



IOT TRAINING SESSION #1 | ISEP | © 2021-24 TG

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# INTERNET OF THINGS

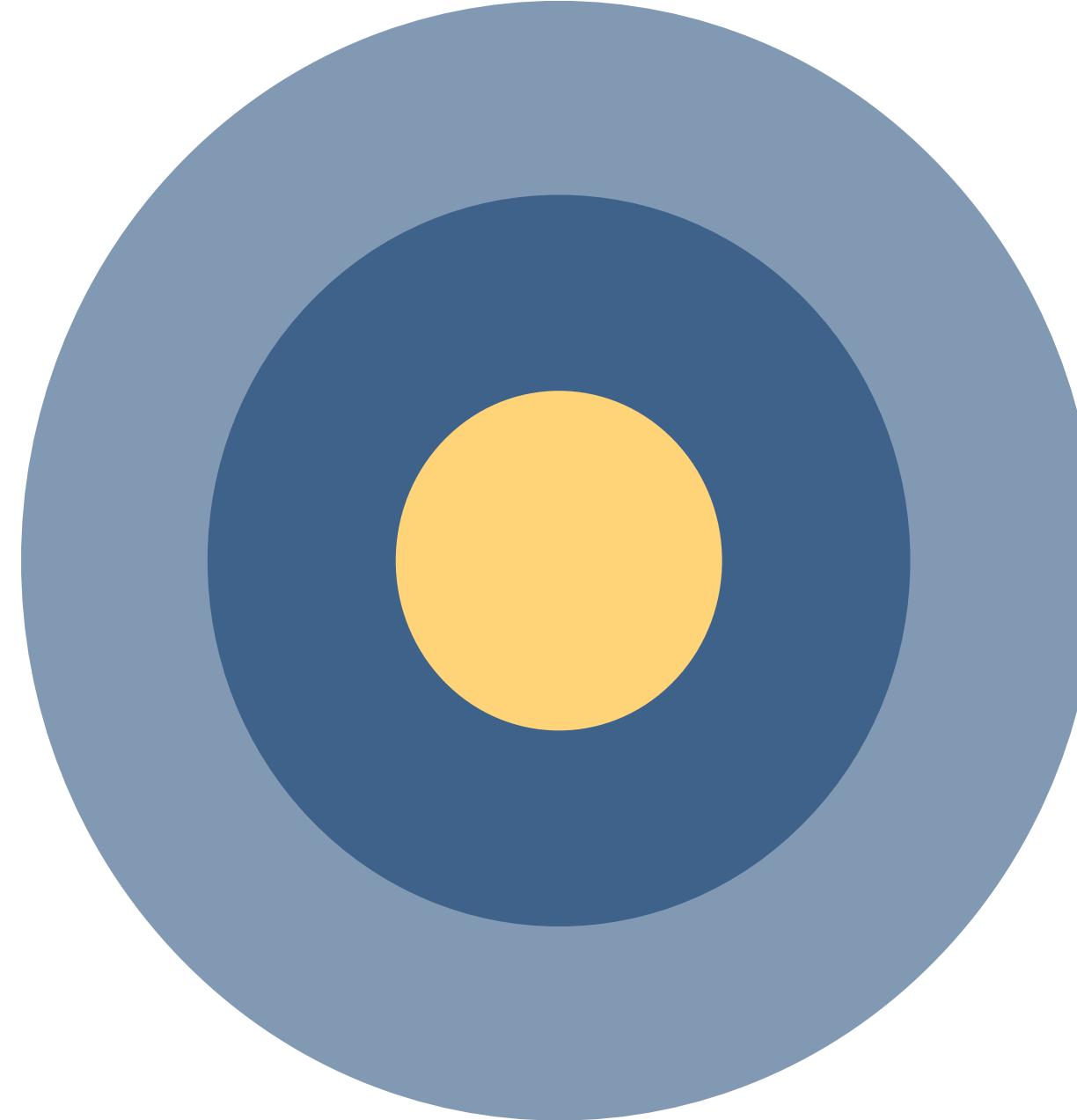
“EVENTUALLY, EVERYTHING CONNECTS –  
PEOPLE, IDEAS, OBJECTS.

THE QUALITY OF  
THE CONNECTIONS  
IS THE KEY  
TO QUALITY PER SE.”

Charles Eames, 1907–1978



# IOT IS NOT JUST ABOUT CONNECTING OBJECTS



**WHY?** & WHY SHOULD YOU CARE?

**HOW?** & HOW CAN YOU START?

**WHAT?** & WHAT'S IN FOR YOU?

# AGENDA

IoT architectures: sensors to apps

Design

IoT devices, networks & platforms

Marketing

IoT data, privacy & security

Economy

Digital transformation & perspectives

Sustainability

IoT verticals, use-cases & success stories



TO GIVE YOU KEYS  
TO BUILD/RUN IOT PROJECTS



# AGENDA

Session 1

# AGENDA

## Fundamentals: standards, networks, protocols

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# IOT / B2C

Consumers market

# R.I.P. GADGETS



NABAZTAG-KAROTZ  
(2005–2015)



FLOWER POWER  
(2013–2020)



SMART TOASTER  
(2017–2017)

# SUCCESS: MICRO MOBILITY



SCOOTERS



TRACKERS



ANTITHEFT DEVICE  
for motorcycles

# SUCCESS AT LAST: SMART HOME



COMFORT



ENERGY



SECURITY

# STEADY GROWTH: ASSISTANCE



SENIORS



ALZHEIMER

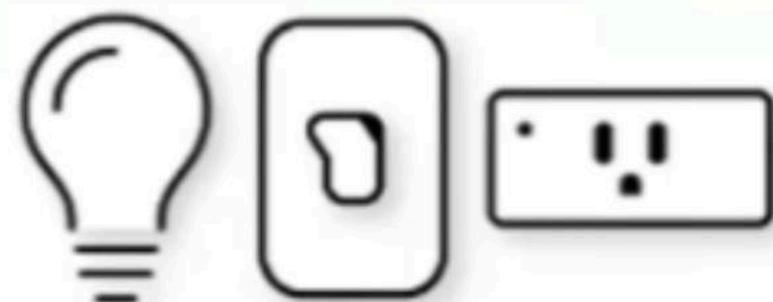


EHPADS

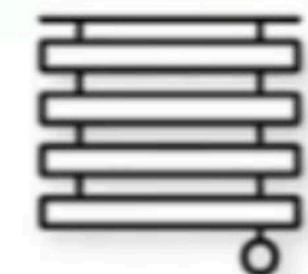
# GAME CHANGER: NEW INTEROPERABILITY



# matter



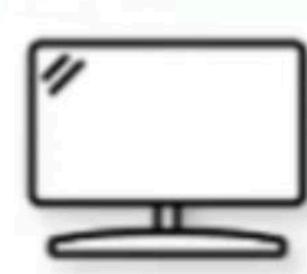
Lighting, Electrical



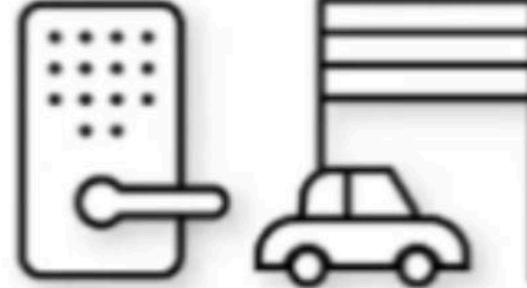
Blinds/Shades



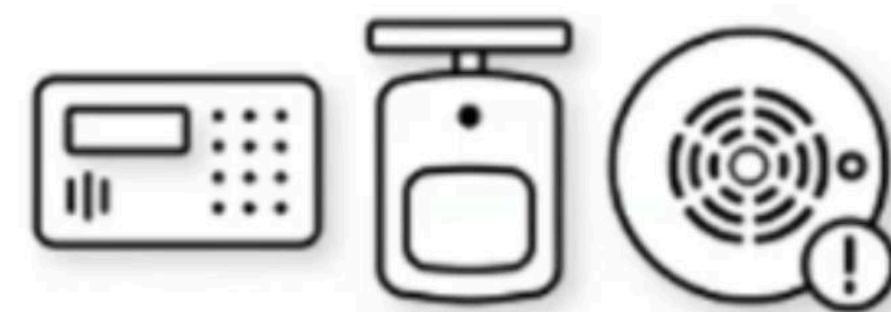
HVAC Controls



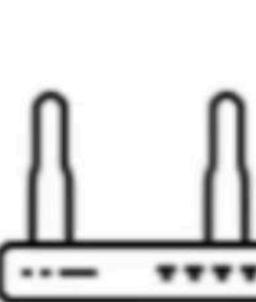
TVs



Access Control



Safety & Security



Access Points, Bridges





THE INTERNET OF THINGS



© marketoonist.com



# IOT: HOME AUTOMATION

Energy • Security • Comfort

# SECURITY

Intelligent Door Locks  
for campuses

Devices deploy simply &  
connect immediately



# ALARM

anti-jamming  
alarm systems



# WATER BREAKER

Stop-Flow

turns water off  
automatically  
in case of leakage  
or abnormal flow





# SMART HOME PARTNERSHIPS

Somfy Tahoma & Connexoon  
Orange Livebox

direct control of connected  
blinds/shutters

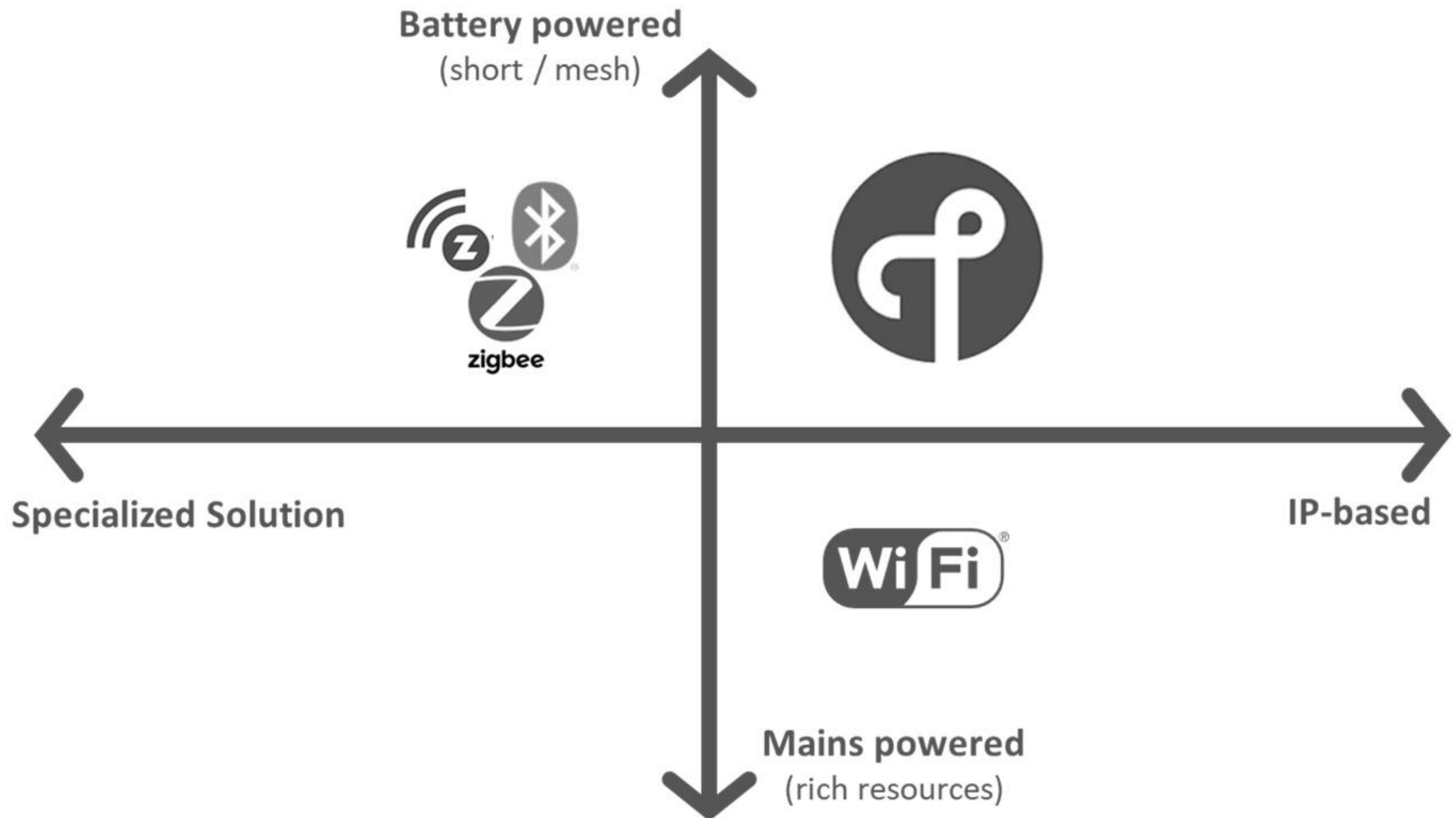




# IOT: HOME AUTOMATION

Connectivity

# RF TECHNOLOGIES



# RF TECHNOLOGIES

	Thread	Bluetooth	Zigbee
Radio Standard	IEEE 802.15.4 (WSN)	Bluetooth owned	IEEE 802.15.4 (WSN)
Range / Topology	Short / Mesh	Short / Point to Point (Except BT Mesh)	Short / Mesh
Power / Resources	Battery / Efficient	Batterly / Efficieint	Batterly / Efficieint
Application layer	Application agnostic	Bluetooth owned	Zigbee owned
Security	IP-Based protocols + Built-in	Built-in	Built-in
Advantage	IPv6 (compatible with the internet)	Ubiquitous, Location Services	Stable and mature
Use-Cases	Smart Home Ecosystems, Lighting, Building Automation	Consumer Electronics, Lighting, Asset Tracking	Smart Home, Smart Security, Smart Meters, Lighting
Thread brings IP to mesh networking protocols			

# THREAD

**Bringing IP seamlessly to low-power, constrained, and mesh devices in smart-home & smart-buildings**



CHIP, HomeKit, OpenWeave, KNX

IP Networking

802.15.4 Radio

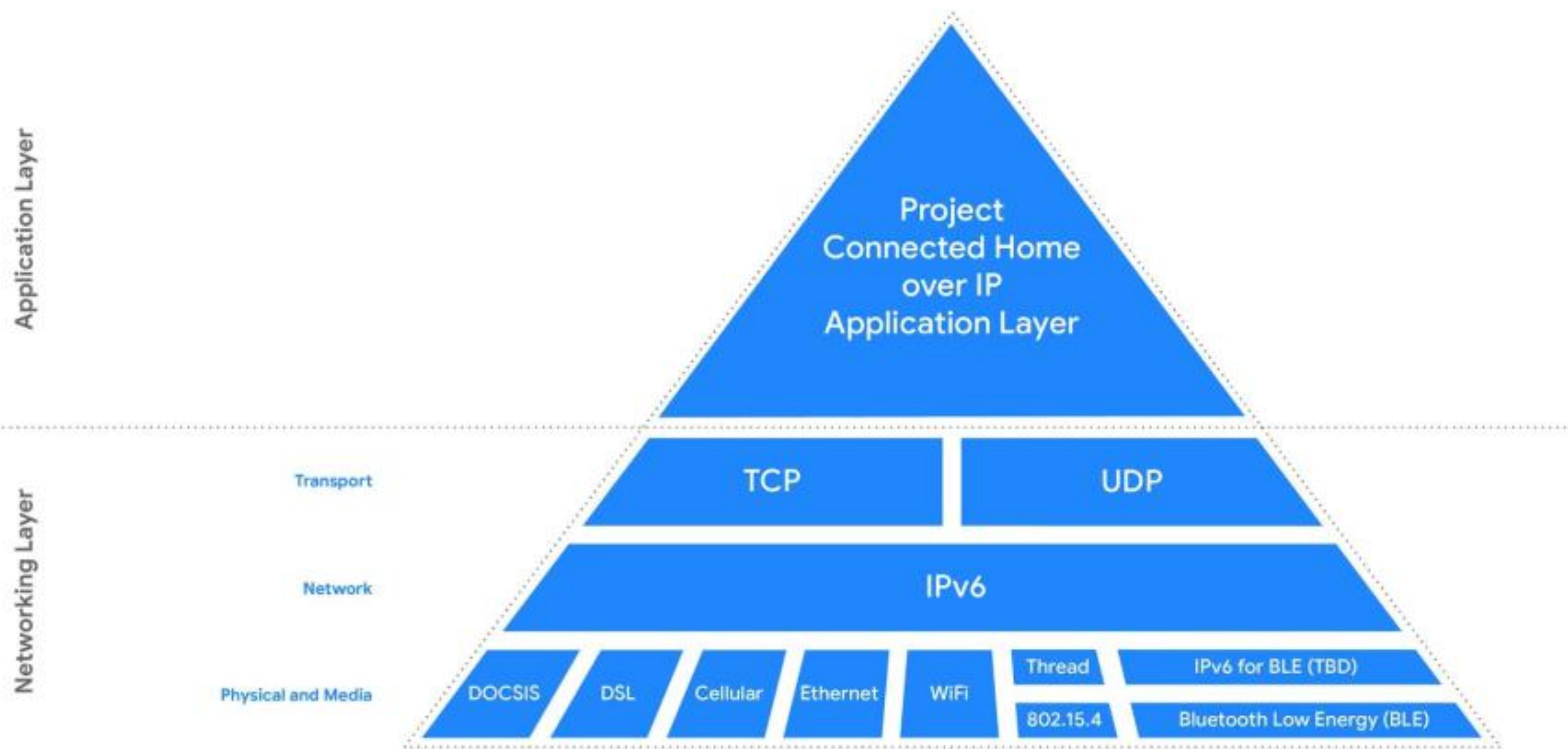
THREAD

Thread is based on IEEE 802.15.4  
low-power, self-healing mesh protocol.

Silicon providers can offer reliable,  
low-cost, low-volume, and power-  
efficient SoCs for Thread end nodes.

# CHIP > MATTER

Amazon, Apple, Google, and the Zigbee Alliance have joined hands to promote the formation of the Working Group driving the Connected Home over IP project: CHIP.



# CHIP > MATTER



ASSA ABLOY



COMCAST



Google

LEEDARSON



legrand®

OPPO

TEXAS  
INSTRUMENTS

OLUTRON

NXP

resideo

SILICON LABS

SmartThings

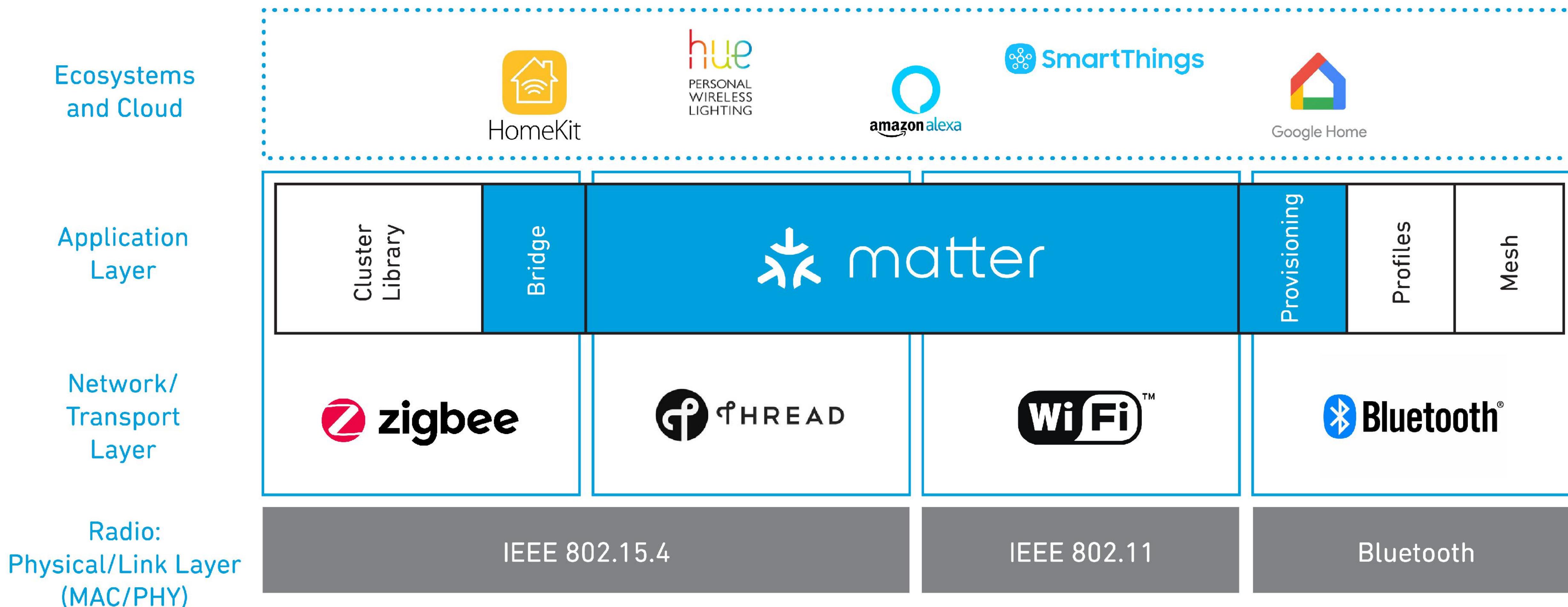
Schneider  
Electric™

signify

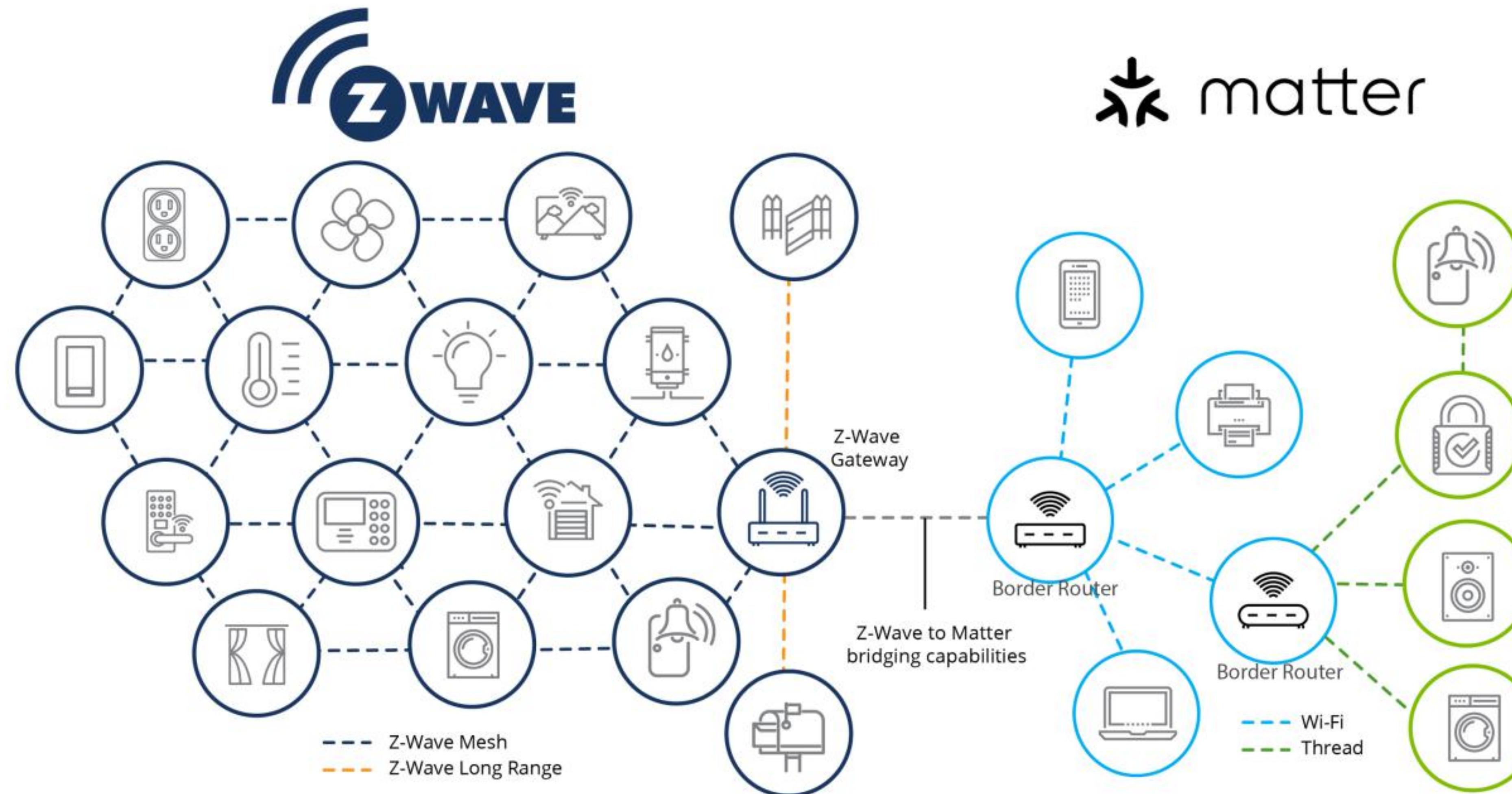
somfy®

Wulian®

# CONVERGENCE MATTERS :-)



# CONVERGENCE VIA GATEWAYS



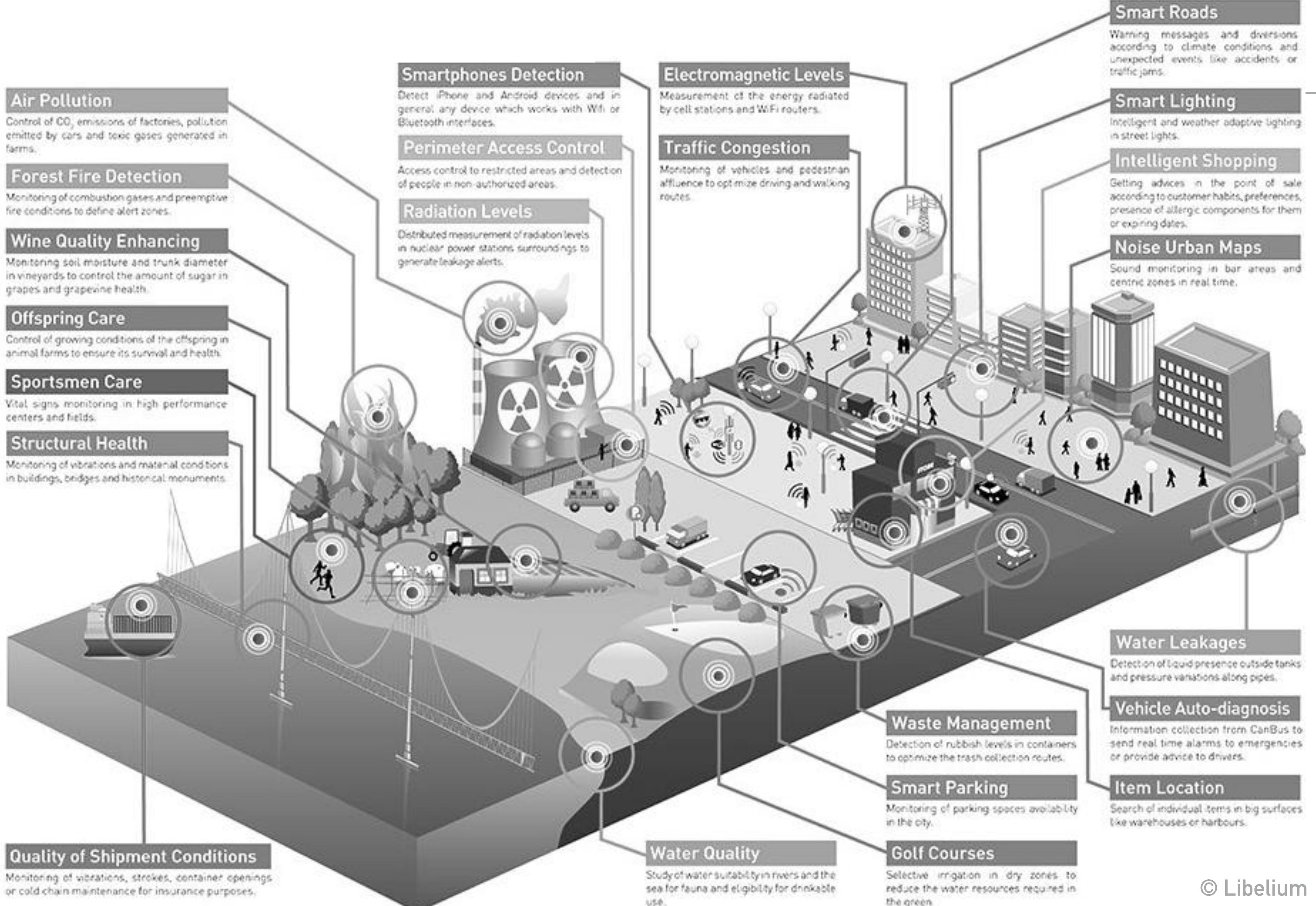
# CERTIFICATION





# IOT / B2B

IoT is the new M2M





Smart tracking:  
15,000 tools  
55,000 m<sup>2</sup>



# IDEAL CONNECTED DEVICE

"

