LoRa & LoRaWAN

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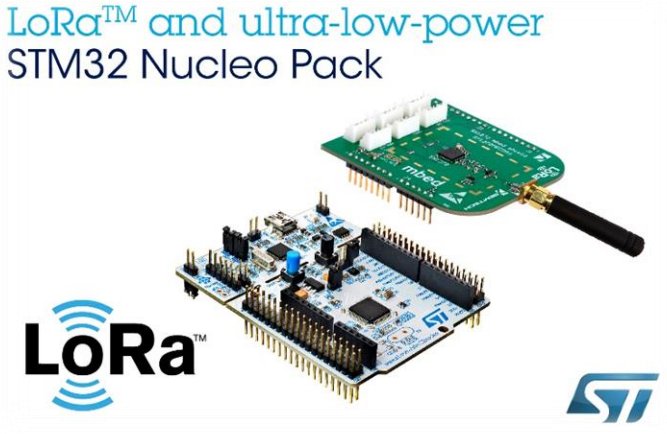
PRESENTATION CONTENT

- LoRaWAN introduction.
- LoRa specifications *(in North American context)*.
- LoRaWAN PROS and CONS.
- LoRaWAN *vs.* other network technologies.
- LoRaWAN network architecture overview.
- My desired LoRa application in an IoT network.



LoRaWAN INTRODUCTION

A brief introduction of LoRaWAN in IoT.

BRIEF LoRaWAN INTRODUCTION

- LoRa and LoRaWAN?
- LoRaWAN is a LPWAN standard *(uses MAC as communication protocol)*.
- LoRaWAN connects and manages end nodes to the internet.
- LoRaWAN manages communication between end nodes and gateways.
- LoRaWAN becoming more popular in industry and cities today because...
- LoRaWAN unique characteristics:
  - *Long operating range (~5 kilometers in urban and ~15 kilometers in rural areas).*
  - *Very long operating lifetime (low power consumption -> suitable for LPWANs).*
  - *Multi-usage operation (battery powered devices can last for years!).*
  - *Low operating cost.*
- Standard managed by the LoRa Alliance group and overseen by the ITU.

