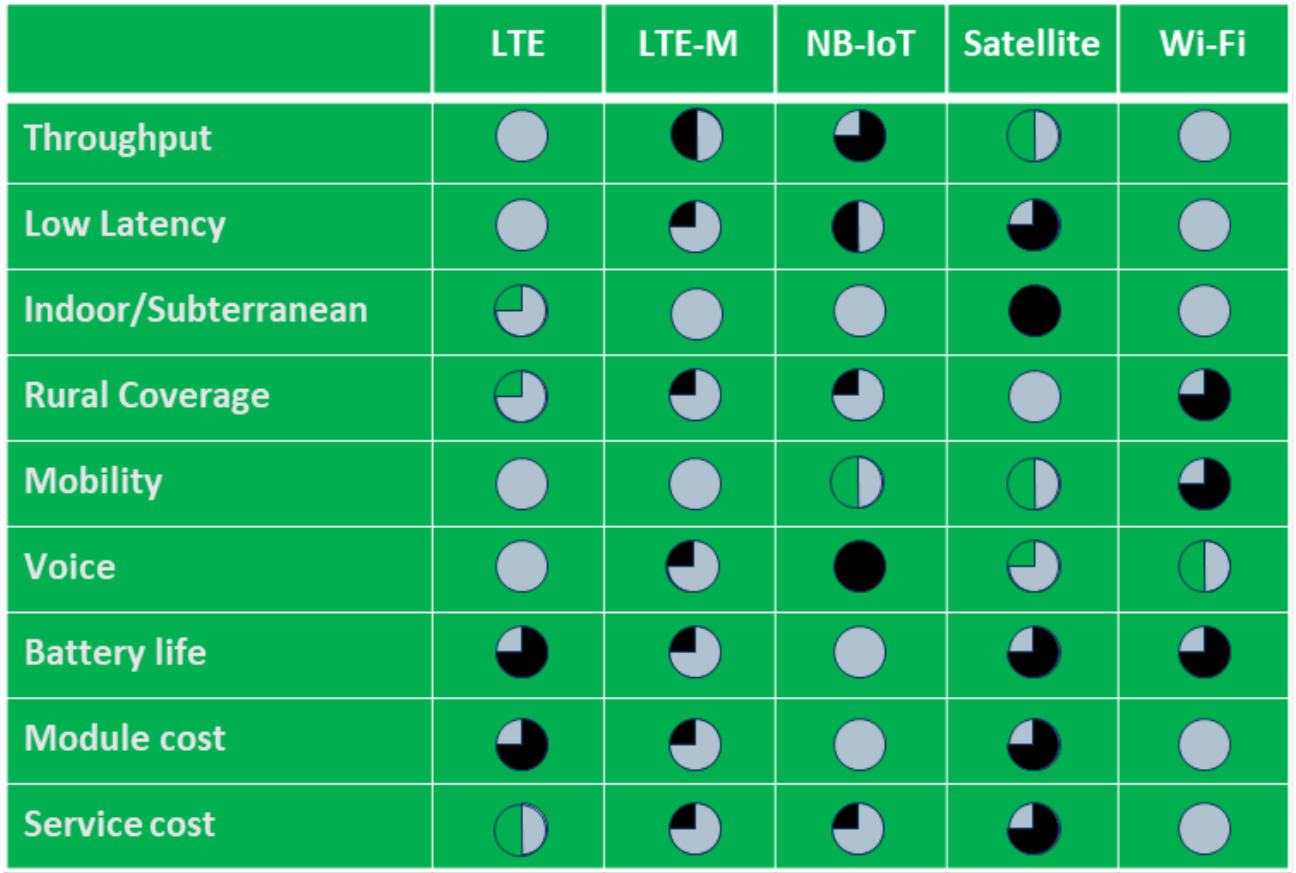
- Power Saving Mode (PSM): allows the device to enter extended “sleep” periods. (Periodic TAU = Tracking Area Update)
- Extended Discontinuous Reception (eDRX): allows for the device to extend the time interval in which it will listen for synchronization messages from the network
- Net Benefit: Both of these features together can extend battery life to 10+ years

- Reference [2]