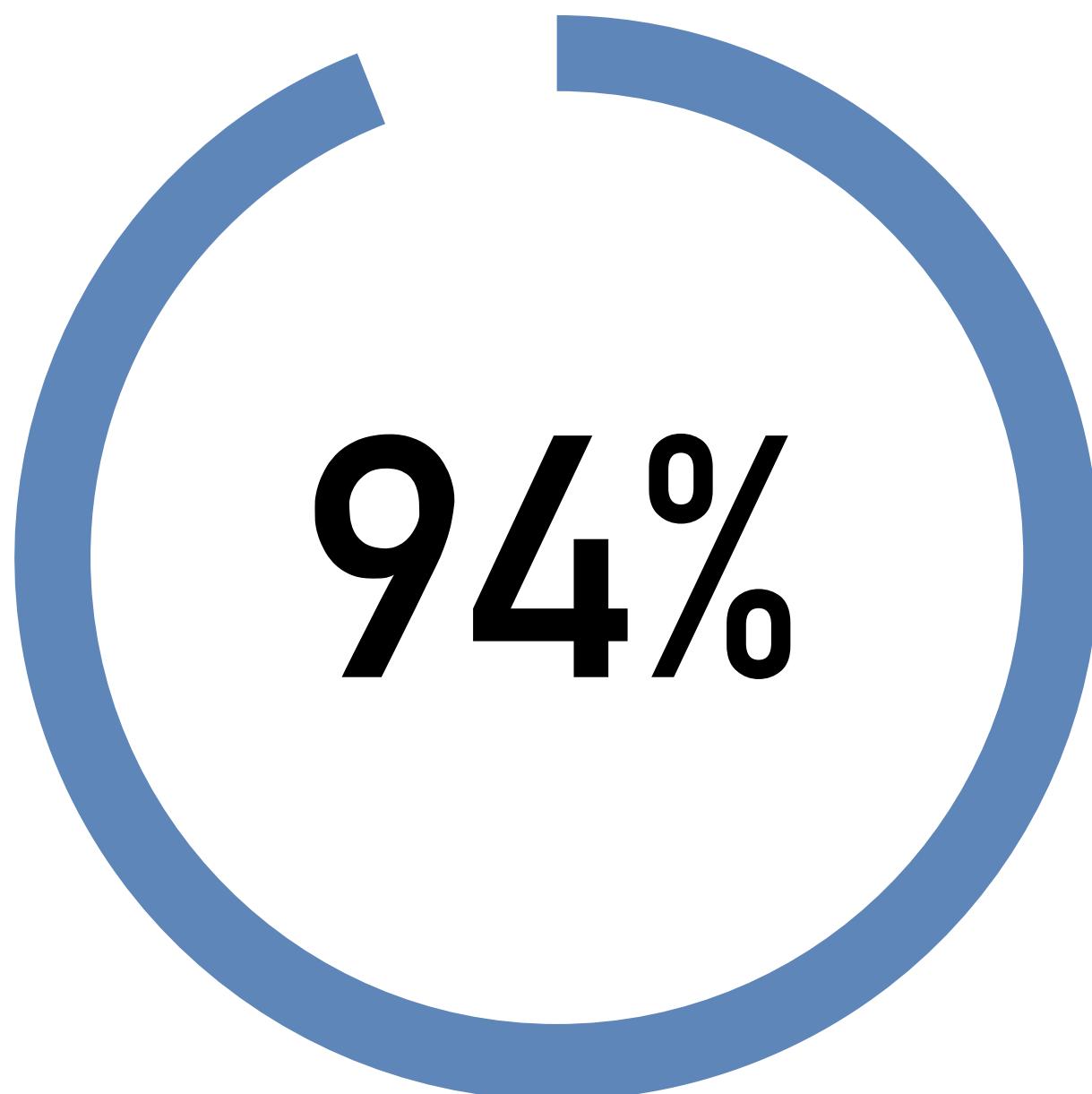
We'd like something small enough to put into every bolt-head, able to communicate anywhere, provide its manufacturing and environmental history and only responds to authorized requests.



Paul Stein  
CTO of Rolls-Royce

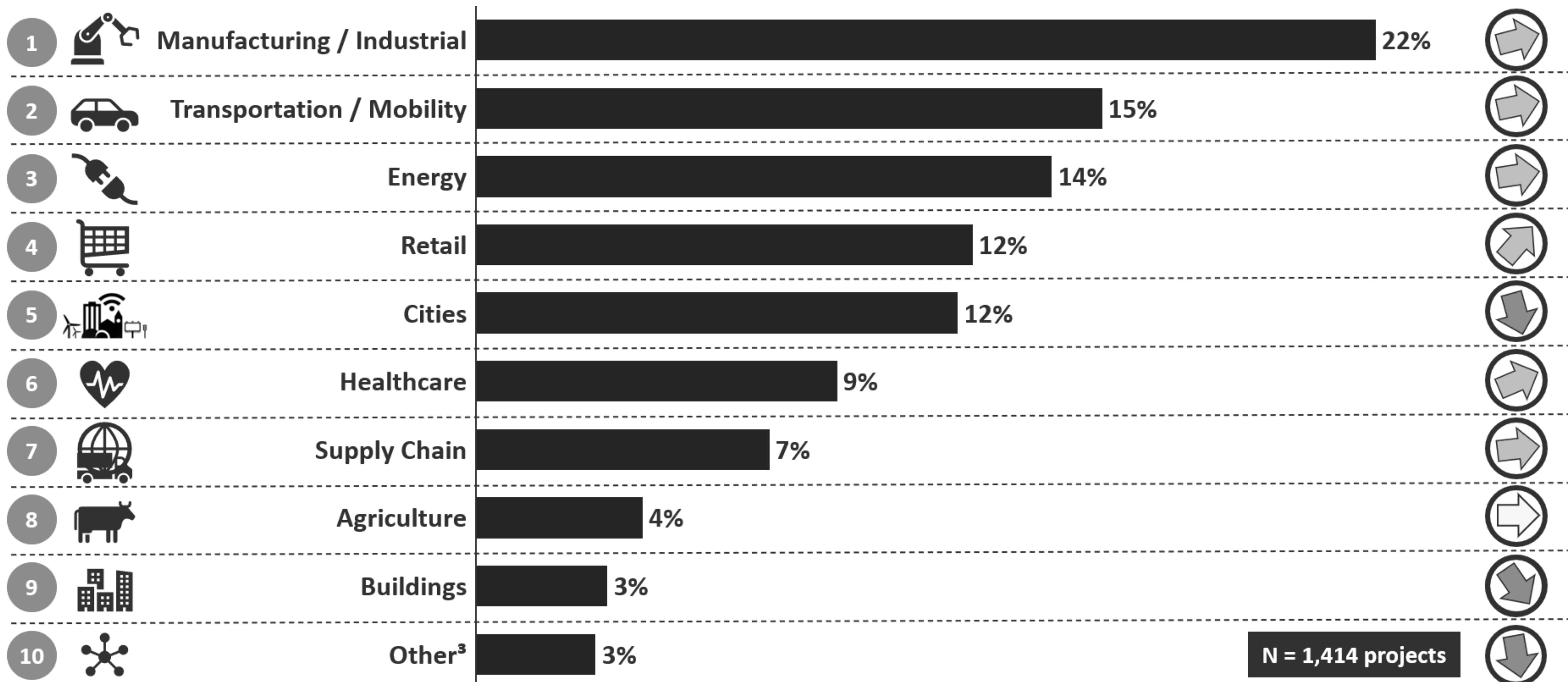


# IOT IS NOT AN OPTION



of businesses  
will be using IoT  
by end of 2021

# TOP10 IOT APPLICATIONS



Note: 1. Based on 1,414 publicly known IoT projects (not including consumer IoT projects eg smart home, wearables, etc.) 2. Trend based on relative comparison with % of projects in the 2018 IoT Analytics IoT project list e.g., a downward arrow means the relative share of all projects has declined, not the overall number of projects. 3. Other includes IoT projects from Enterprise & Finance sectors. Source: IoT Analytics Research - July 2020

Source: IoT Analytics, 2020

# IOT BENEFITS & DRIVERS

**Enhanced, connected customers relationship**

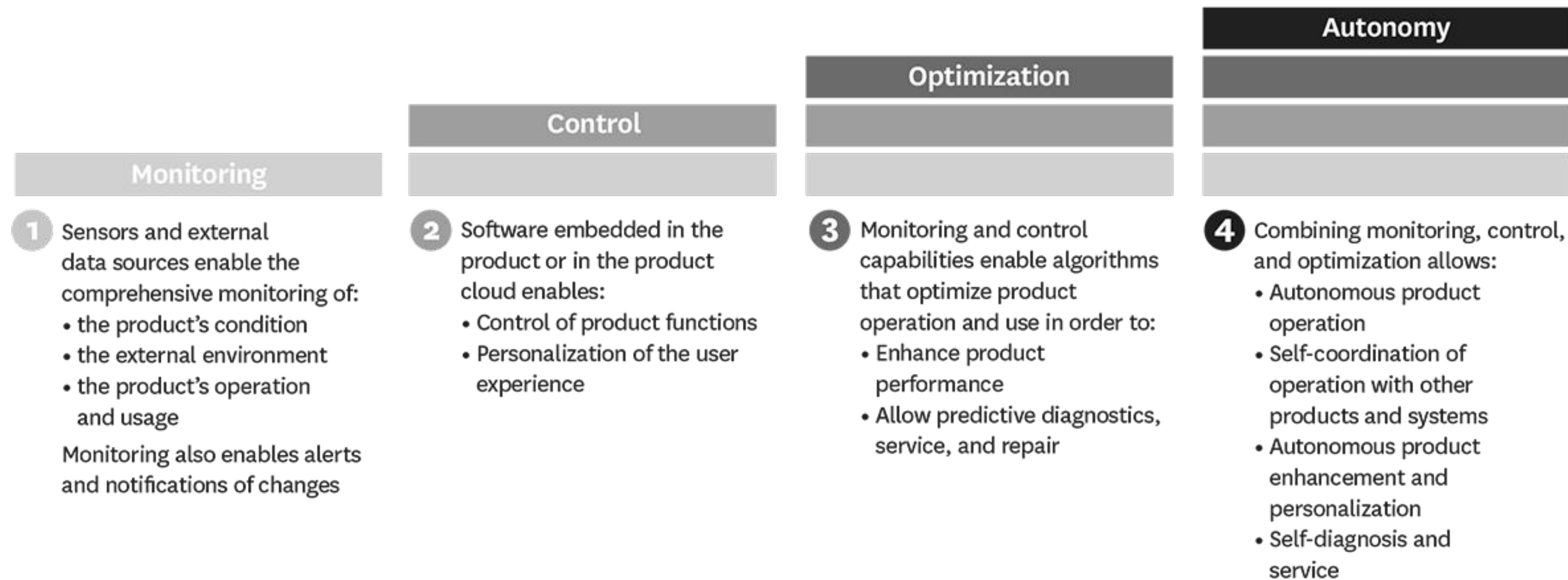
**Actual usage data analysis vs. early assumptions**

**Predictive maintenance to mitigate risks & downtimes**

**Enhanced productivity & quality control**

**Improved logistics / supply chain**

# IOT: FROM MONITORING TO AUTONOMY



# IOT PROJECTS SUCCESS RATIOS

**35%** According to  
Technical executives

**15%** According to  
Business executives

# IOT PROJECTS SUCCESS RATIOS

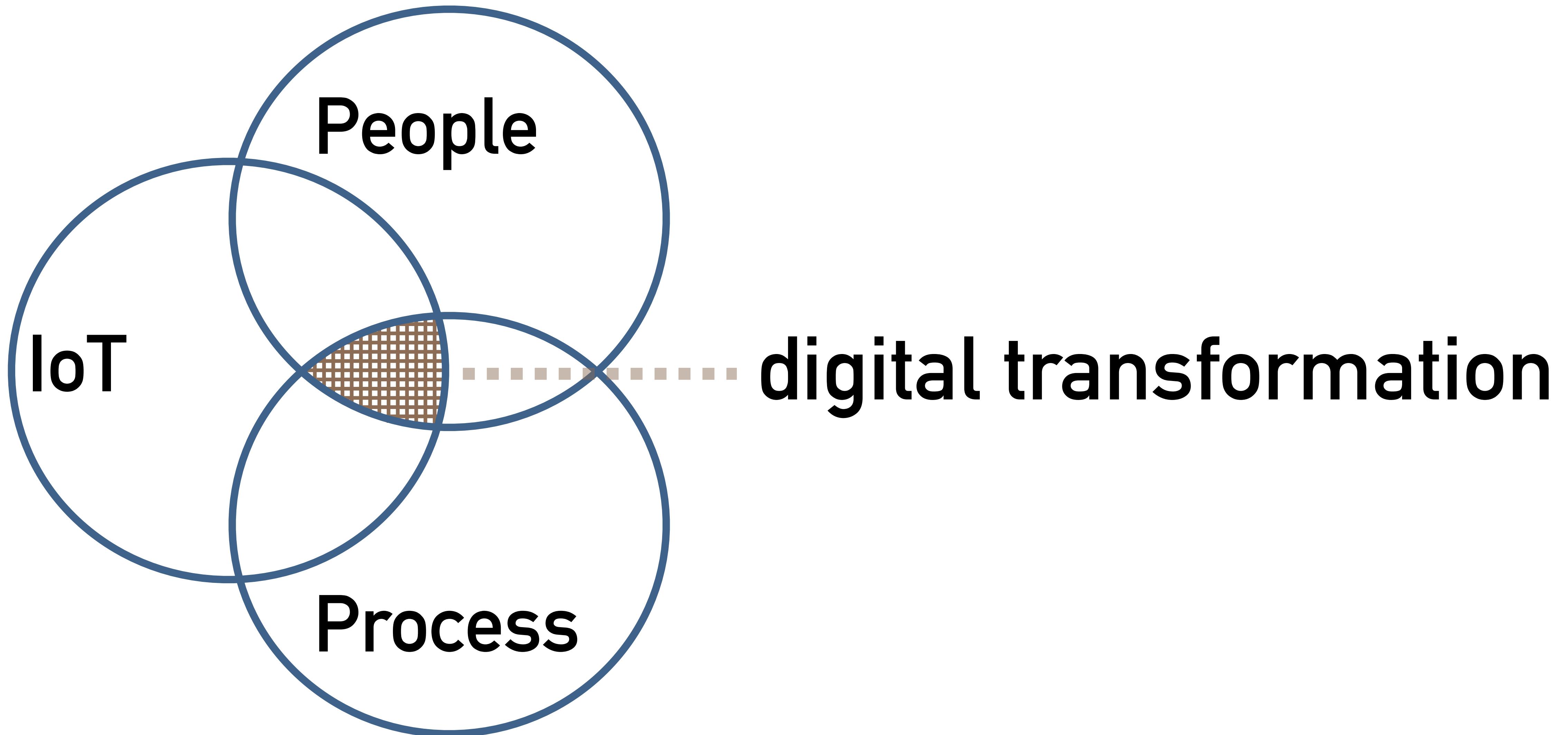


doing things right

≠

doing the right things

# IOT IS PART OF DIGITAL TRANSFORMATION



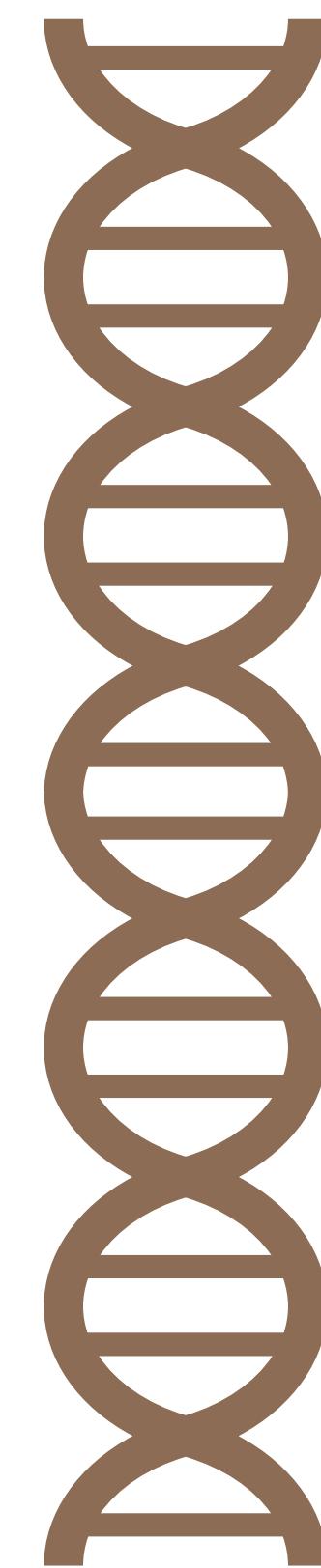
# IOT REQUIRES MULTIPLE PLAYERS

Device makers

Telecom operators

Solution editors

Client teams

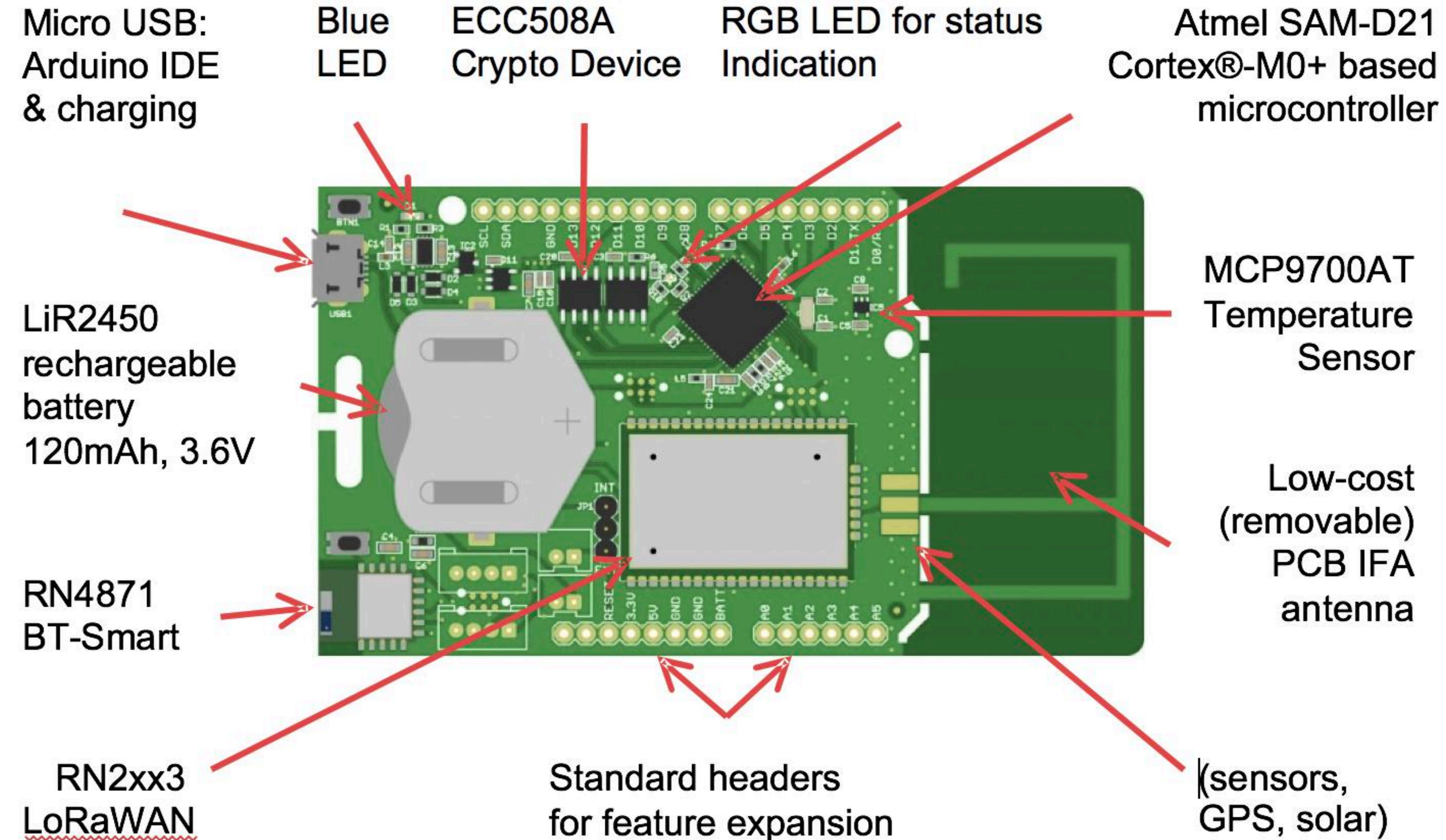


Design houses

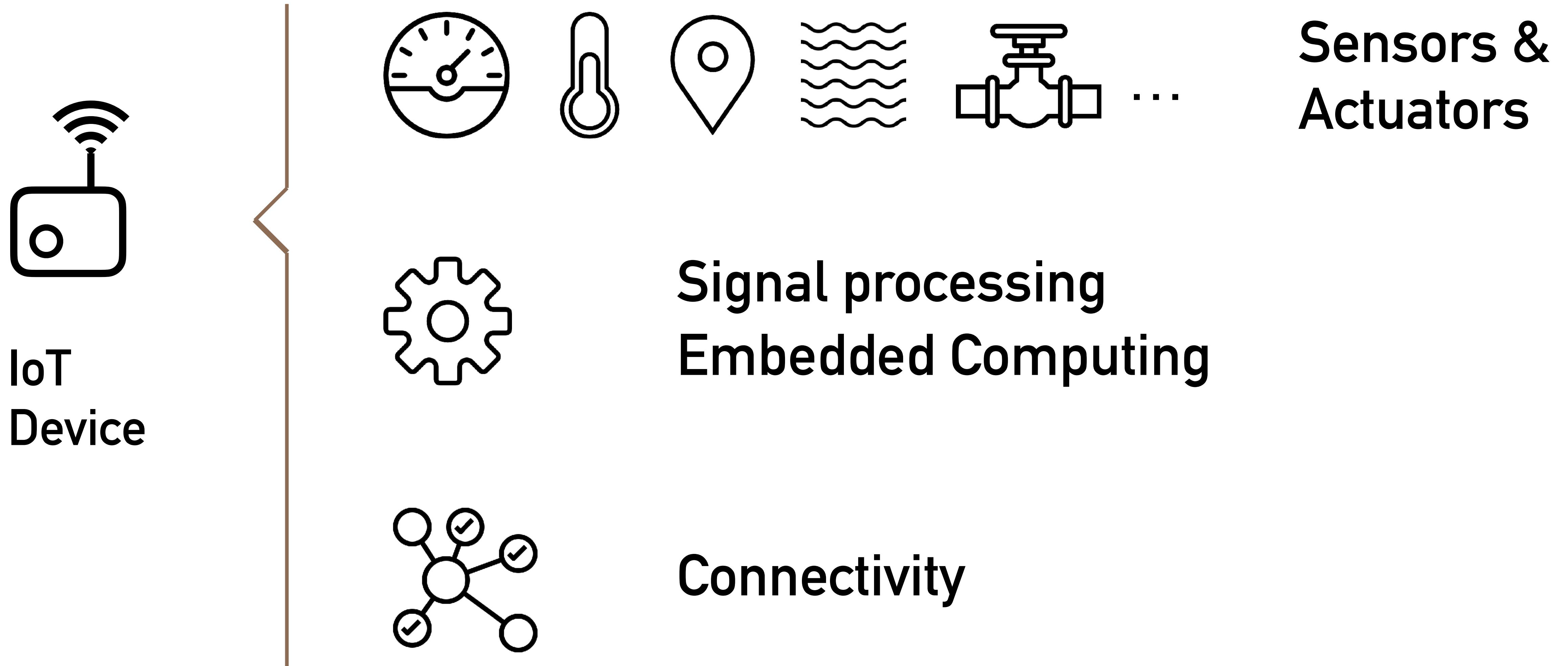
System integrators

Consultants

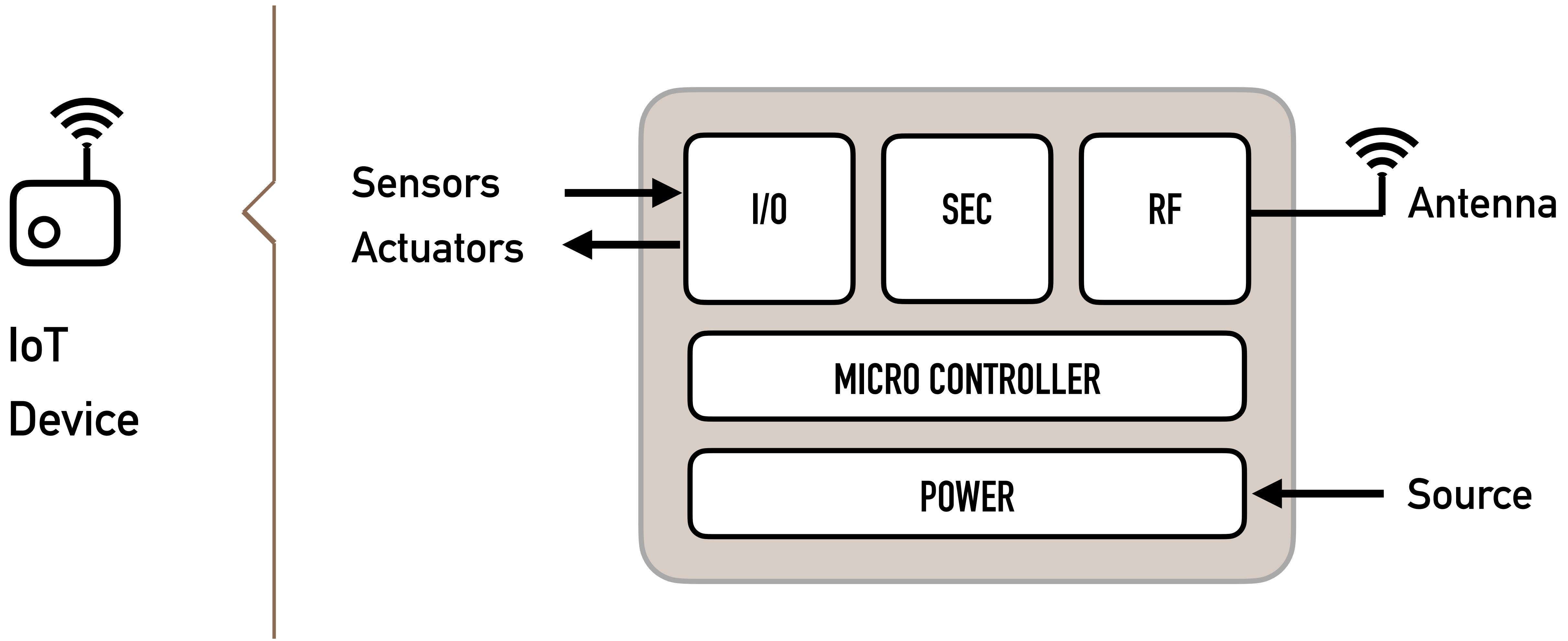
# IOT BOARD



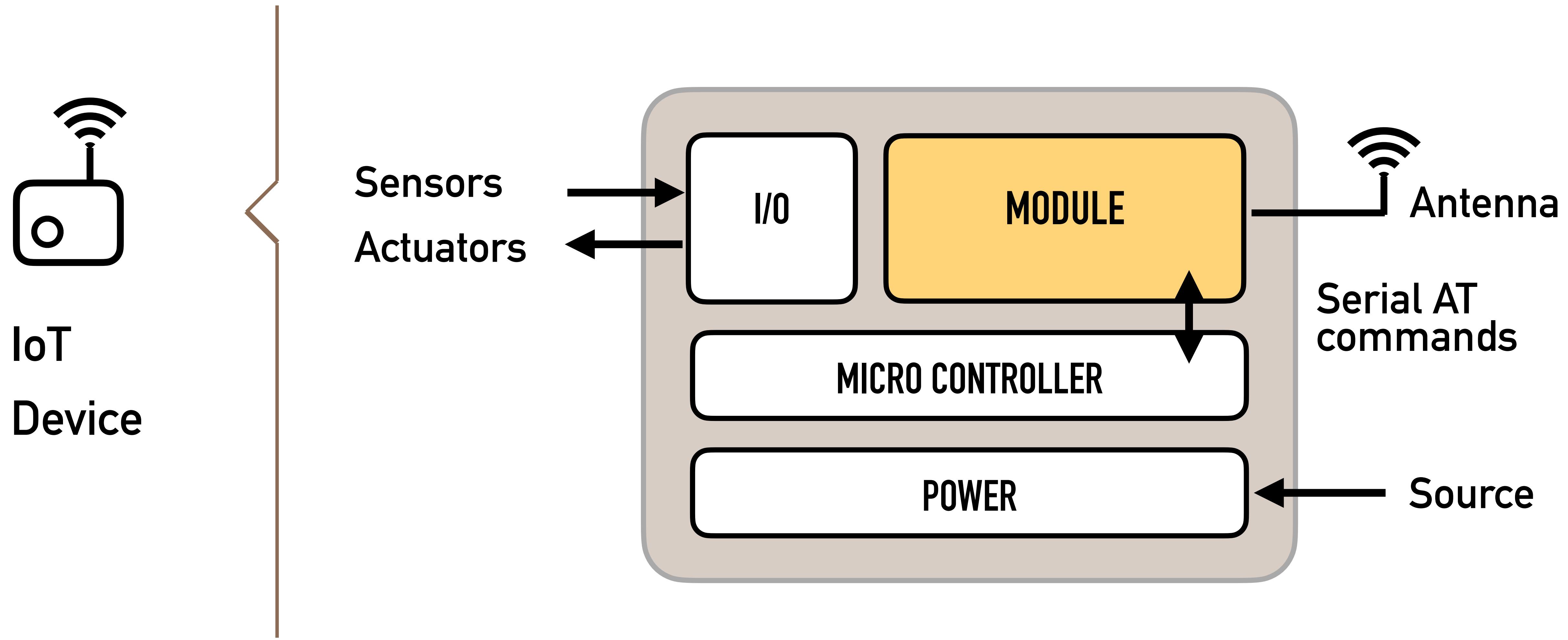
# IOT: PHYSICAL, SMART, CONNECTED DEVICES



