Embedded IoT Network
LoRaWAN: Long Range WAN

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Lecture References:

- Reading Article:
  - **A technical overview of LoRa® and LoRaWAN**. *Technical Marketing Workgroup 1.0, LORA Alliance, 2015.*

WHAT IS LoRa?

- LoRa is the physical layer or the wireless modulation utilized to create the long range communication link.
- LoRa is based on chirp spread spectrum modulation, which maintains the same low power characteristics as FSK modulation but significantly increases the communication range.
- Chirp spread spectrum has been used in military and space communication for decades due to the long communication distances that can be achieved and robustness to interference
- LoRa is the first low cost implementation for commercial usage.

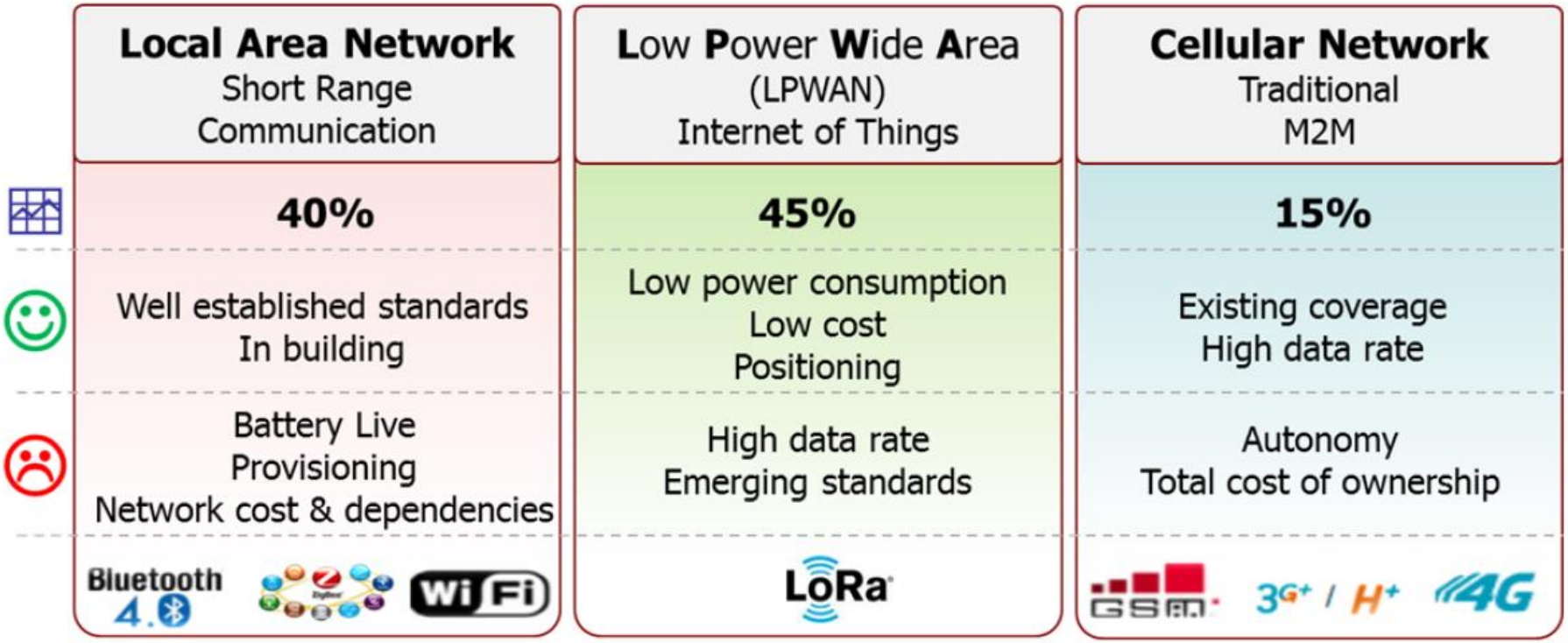
Long Range (LoRa)

- The advantage of LoRa is in the technology's long range capability.
- A single gateway or base station can cover entire cities or hundreds of square kilometers.
- Range highly depends on the environment or obstructions in a given location, but LoRa and LoRaWAN have a link budget greater than any other standardized communication technology.
- The link budget, typically given in decibels (dB), is the primary factor in determining the range in a given environment.

