

CAN WE DEPLOY SMART OBJECTS EVERYWHERE?

KEYNOTE AT IESTEC 2026
OCT. 21ST, 2026



IOT-SENSING-SYSTEM

Internet-of-Things and Sensing System Research Activities at University of Pau, France



La France au Panama et aux Bahamas

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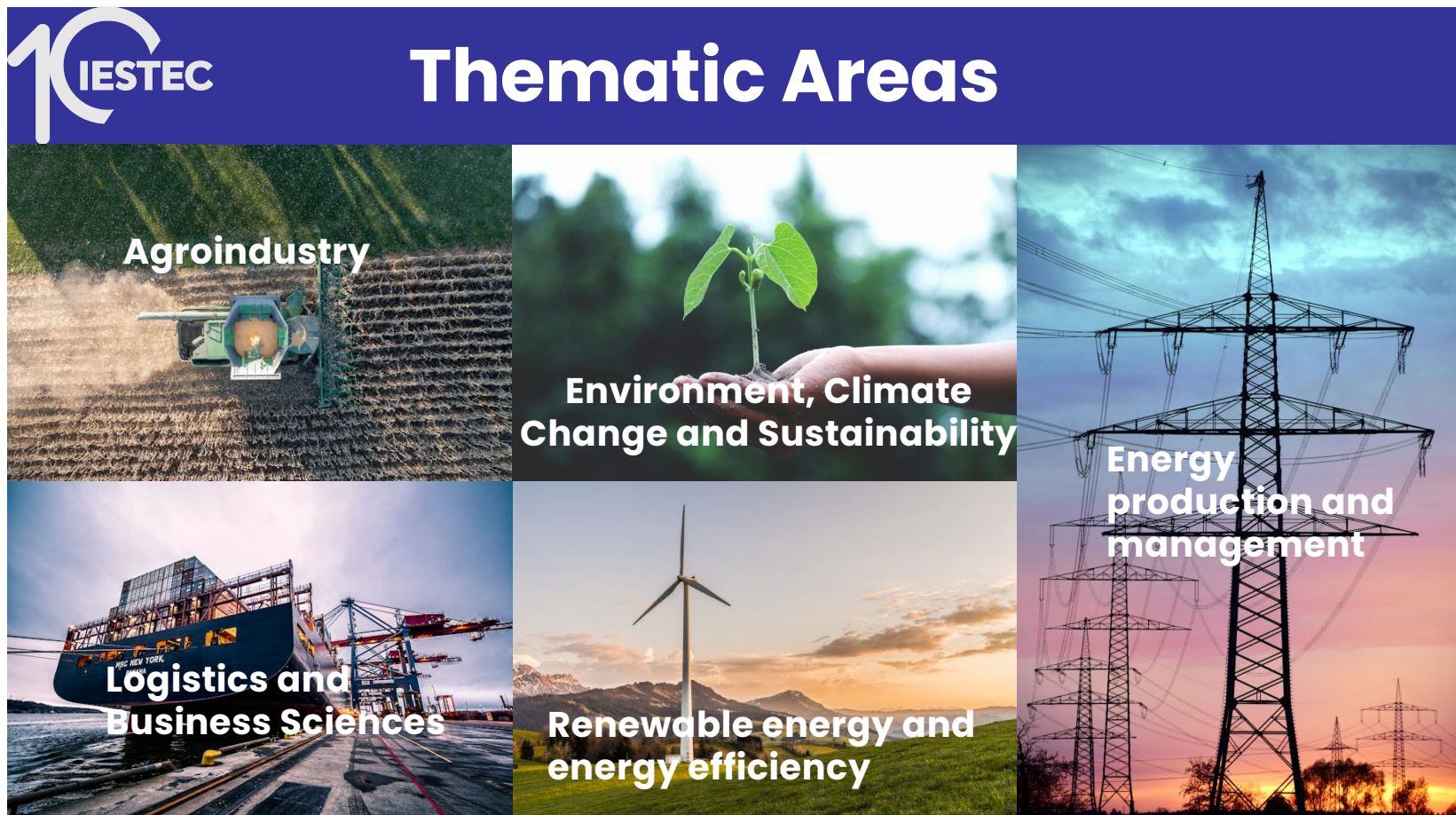
Horizon 2020
European Union funding
for Research & Innovation



Paving for the next 10 years
of innovation in IoT and AI



What do they have in common?



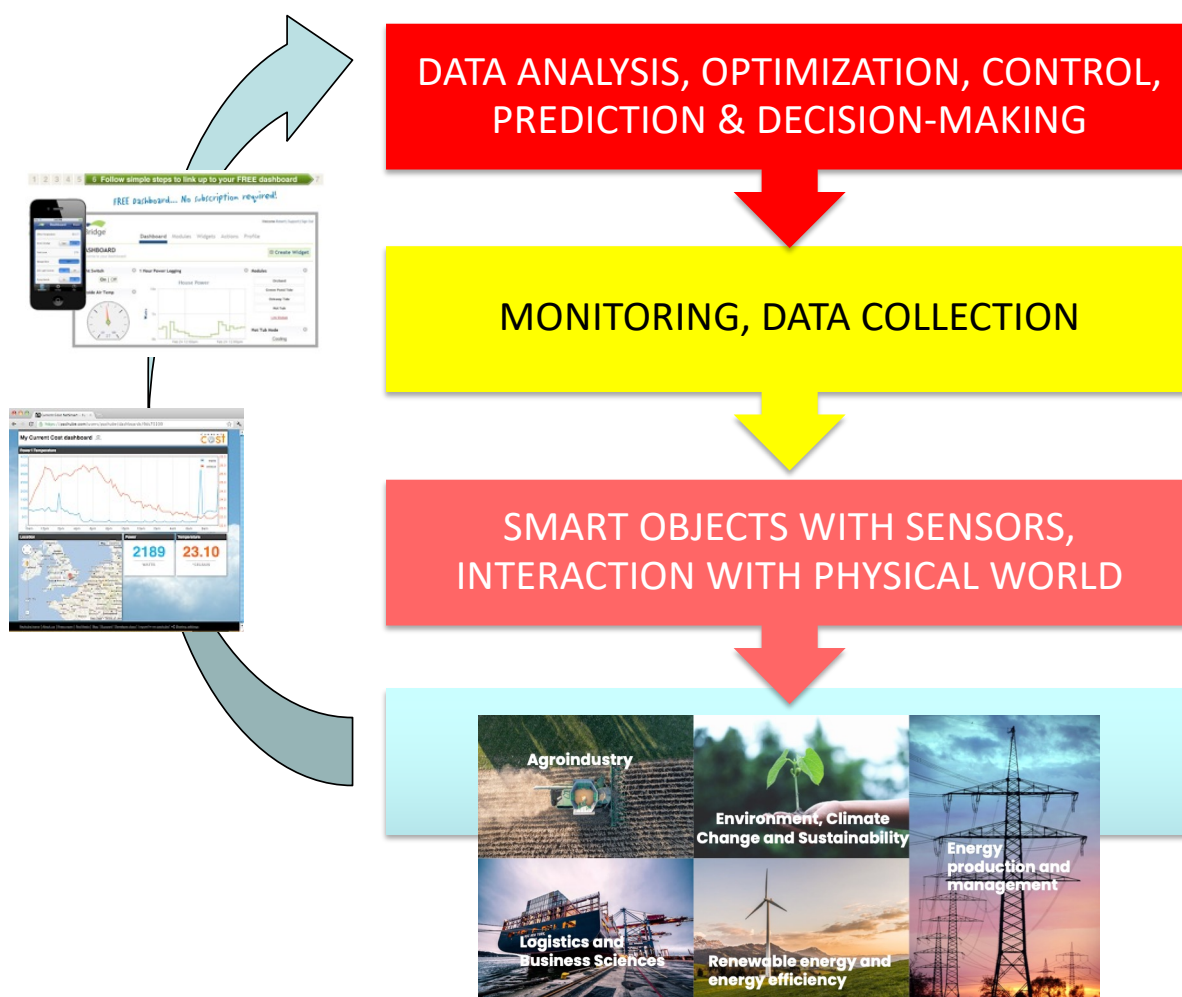
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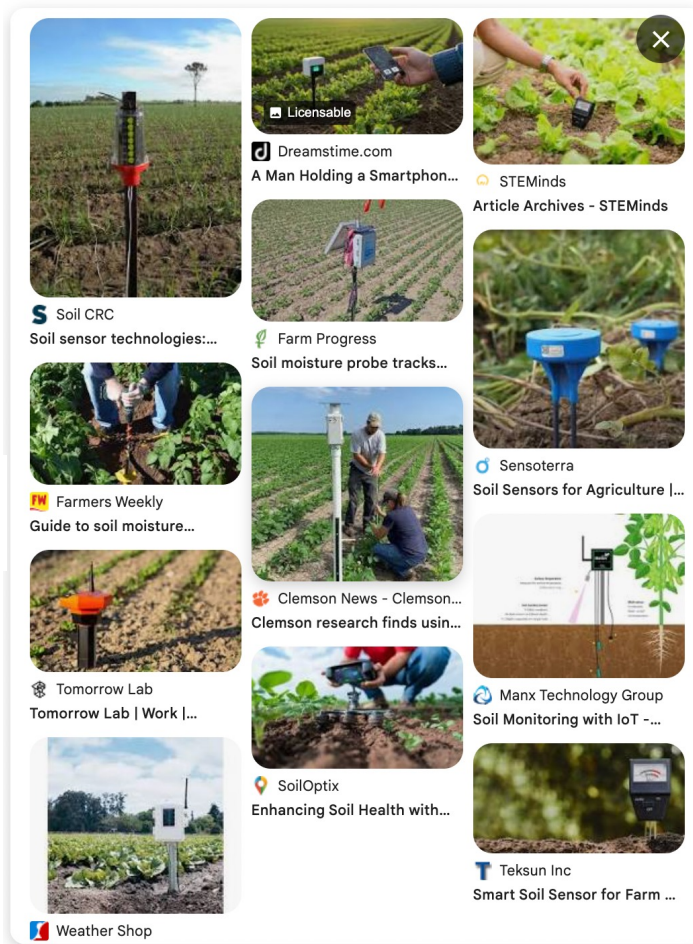
THEY CAN ALL BENEFIT FROM SMART OBJECTS!