LoRaWAN devices

LoRa devices

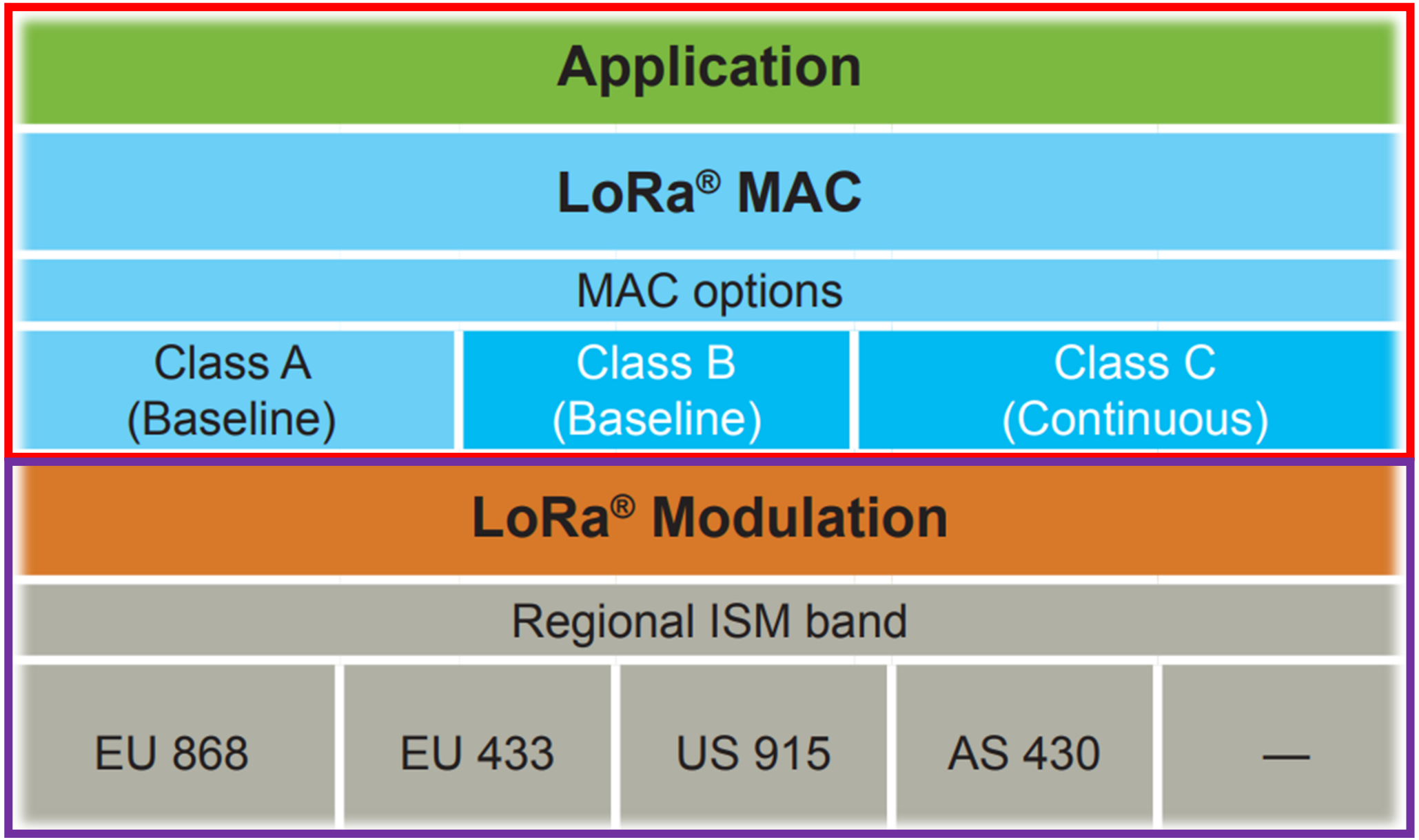


Figure 1. LoRaWAN & LoRa protocol stack.

LoRa SPECIFICATIONS

LoRa specifications in the North American context.

LoRa SPECIFICATIONS FOR NORTH AMERICA

- Other legacy wireless systems use Frequency Shifting Keying (FSK) modulation.
- LoRa uses Chirp Spread Spectrum (CSS) modulation.
- CSS has very robust and long-range transmission.
- LoRa can be operated on the license free sub-gigahertz band.
  - *Example: can be operated on the 915 MHz, 868 MHz and 433 MHz bands.*
- LoRa can also be operated on higher frequency bands.
  - *Example: can also be operated on the 2.4GHz band.*
- Exact specifications vary from region to region.

	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				

Figure 2. North America and global LoRa communication specifications.

64x 125kHz wide LoRa uplink channels (200kHz apart)

8x additional 500kHz wide LoRa uplink channels (1.6MHz apart)

8x 500kHz wide LoRa downlink channels (600kHz apart)