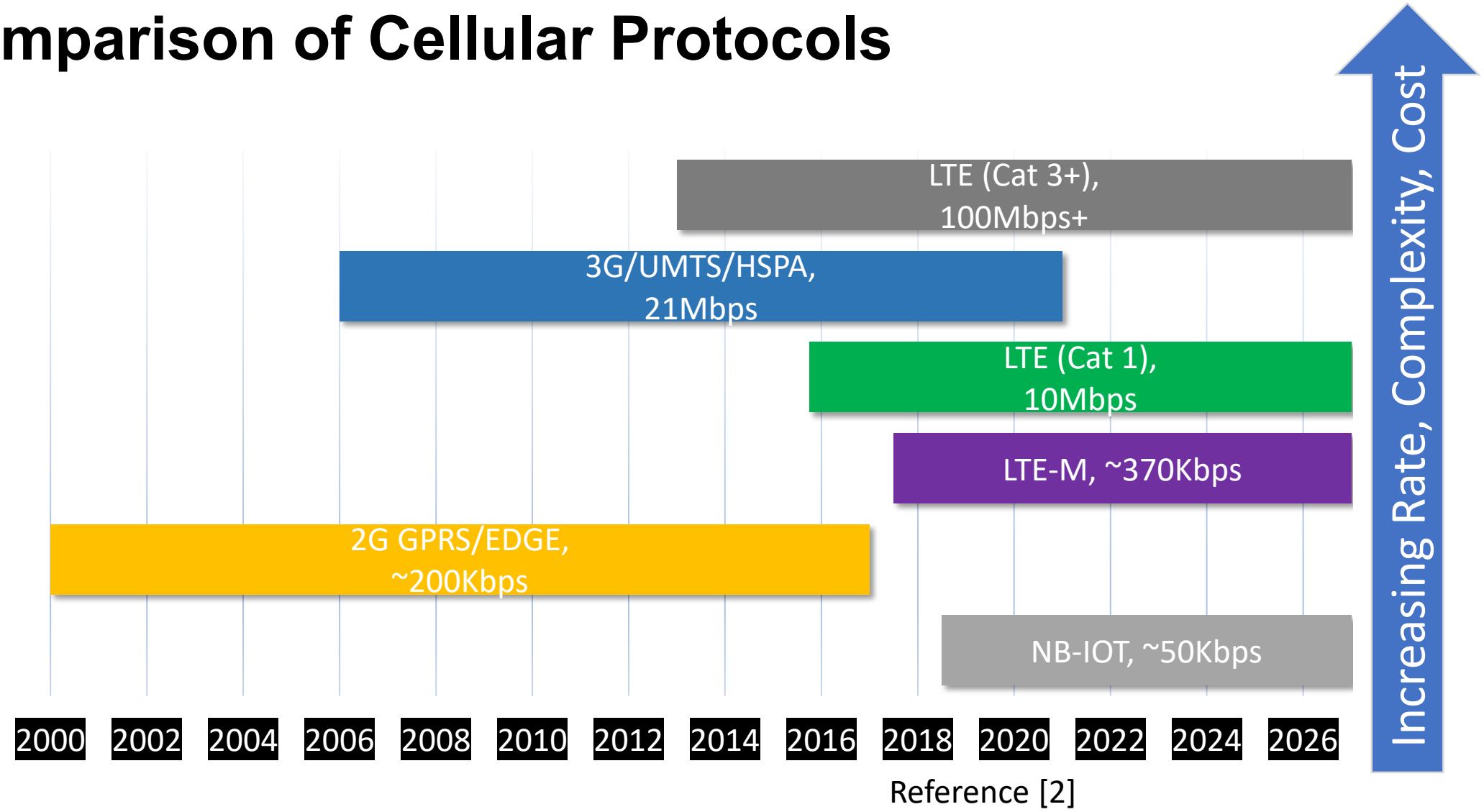
LPWAN Comparisons

- Benefits
  - Optimized for IoT
  - Lower cost modems
  - Longer battery life
  - Extended coverage for indoor and underground penetration
  - Greater coverage, roaming, security, and reliability than unlicensed alternatives
- **LTE-M:** IoT-optimized cellular enables lower cost with moderate throughput
- **NB-IoT:** Lower module costs with less mobility support and lower throughput.
  - AT&T recently launched NB-IoT in US.



	LTE	LTE-M	NB-IoT	Satellite	Wi-Fi
Throughput					
Low Latency					
Indoor/Subterranean					
Rural Coverage					
Mobility					
Voice					
Battery life					
Module cost					
Service cost					