Deploy, Sense, Monitor, Optimize ...

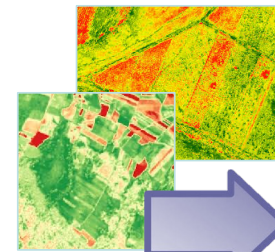
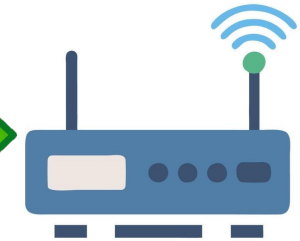
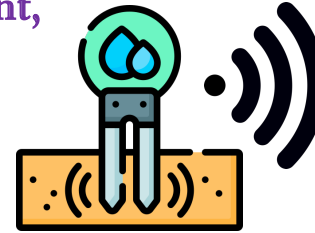


Smart Sensors in Agriculture

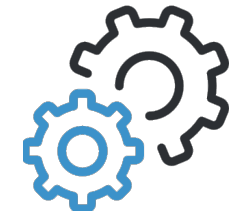


Ground Sensors

Soil, Water,
Environment,
Plant,
etc.



NDVI, etc.



REAL-TIME DATA



Collaboration on cost-effective sensors in agriculture & agroecology



La France au Panama et aux Bahamas



OK, you said “Deploy, Sense & Monitor”?



OK, you said “Deploy, Sense & Monitor”?



CAN WE DEPLOY SMART OBJECTS EVERYWHERE?