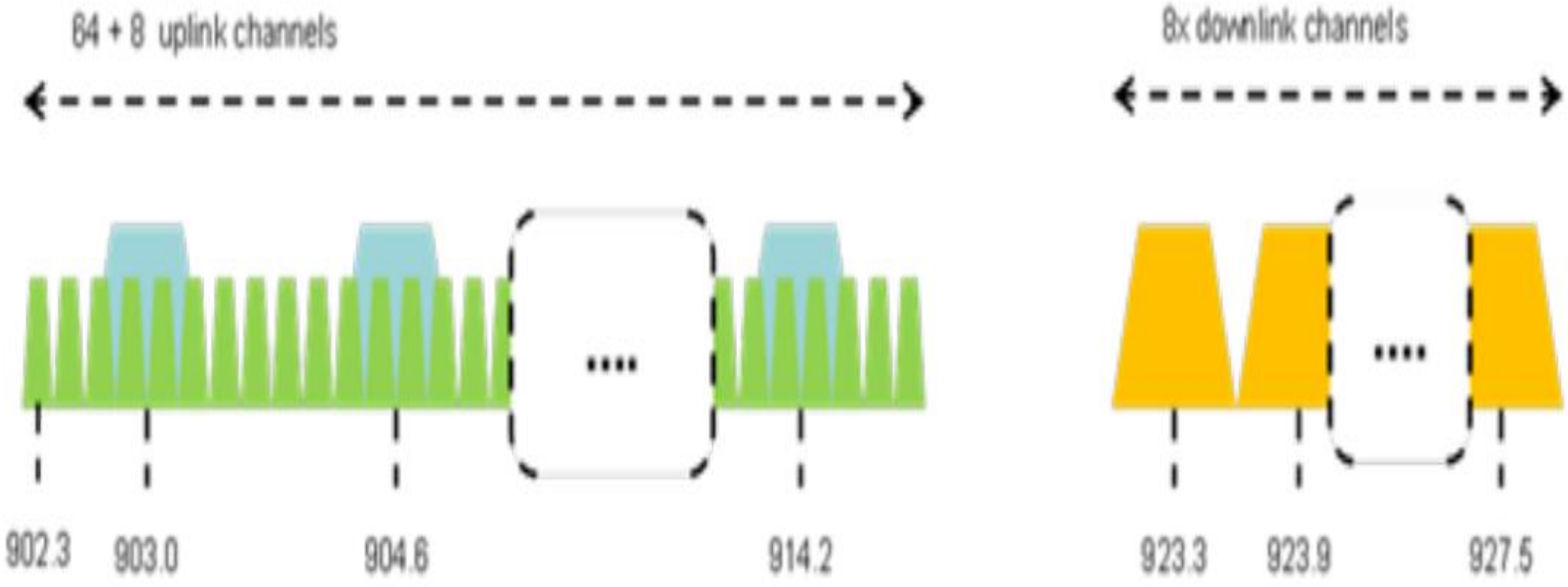


Figure 3. Typical LoRa communication spectrum for North America.