Comparison of Cellular Protocols



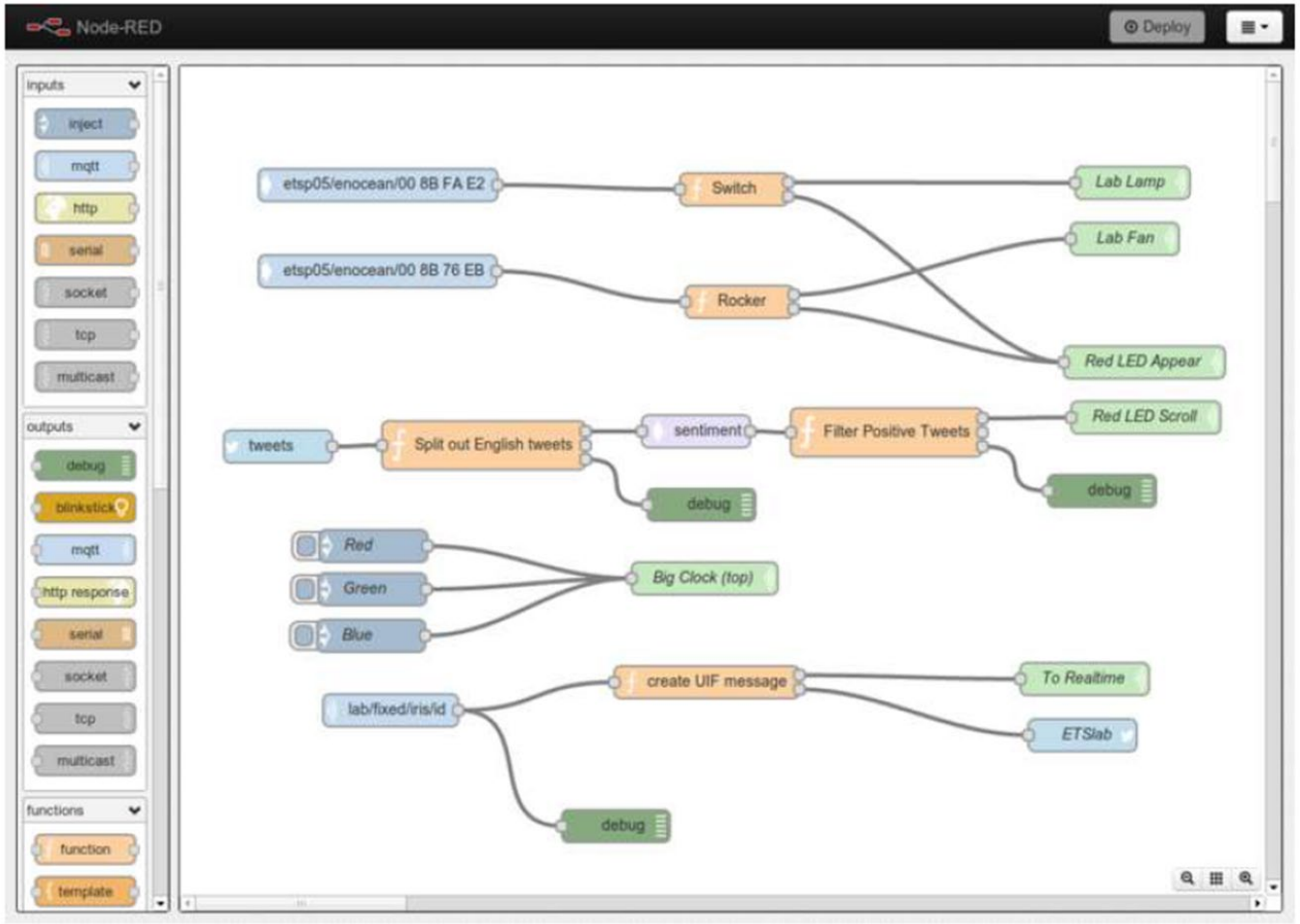
Reference [2]

AT&T Support for IoT Development

- Developer kit for AT&T LTE-M connectivity
- Includes a FRDM-K64F and an AT&T LTE-M board as well as a developer cell plan
- https://marketplace.att.com/products/att-iot-starter-kit-stm32-lte-m