Energy – Range dilemma

ENERGY

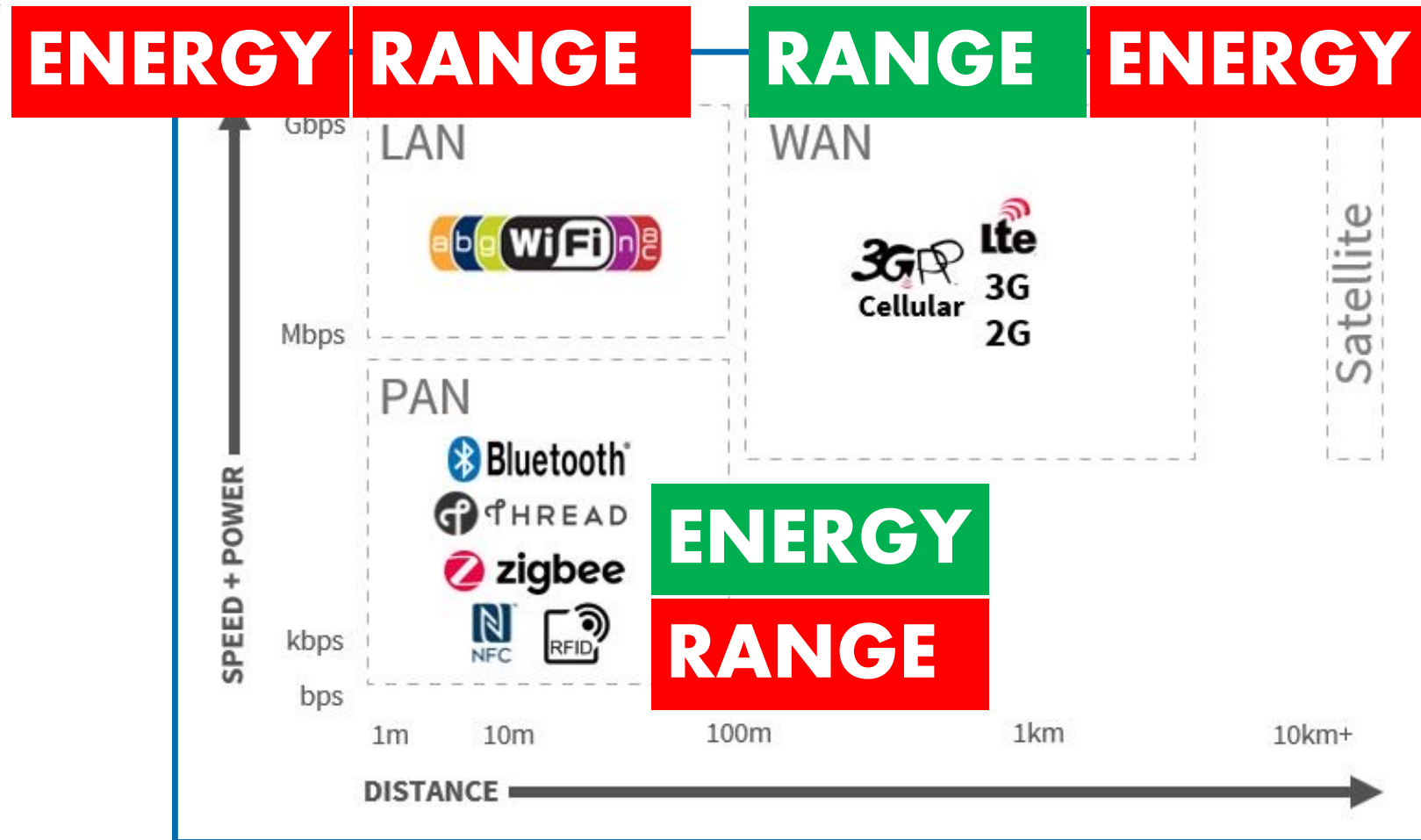
RADIO RANGE



2500mA

**CAN WE HAVE SEVERAL YEARS
OF AUTONOMY?**

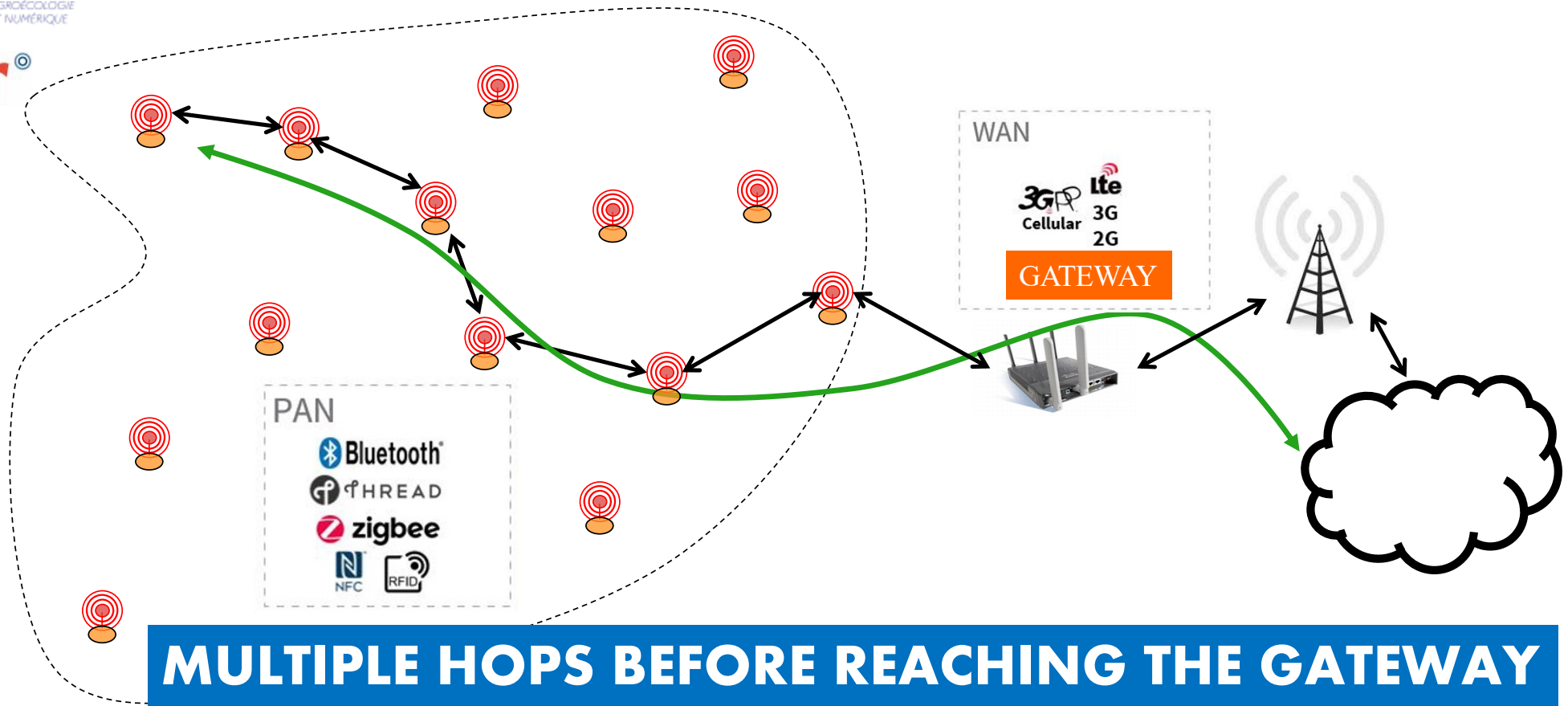
Radio technologies



Before 2015

ENERGY

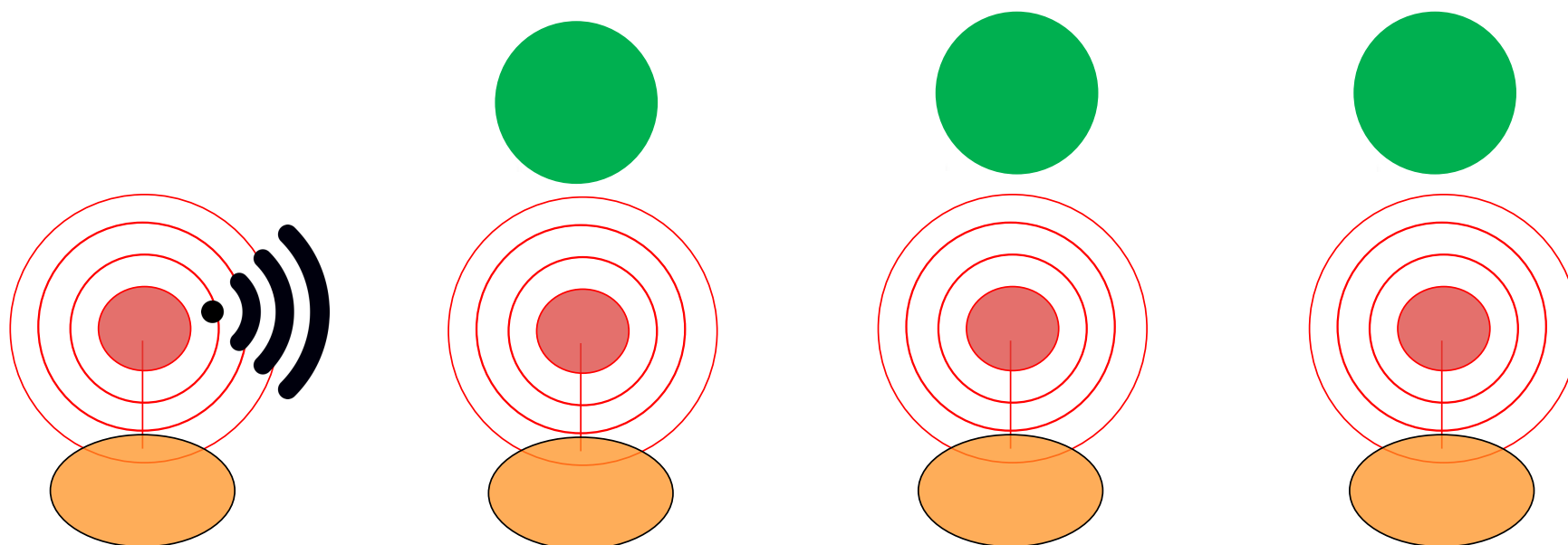
RANGE



MULTIPLE HOPS BEFORE REACHING THE GATEWAY

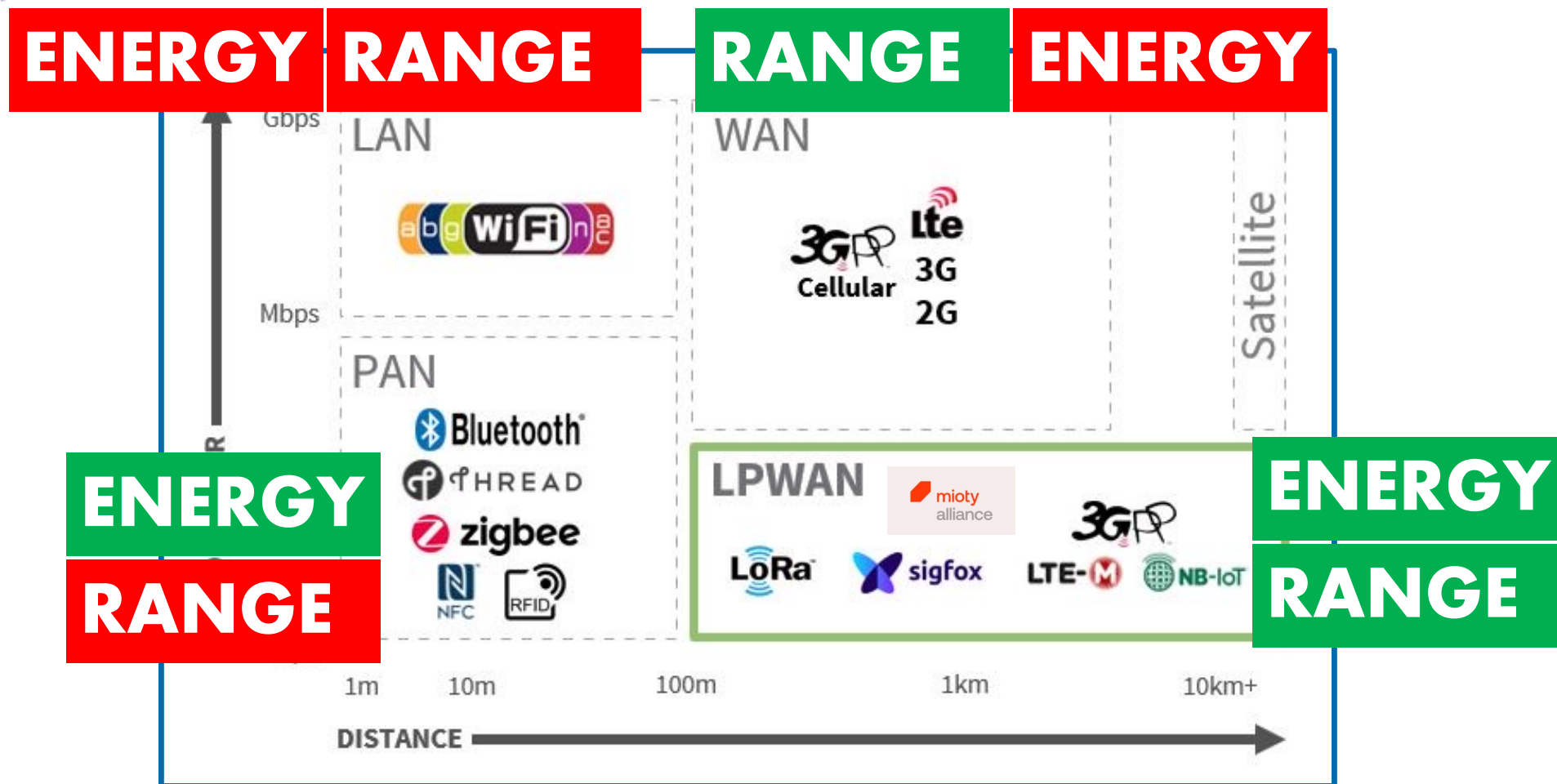
The golden age of multi-hop wireless sensor networks!