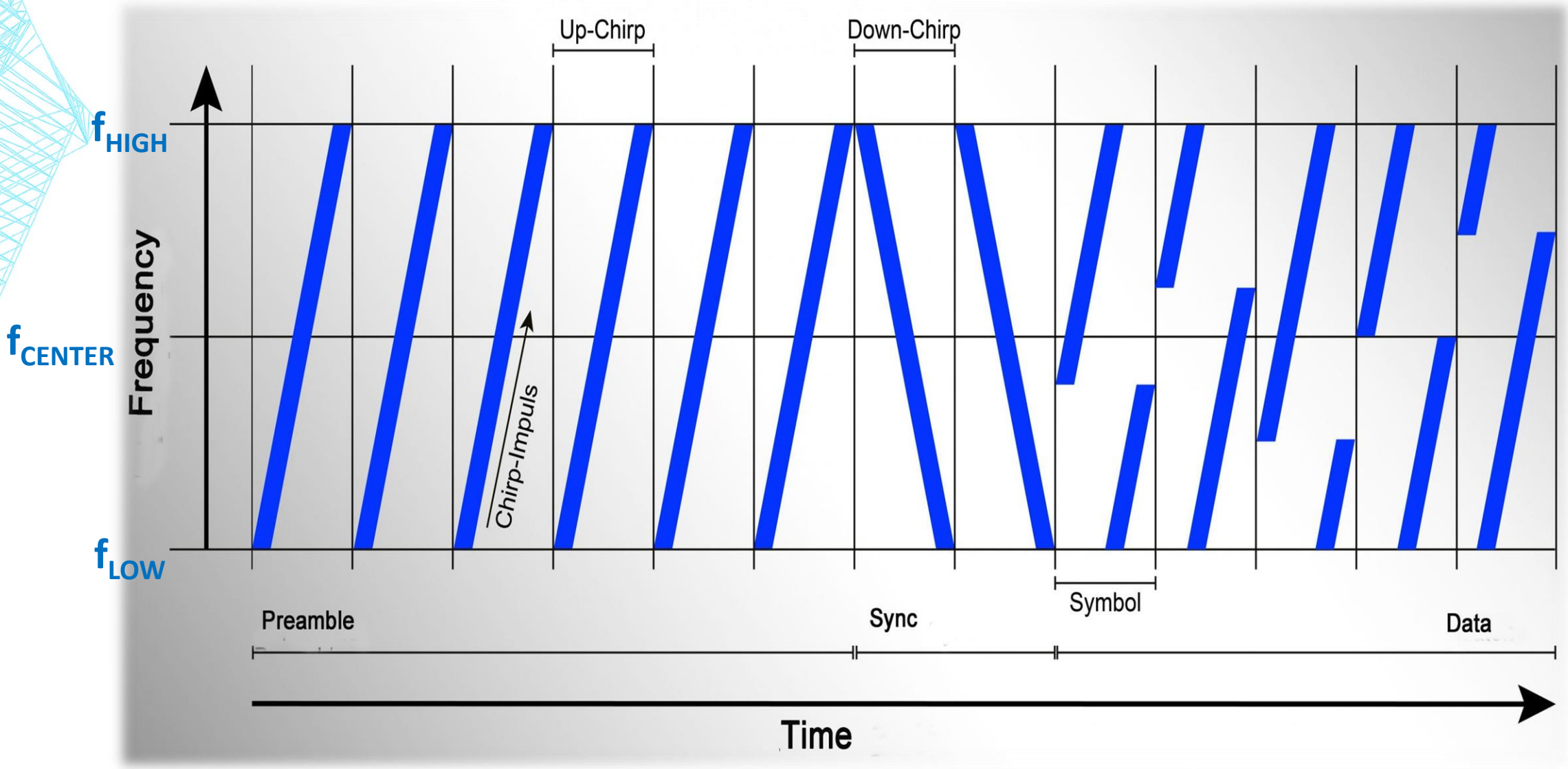


Figure 4. Typical LoRa communication frame (modulated using CSS).

Figure 5. Proximus IoT network coverage in Belgium using LoRa.

LoRaWAN PROS & CONS

Advantages and disadvantages of LoRaWAN.

PROS AND CONS

LoRaWAN PROS

- Low power consumption.
- Low operating cost.
- Can be positioned anywhere.
- Long operating range.
- Minimal hardware required for operation.

LoRaWAN CONS

- Cannot handle high data rates easily.
- Operation limited to low data rates *(~around 27 kbps)*.
- Network size limited by transmission duty cycle.
- Not ideal for real-time applications.

LoRaWAN *vs.* OTHER NETWORK TECHNOLOGIES

LoRaWAN compared to other existing network technologies.