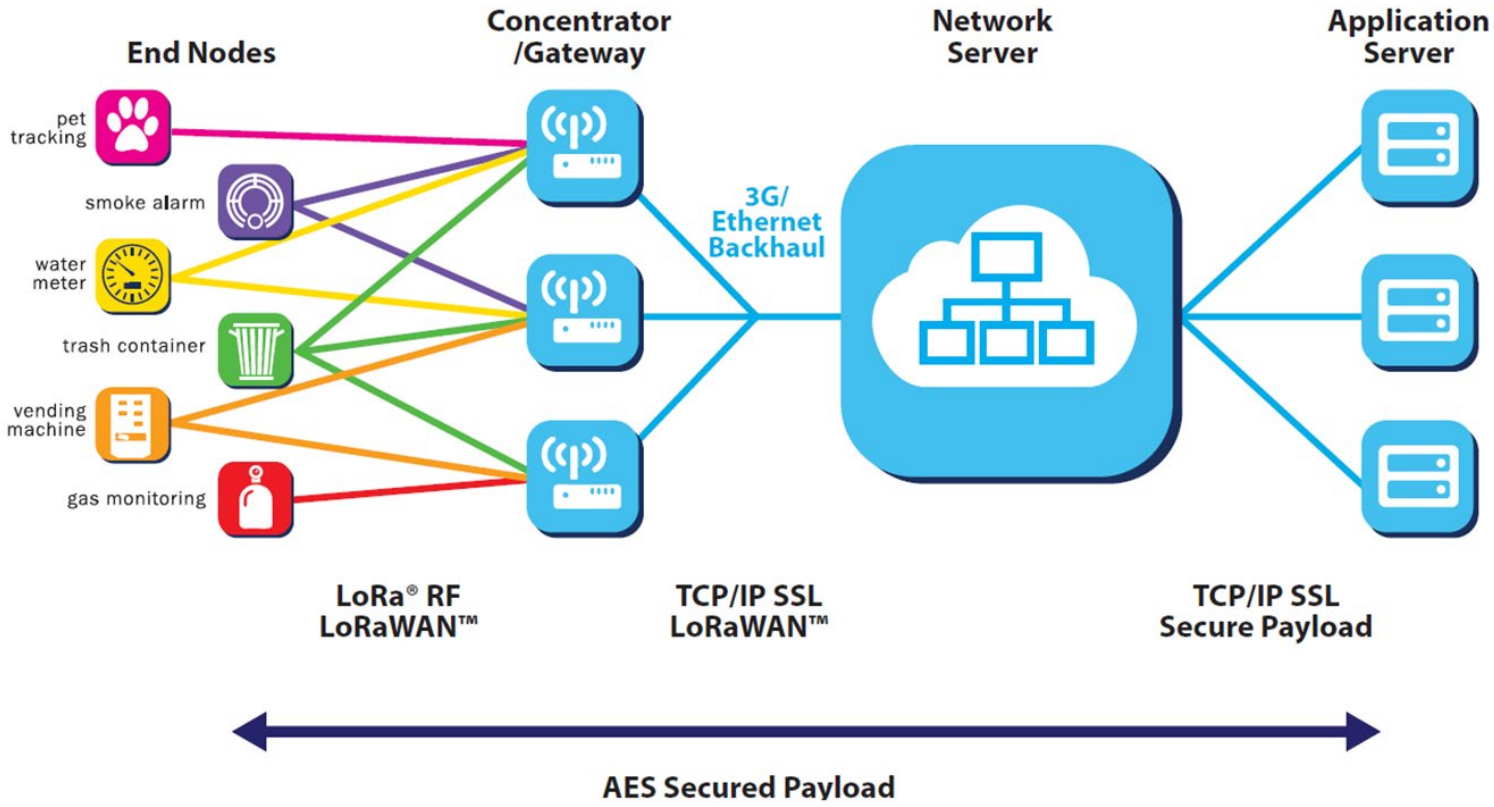
AT&T Flow development framework

- Visual programming environment for simple transactions
- More on AT&T IoT SDKs, APIs, Tools [4]



LoRa/LoRaWAN, an alternative to cellular IoT

- LoRa, a proprietary protocol from Semtech [5], does not define functionality above RF/physical layer, LoRaWAN adds the higher network layers
- Based on a chirp spread spectrum modulation
- Long Range
  - Better than Cellular
  - Deep indoor coverage
  - Star topology
- Long Battery Life
  - 10 – 20 yr lifetime