Managing energy? A nightmare!



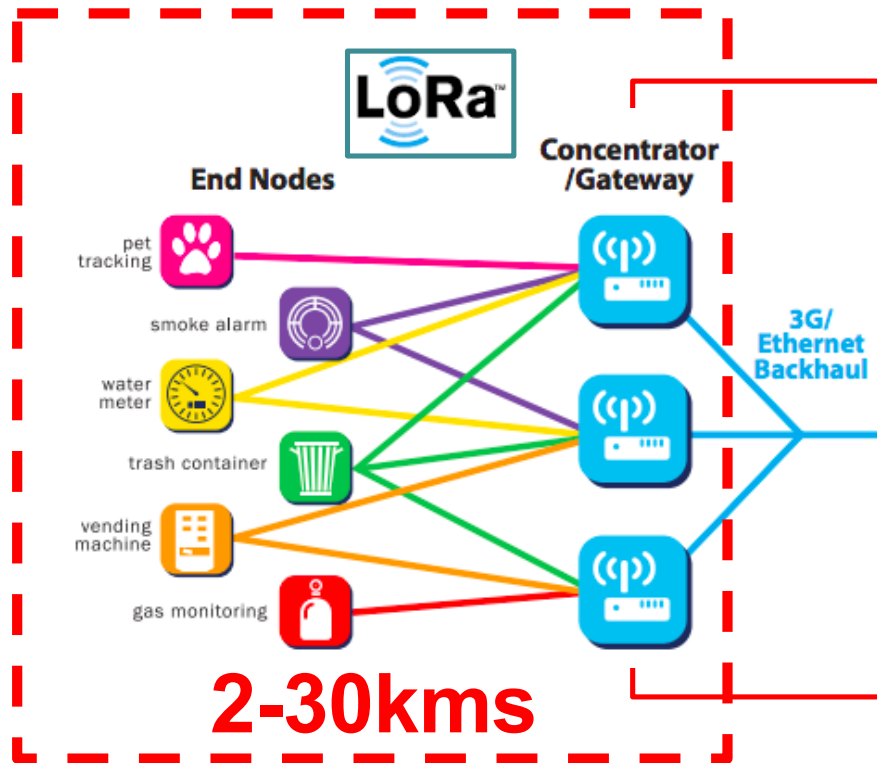
From 2015: LPWAN!

Low Power Wide Area Network



LPWAN: star topology, gateway-centered

- ⦿ A typical architecture taking graphics from LoRa networks



LoRa®
EVERYTHING

The Internet of Things and LoRa® are making a better, sustainable world to live, work and play.
LoRa and the LoRaWAN® standard provide a "voice" to things – carrying an explosion of data and analytics to solve real world challenges.

AGRICULTURE
Precision irrigation reduces water resources **UP TO 30%**
Cattle health monitoring increases milk harvest by 1,200 liters per cow

BUILDINGS
Desk and meeting room occupancy tracking optimizes space utilization
24/7 monitoring of cracks, tilt and foundation strength improves safety

HEALTHCARE
Wearable tracks dementia patient location and alerts caregivers
Free secure wireless data network to the entire Madrid healthcare system during the Coronavirus crisis

HOME
Monitoring gas, electrical and water use reduces consumption
Real-time leak detection predicts and prevents property damage

SUPPLY
Indoor/Outdoor geolocation asset tracking increases efficiency
Remote temperature monitoring of refrigerated food ensures quality

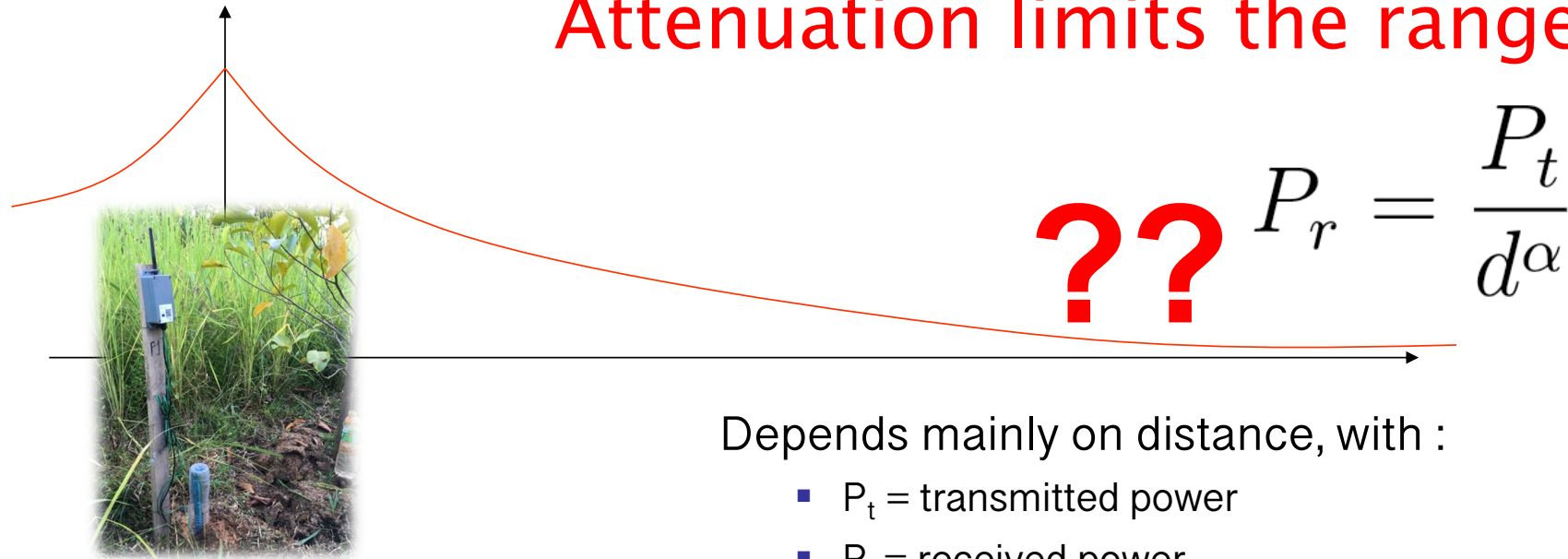
UTILITIES
Remote metering applications replace costly manual processes
Advanced Metering Infrastructure (AMI) increases grid efficiency **UP TO 25%**

191 MILLION
connected IoT devices leveraging LoRa

Big issue: signal attenuation

X watts

Attenuation limits the range!