LoRaWAN *vs.* OTHER NETWORK TECHNOLOGIES

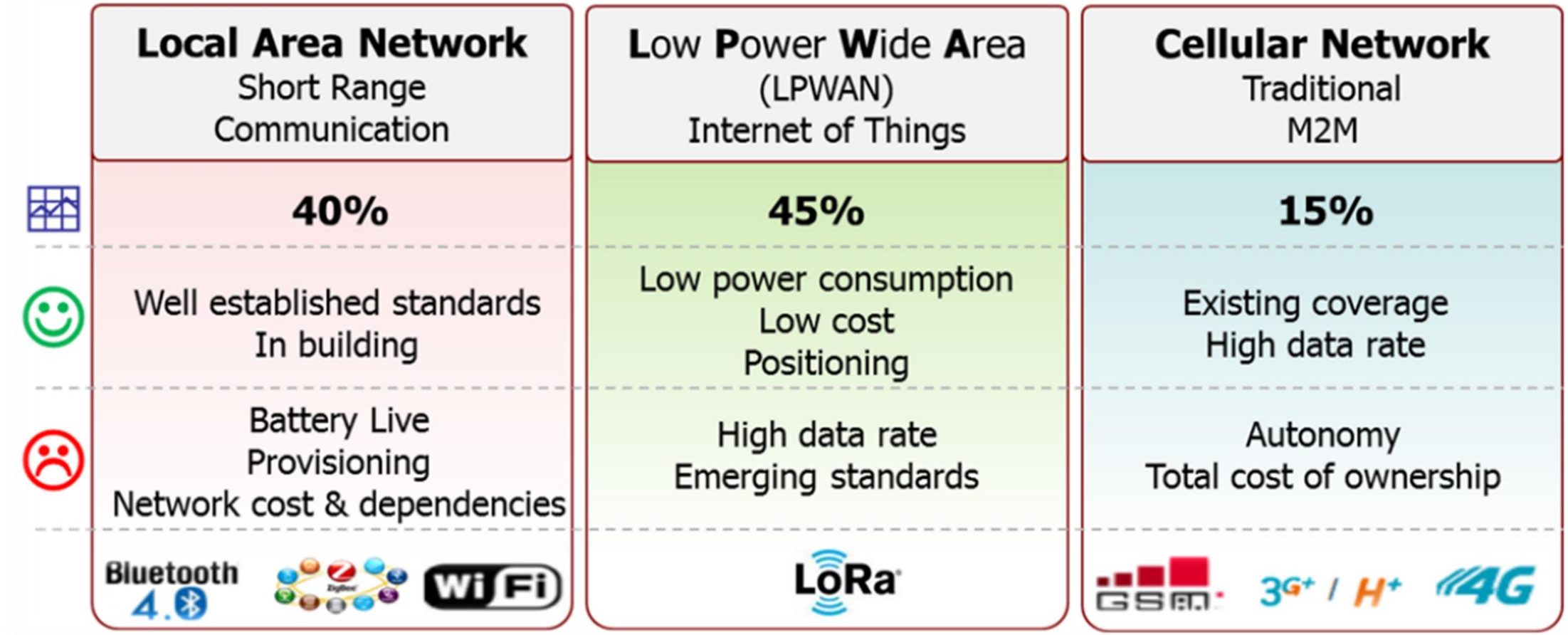


Figure 6. Major network technologies vs. LoRaWAN.

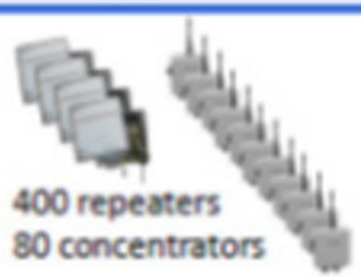
Feature	LoRaWAN	Narrow-Band	LTE Cat-1 2016 (Rel12)	LTE Cat-M 2018 (Rel13)	NB-LTE 2019(Rel13+)
Modulation	SS Chirp	UNB / GFSK/BPSK	OFDMA	OFDMA	OFDMA
Rx bandwidth	500 - 125 KHz	100 Hz	20 MHz	20 - 1.4 MHz	200 KHz
Data Rate	290bps - 50Kbps	100 bit/sec 12 / 8 bytes Max	10 Mbit/sec	200kbps – 1Mbps	~20K bit/sec
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

Figure 7. Major network technologies specifications vs. LoRaWAN specifications.

2000 apartments
80 buildings/staircases
Sensor cost equal

An average of 5 sensors/apartment (temperature, humidity and warm water consumption).
Fire detection optional.
Potential IoT revenue with LoRa.

M-Bus wireless



400 repeaters
80 concentrators

LoRa®

WM-Bus

CAPEX	Design, prep	4 000	€100/hour
	Repeaters	32 000	€80/each
	Concentrators	20 000	€250/each
	Installation	24 200	€55/hour
	SUM	€ 80 200	
REVENUE	Business logic & Statistics	36 842	Yearly occuring
	Billing, Invoice		

LoRa Network Operator

CAPEX	Design, prep	1 600	€100/hour
	GW	6 000	€1500/each (500apts/GW)
	Installation	880	€55/hour
	SUM	€ 8 480	
REVENUE	Business logic & Statistics		Yearly occuring
	Billing, Invoice		Yearly occuring
	Other IoT services		Occuring

Figure 8. Real life M-Bus wireless deployment vs. LoRa deployment done by Talkpool.