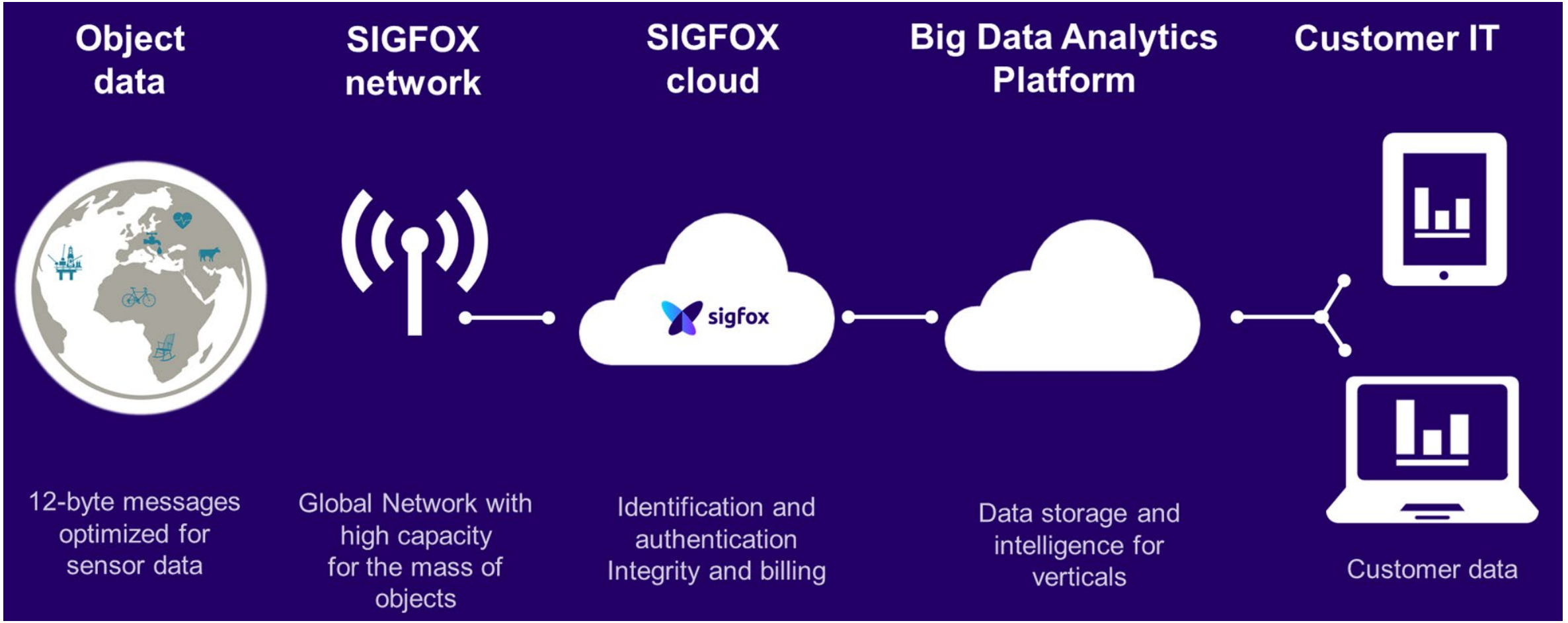


LoRaWAN

- Uses unlicensed ISM bands in NA and EU (tbd elsewhere)
- Data rates from 250 bps to 50 kbps
- LoRa GPS RPi Hat from Dragino [8]

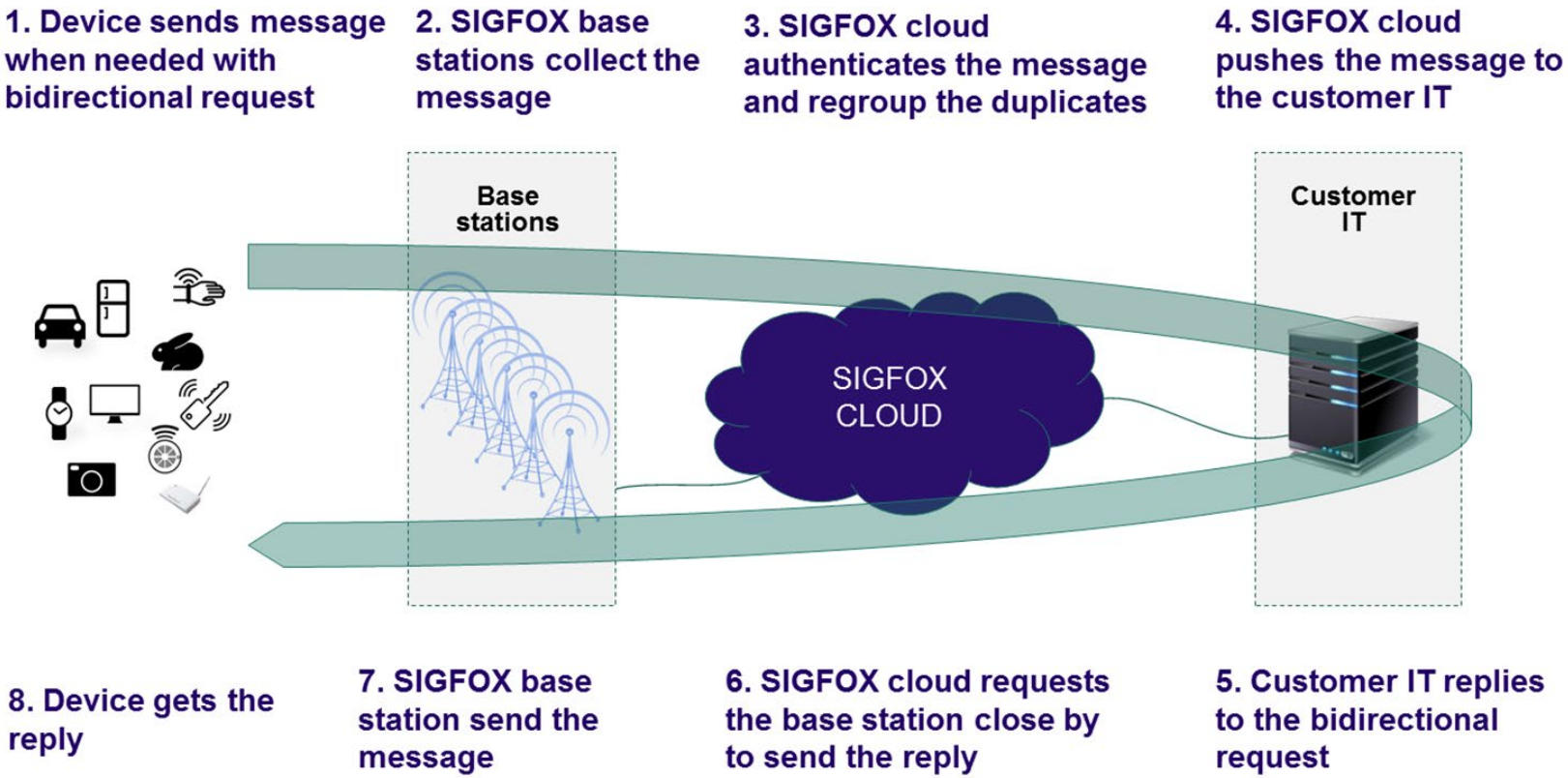
	Europe	North America	China	Korea	Japan	India
Frequency band	867-869MHz	902-928MHz	470-510MHz	920-925MHz	920-925MHz	865-867MHz
Channels	10	64 + 8 +8	In definition by Technical Committee	In definition by Technical Committee	In definition by Technical Committee	In definition by Technical Committee
Channel BW Up	125/250kHz	125/500kHz				
Channel BW Dn	125kHz	500kHz				
TX Power Up	+14dBm	+20dBm typ (+30dBm allowed)				
TX Power Dn	+14dBm	+27dBm				
SF Up	7-12	7-10				
Data rate	250bps- 50kbps	980bps-21.9kpbs				
Link Budget Up	155dB	154dB				
Link Budget Dn	155dB	157dB				