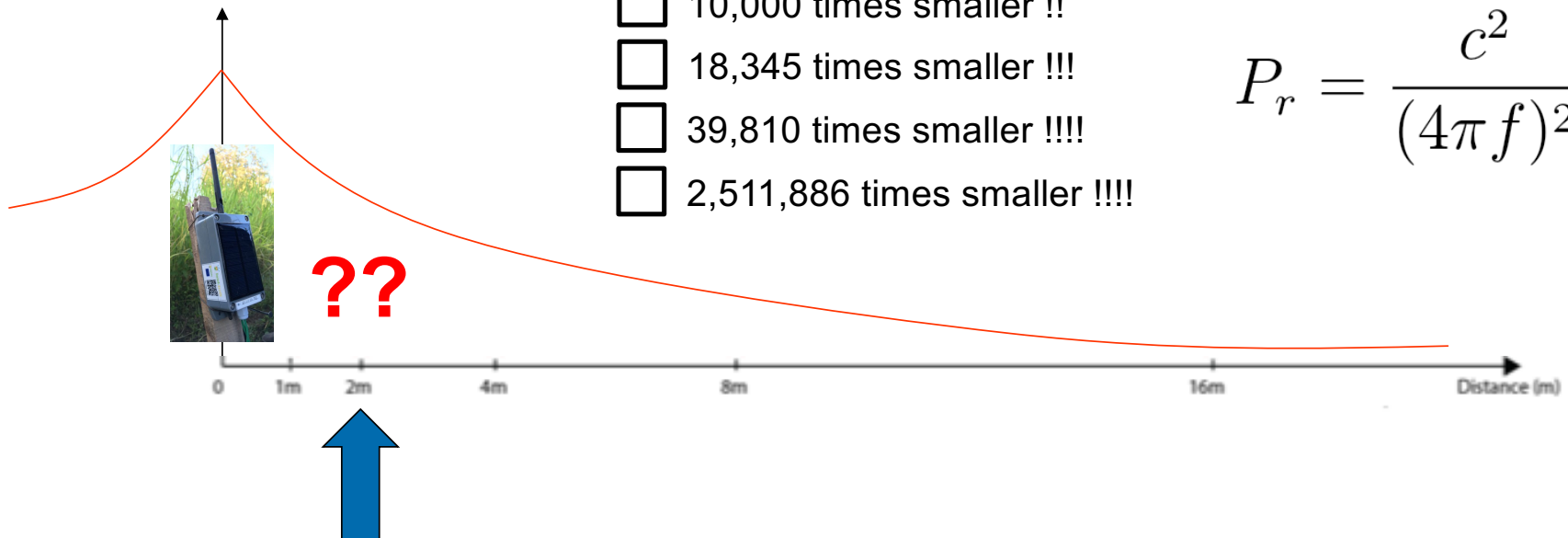
Depends mainly on distance, with :

- P_t = transmitted power
- P_r = received power
- d = distance between antennas
- α from 2 to 4

Wireless attenuation, let's take a quizz!

FOR A 2.4GHZ SIGNAL AT 2M

25mW



- ☐ 3,500 times smaller !
- ☐ 10,000 times smaller !!
- ☐ 18,345 times smaller !!!
- ☐ 39,810 times smaller !!!!
- ☐ 2,511,886 times smaller !!!!

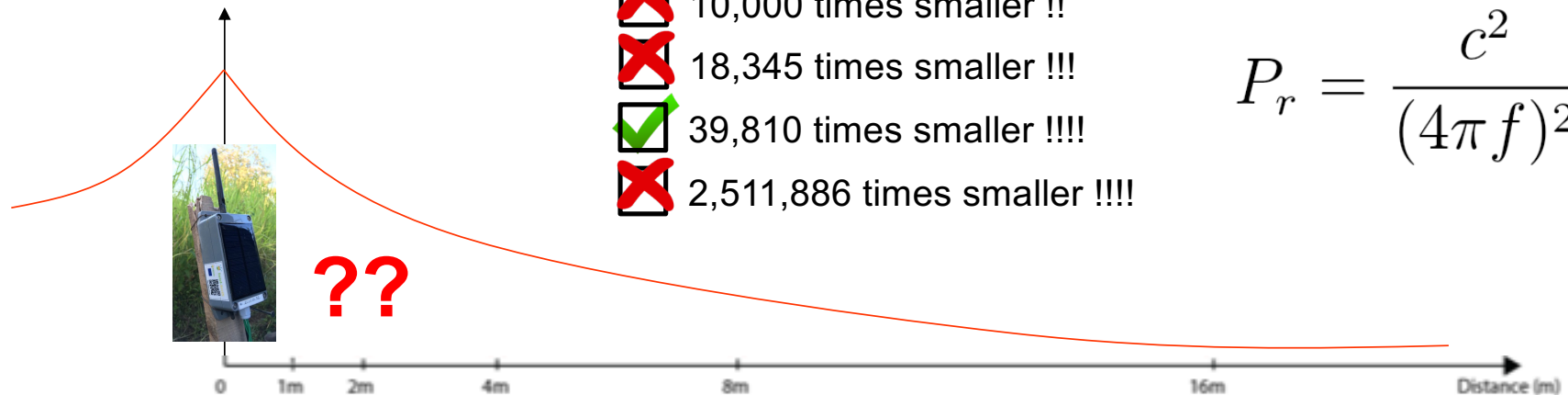
Free Space Path Loss model

$$P_r = \frac{c^2}{(4\pi f)^2} \frac{P_t}{d^2}$$

Wireless attenuation, let's take a quizz!

FOR A 2.4GHZ SIGNAL AT 2M

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Free Space Path Loss model

$$P_r = \frac{c^2}{(4\pi f)^2} \frac{P_t}{d^2}$$

0.0025mW 0.00062mW

x10,000 smaller! x39,810 smaller!

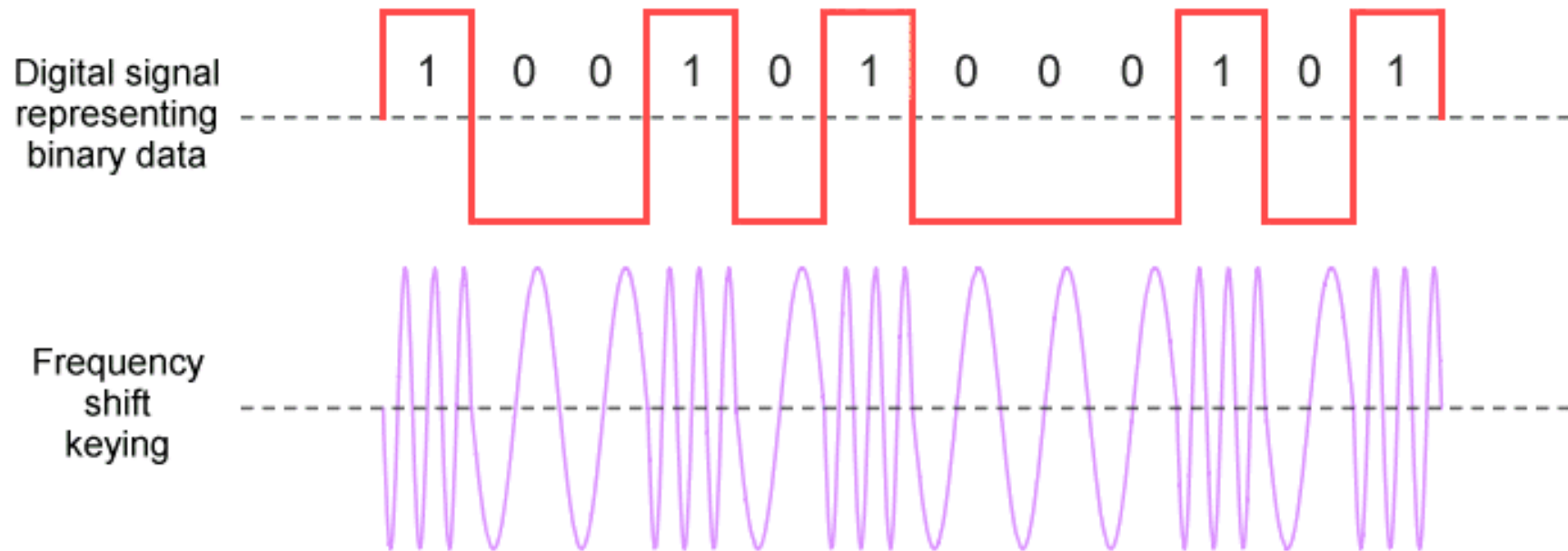
0.0000099526mW

x2,511,886 smaller!

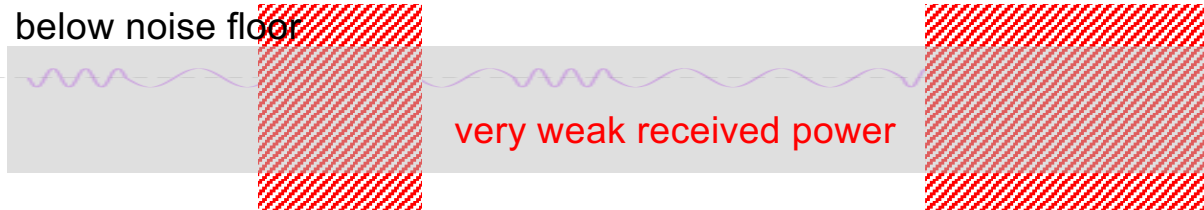
LPWAN's big challenge – simplified!