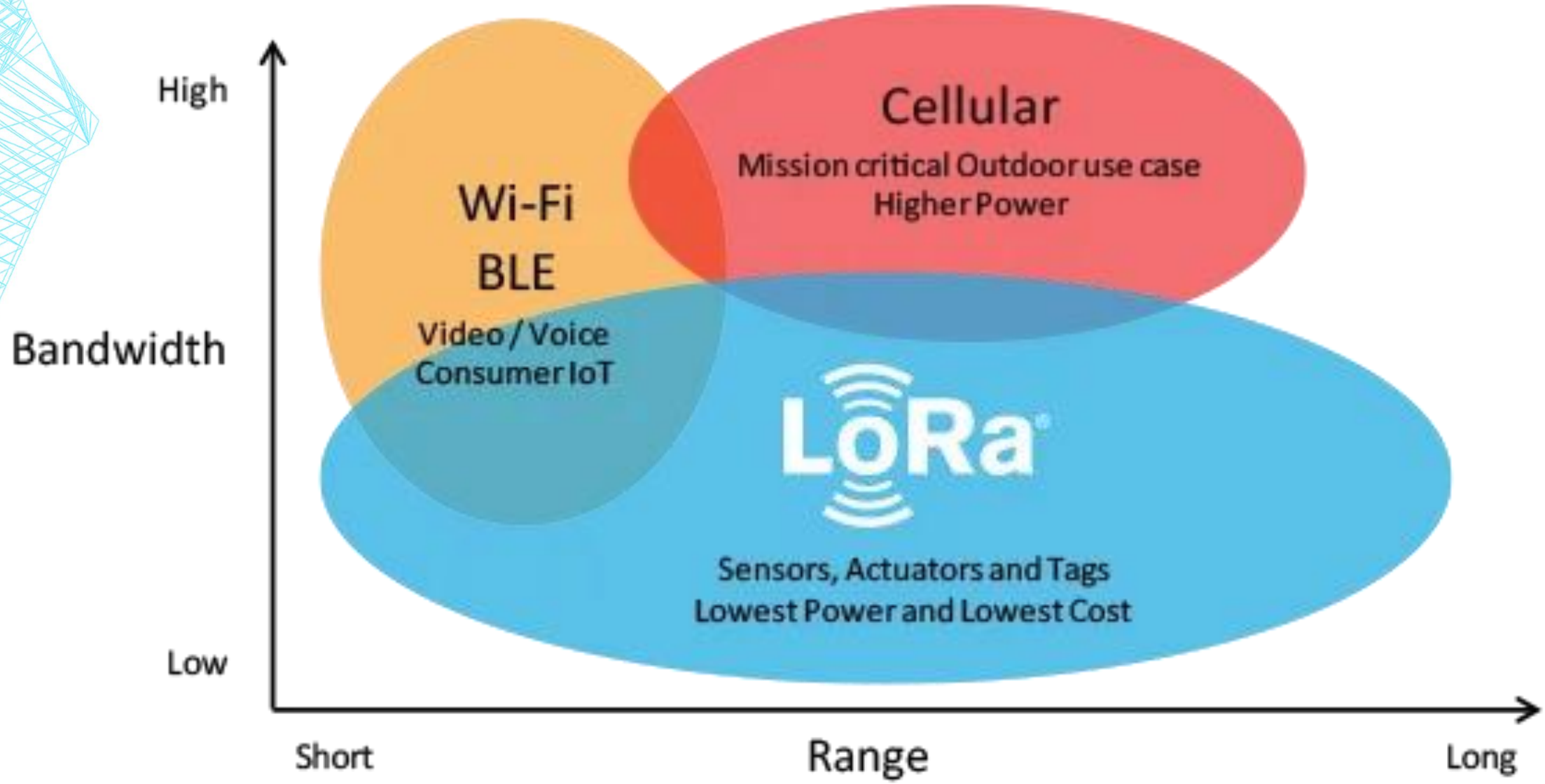


Figure 9. Graph showing bandwidth vs. range for various network technologies.

LoRaWAN NETWORK ARCHITECTURE OVERVIEW

A basic working LoRaWAN network architecture.

BASIC LoRaWAN NETWORK OVERVIEW

- Two main components:
  - *IoT end devices*.
  - *IoT network gateways*.
- LoRaWAN based on star architecture *(more efficient than mesh topology)*.
- End devices can communicate with multiple gateways and vice versa.
- Gateways forward data from end devices to other parts of the network.
  - *Example: gateways can forward data from end devices to the cloud*.
- All data processing and complexity handed off to a remote server.
  - *Example: server filters out redundant received packets, performs security checks, etc.*
- No handovers needed! *(good for tracking tasks)*