SIGFOX – Another low power WAN alternative



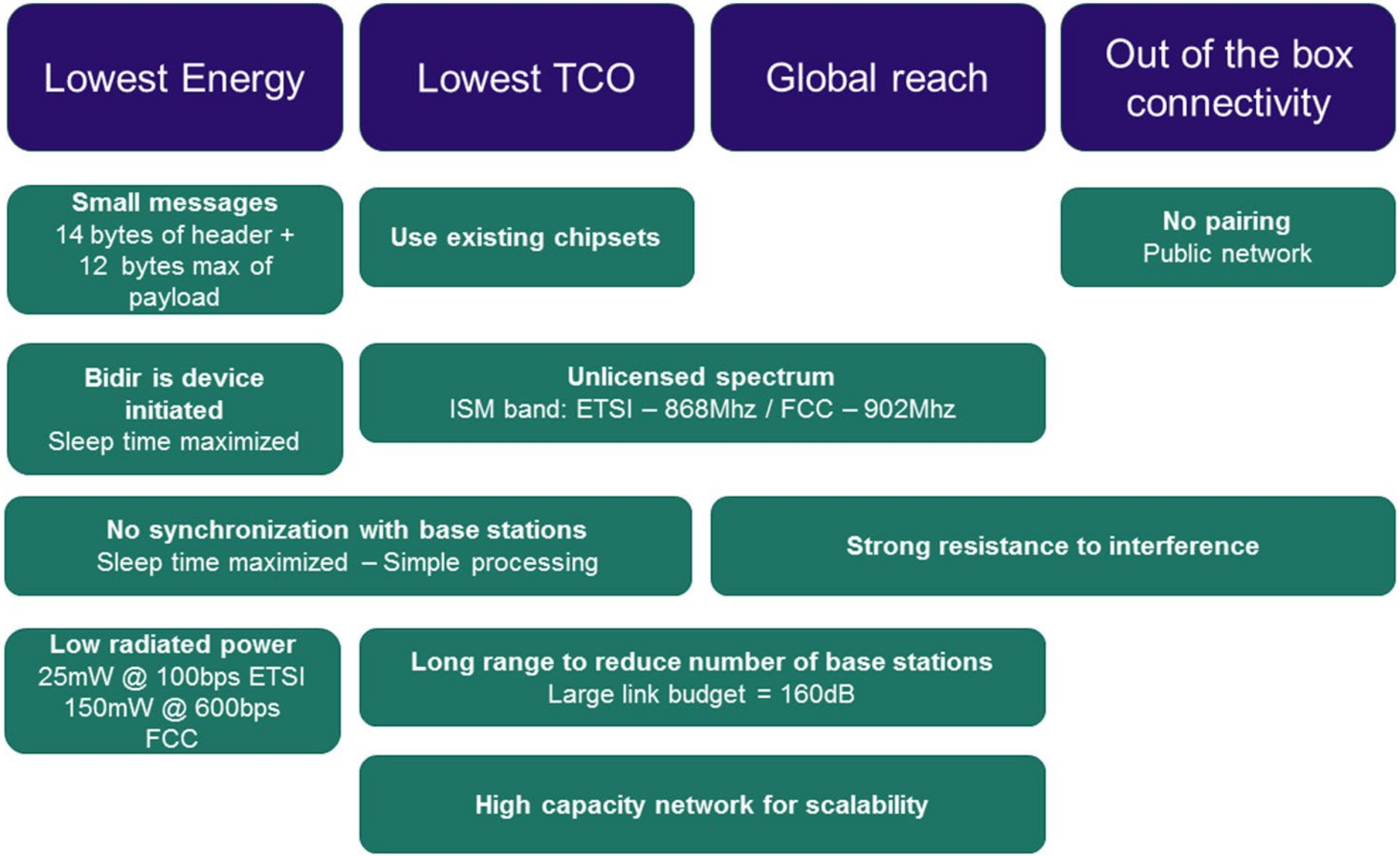
SIGFOX

- Depends on a proprietary network of base stations being built worldwide
- Has a subscription cost model – each device you connect to the SIGFOX cloud is billable
- Reference [6]



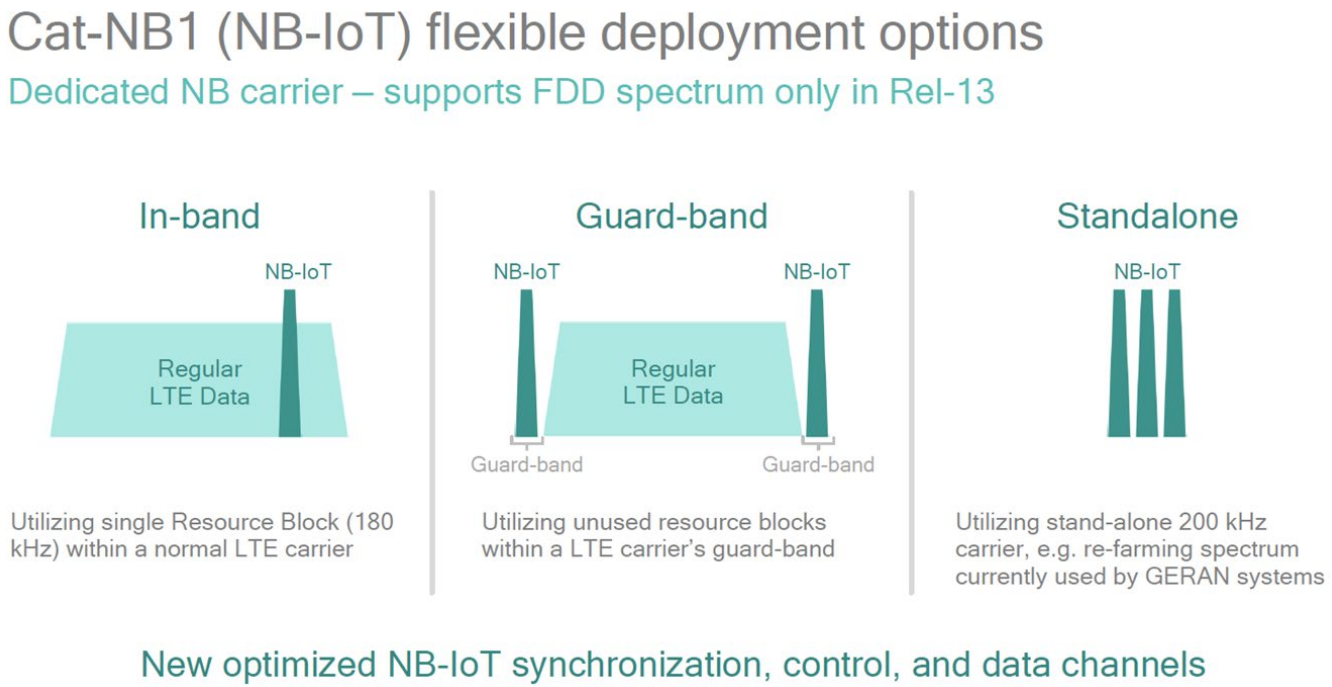
SIGFOX

- Small message sizes
- Uses unlicensed ISM bands
- Install base in EU, building out in US