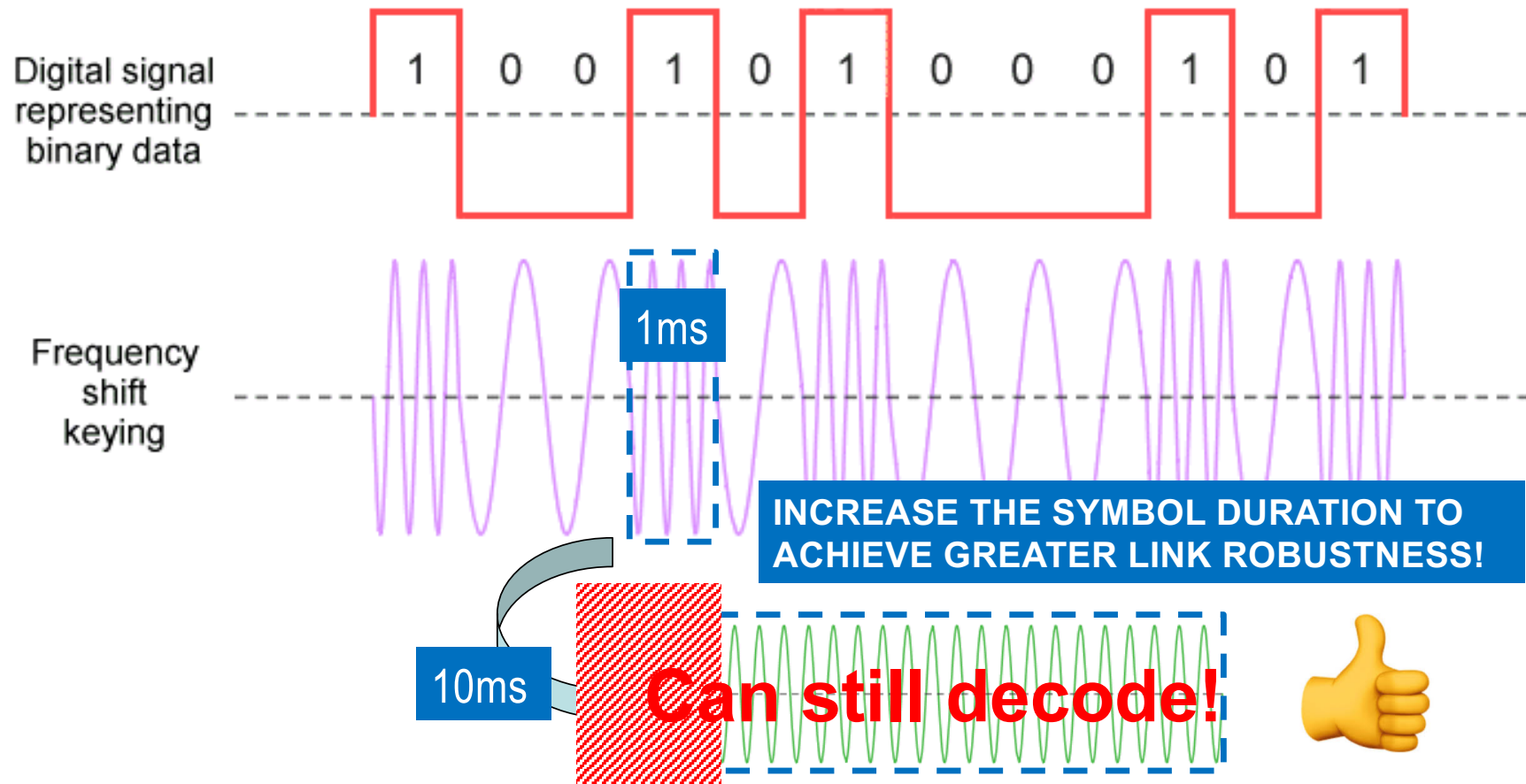
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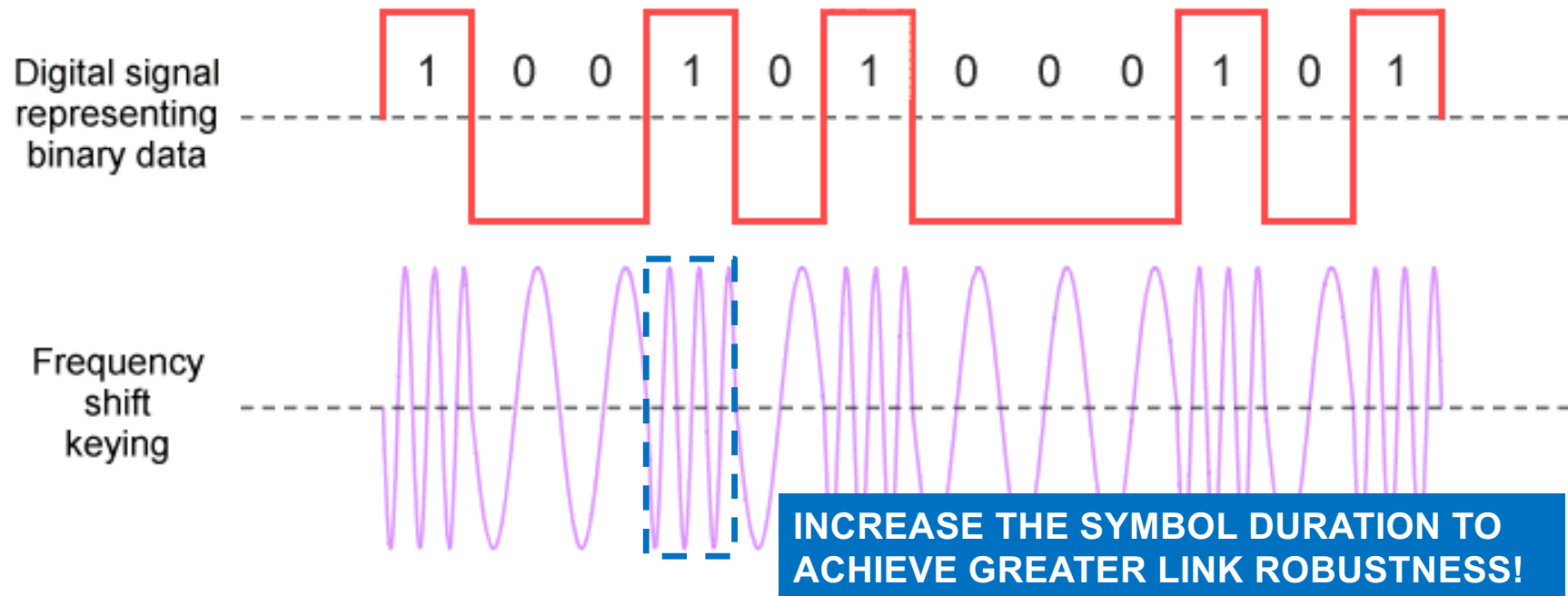
**LOT'S OF
ATTENUATION!!!**



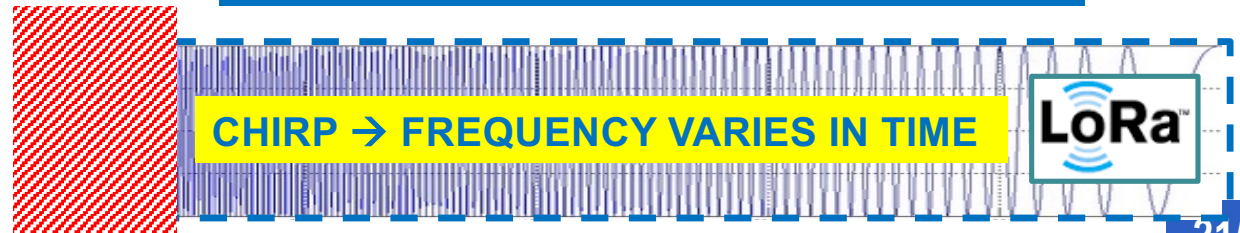
More robust transmission?



Use a chirp for even more robustness!