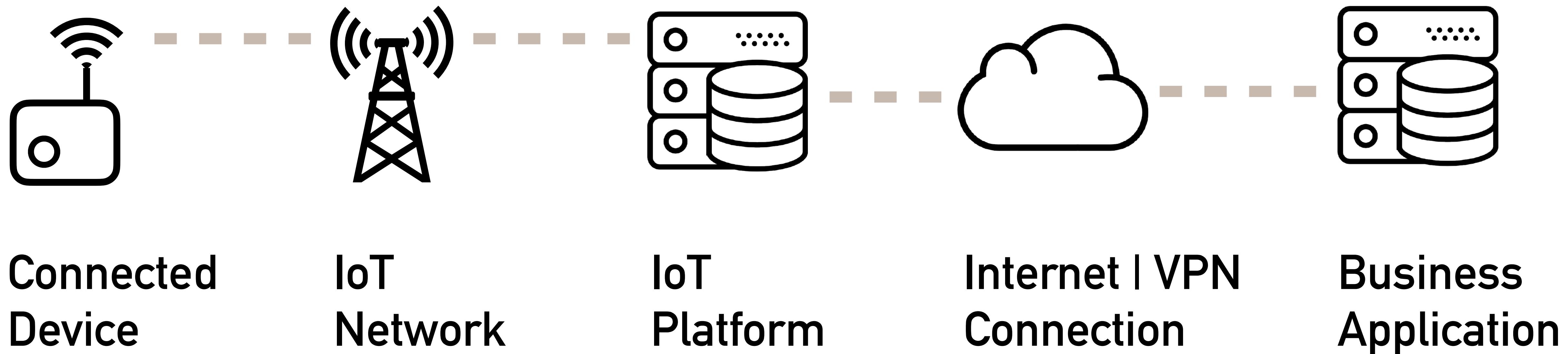
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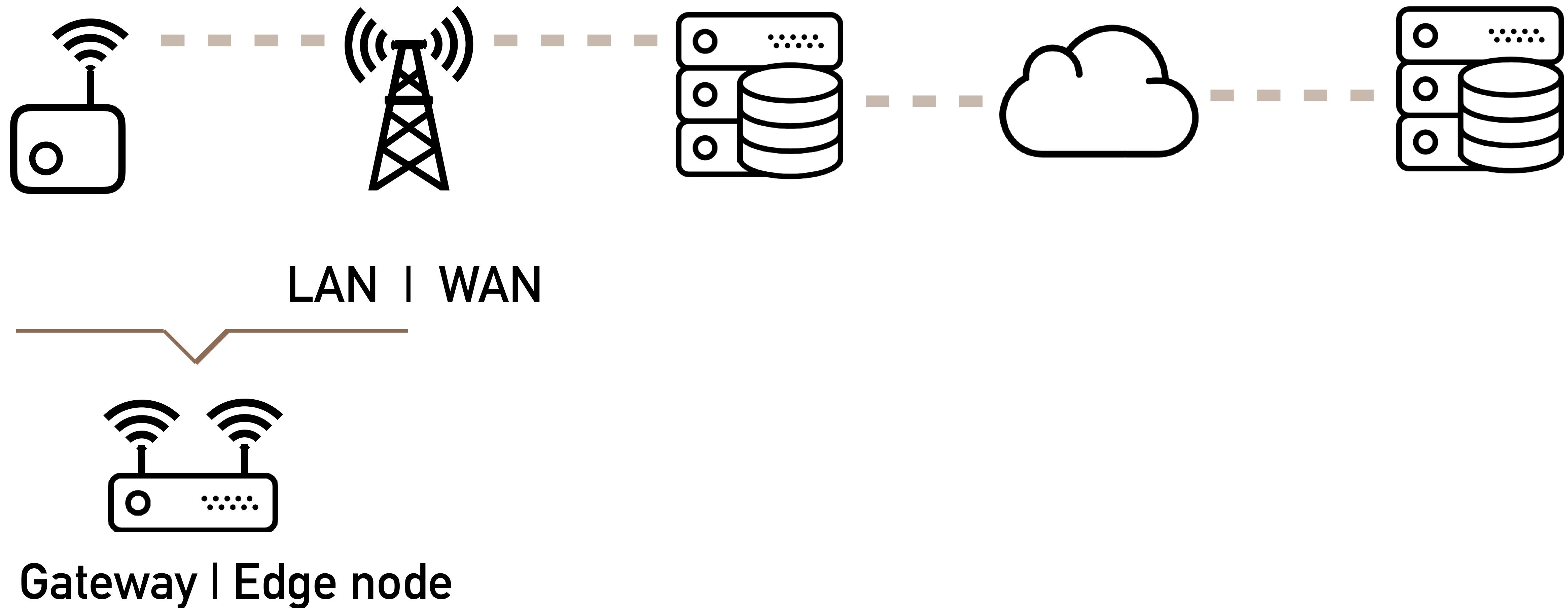
# IOT: PHYSICAL, SMART, CONNECTED DEVICES



# IOT VALUE CHAIN



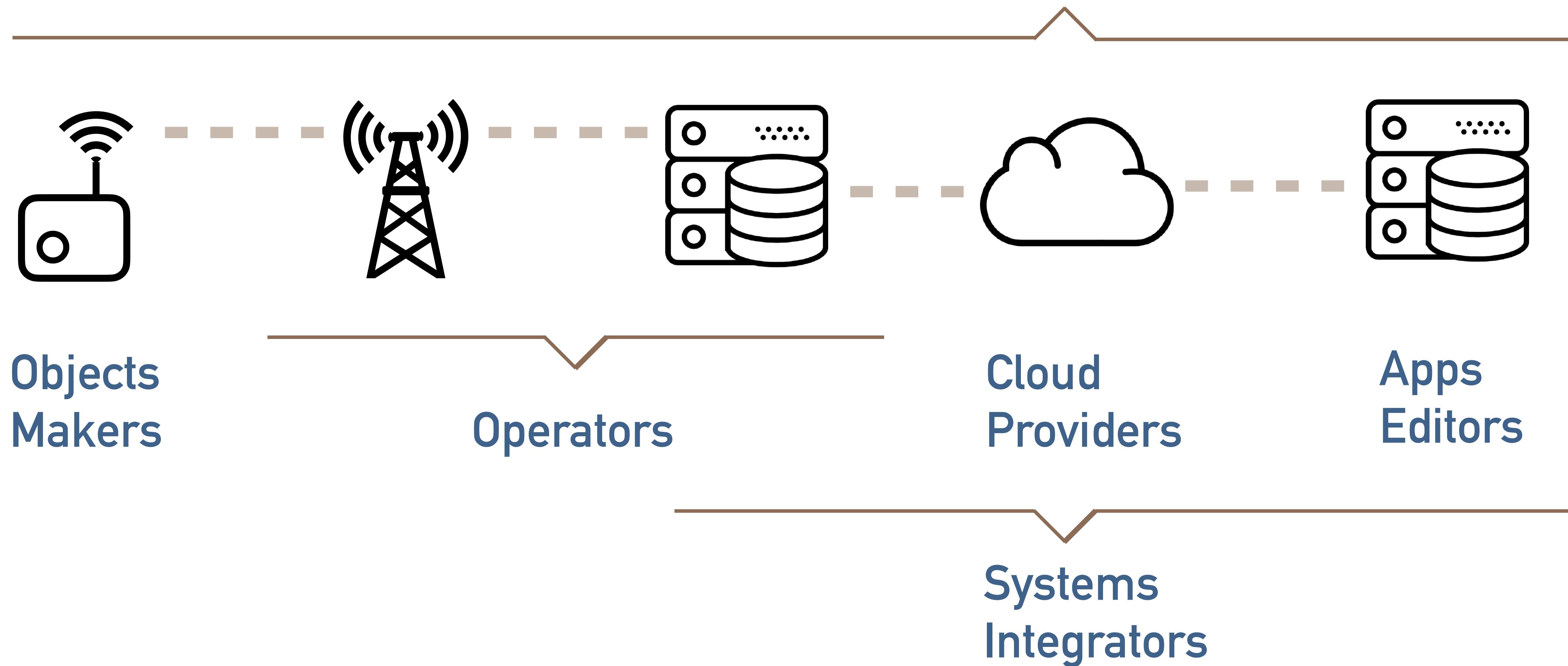
# IOT VALUE CHAIN



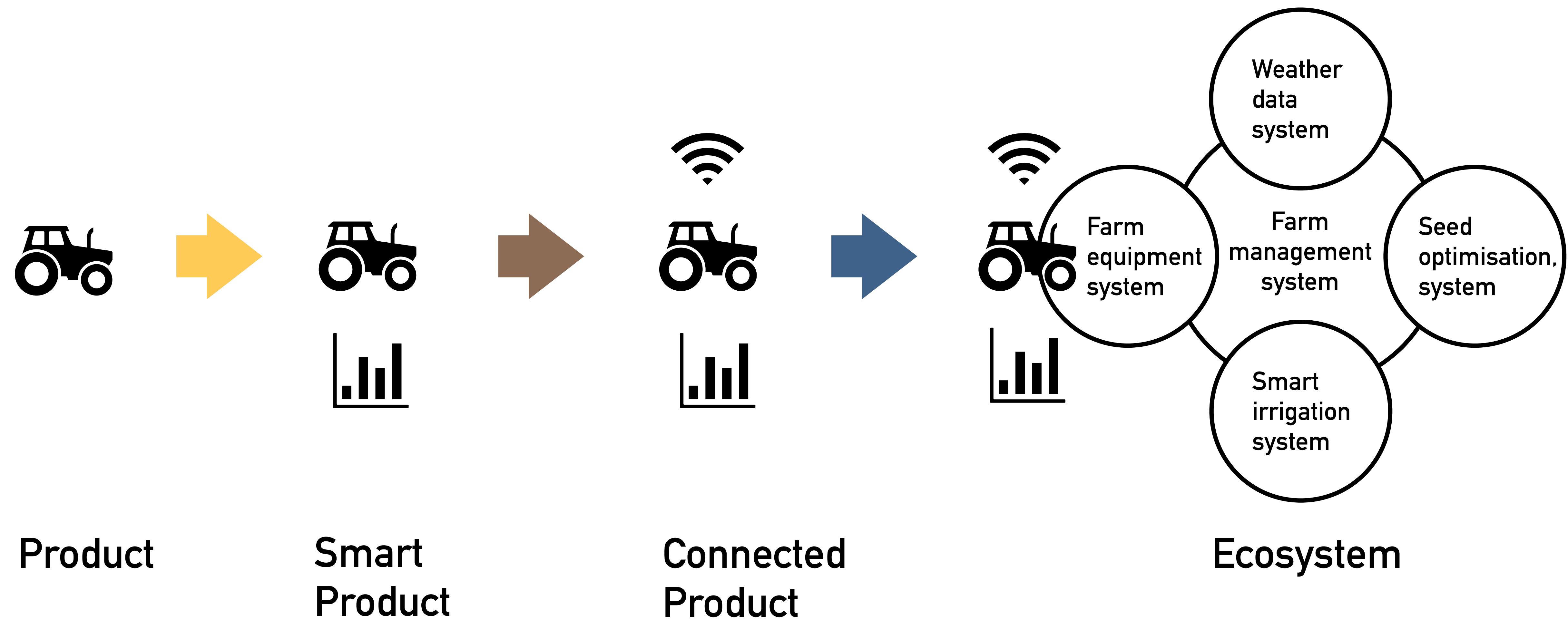
# IOT CLIENT



# IOT PLAYERS



# IOT: FROM PRODUCTS TO ECOSYSTEMS



# IOT ECOSYSTEM

## SIM makers

Idemia

G+D

Thales

## Chipset makers

Altair

Qualcomm

Intel

Mediatek

Sequans...

## Semiconductors

Microchip

NXP

Renesas

STMicrosystems...

## Module makers

Nordic

Quectel

Murata

Sierra Wireless

SimCom

Telit

Ublox...

## Manufacturers

Bosch

CETC

Eolane

Foxconn

Flex

Lacroix

Sercom...

## Distributors

Arrow

Avnet

DigiKey

EBV Elektronik

Farnell

GoTronic

Richardson RFPD

RS

Rutronik...

## Cloud providers

AWS, Google Cloud

IBM, Microsoft Azure

...

## Telecom vendors

Cisco, Ericsson,

Huawei, Nokia,

ZTE...

## Design houses, integrators

A5sys

Altyor

Ela Innovation

Exotic Systems

Heyliot

IneoSense

Inventhys

Makerz

Rtone

Stimio

Synox

Wi6Labs

Wiifor...

## Operators

AT&T, Deutsche Telekom,

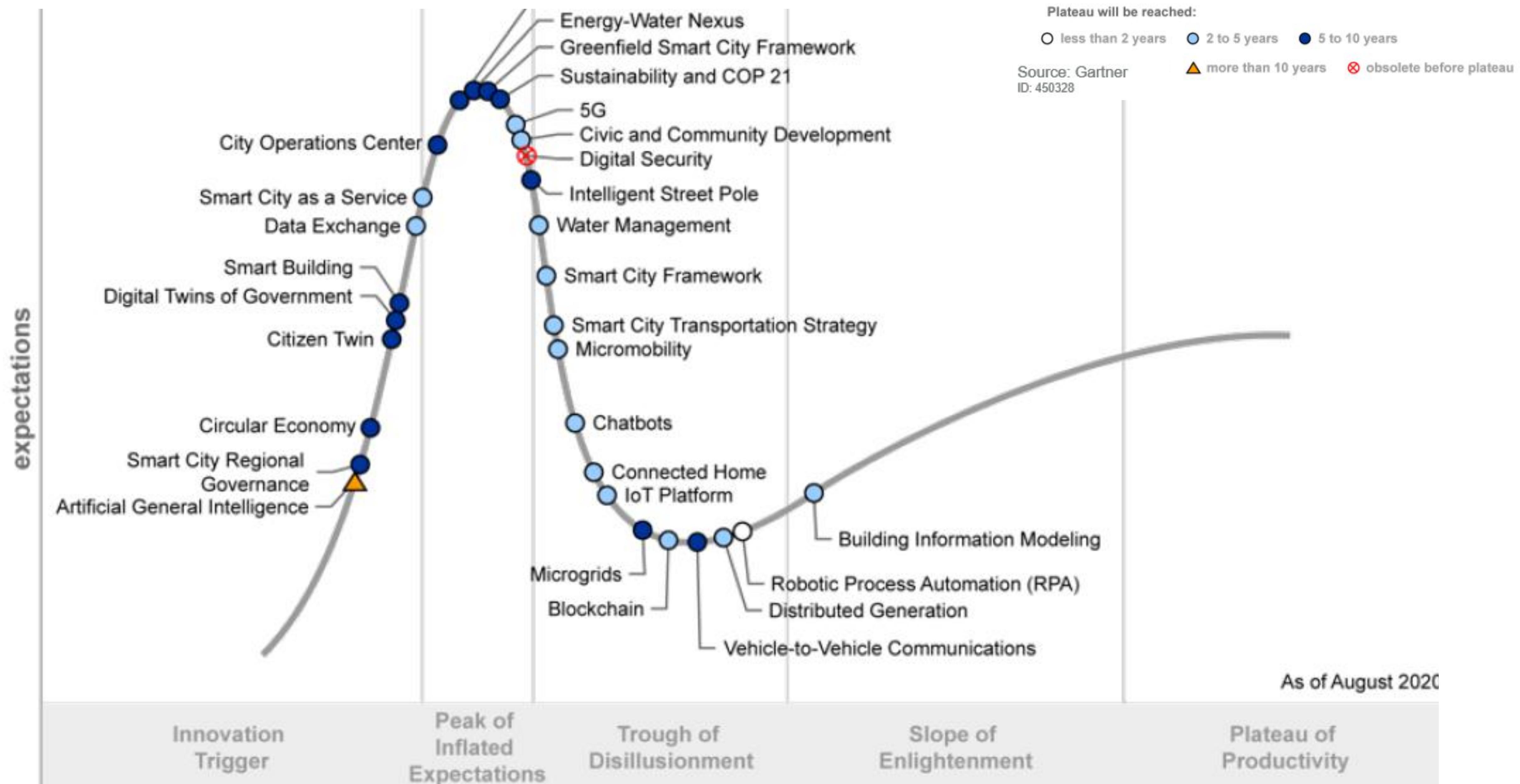
Orange, Telefónica,

Vodafone...

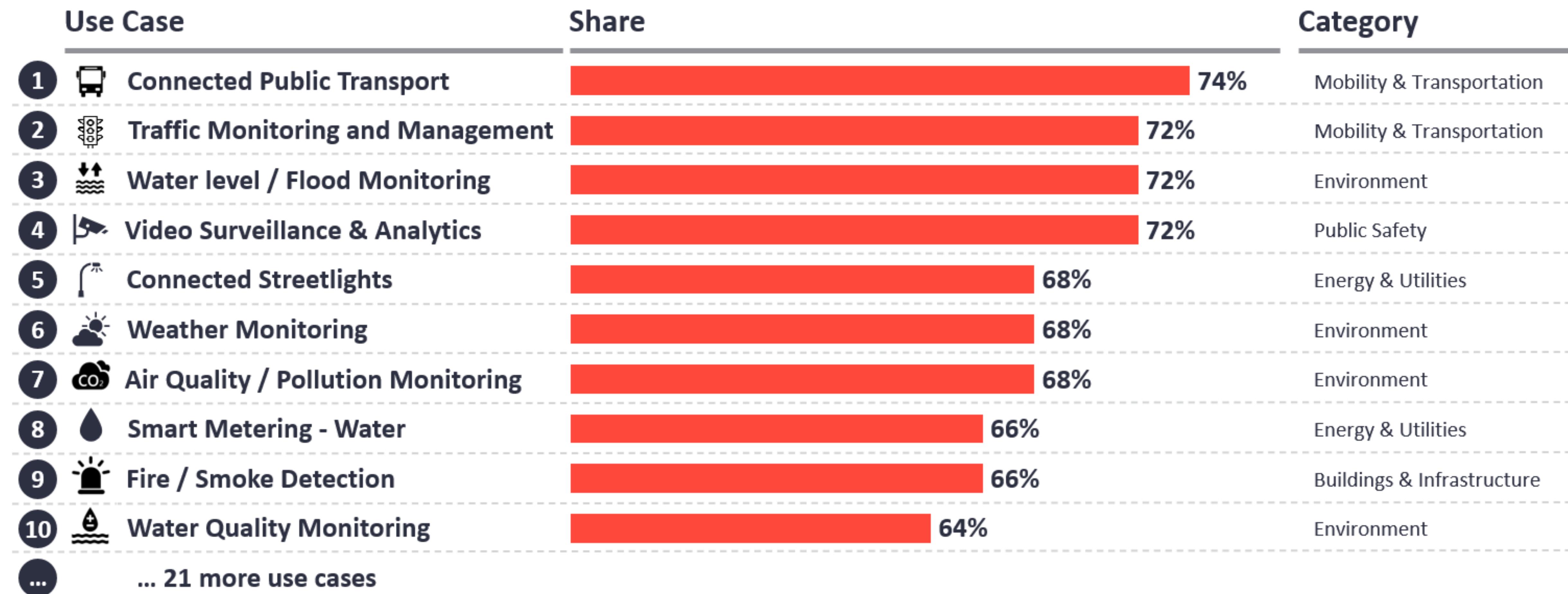


# IOT: SMART CITY

Traffic • Security • Comfort



# The top 10 Smart City use cases



Share = Percentage of cities that have fully or partially deployed the use case as part of their Smart City initiative; n= 50 cities across the globe

Source: IoT Analytics Research – August 2020 (For more information, refer to: Smart City Use Cases & Technology Adoption Report 2020)

# STREET LIGHTING

6 gateways for 150 lighting and water sensors, since 2017

Open data platform for 3rd parties

Intelligent public transport solution (15 means) with Wi-Fi access to secure Internet for passengers, real-time positioning information, speed and direction of travel



# SMART PARKING

Real time parking availability

Automated duration control

Statistics on usage patterns



# MOTORWAY AREA

6-month successful trial

Fully automated premises

Remote surveillance

CSAT monitoring, etc.



# CRANE CARE

Operational efficiencies

Collecting real-time information  
from cranes to carry out  
diagnostics globally.



# MIXER TRUCK

Concrete mixing  
monitoring

Rotation,  
temperature,  
position, etc.





# IOT: SMART METERING

Utilities: Gas • Water • Electricity

# WATER UTILITIES

Leading utility company

Several million water  
meters in France  
in next few years

Control of the full  
value chain



# GAS METERING

Direct pulse counting

Alarm thresholds

LPWAN or cellular connectivity

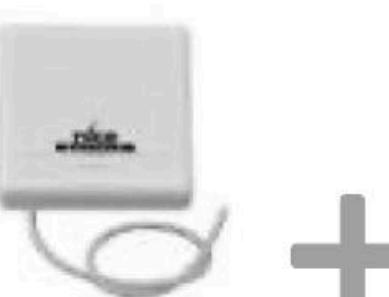




## Télérelève des compteurs d'eau non connectés



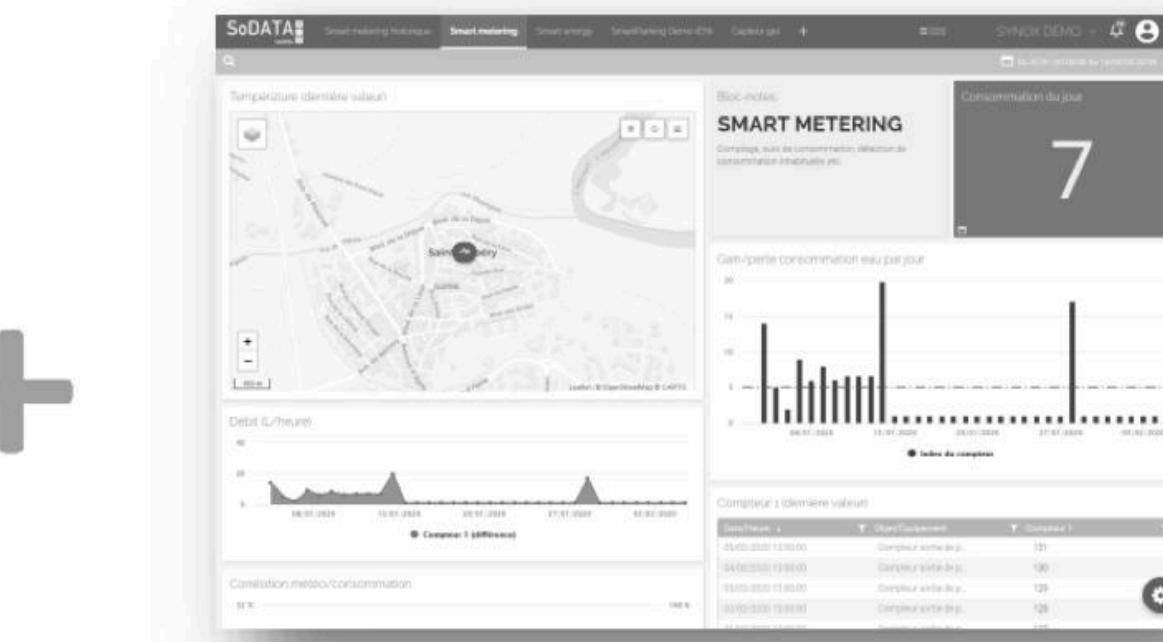
Capteur



+



Réseau



Plateforme de visualisation

**SYNOX**  
Innovate together

### Les usages

- Télérelever des compteurs à intervalles réguliers
- Déetecter les fuites, les fraudes et les vols
- Suivre la consommation en temps réel
- Gérer les pics de consommations
- Suivre les états de fonctionnement des compteurs
- Anticiper et optimiser les interventions techniques



Réalisez des économies



Améliorez la sécurité



Contrôlez les dépenses en eau

### Les fonctionnalités proposées

- Visualisation des compteurs d'eau sur une carte
- Paramétrage des alertes en fonction de seuils personnalisables
- Réception de notifications en cas de dépassement des seuils ou de consommation anormale
- Suivi des données en temps réel
- Historisation des données de consommation



## Télérelève des compteurs d'eau connectés

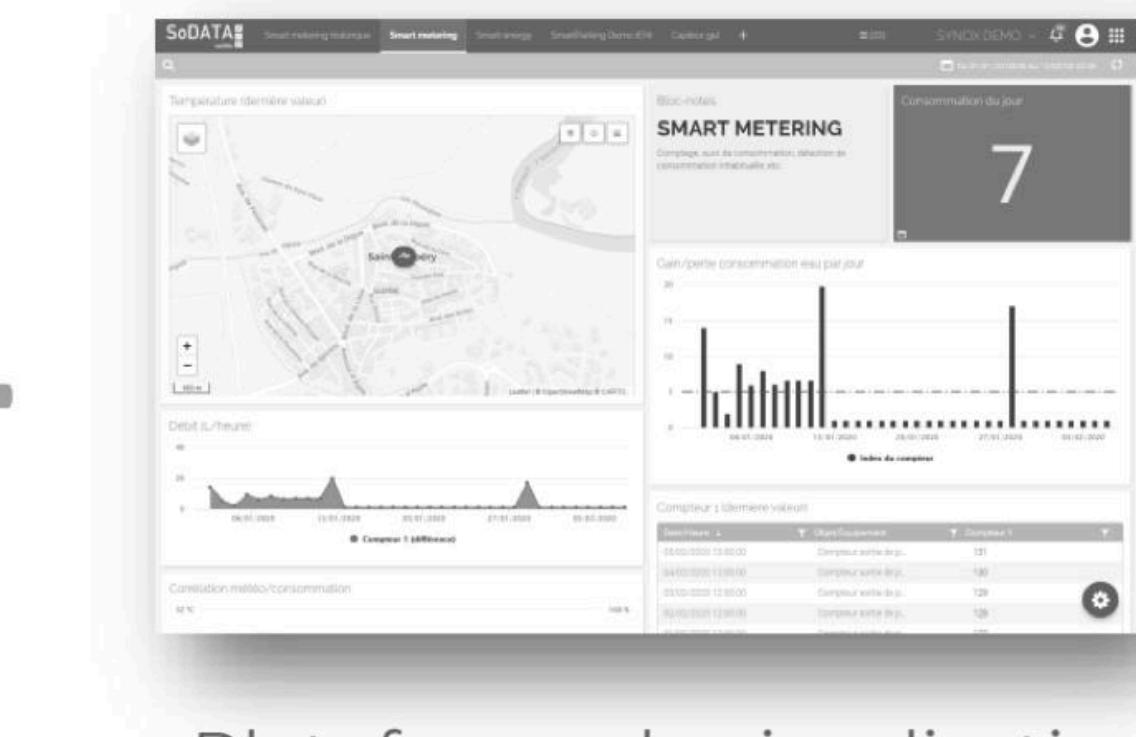
 **SYNOX**  
Innovate together



Capteur



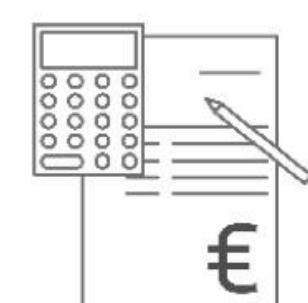
Réseau



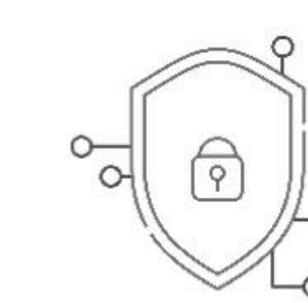
Plateforme de visualisation

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## Détection d'intrusions dans un bâtiment