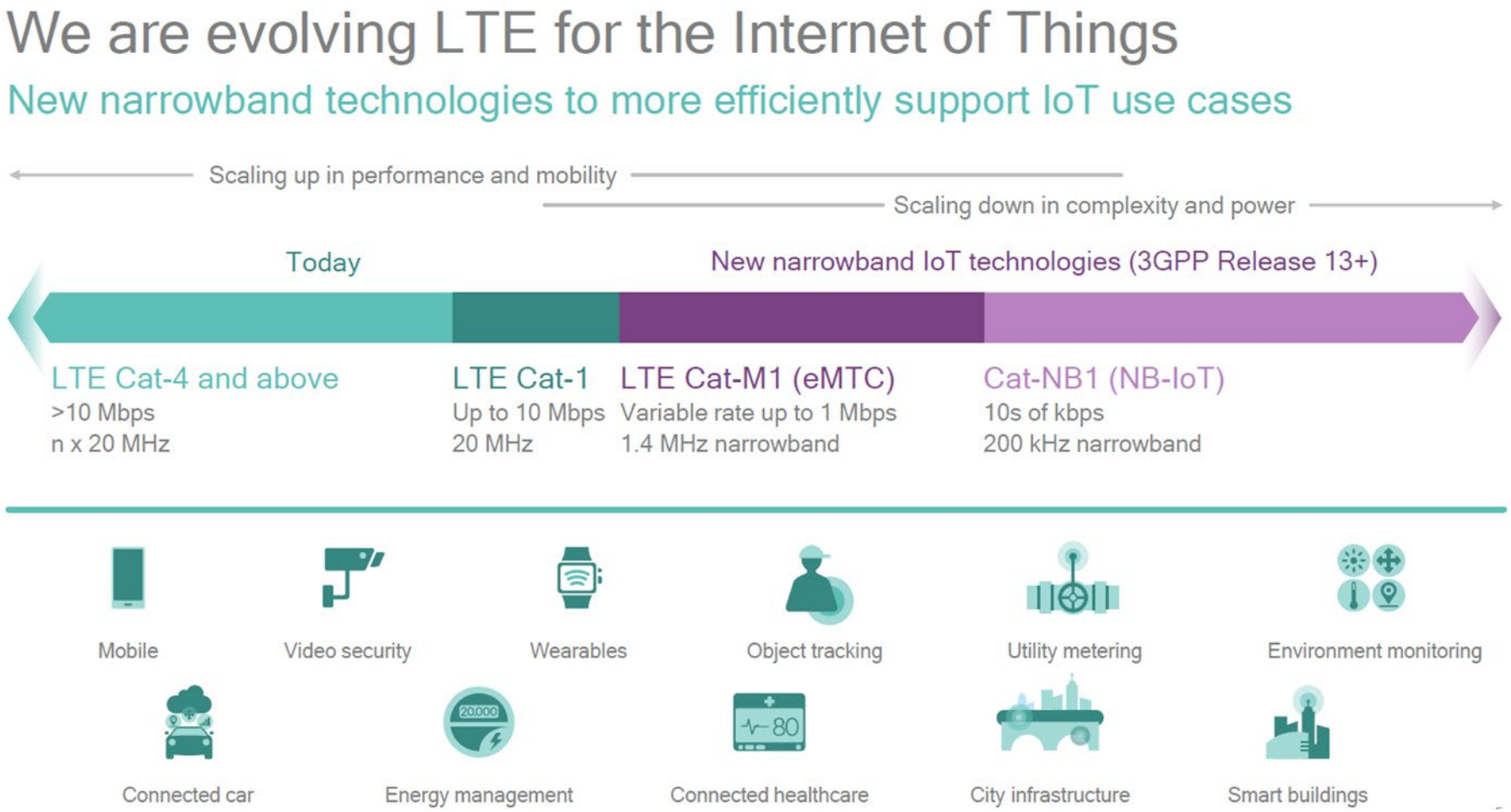
Considerations for Low Power WANs

- Cellular strategies have sleep modes – difficult to use for life safety or high priority messages
- NB-IoT and low data rate technologies cannot support voice
- LoRaWAN and SIGFOX are dependent on proprietary networks in the unlicensed bands – difficult to guarantee QoS and delivery – LTE-M and NB-IoT use the existing LTE network structure
- Cellular systems supported by large telecomms: AT&T, Verizon, Qualcomm, etc. – likely to have an easier time with market penetration
- Qualcomm reference [7]



Qualcomm NB-IoT Support

Qualcomm is producing silicon to support the Low Power cellular approaches like LTE-M and NB-IoT [7]



References

[1] From AICC Verizon Presentation – Varney/O'Shello
[2] From AICC AT&T Presentation – Steve Hardin
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