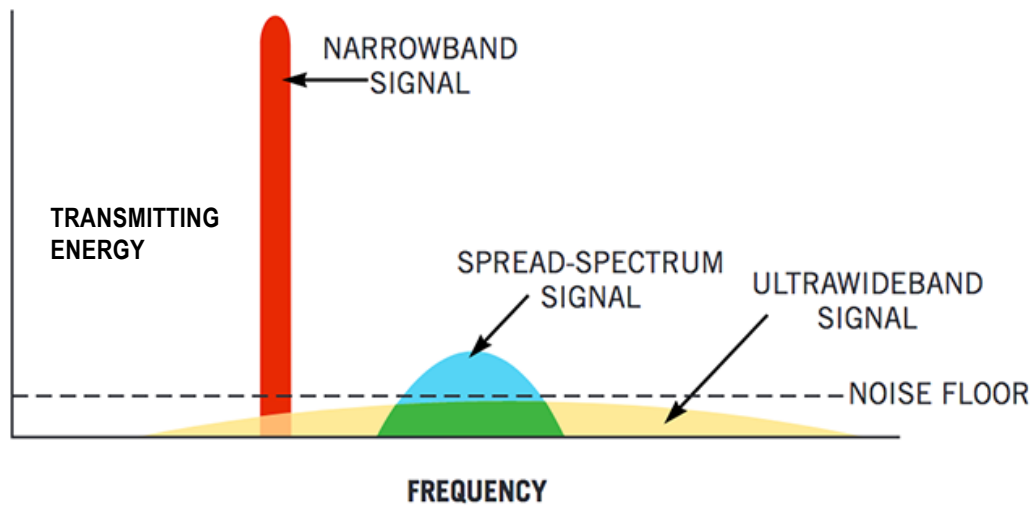


Immunity to In-Band Interference and Jamming
Resistance to Multipath Fading
Doppler Shift Tolerance



Another solution: BE INVISIBLE!

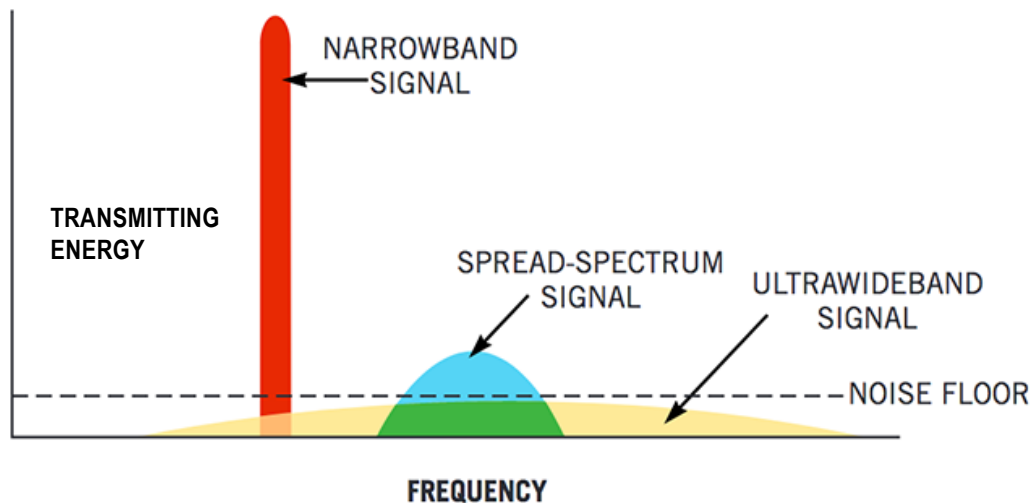
- Ultra-narrow band (UNB) of about only 100Hz (e.g. )
- But decoding is much more complex...



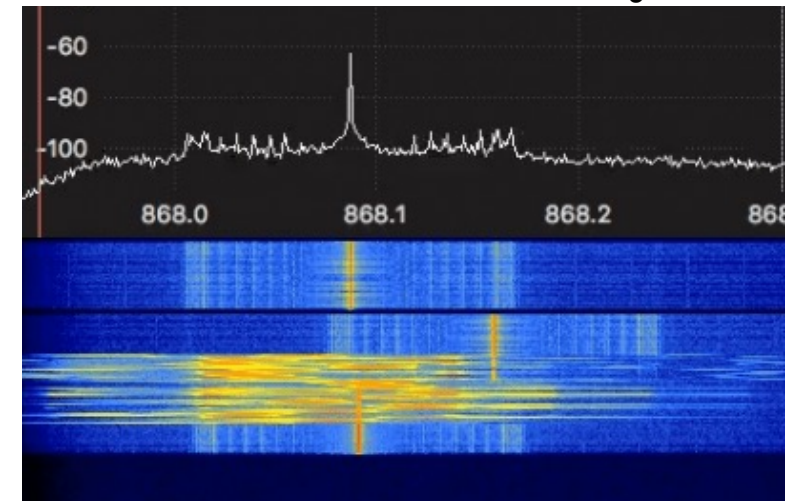
Another solution: BE INVISIBLE!

- Ultra-narrow band (UNB) of about only 100Hz (e.g. SIGFOX)
- But decoding is much more complex...

Credit: disk91.com – the IoT blog



Credit: <https://www.edn.com/ultrawideband-the-next-wireless-panacea/>



100Hz → 1250 times smaller!



125000 Hz

ALMOST INVISIBLE: where to search?

- Decoding is much more complex
- The "**needle in a haystack**" problem
- You need to have some clue
 - Top? Bottom?
 - Left? Right?
 - Middle?
- Sigfox base stations operate with very wideband receivers (typically tens of kHz to several MHz).
- Continuously monitor the whole usable ISM band → **need high-end & costly hardware!**



Time matters!

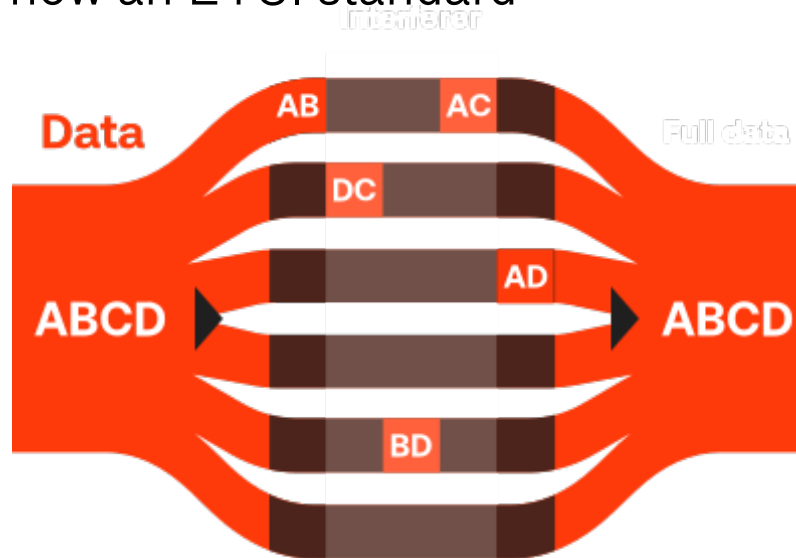
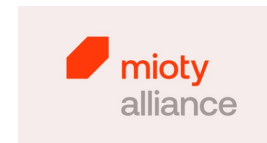
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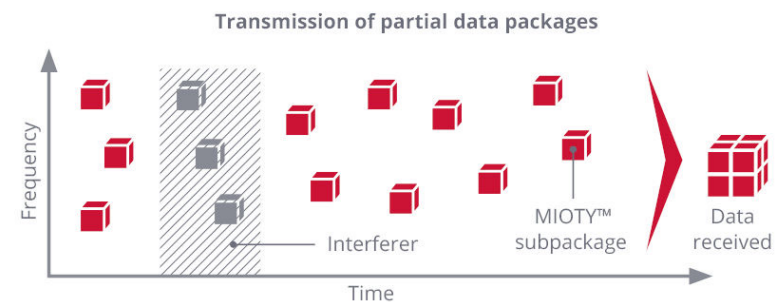
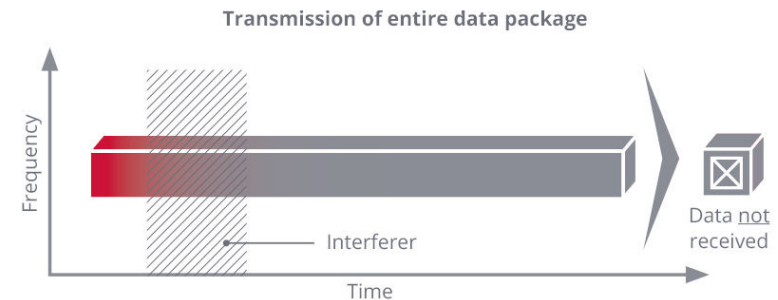
www.jolyon.co.uk

Distribute AND (try to) be invisible!