Capteur  
ouverture/  
fermeture



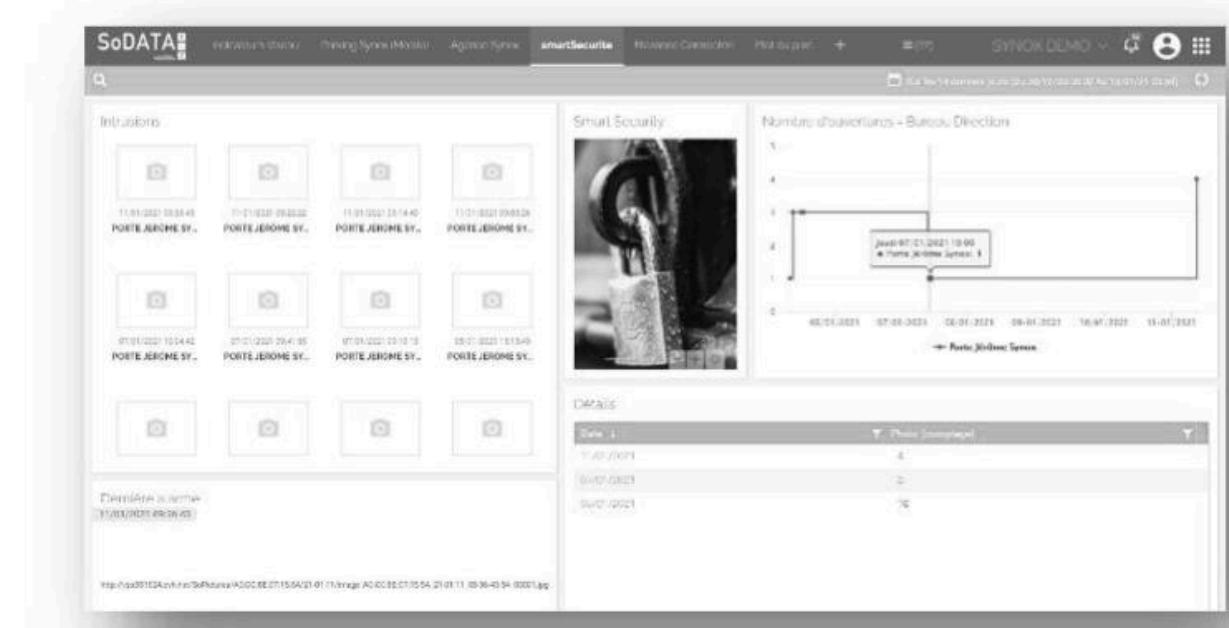
LoRaWAN™



sigfox

Capteur

Réseau



Plateforme de visualisation

### Les usages

- Surveiller les infrastructures
- Déceler les intrusions ou les vols ; sur un site, chantier, bâtiment....
- Détecter l'ouverture ou la fermeture des portes, des fenêtres, des armoires fortes ou même des chambres froides
- Détecter la présence par la chaleur corporelle



Améliorez la sécurité des sites



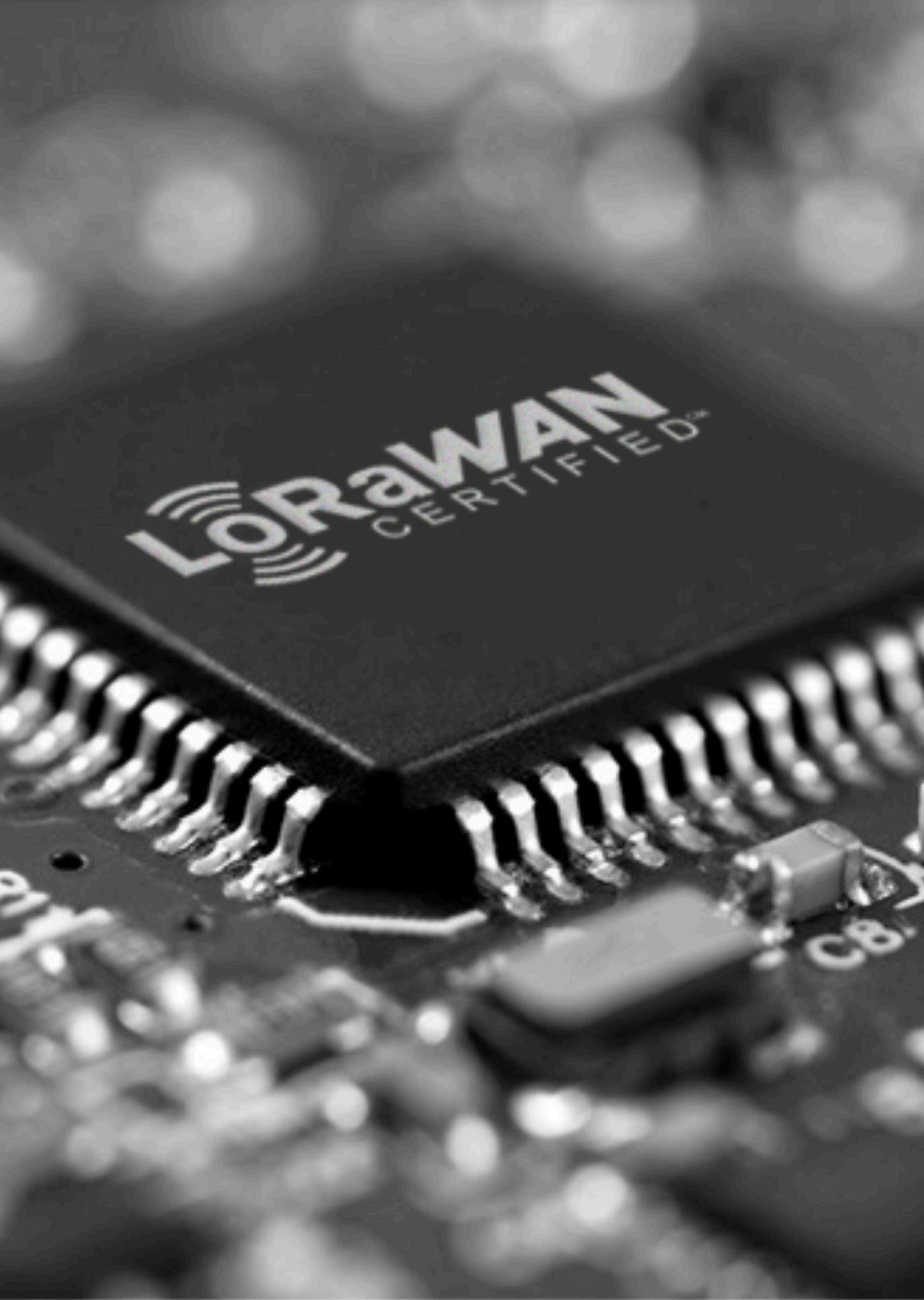
Soyez alerté en temps réel



Anticipez les situations à risques

### Les fonctionnalités proposées

- Visualisation des infrastructures sur une carte
- Paramétrage des alertes en fonction de seuils personnalisables
- Réception de notifications en cas d'intrusion
- Comptage du nombre de changements d'états
- Activation ou redémarrage des équipements à distance
- Suivi des données en temps réel
- Historisation des données



# LORAWAN

## LoRa Alliance

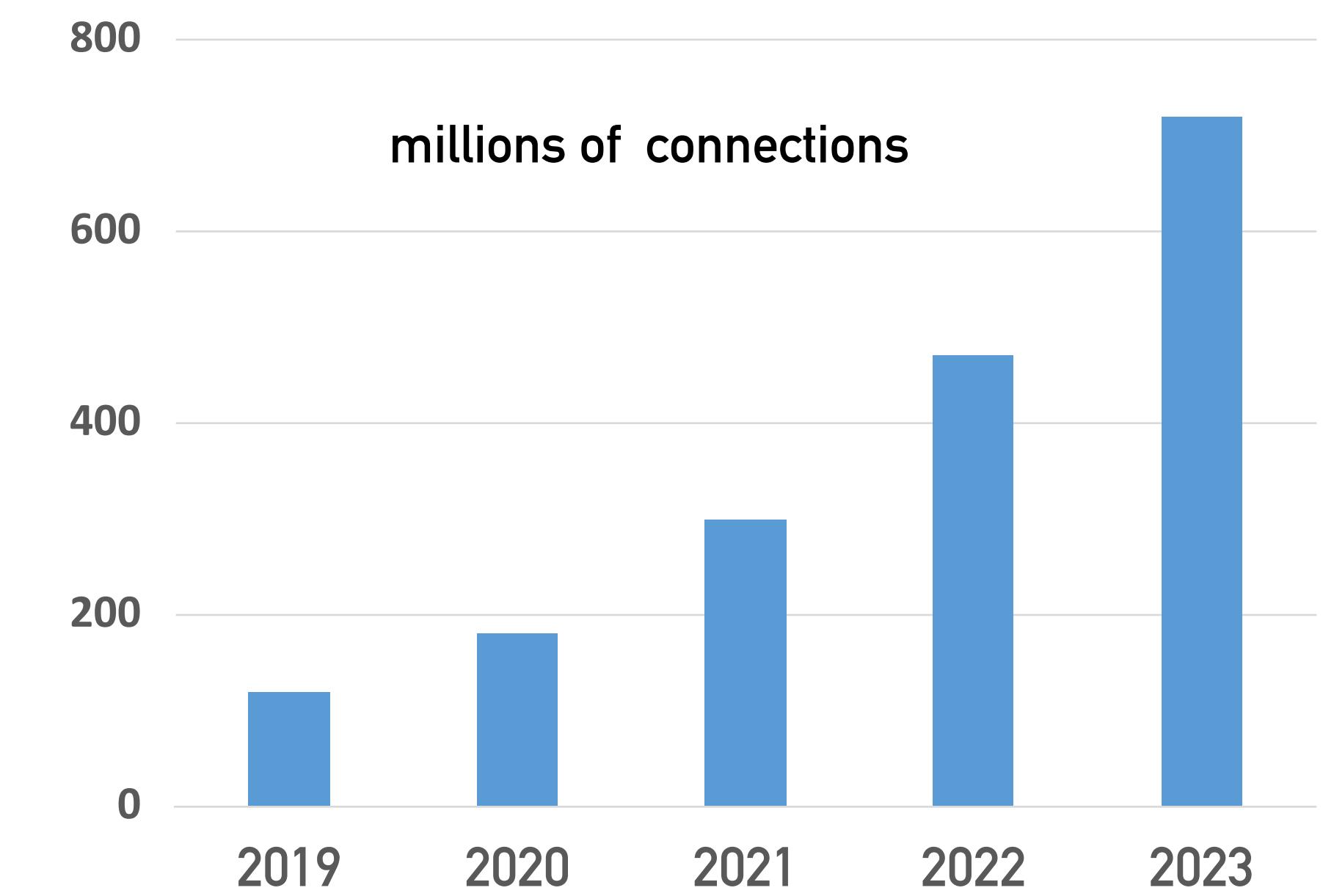
# LORA ALLIANCE

500 members in 157 countries

137 operators



100 million connected objects  
via LoRaWAN®



Source: IHS Markit 2019

# LORA ALLIANCE



...

# LORAWAN ESSENTIALS

**Network based on LoRa® radio technology**

**Long distance, low power, low cost**

**Low data rates, small volumes**

**ISM bands spectrums, with 1% duty cycle**

**Bidirectional / 3 classes**

# LORAWAN ESSENTIALS - CONTD

Optimized energy management

Excellent coverage

High security level

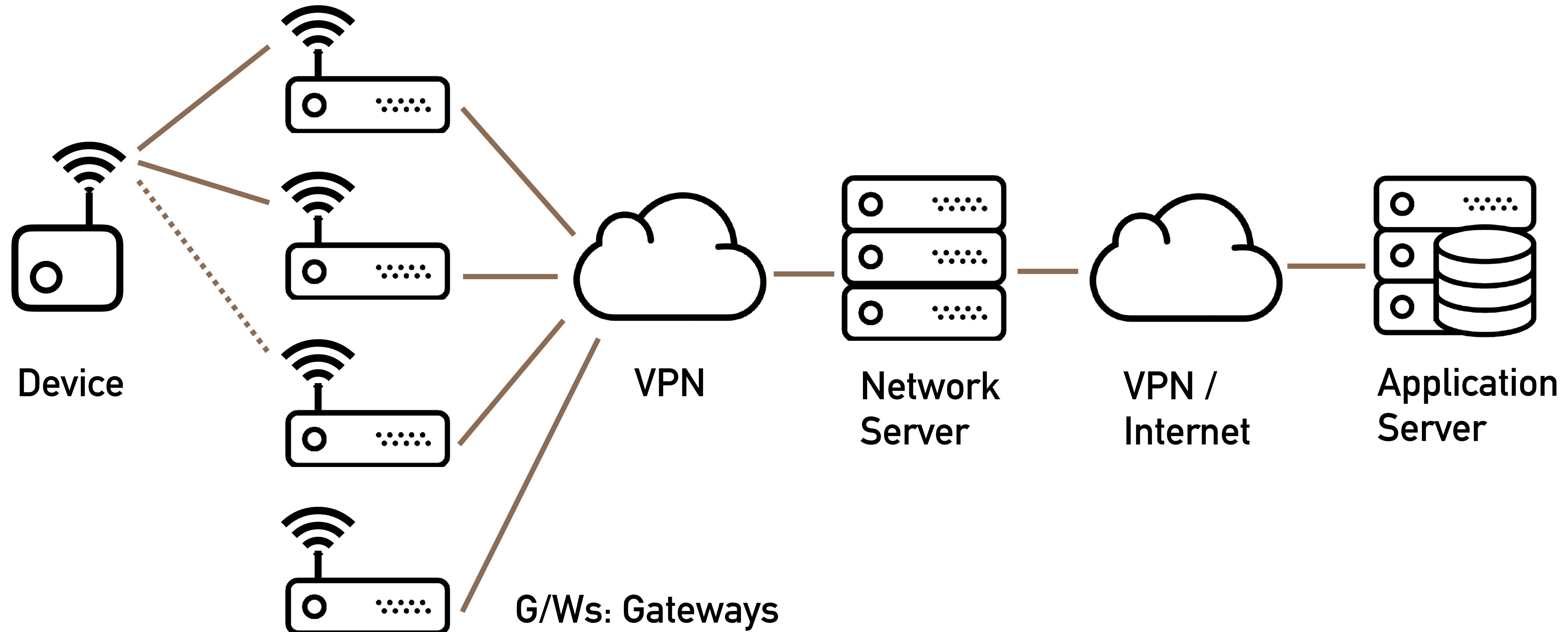
Very large & active ecosystem



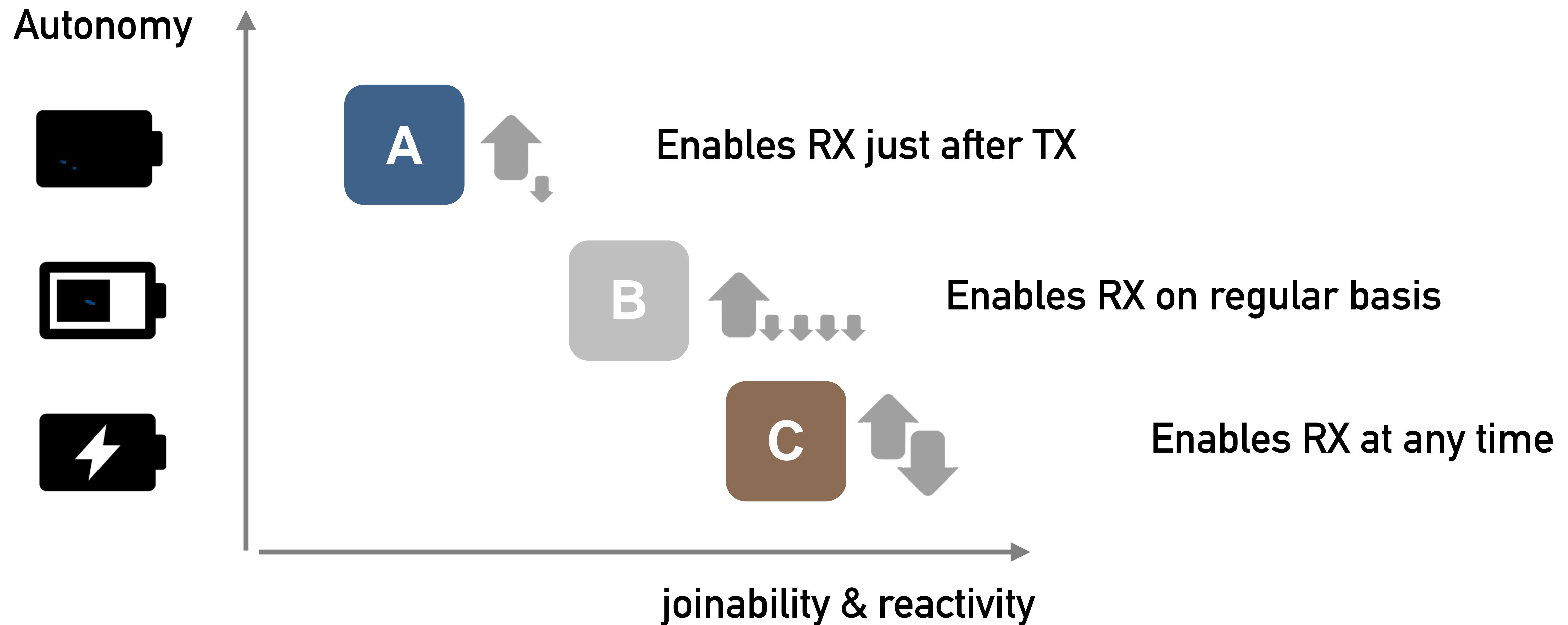
95% population coverage



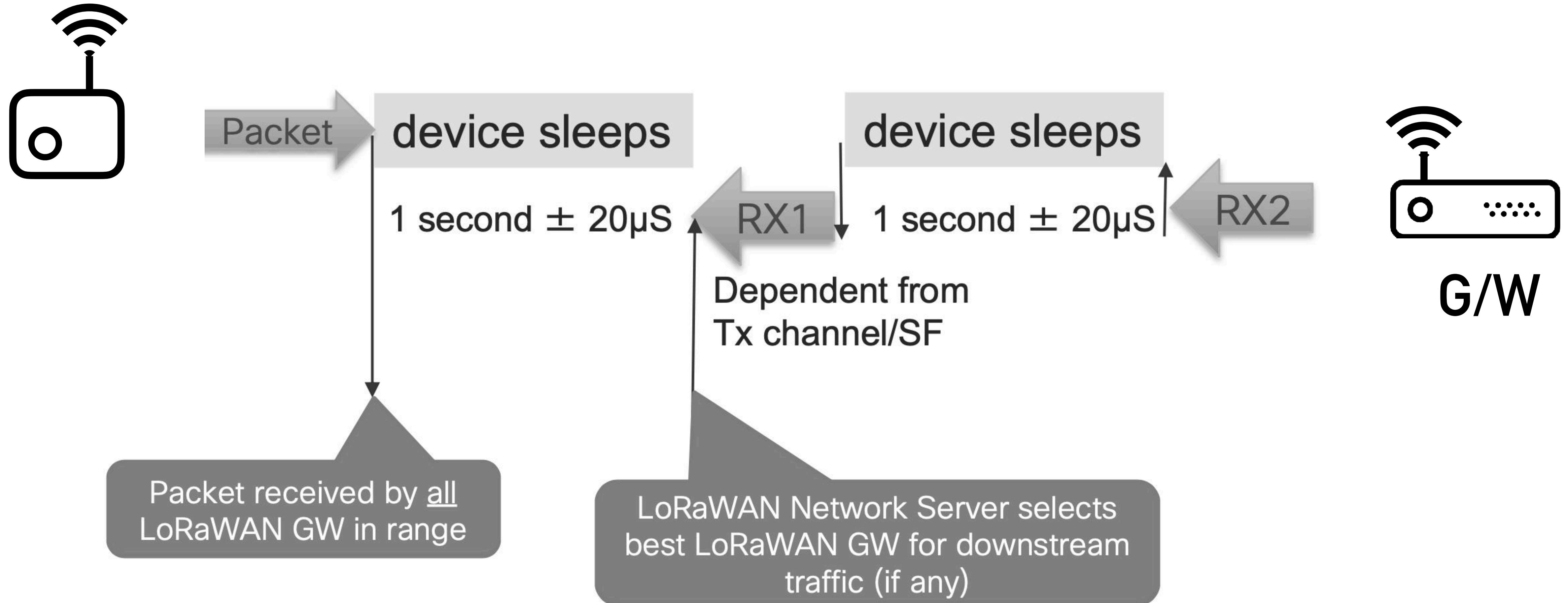
# LORAWAN ARCHITECTURE



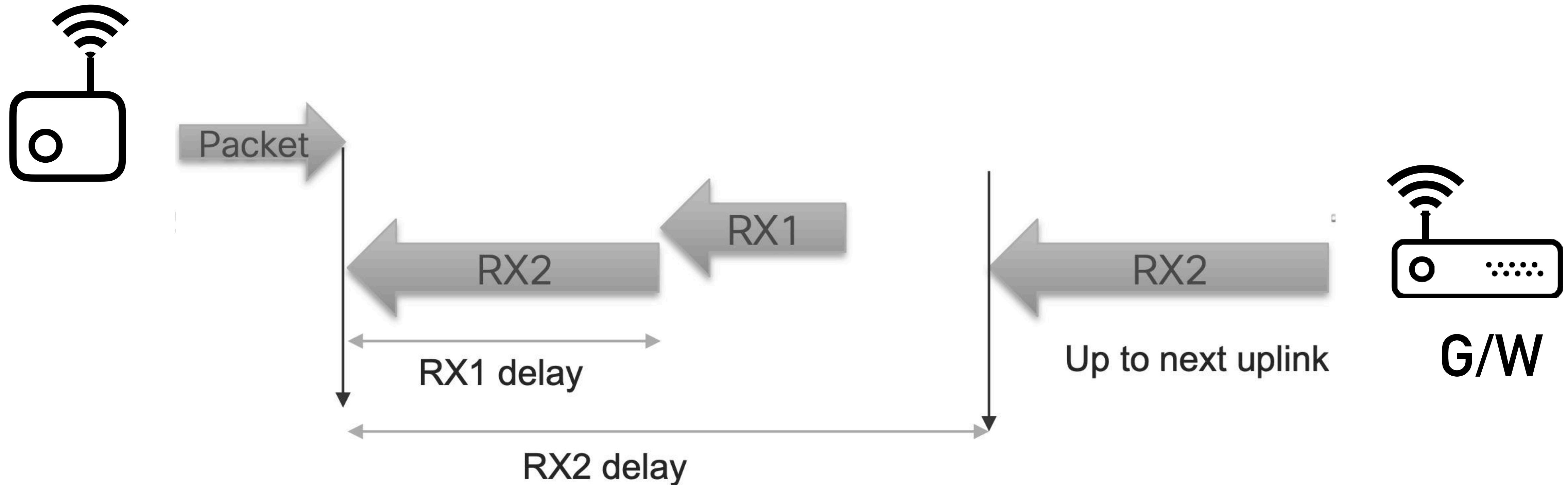
# CLASSES



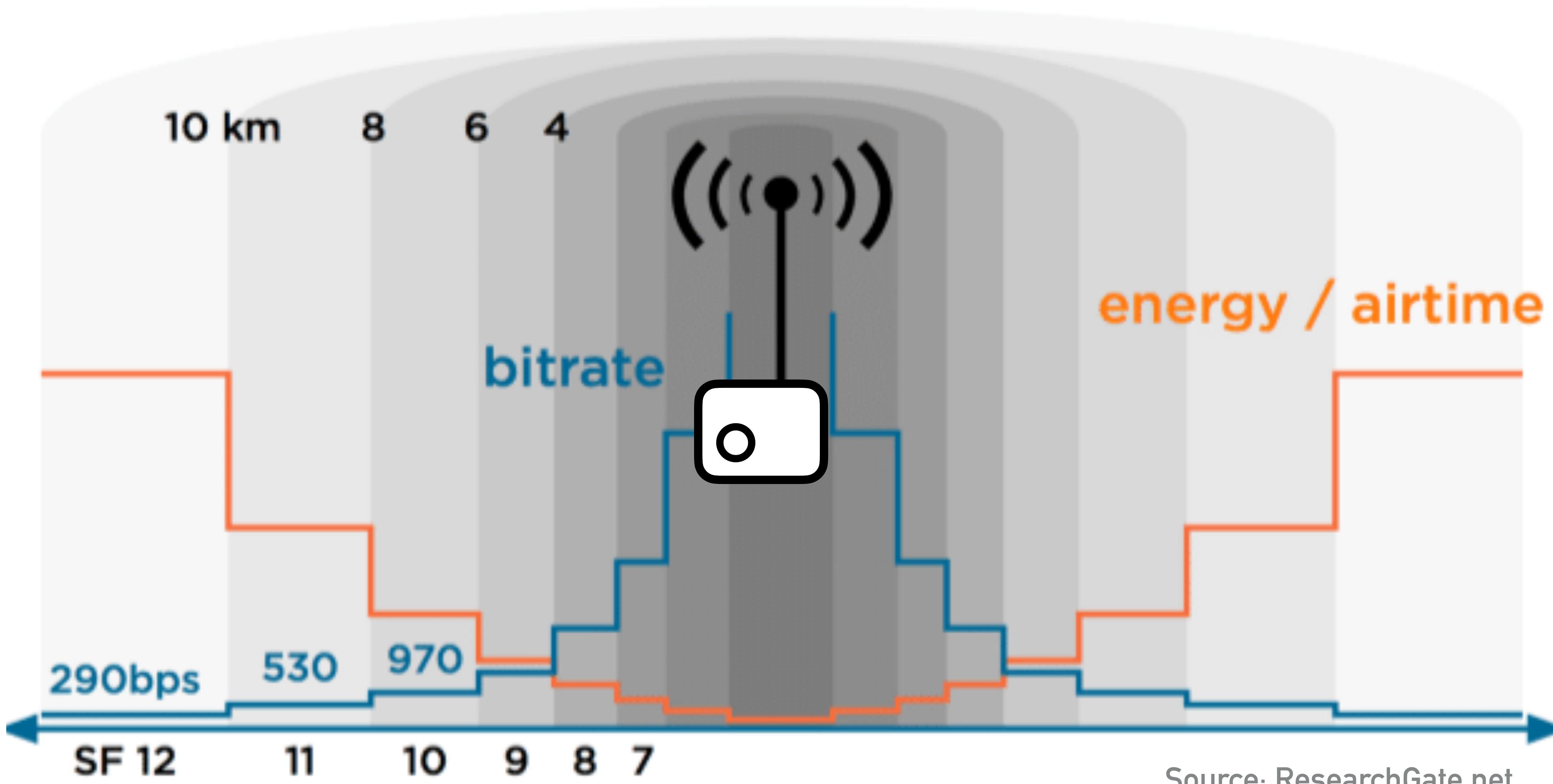
# CLASS A



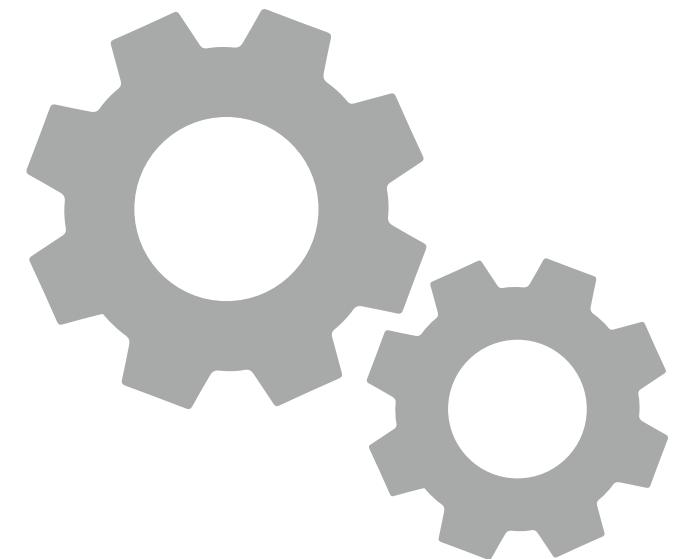
# CLASS C



# LORAWAN SF: SPREADING FACTOR



# ADR: ADAPTATIVE DATA RATE

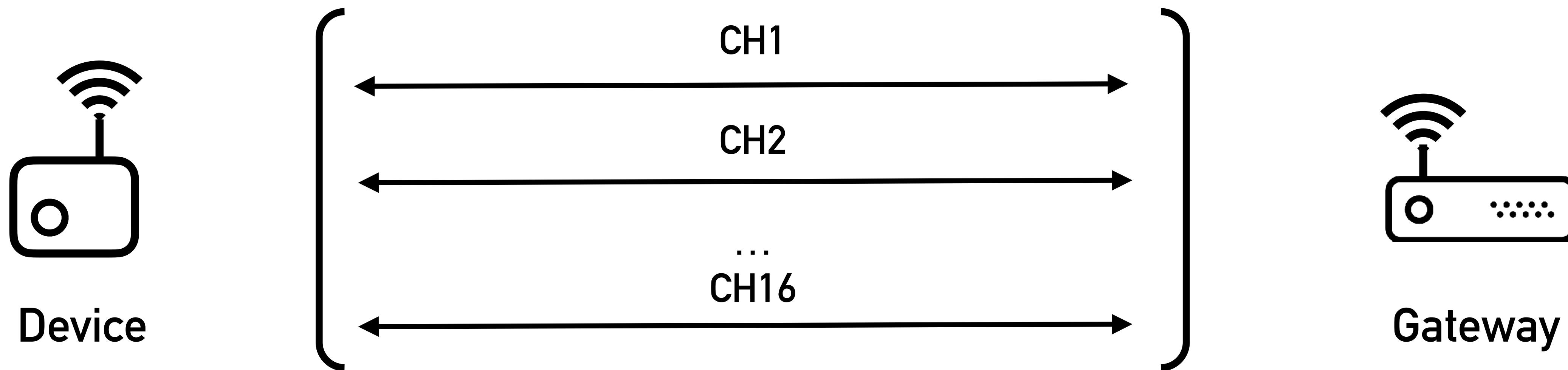


Auto adaptative trade-off between QoS and Autonomy

$$\left[ \begin{array}{l} \text{Energy} \\ \text{Repetitions} \\ \text{Spreading Factor} \end{array} \right] = f \left[ \begin{array}{l} \text{Settings} \\ \text{Radio conditions} \end{array} \right]$$