WHERE DOES LPWAN FIT?

- One technology cannot serve all of the projected applications and volumes for IoT.
- WiFi and BT are widely adopted standards and serve the applications related to communicating personal devices quite well.
- Cellular technology is a great fit for applications that need high data throughput and have a power source.
- LPWAN offers multi-year battery lifetime and is designed for sensors and applications that need to send small amounts of data over long distances a few times per hour from varying environments

WHERE DOES LPWAN FIT?

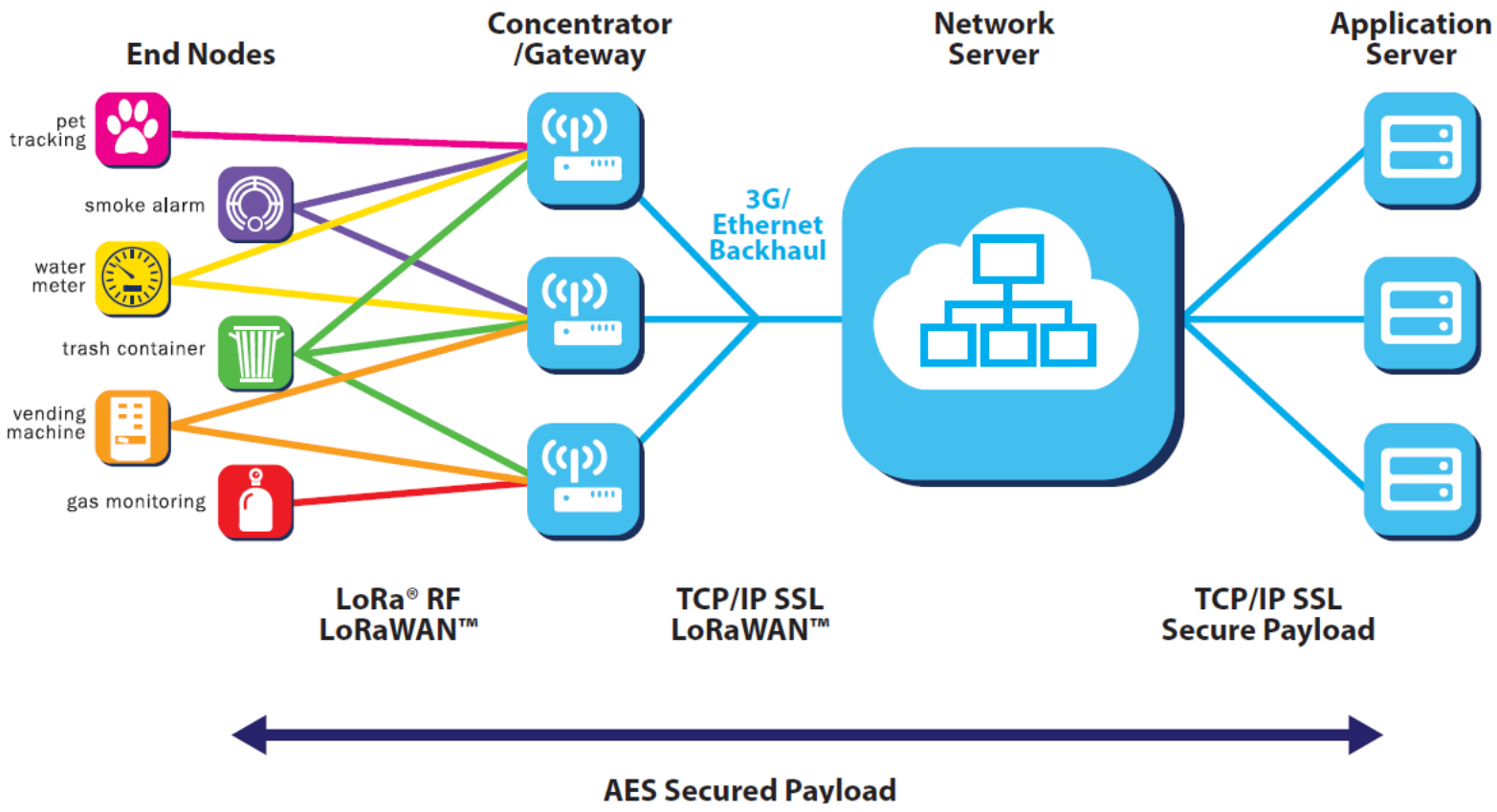


Factors of LPWAN

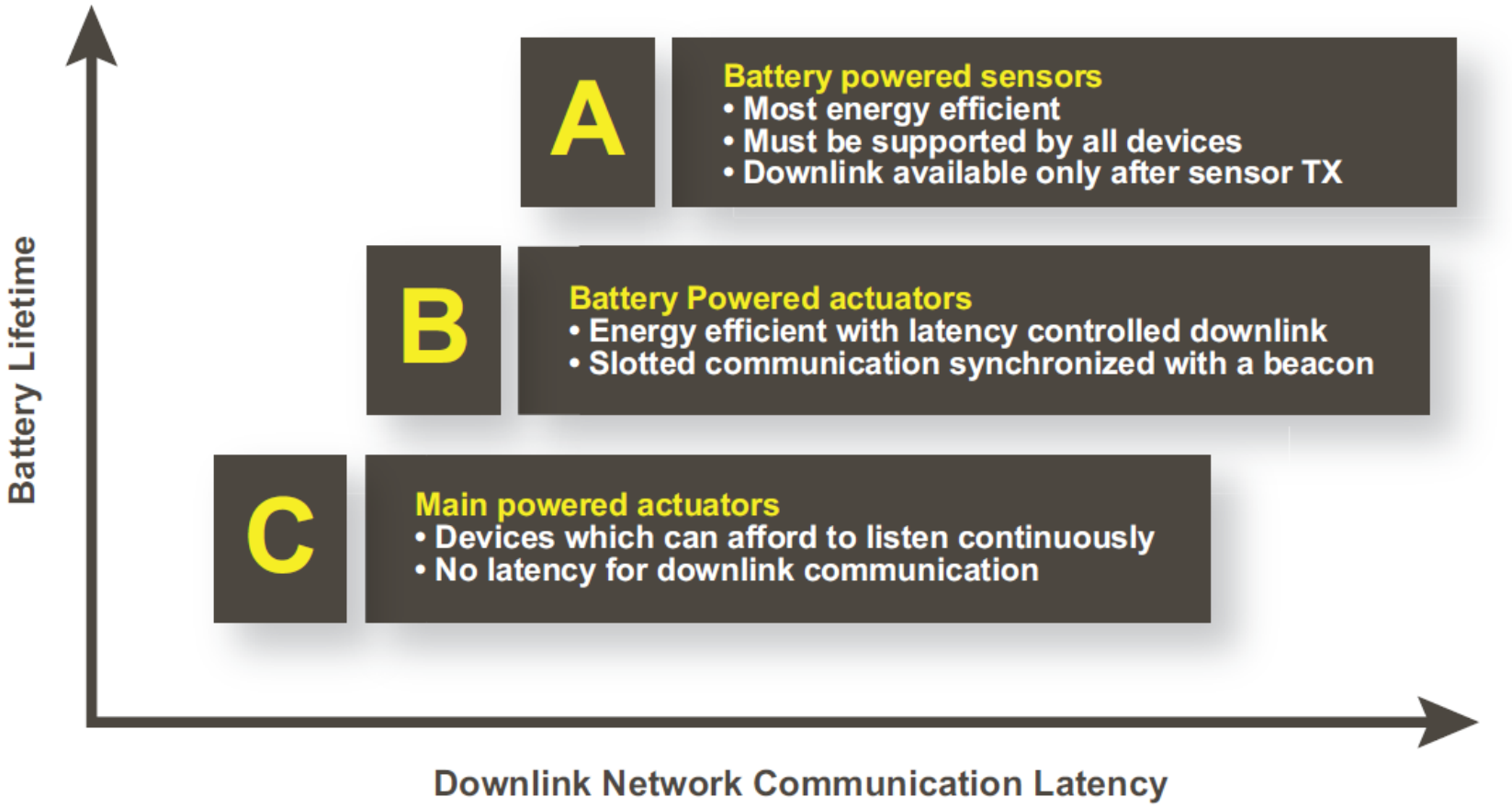
The most critical factors in a LPWAN are:

- **Network architecture**
- **Communication range**
- **Battery lifetime or low power**
- **Robustness to interference**
- **Network capacity (maximum number of nodes in a network)**
- **Network security**
- **One-way vs two-way communication**
- **Variety of applications served**

LoRaWAN Architecture



LoRa Device Classes



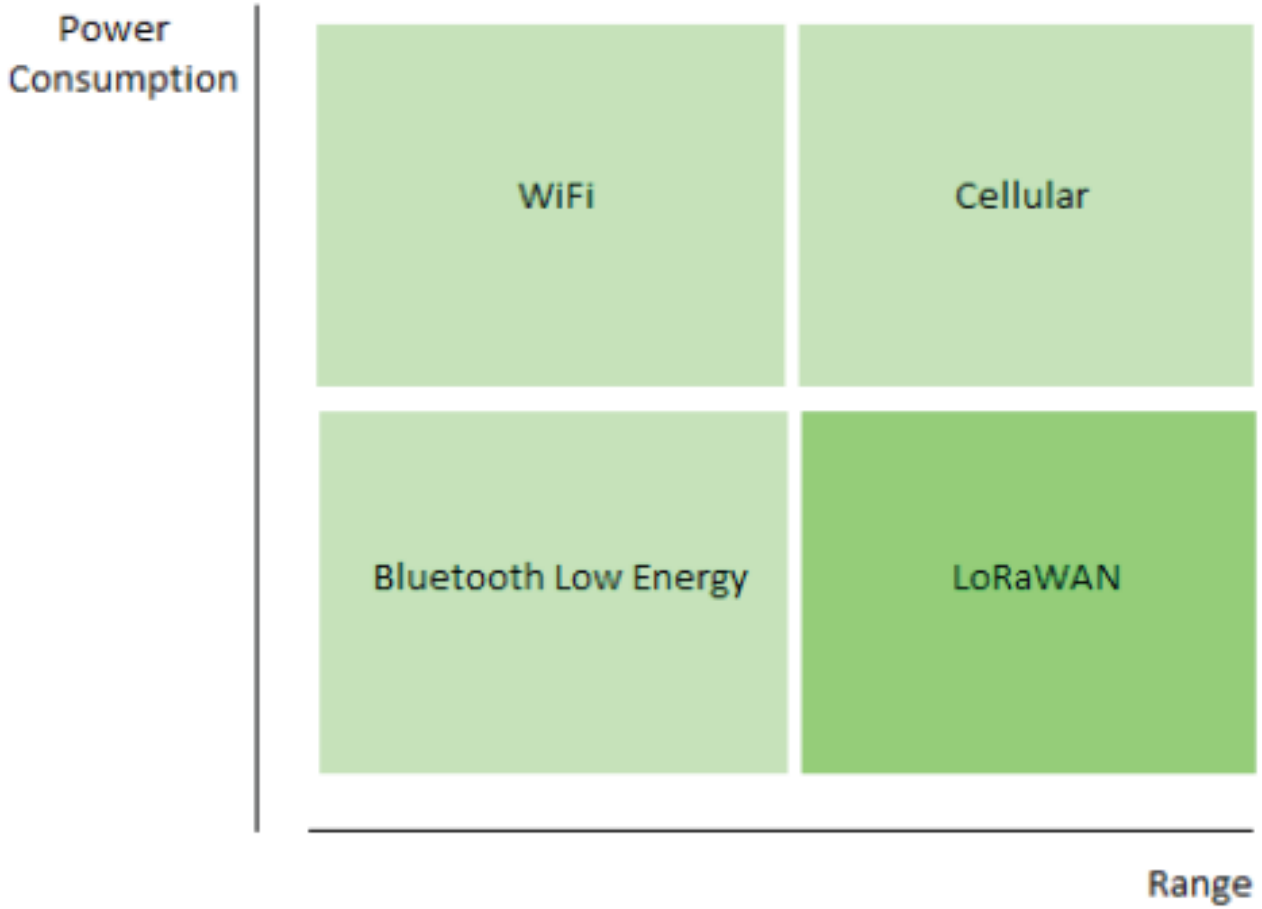
LoRa Frequency: Regional Summary

	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				

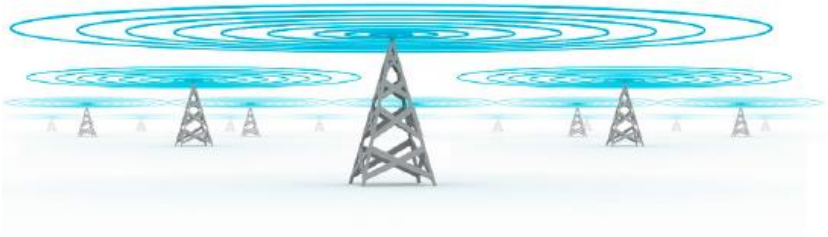
LPWAN Technology Comparisons

Feature	LoRaWAN	Narrow-Band	LTE Cat-1 2016 (Rel12)	LTE Cat-M 2018 (Rel13)	NB-LTE 2019(Rel13+)
Modulation	SS Chirp	UNB / GFSK/BPSK	OFDMA	OFDMA	OFDMA
Rx bandwidth	500 - 125 KHz	100 Hz	20 MHz	20 - 1.4 MHz	200 KHz
Data Rate	290bps - 50Kbps	100 bit/sec 12 / 8 bytes Max	10 Mbit/sec	200kbps – 1Mbps	~20K bit/sec
Max. # Msgs/day	Unlimited	UL: 140 msgs/day	Unlimited	Unlimited	Unlimited
Max Output Power	20 dBm	20 dBm	23 - 46 dBm	23/30 dBm	20 dBm
Link Budget	154 dB	151 dB	130 dB+	146 dB	150 dB
Batery lifetime - 2000mAh	105 months	90 months		18 months	
Power Efficiency	Very High	Very High	Low	Medium	Med high
Interference immunity	Very high	Low	Medium	Medium	Low
Coexistence	Yes	No	Yes	Yes	No
Security	Yes	No	Yes	Yes	Yes
Mobility / localization	Yes	Limited mobility, No loc	Mobility	Mobility	Limited Mobility No Loc

Wireless Technology Comparisons



LoRaWAN: Advantages



Long Range

- Greater than cellular
- Deep indoor coverage
- Star topology

Max Lifetime

- Low power optimized
- 10-20yr lifetime
- >10x vs cellular M2M

LoRaWAN: Advantages

Multi-Usage

- High capacity
- Multi-tenant
- Public network

Low Cost

- Minimal infrastructure
- Low cost end node
- Open SW

Thank You !!