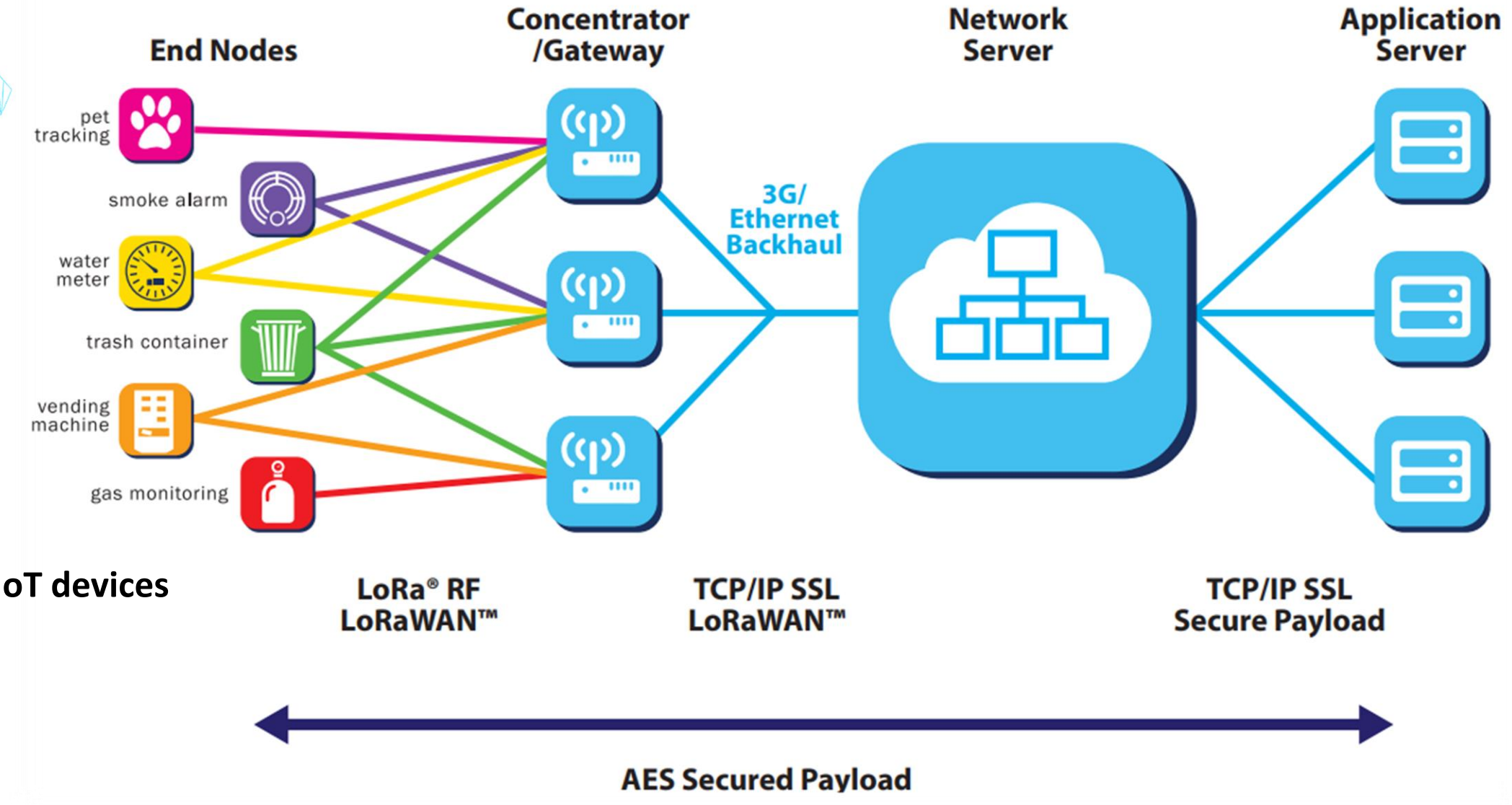


Figure 10. Typical LoRaWAN network topology.

DESIRED LoRa APPLICATION

My desired LoRa application in IoT.

MY DREAM LoRa APPLICATION

- A datacenter monitoring solution!
- Plan: deploy a large LoRa and LoRaWAN network *(using similar star topology)*.
- The job of the IoT network:
  - Monitor datacenter security.
    - *Example*: *monitor critical entry points, server cabinet access, emergency alarms, etc*.
  - Monitor datacenter power grid.
    - *Example*: *monitor grid voltage, power consumption, UPS status (generators and batteries), etc*.
  - Monitor datacenter environmentals.
    - *Example*: *monitor datacenter room and server cabinet humidity, temperature, etc*.
- Datacenter monitoring solution will be a compact application accessible from anywhere.