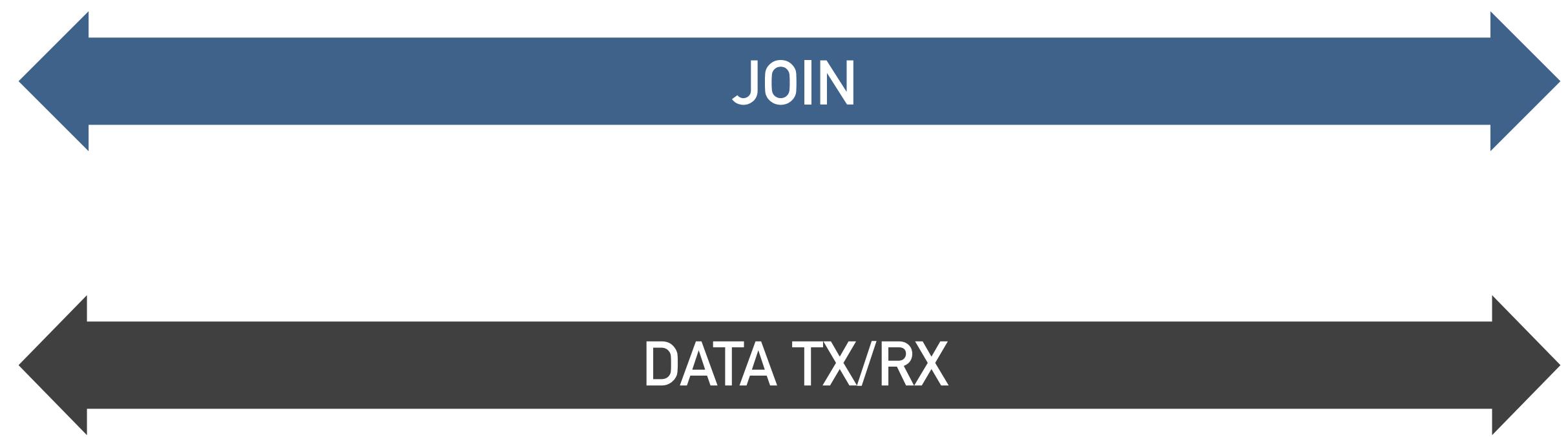
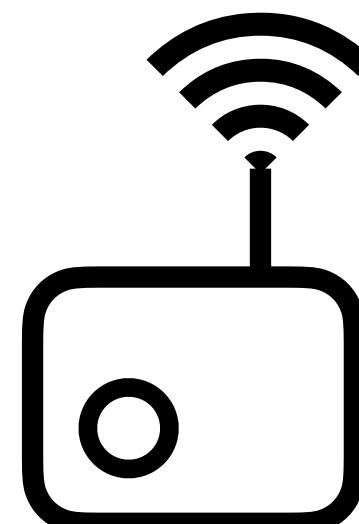
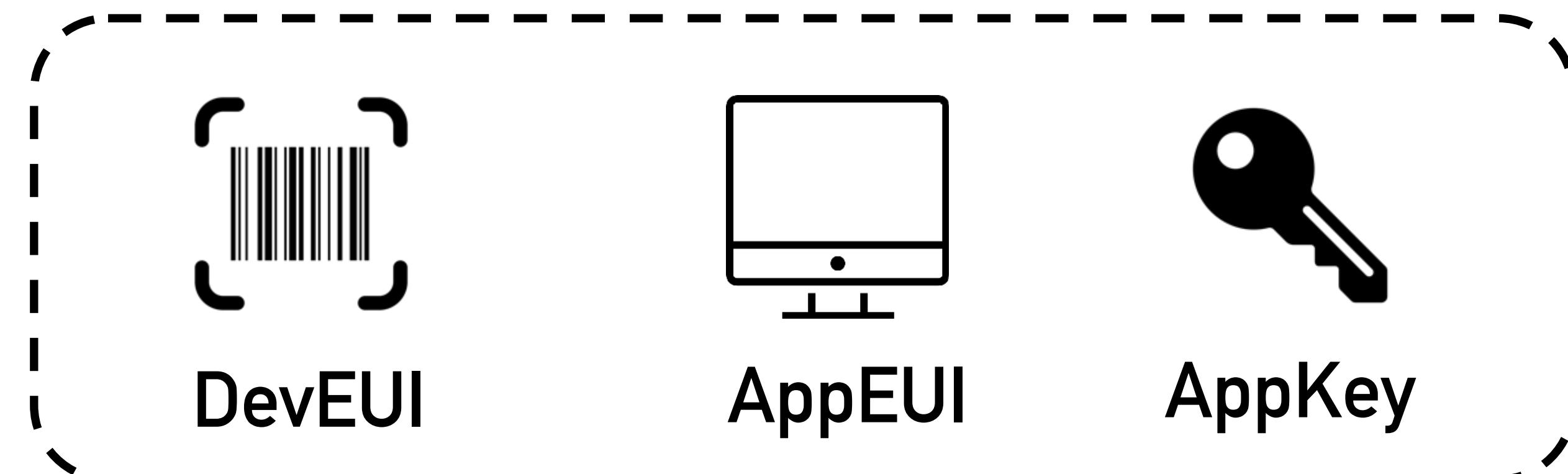
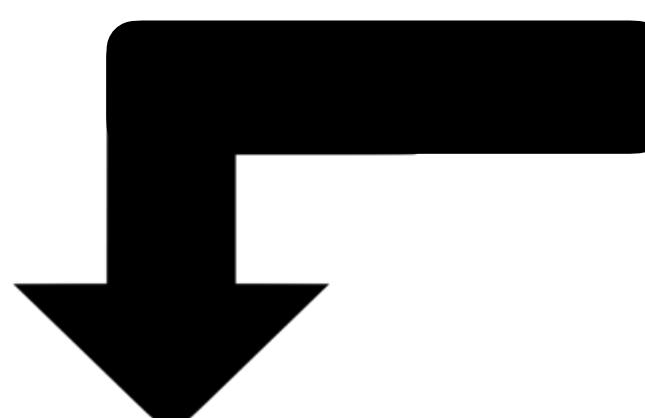
# QOS & CAPACITY

Up to 16 channels in the ISM band - 868 MHz (EU)

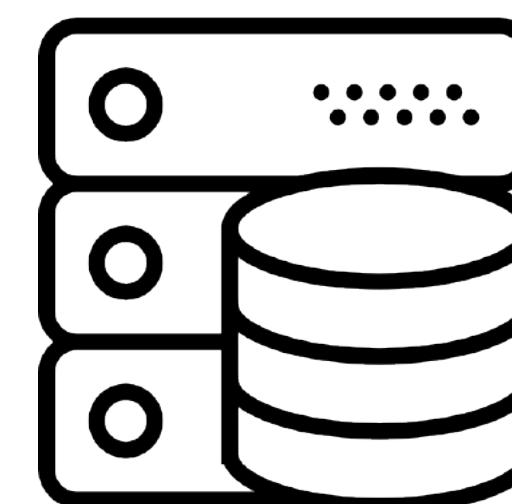


# OTAA PROVISIONING

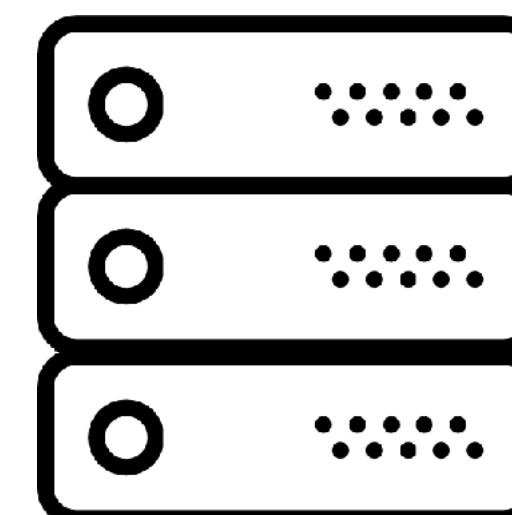
Over the Air  
Activation



Join  
Server



Network  
Server



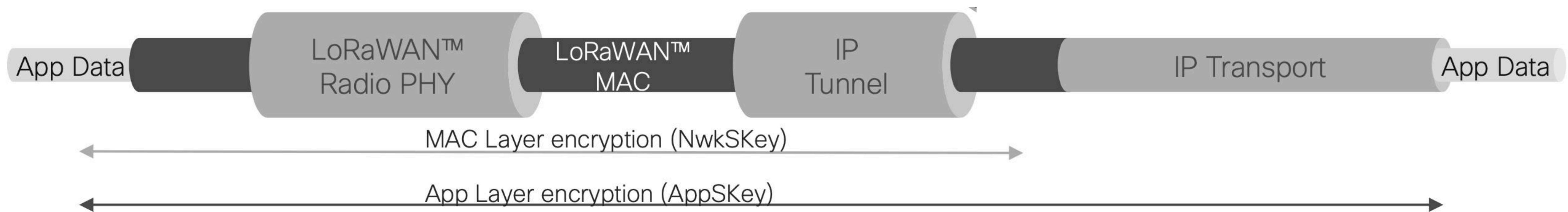
# SECURITY

Strong Authentication

Integrity by design

End-to-end AES128 encryption

Anti-replay mechanism

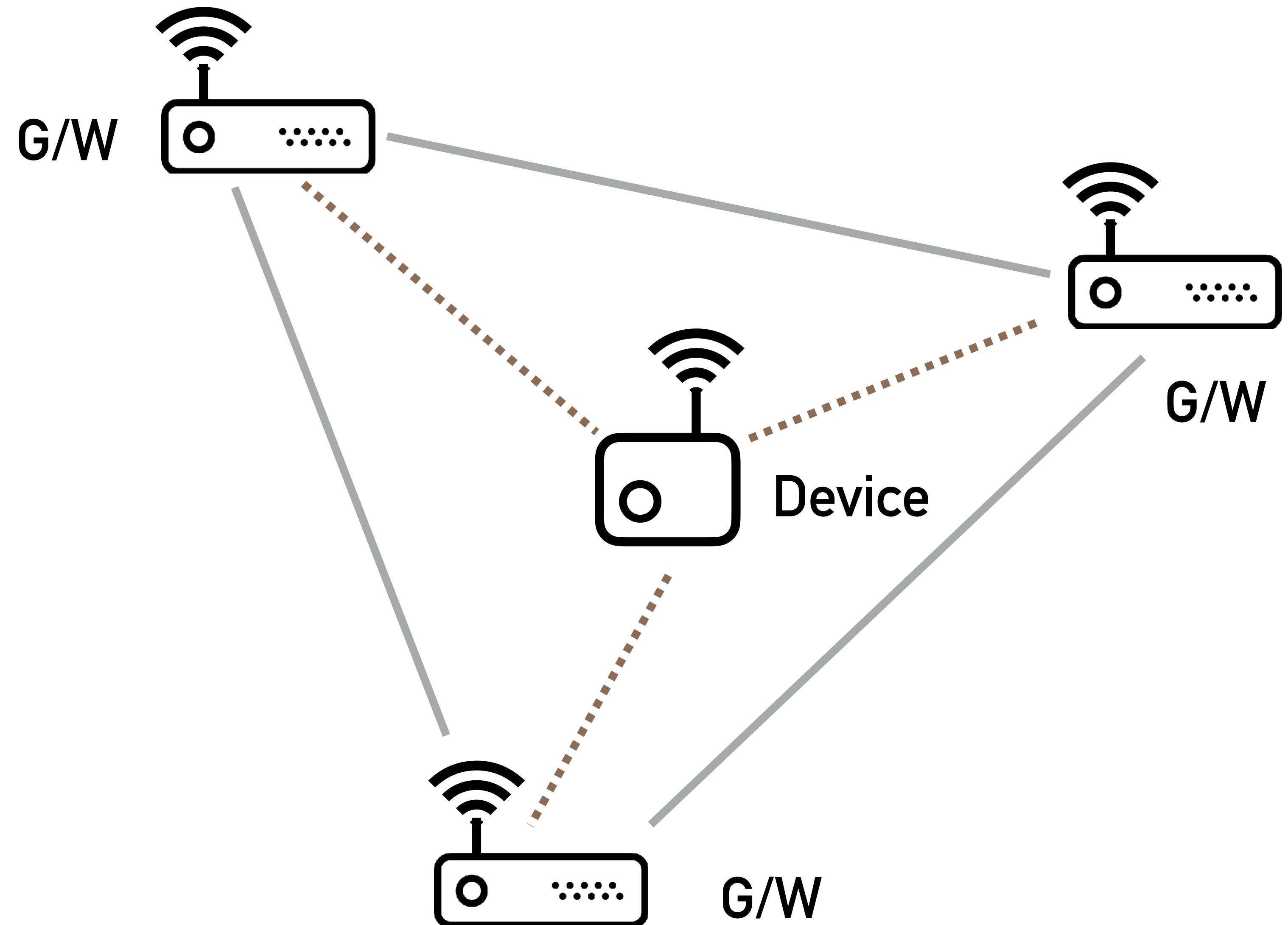


# GEOLOCATION

Network based  
macro geolocation

< 10 km accuracy

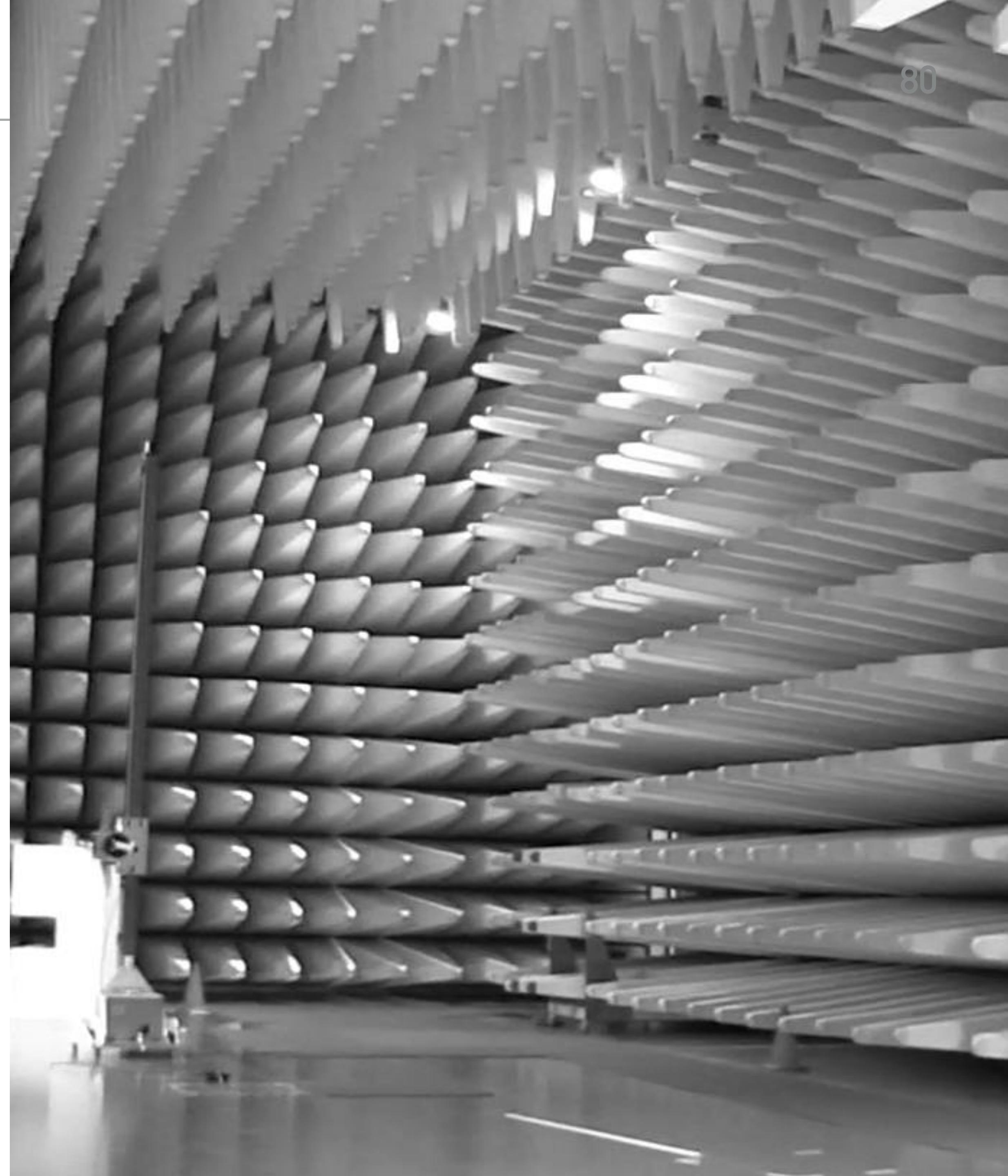
RSSI vs. TDOA



# CERTIFICATION

LoRa Alliance® tests +  
Operators tests

Interoperability  
Security  
Energy  
Performances



# ROAMING - LORAWAN V.1.1

Successful tests & PoCs in Europe

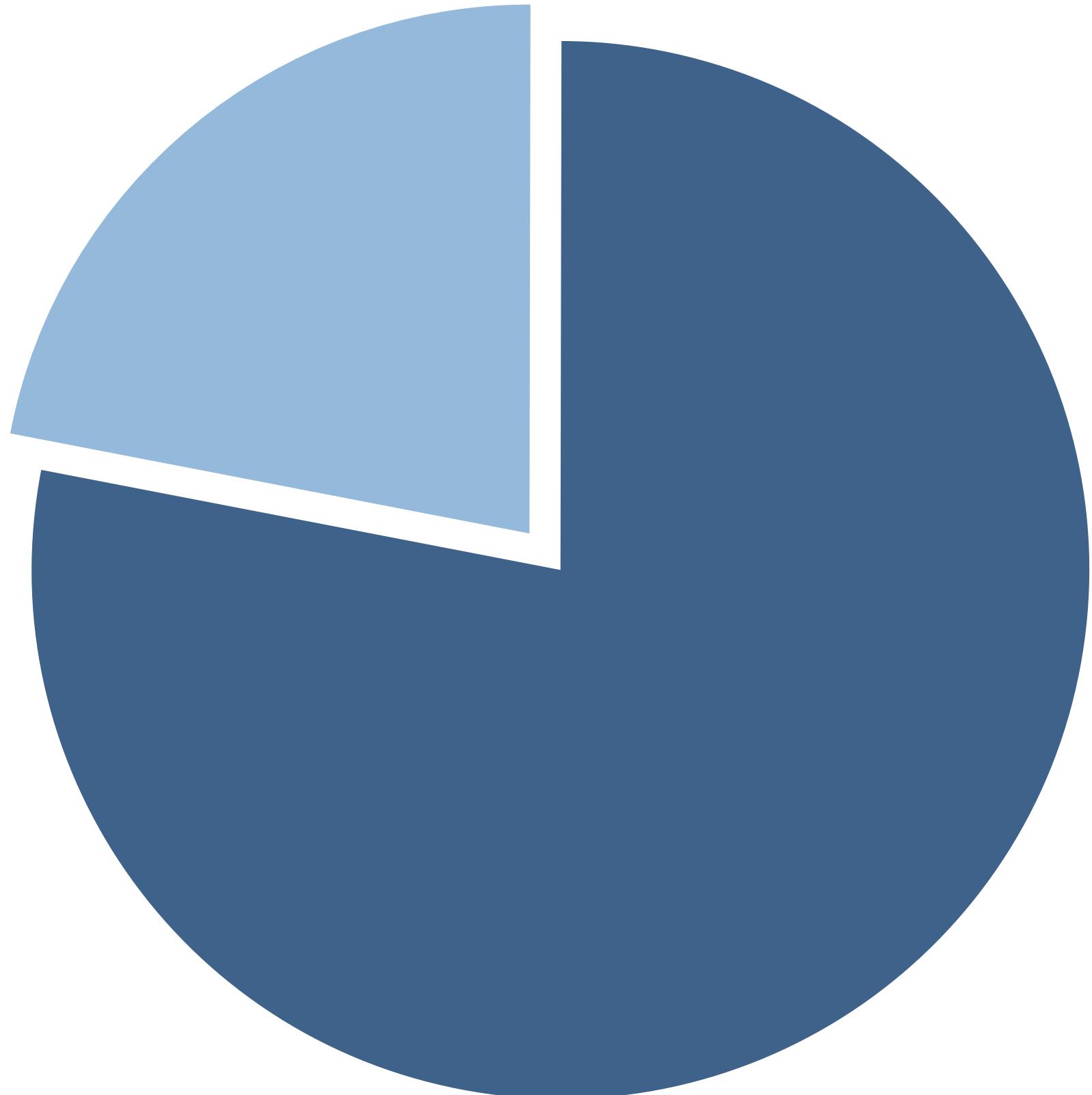
Cf. Orange, Objenious, KPN, Swisscom...

With Actility, Kerlink...

No technical issue

Business model still TBD

# PRIVATE LORAWAN NETWORKS



Vast majority of LoRaWAN networks are private

Why? CapEx vs. Opex,  
total control, adhoc coverage,  
TCO with high device density  
in the same campus/site...

# PRIVATE LORAWAN NETWORKS

However, public networks are so convenient:

- Wider coverage
- QoS as they are managed by operators
- Certified/tested devices
- OpEx vs. CapEx model

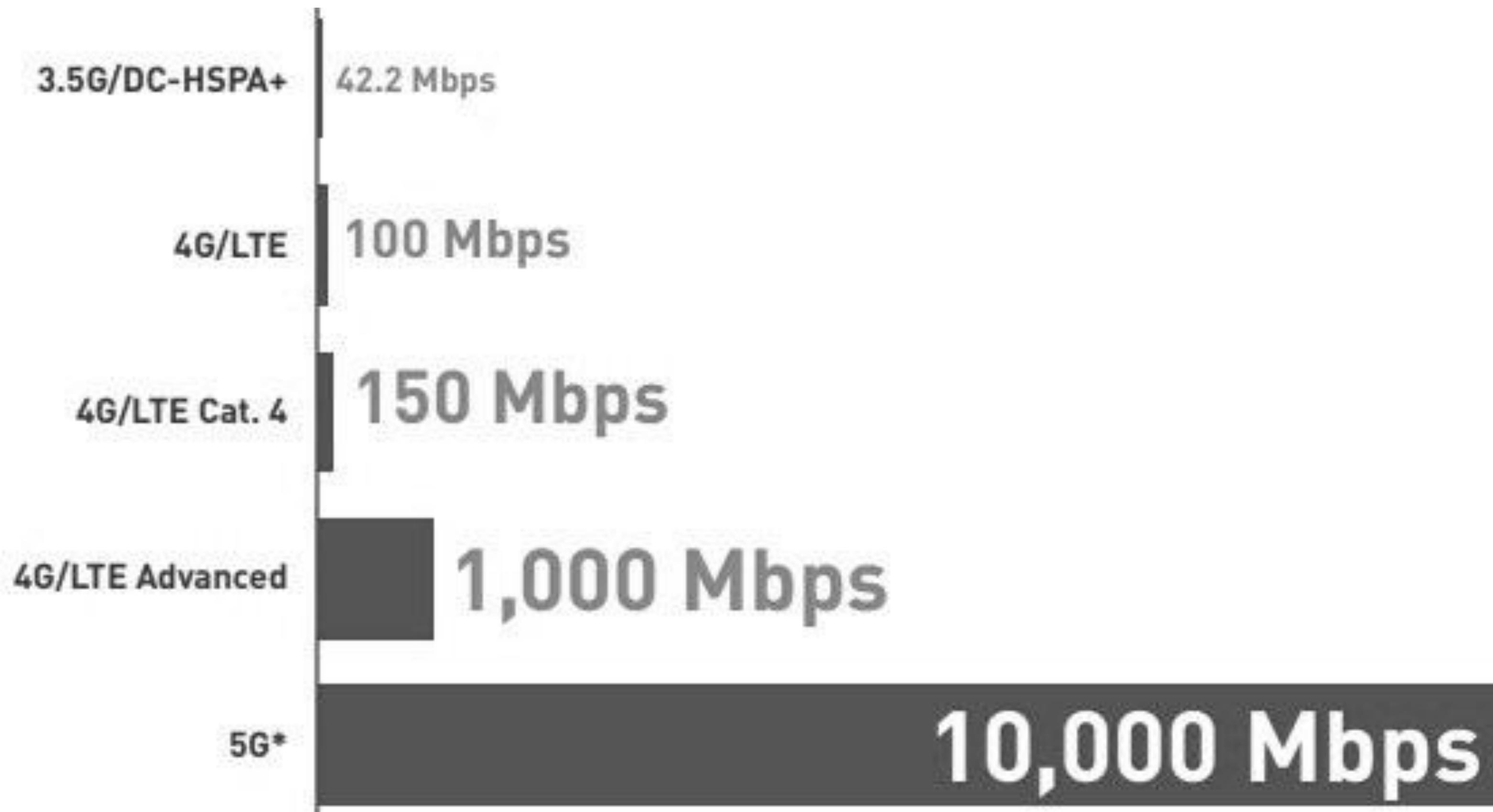
Hybrid, public/private networks alternative



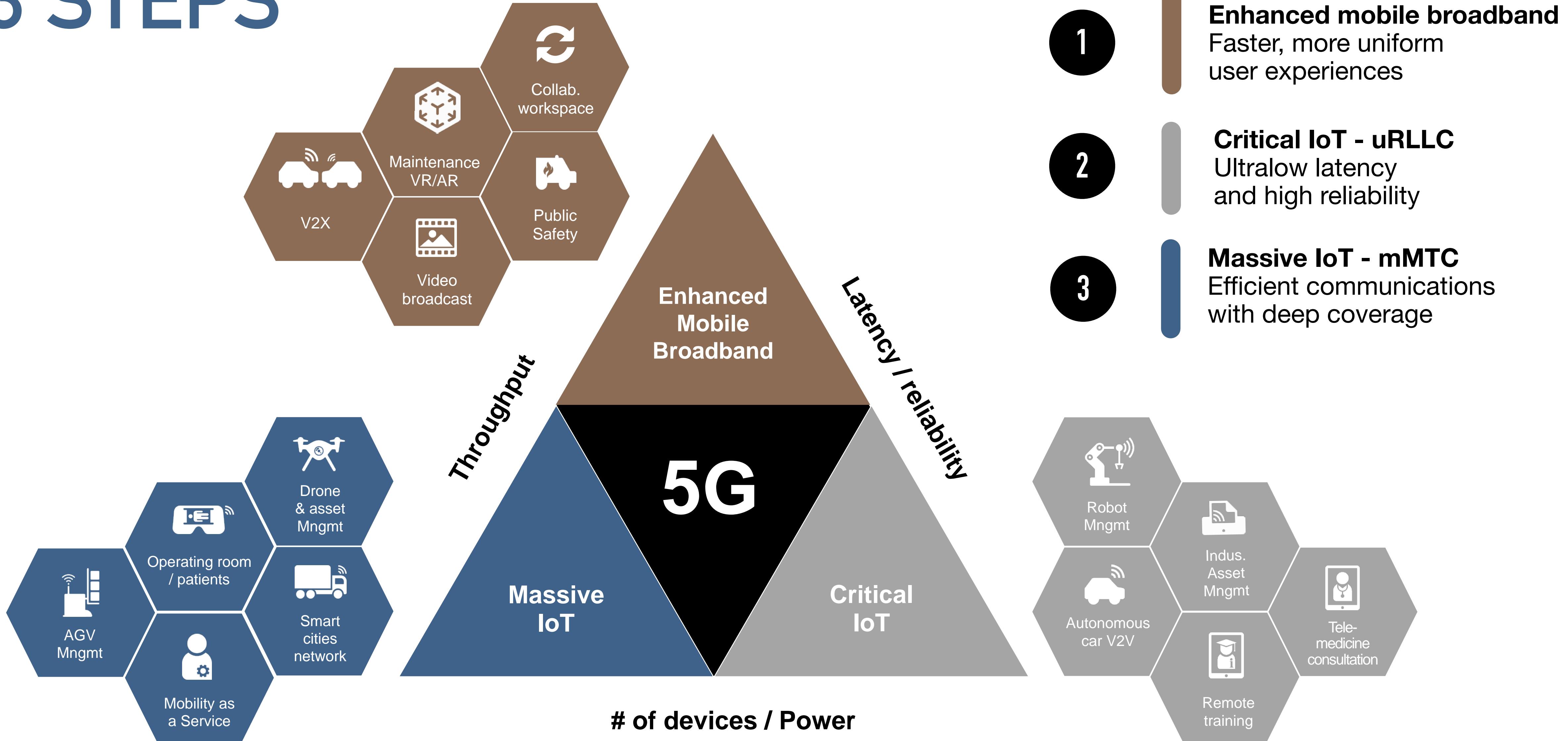
# 5G

the promise

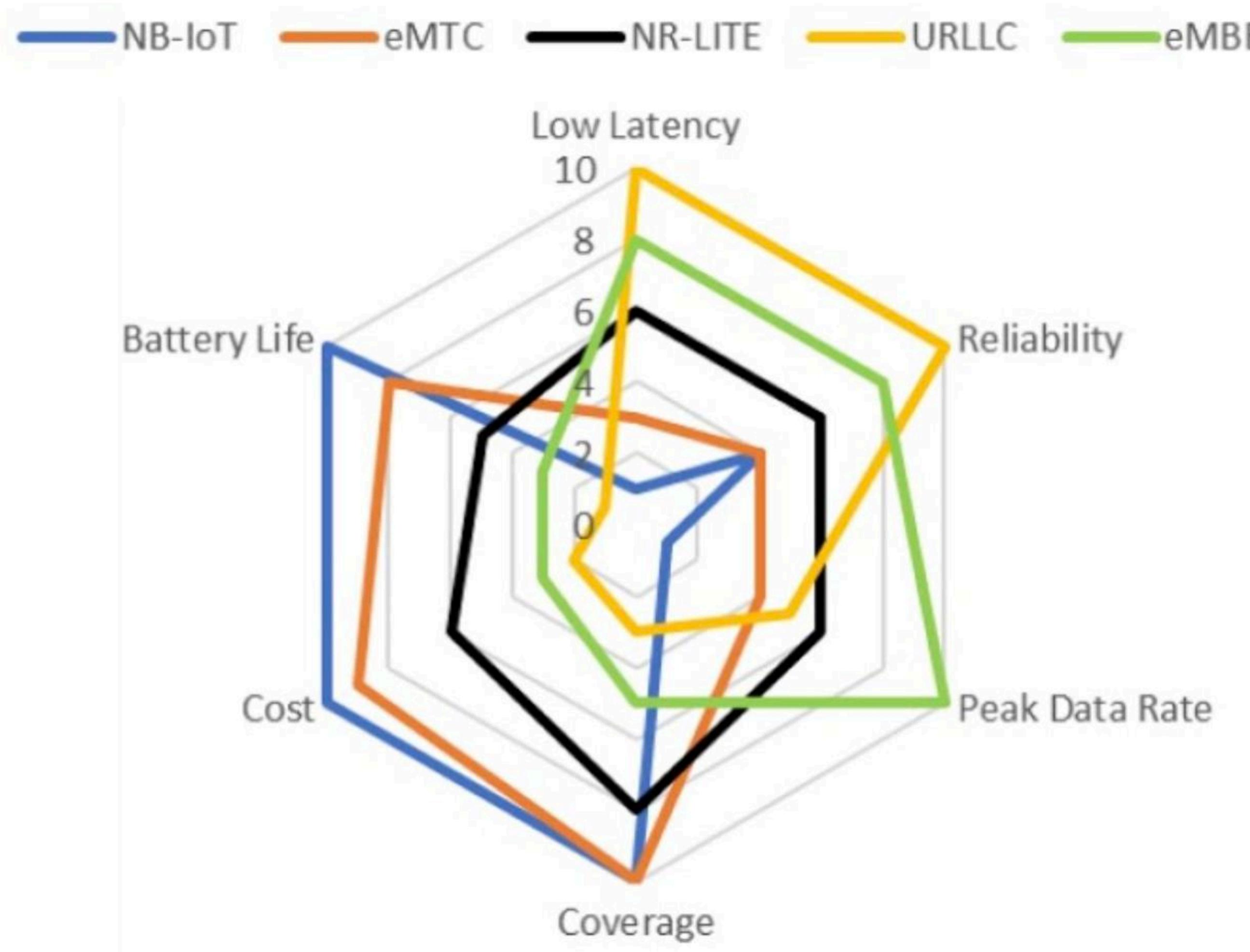
# HOW FAST CAN 5G BE?



# 3 STEPS



# TRADE-OFF



**eMBB** - enhanced Mobile Broadband

**uRLLC** - ultra Reliable Low Latency Communications  
critical IoT

**mMTC** - massive Machine Type Communications  
massive IoT

**RedCap** - aka NR Lite - Reduced Capacity

# WHAT IS 5G?

Evolution

+

Révolution

Coverage

Deployment

Devices

Standards

Active antennas

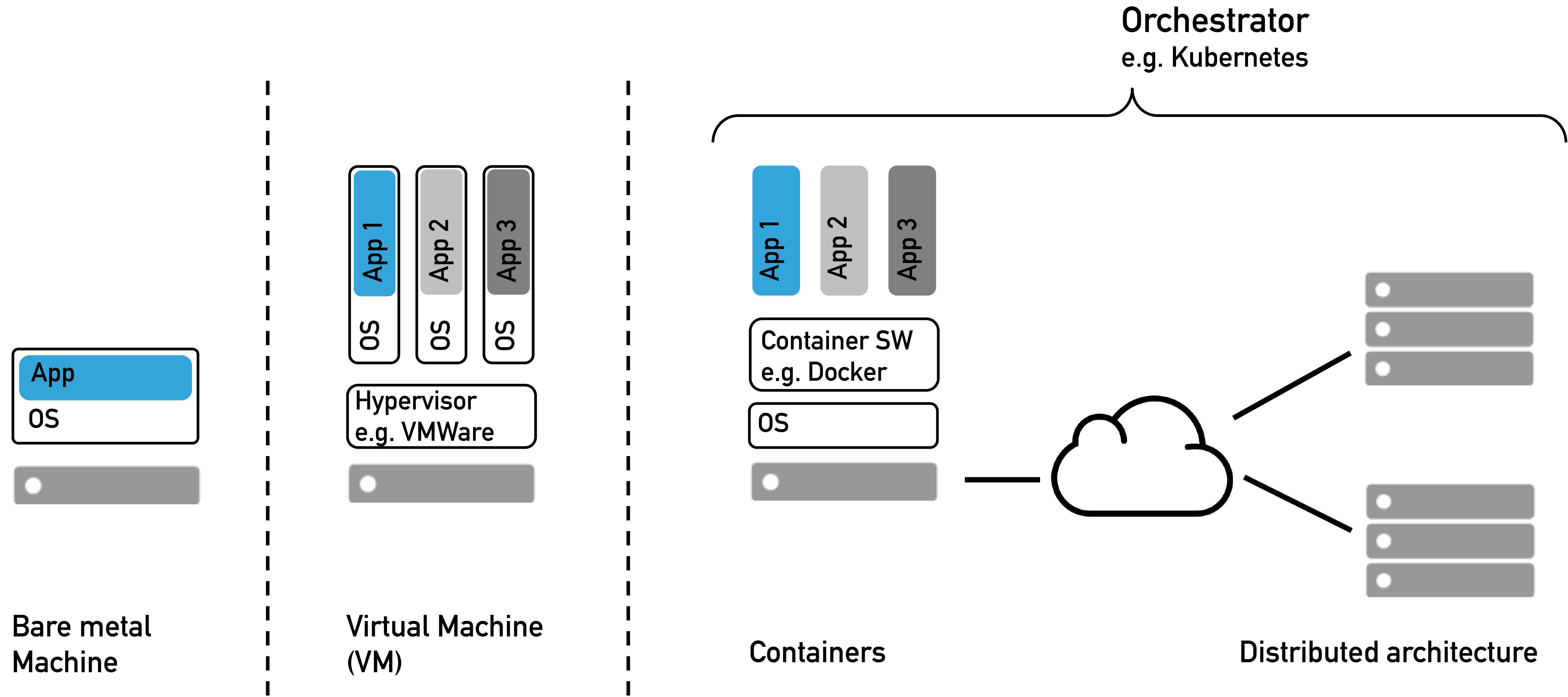
New frequencies

Edge computing

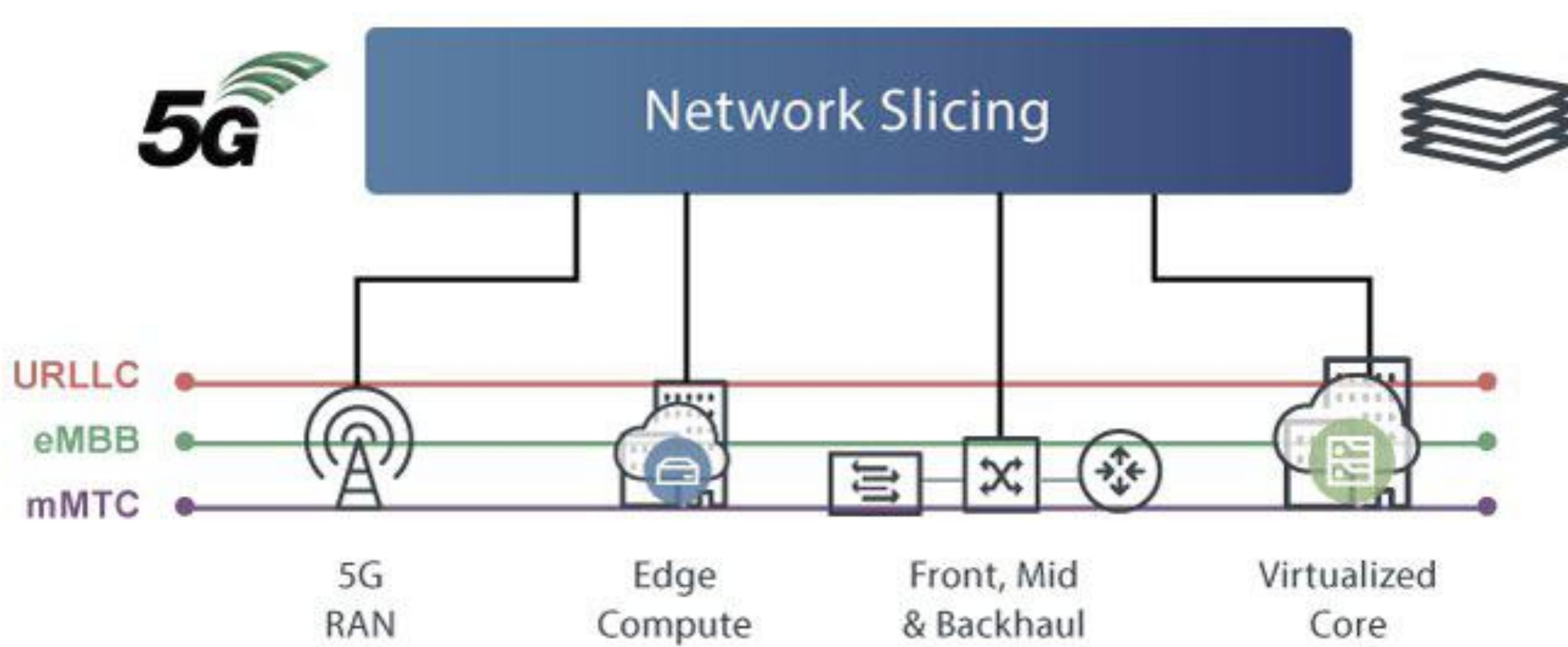
New network core

Slicing, etc.

# 5G VIRTUALIZATION



# 5G SLICING



# MAIN FREQUENCY BANDS (FRANCE)

Source : Arcep – 2020

**700 MHz**

**3.5 GHz**

**26 GHz**

**3,5 GHz**

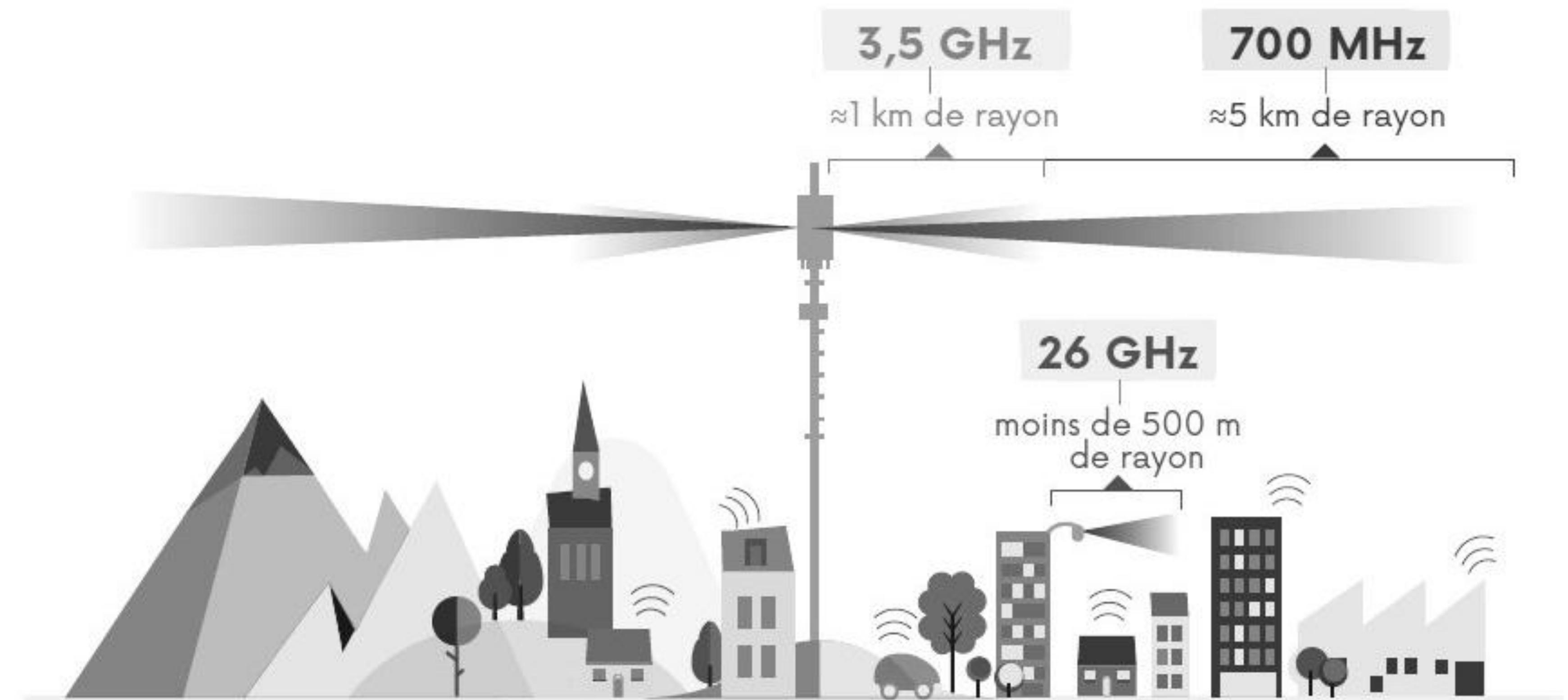
≈1 km de rayon

**700 MHz**

≈5 km de rayon

**26 GHz**

moins de 500 m  
de rayon



# FREQUENCY TRADE-OFF

## 4G like throughputs

**700 MHz**

FDD Frequency-division duplexing

Indoor	Range	Throughput
++	++	--

Bandwidth: 20 MHz

## 4G < throughputs

**3.4-3.8 GHz**

TDD Time-division duplexing

Indoor	Range	Throughput
-	-	+

Bandwidth: 100 MHz

## Fiber-like throughputs

**26 (24-27) GHz**

TDD Time-division duplexing

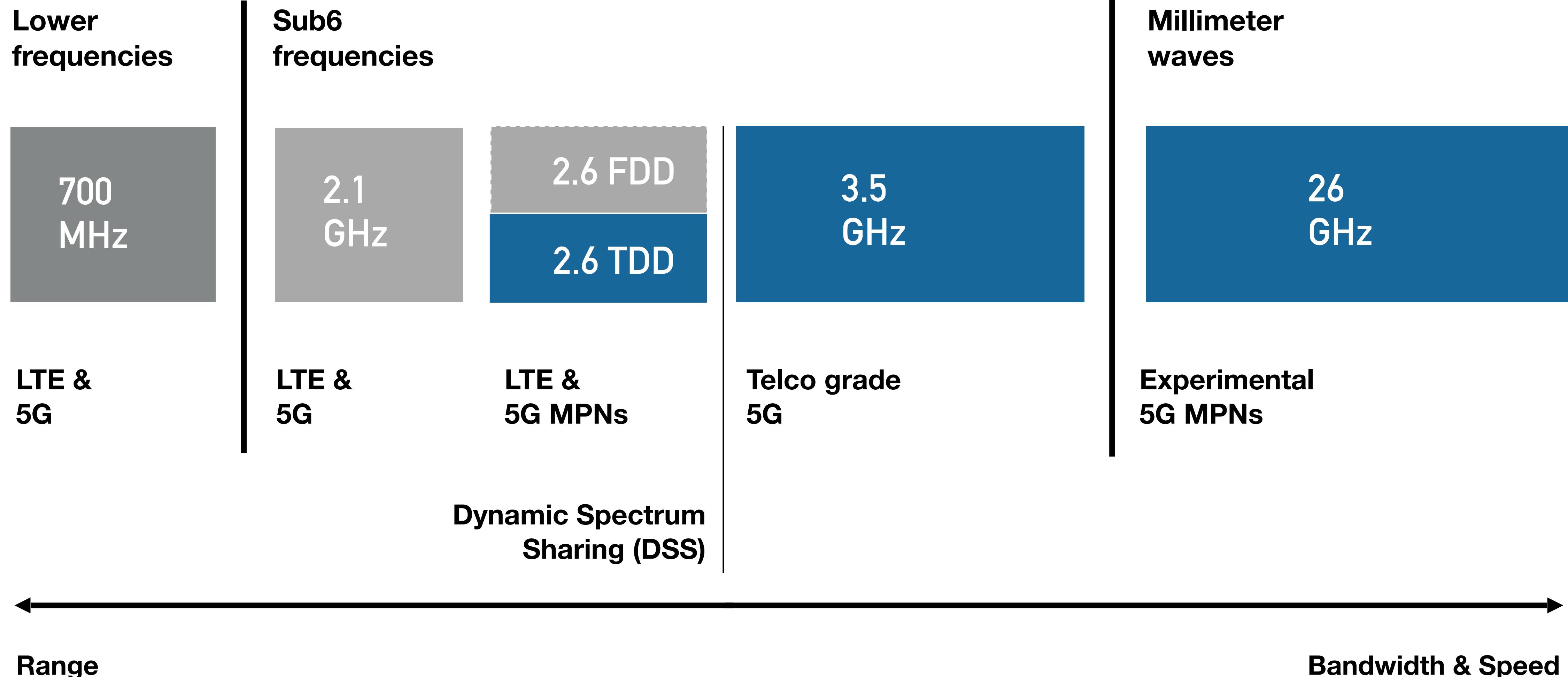
Indoor	Range	Throughput
--	--	+++

Bandwidth: 400 MHz

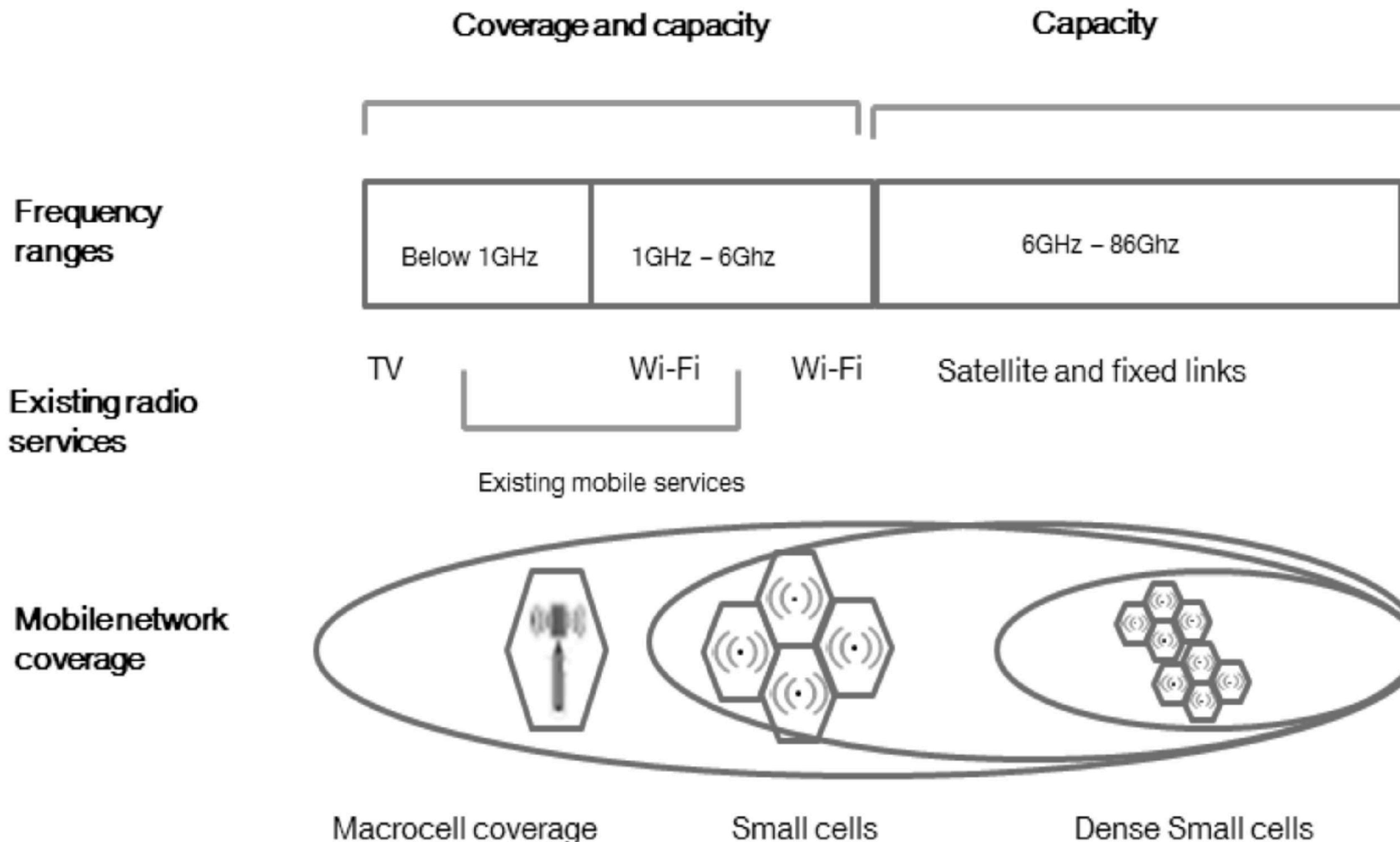
Deployed in 2020

Trials - e.g. mobile hotspots & FWA

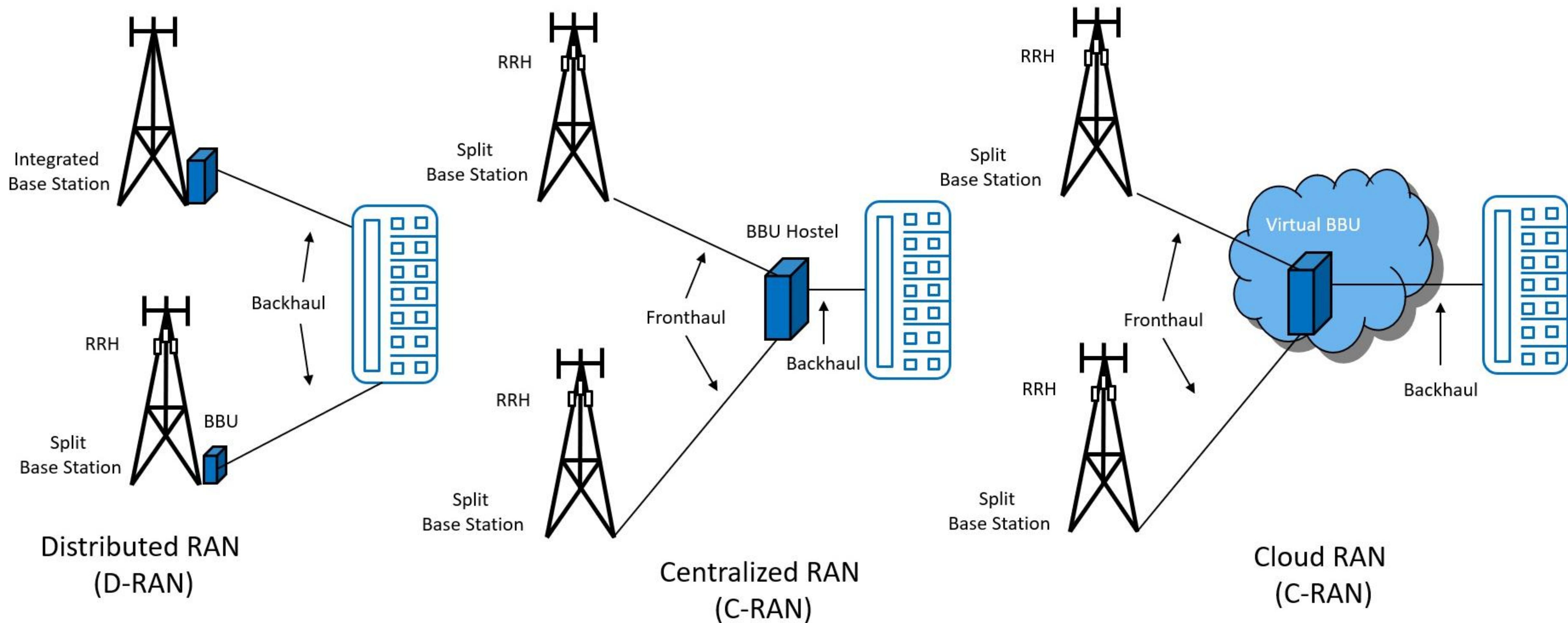
# FREQUENCIES (FRANCE)