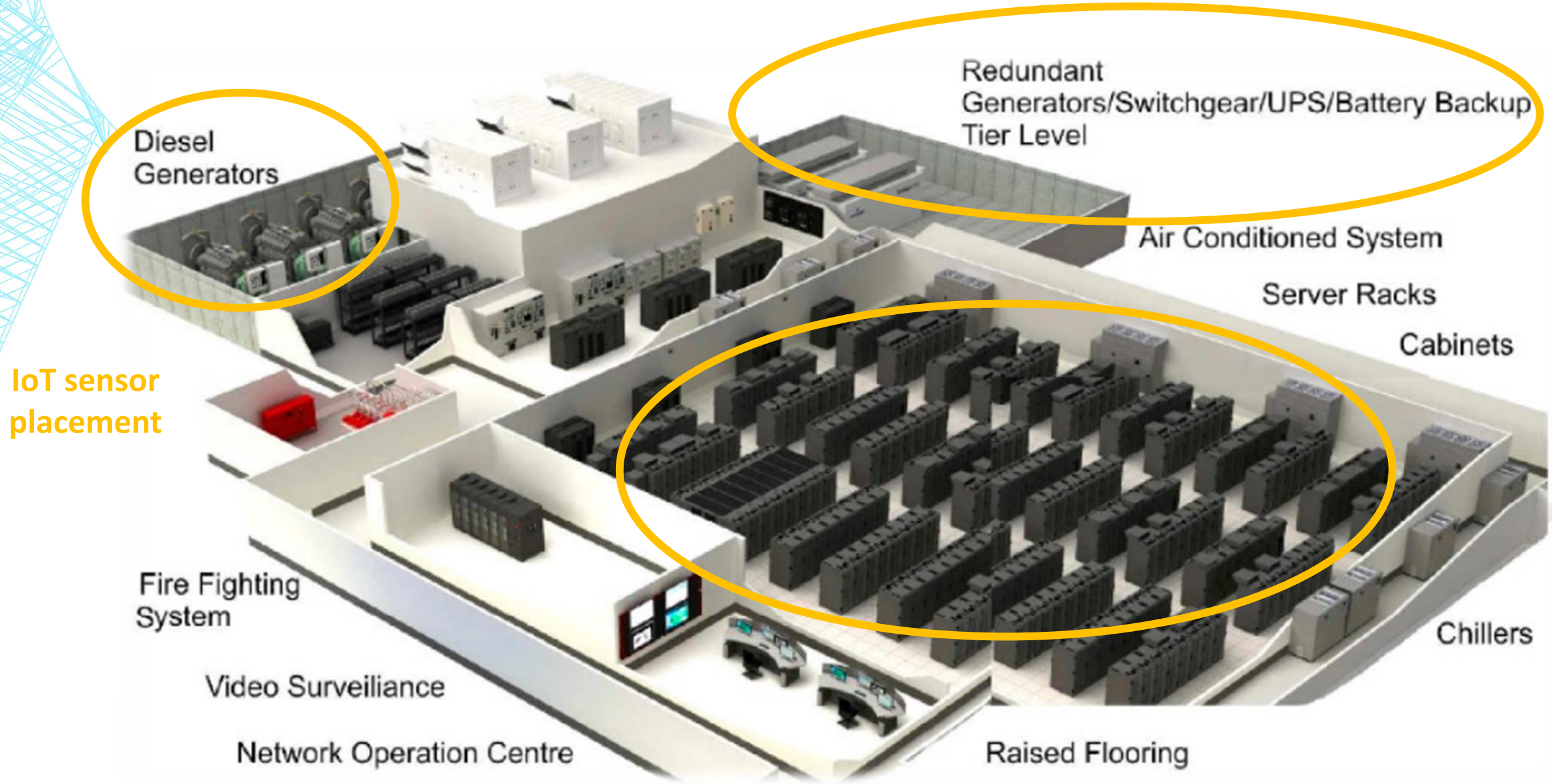


Figure 11. A typical datacenter with IoT sensor placement.

RESOURCES USED

- https://www.trendmicro.com/vinfo/us/security/definition/lorawan#:~:text=LoRaWAN%20is%20a%20low%2Dpower,node%20devices%20and%20network%20gateways.
- https://lora-alliance.org/wp-content/uploads/2020/11/what-is-lorawan.pdf
- https://www.thethingsnetwork.org/docs/lorawan/what-is-lorawan/
- https://www.youtube.com/watch?v=lg0eZWZFKiE

THANK YOU!

Thank you for listening to my presentation on LoRa and LoRaWAN.

Any questions?