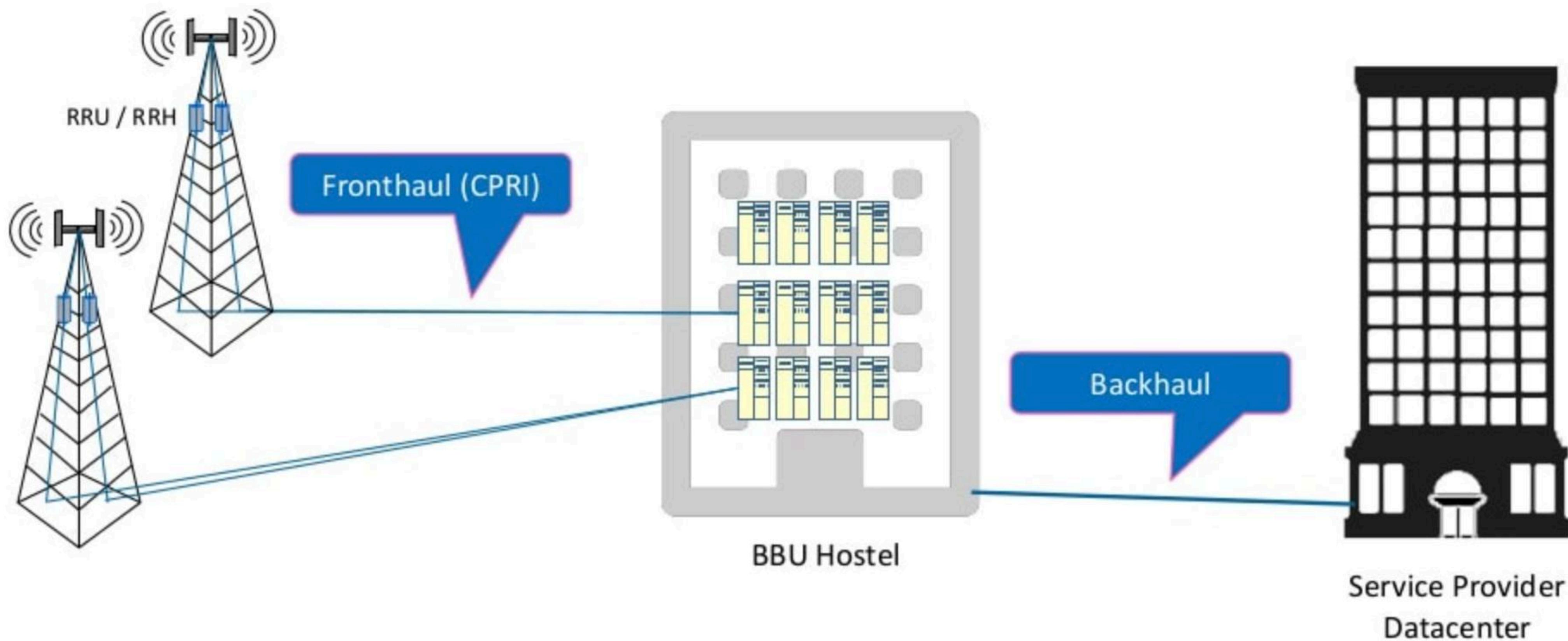
# CELLS



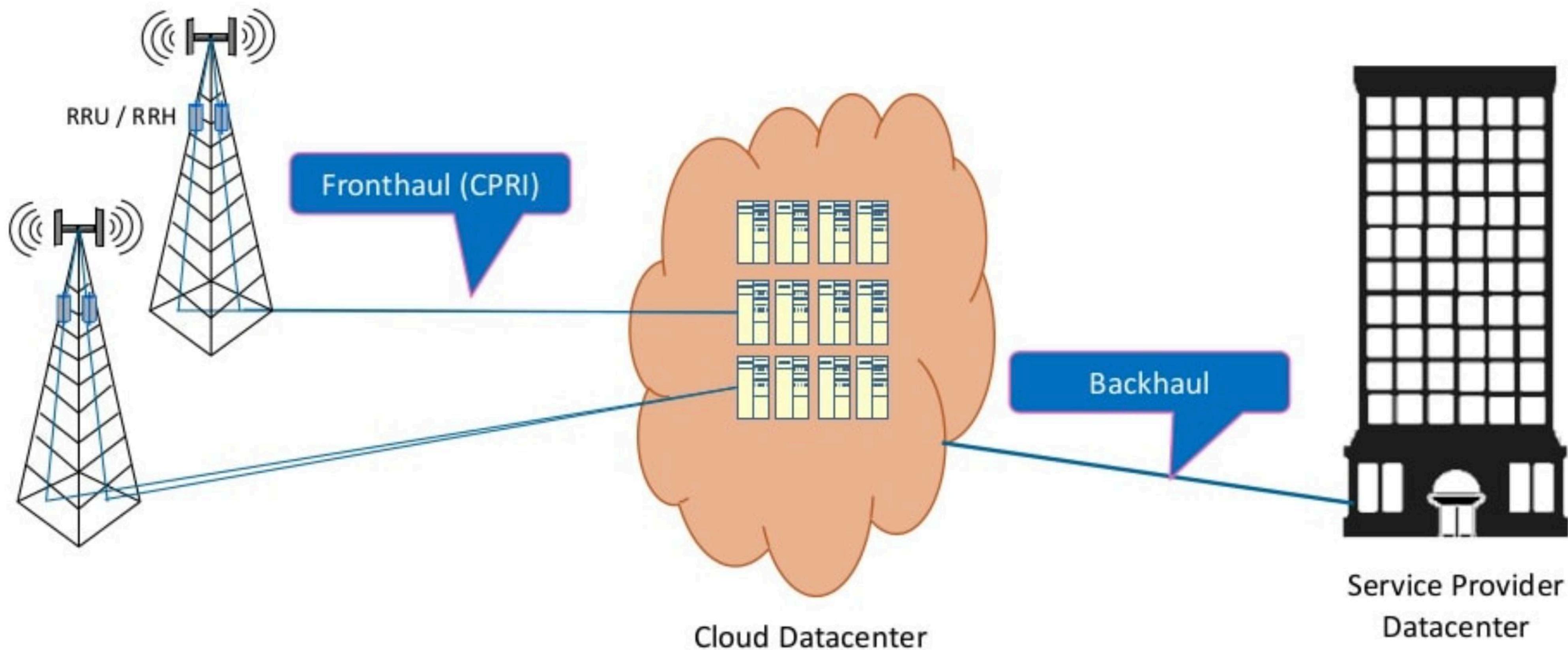
# DEPLOYMENT OPTIONS



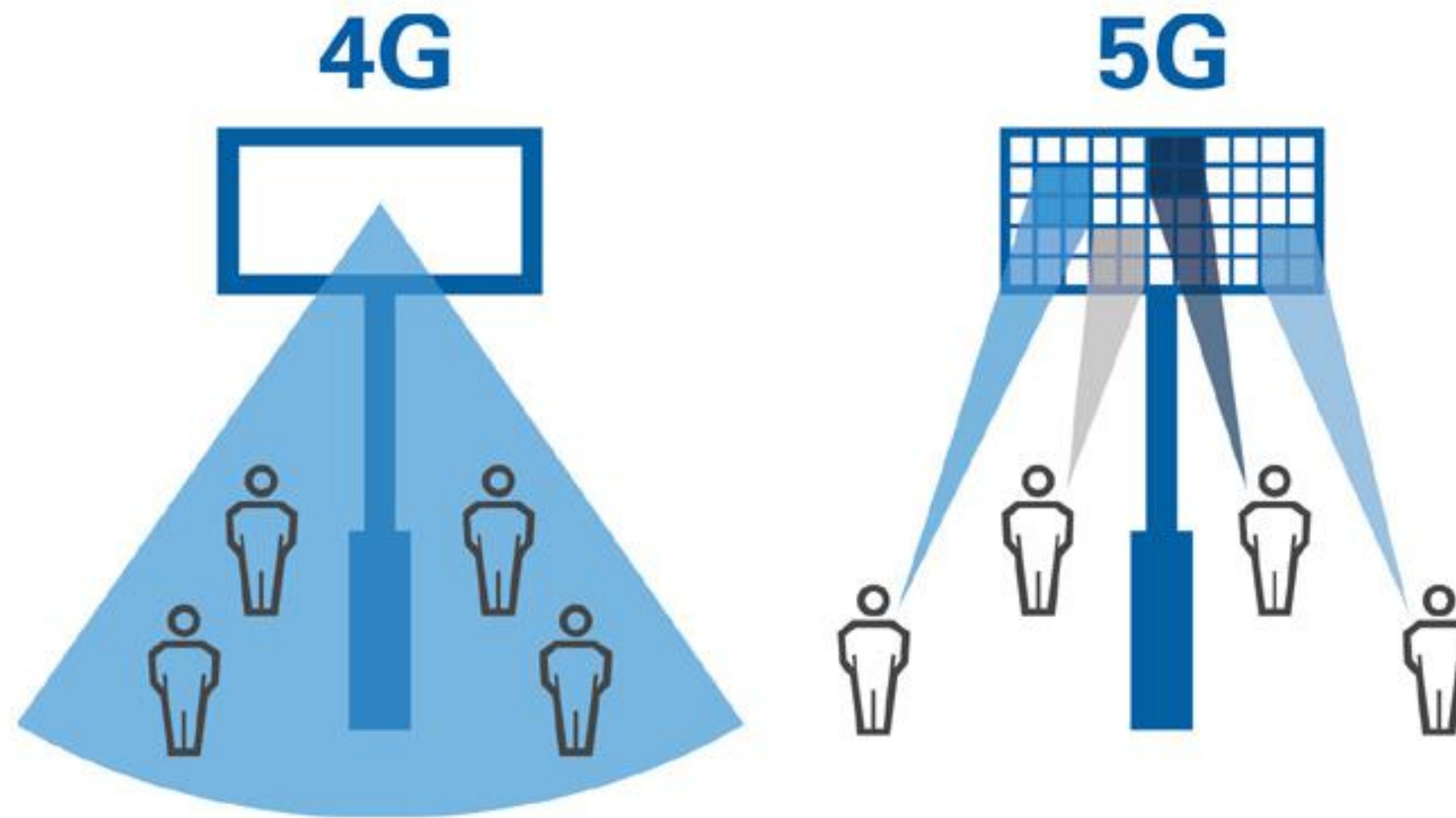
# DEPLOYMENT / CENTRALIZED RAN



# DEPLOYMENT / CLOUD RAN



# ANTENNAS

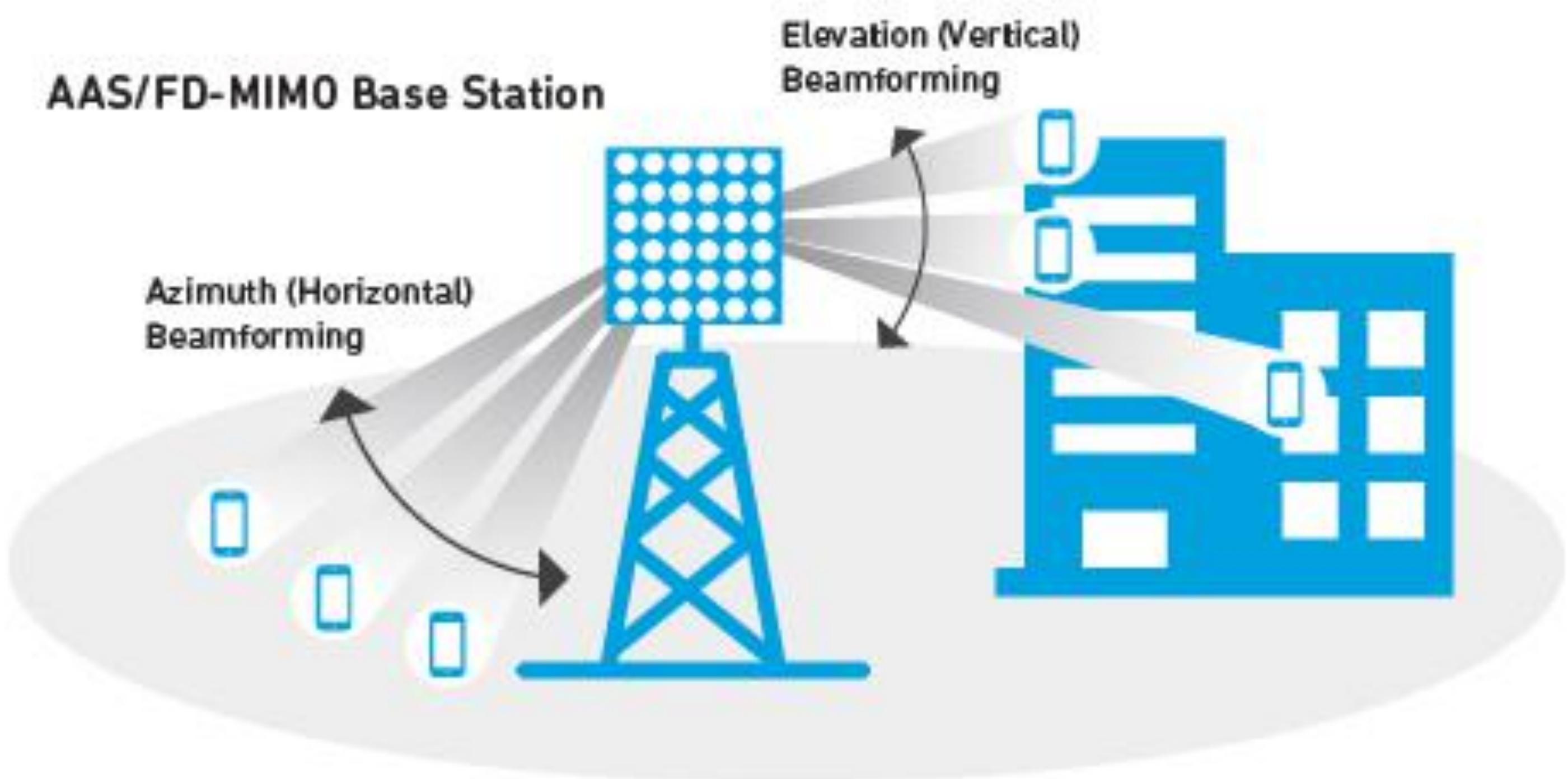


MU-MIMO CAPABILITIES  
WITH ACTIVE ANTENNA ARRAYS

MU-MIMO: MultiUser MIMO (Multiple-Input Multiple-Output)

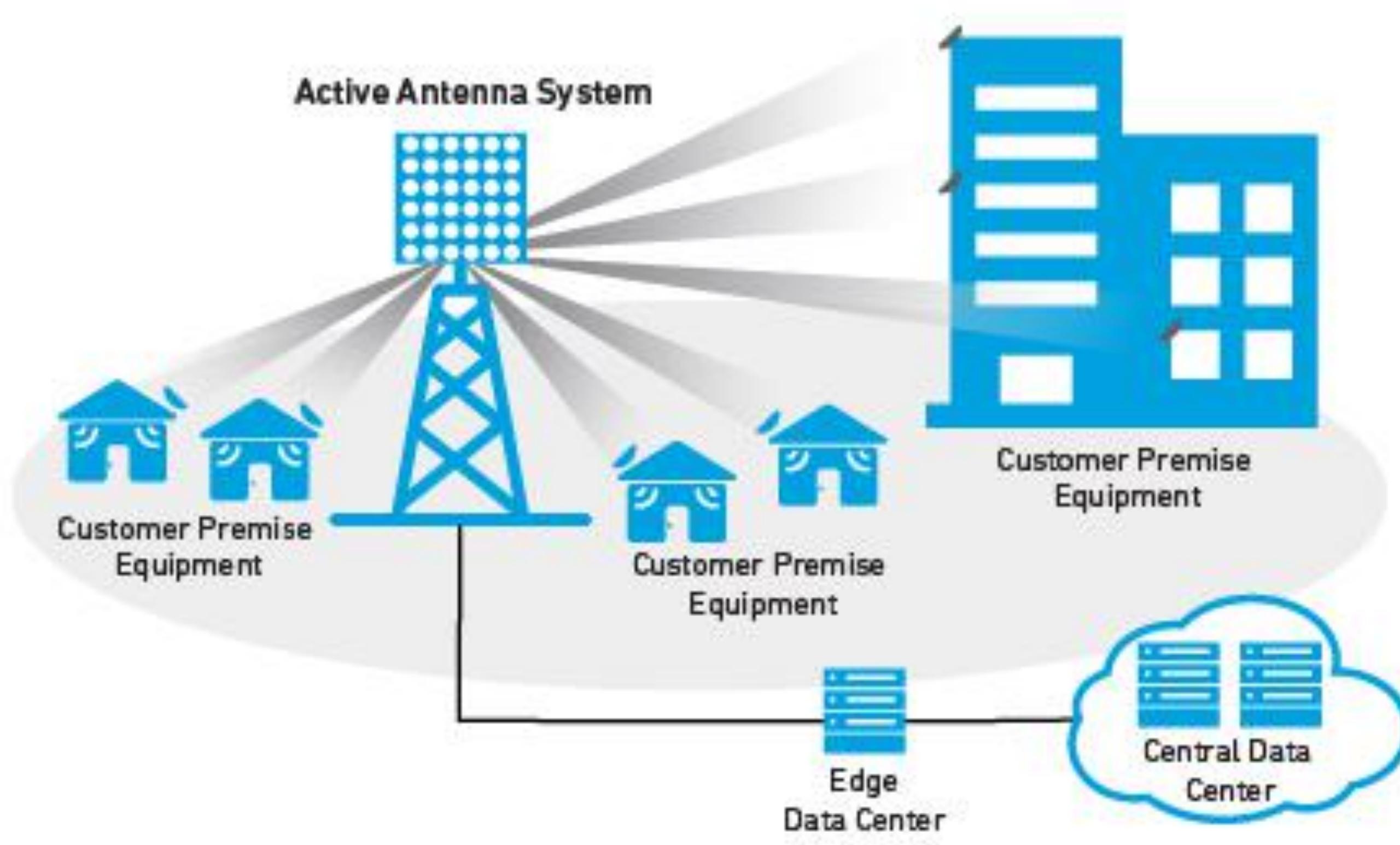
# BEAM FORMING

## Antenna Beam Forming



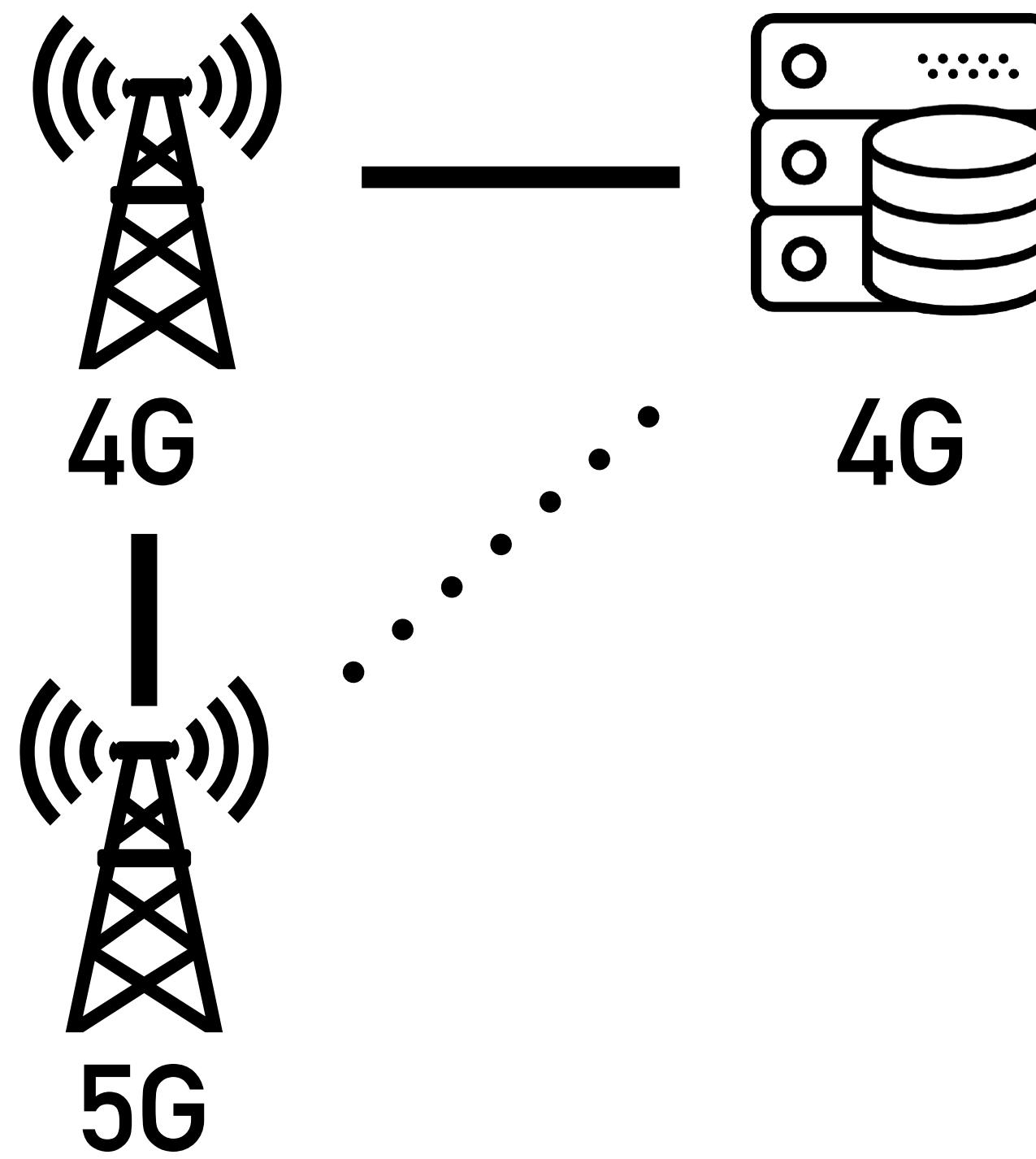
# FIXED WIRELESS ACCESS (FWA)

5G End-to-End Fixed Wireless Access (FWA)  
Networking Using Beam Steering

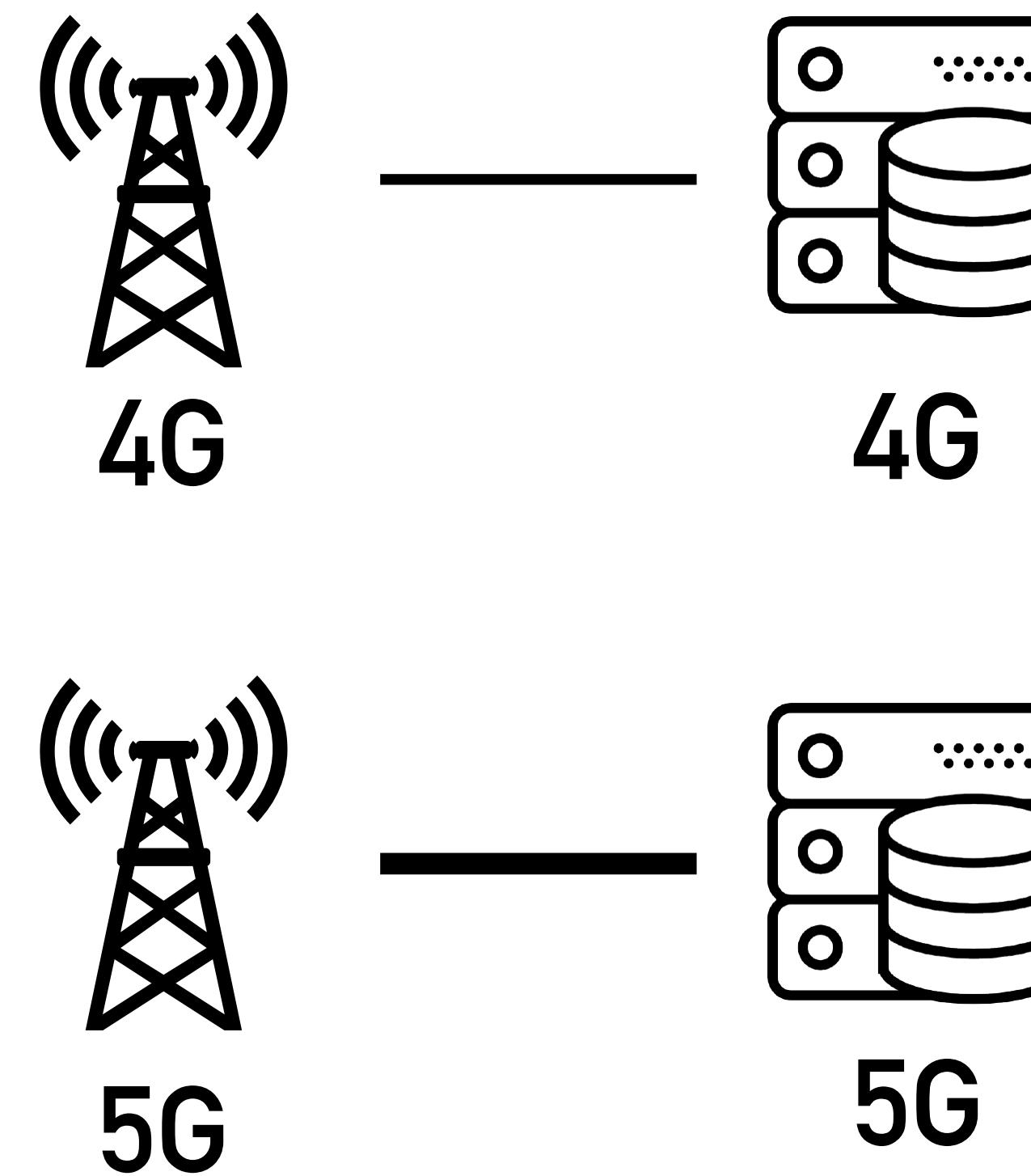


# NSA & SA 5G

## Non standalone



## Standalone



# PATHS TO 5G

**4G**

LPWA

**5G**

LPWA

Advancing your design from 4G LPWA to 5G LPWA is a simple firmware upgrade with no hardware change.

**4G**

LTE

**5G**

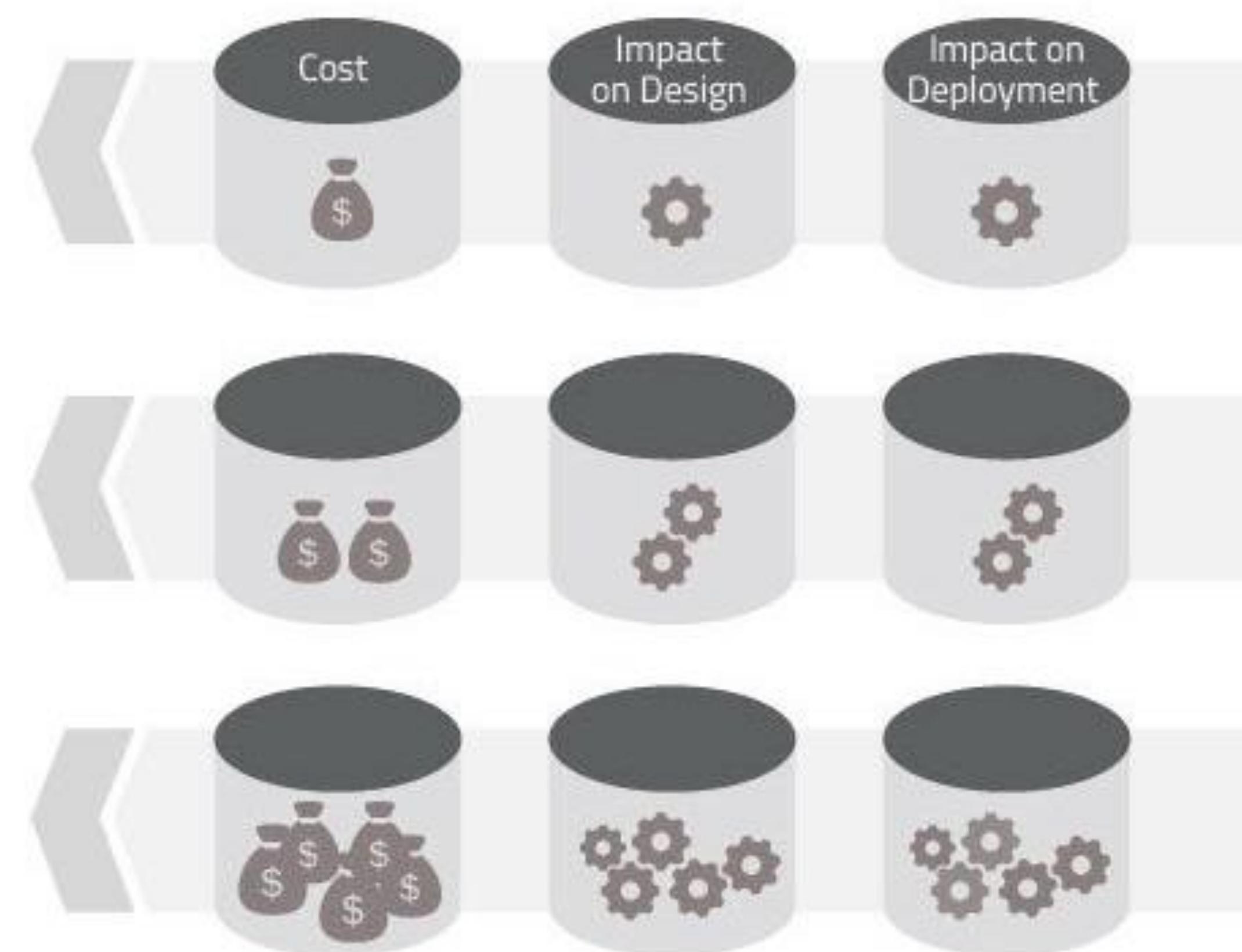
Sub-6

Going from LTE to 5G Sub-6 requires a new radio and potential improvements in product design.

**4G LTE /  
5G Sub-6****5G**

mmWave

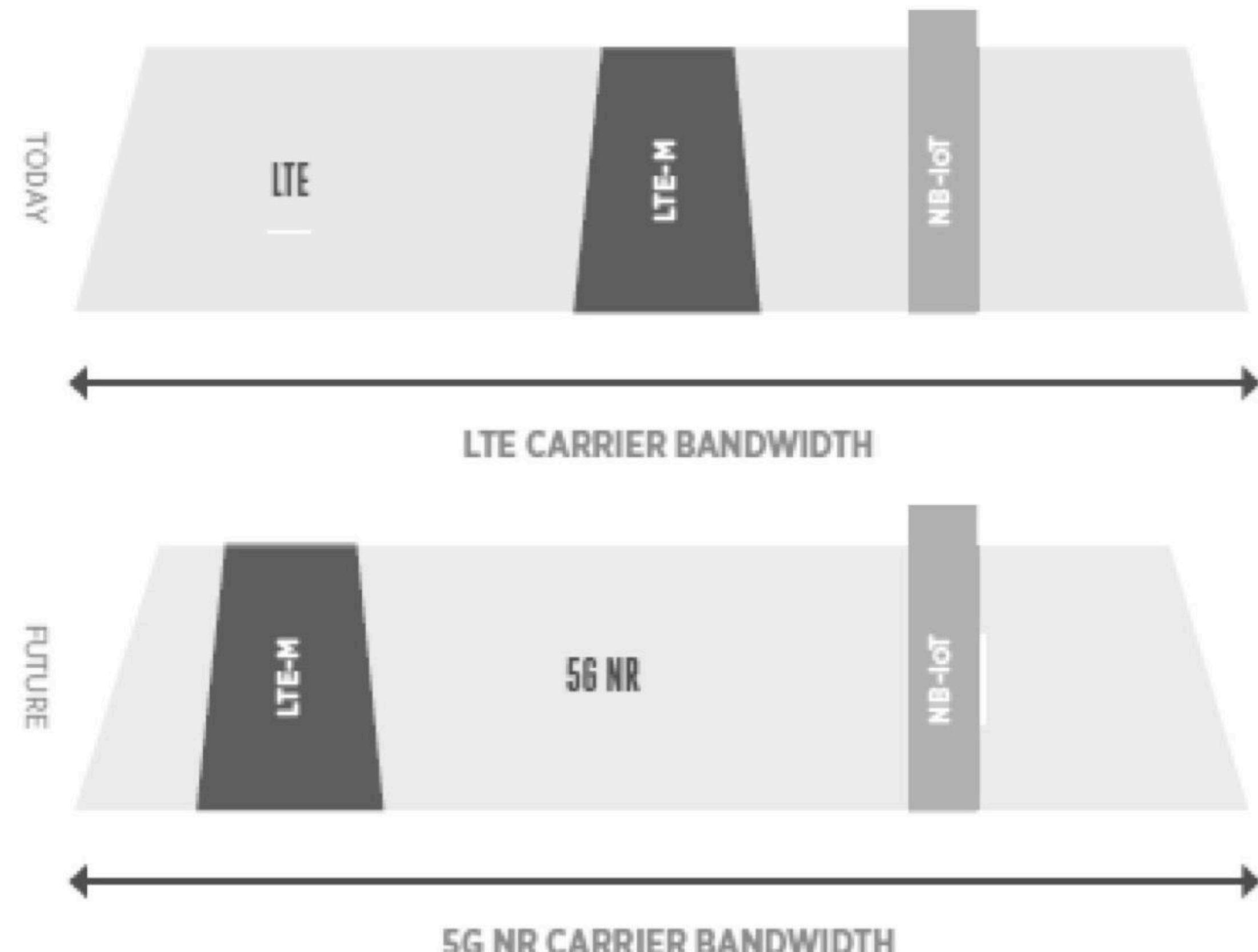
Upgrading from LTE or 5G Sub-6 to 5G mmWave will require a major product redesign.



# PATHS FROM LTE-M & NB-IOT

## 5G NR with in-band NB-IoT and LTE-M

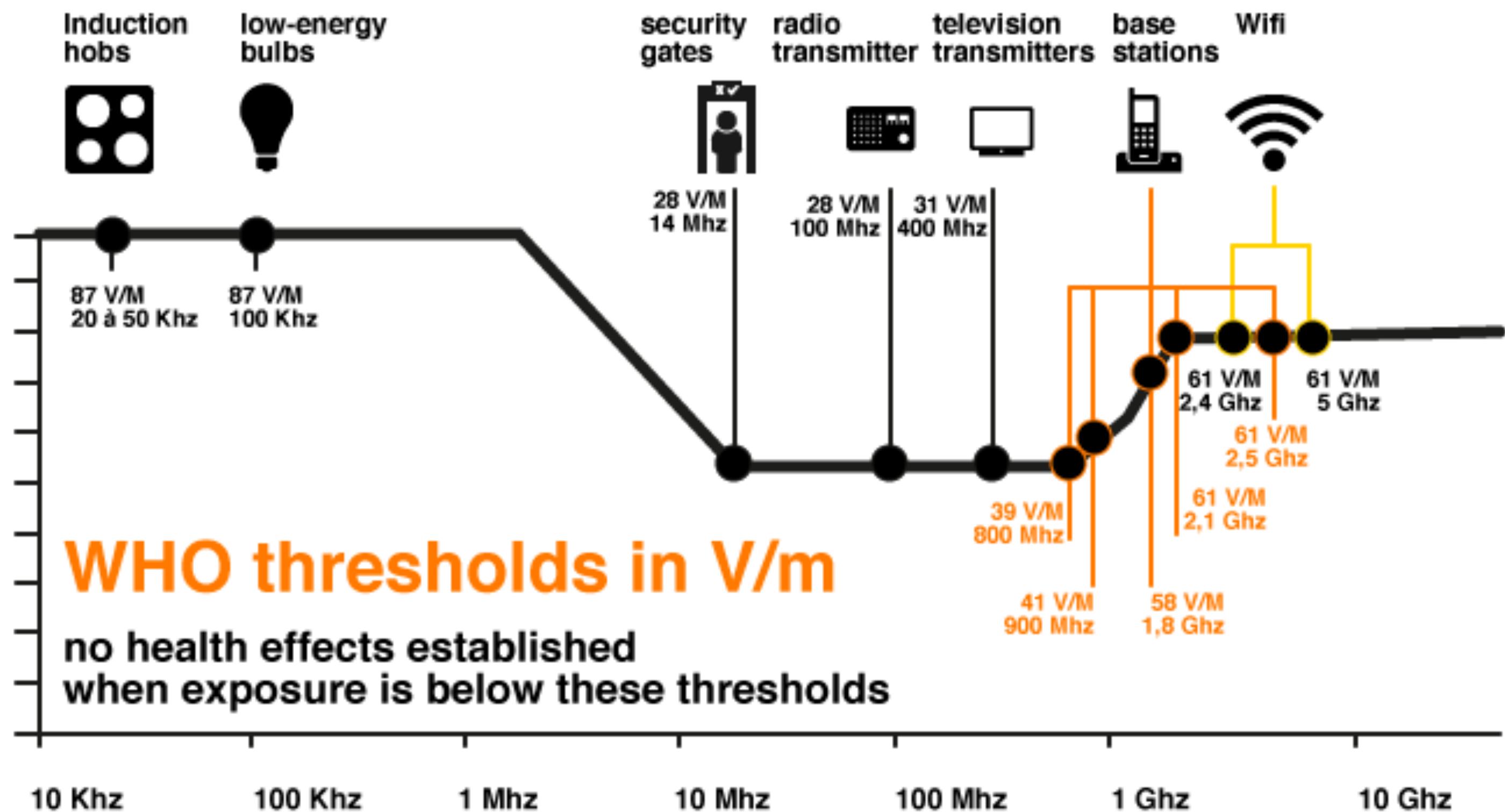
The figures below show in-band operation for NB-IoT and LTE-M within LTE and 5G NR carrier bandwidths.



**Current deployments of LTE-M and NB-IoT:  
L800 / L1800 bands in Europe**

3GPP has specified co-existence scenarios  
between LTE-M / NB-IoT and 5G NR  
in the same band

# 5G & HEALTH



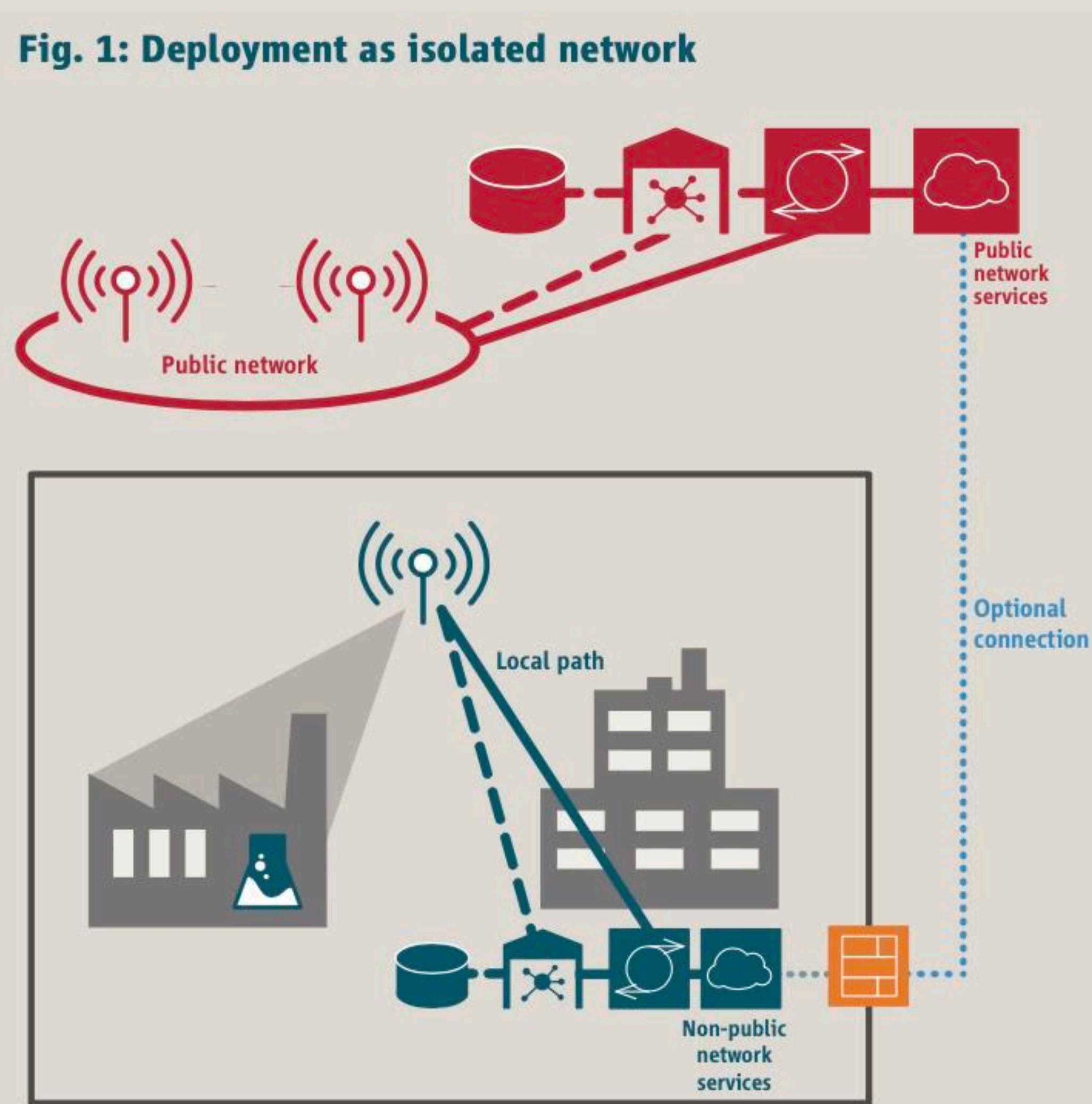
The World Health Organisation (WHO) recommendations cover exposure limits from 0 to 300 GHz.

WHO has concluded that exposure linked to wireless networks and their use does not cause adverse health effects if this exposure is below recommended limits.

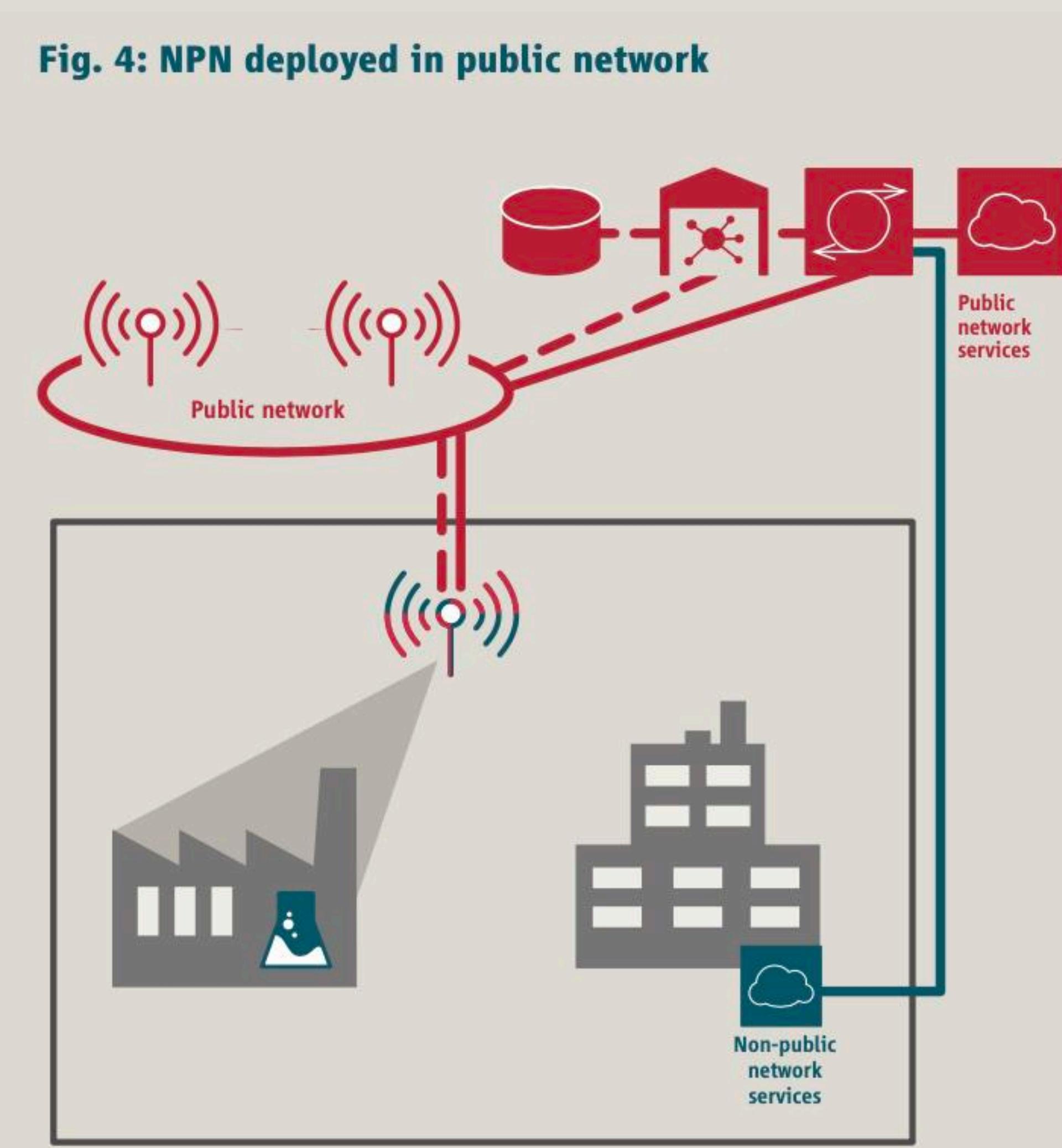
For 5G, the threshold is 39 V/m at 700 MHz and 61 V/m at 3.5 GHz and 26 GHz

# PRIVATE 5G NETWORKS

**Fig. 1: Deployment as isolated network**



**Fig. 4: NPN deployed in public network**



# PRIVATE 5G NETWORKS

Fig. 2: Deployment with shared RAN

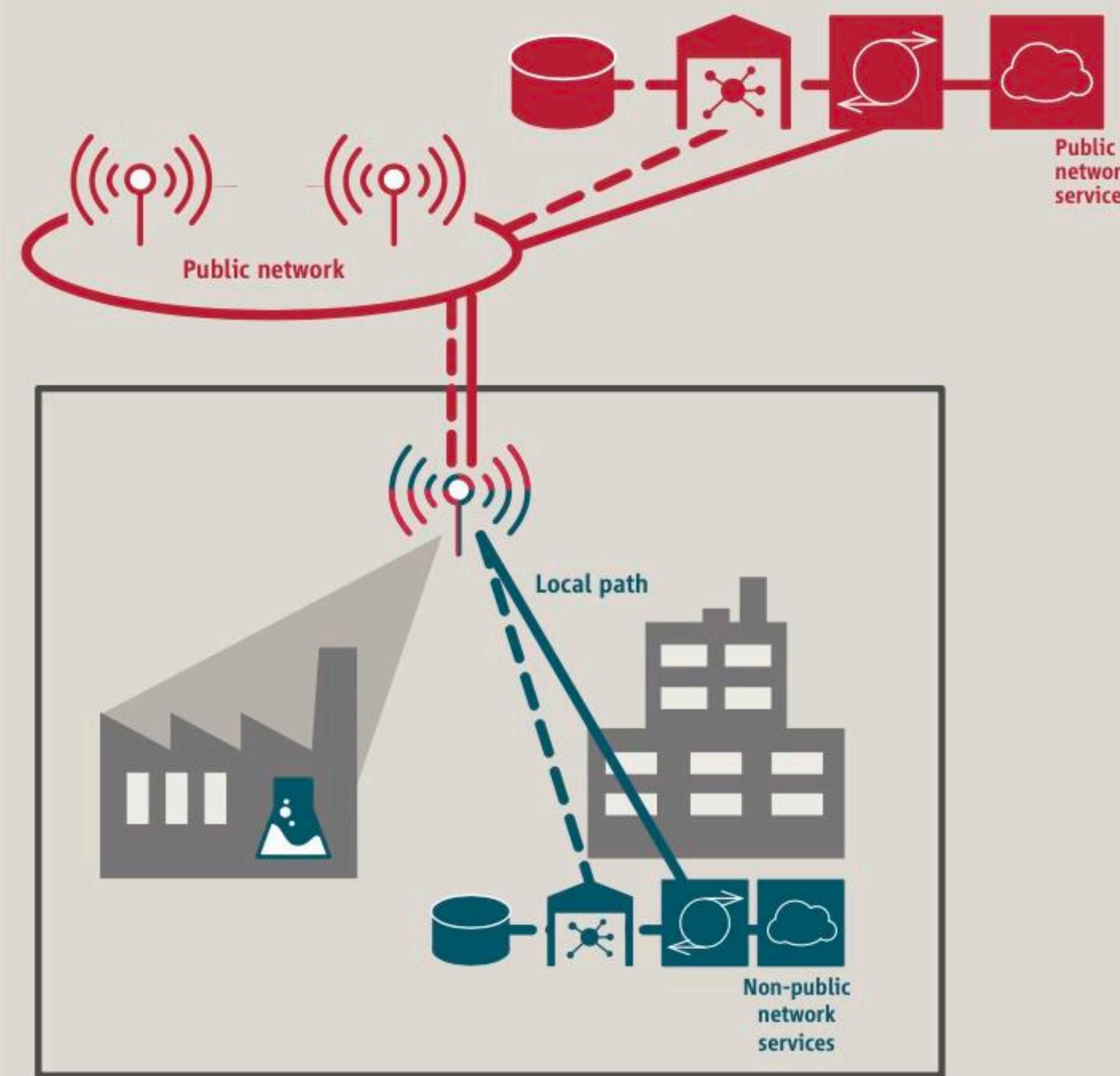
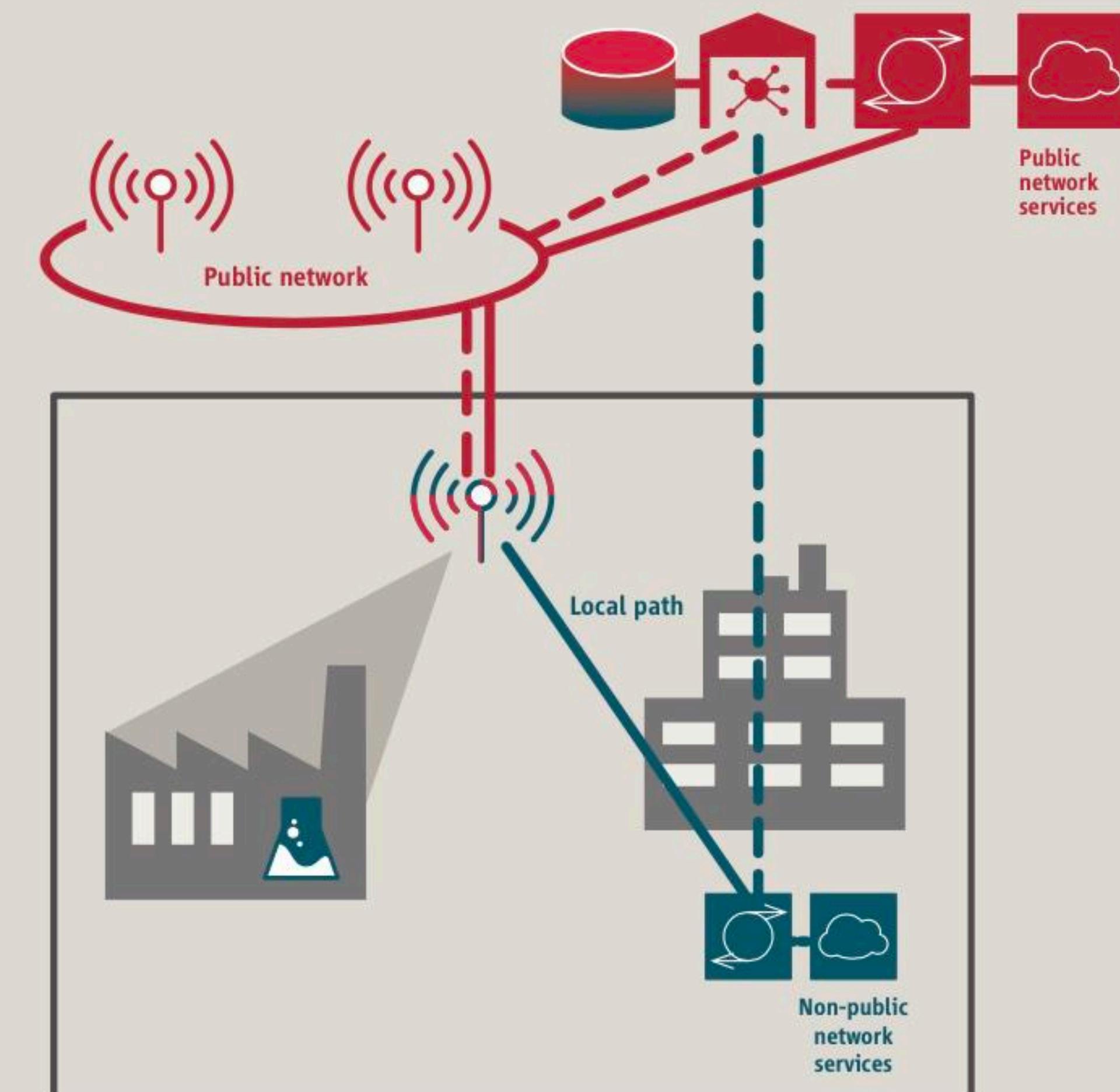
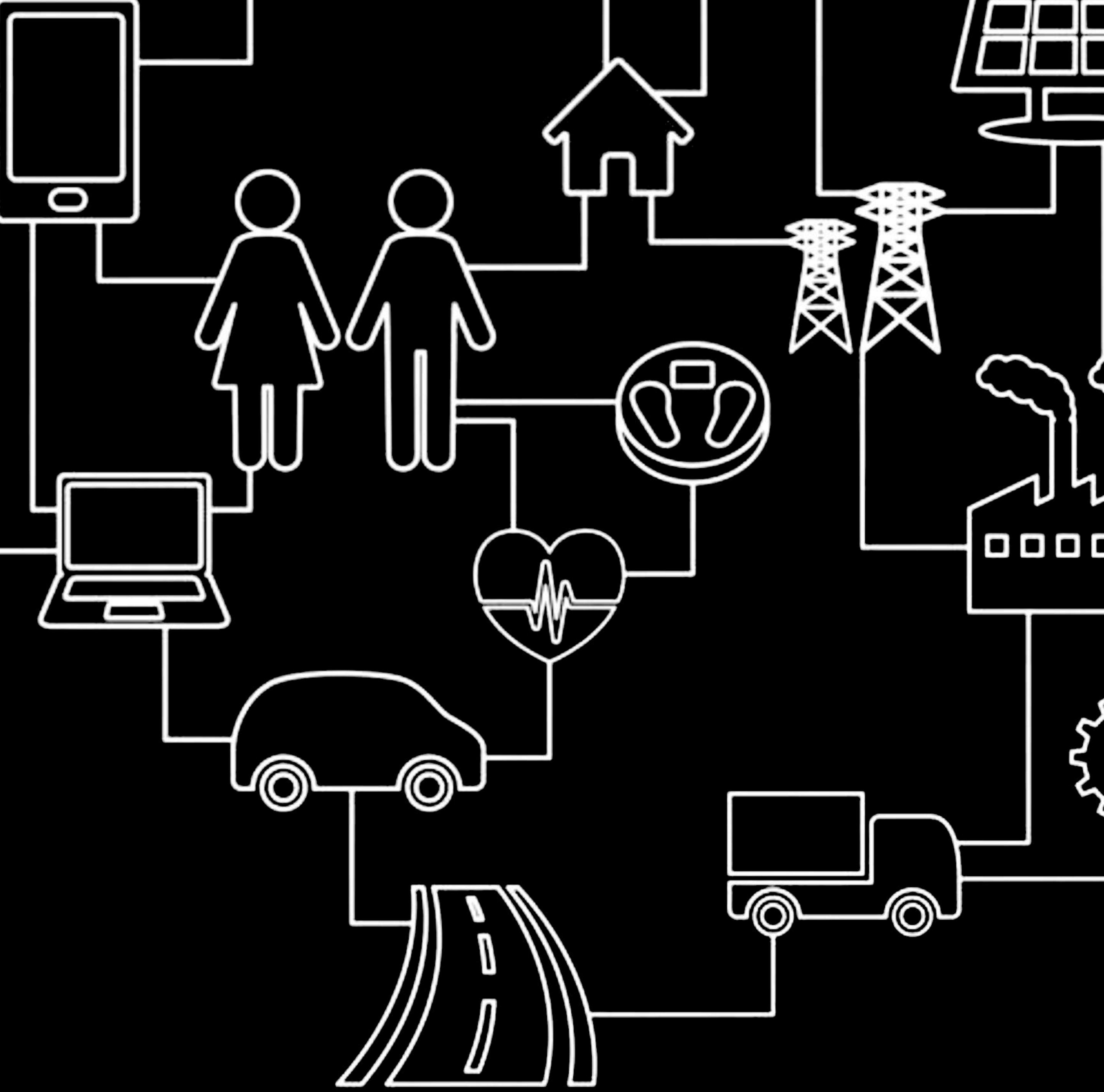


Fig. 3: Deployment with shared RAN and control plane





# IOT

more than connectivity