- A new comer: mioty technology based on Telegram-Splitting-UNB
- Developed by Fraunhofer IIS – now an ETSI standard



ADD REDUNDANCY FOR MORE ROBUSTNESS



Telegram-Splitting

- Randomness everywhere! Random time intervals & frequency carriers
- Again, decoding is much more complex...

> Packet (telegram) split into a minimum of 24 burst (core frame)

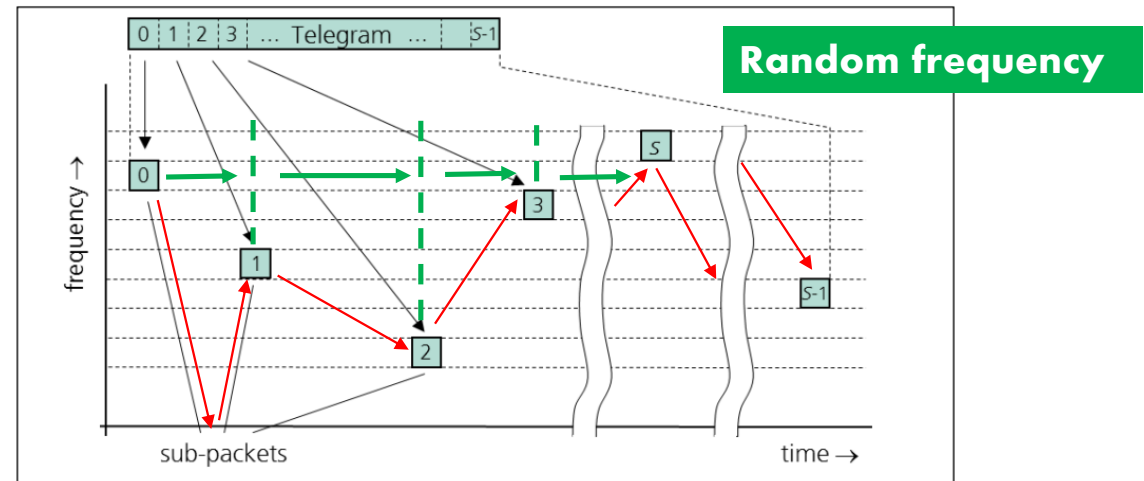
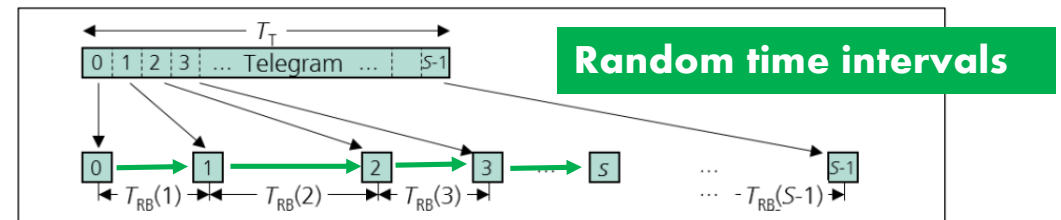
> Each burst is sent on a different frequency (up to 34)

> Each burst is separated from the others by a certain time

> Each burst includes 1/3 of sync data (but no identification)

> Information is triplicated to support collision

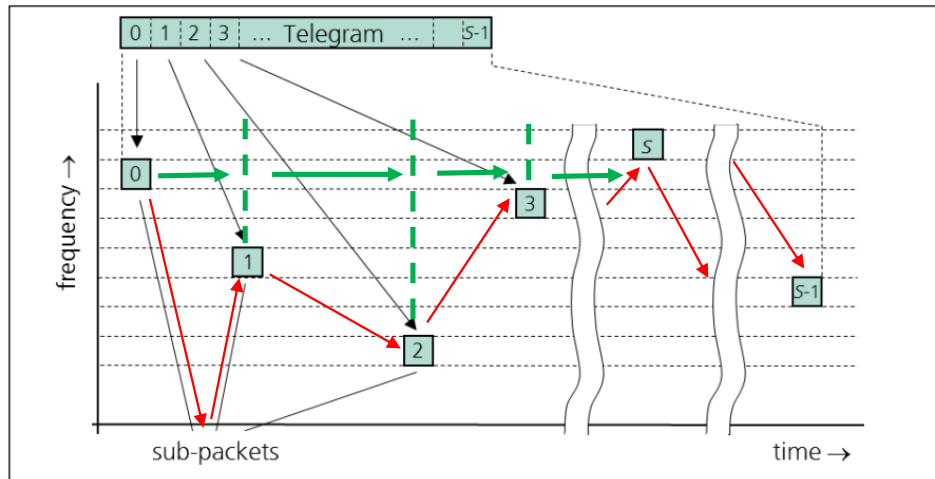
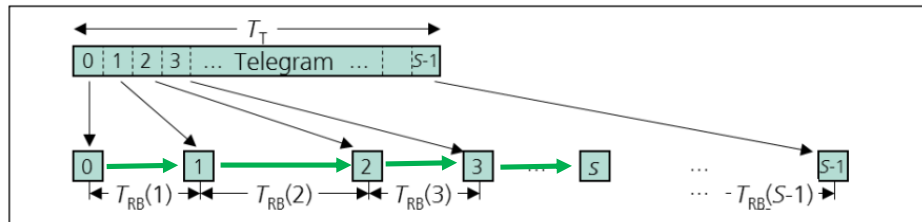
> Creates time and frequency diversity with redundancy



Author – Paul Pinault / Disk91.com

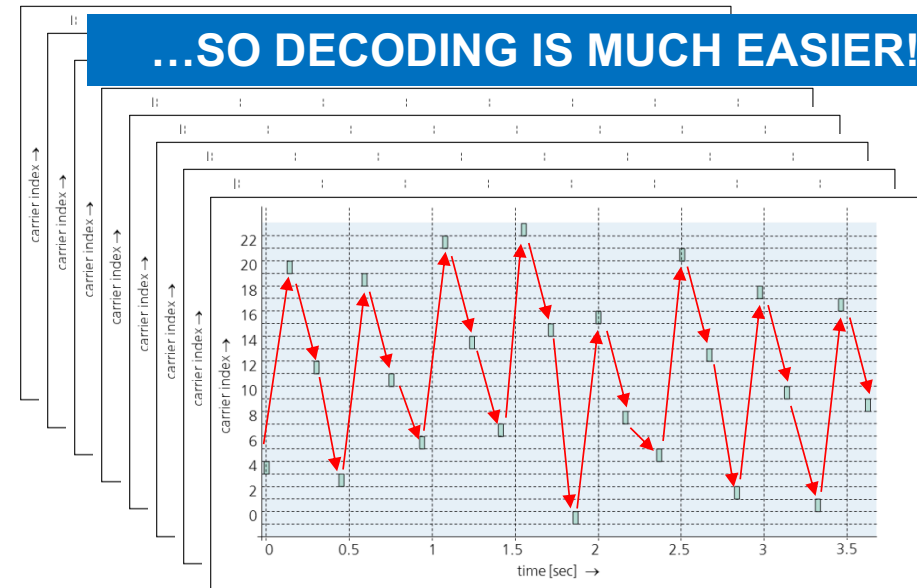
Needle in a haystack?

- mioty uses TS-UNB, so do we have the "needle in a haystack" issue?
- mioty uses time and frequency diversity



BUT USES 8 PRE-DEFINED PATTERNS

...SO DECODING IS MUCH EASIER!



LoRa, Sigfox, mioty: common point?

- LoRa: Spread Spectrum with innovative use of chirp signals
- Sigfox: Ultra-Narrow-Band with complex decoders
- mioty: Ultra-Narrow-Band + Telegram Splitting

WHY ALL THESE HASSLES?

BECAUSE THEY USE UNLICENSED BANDS!

AND SO?

**ANYBODY CAN USE THESE BANDS, NEED
TO BE MORE ROBUST & SMARTER!**

WHAT IF LICENSED BAND?

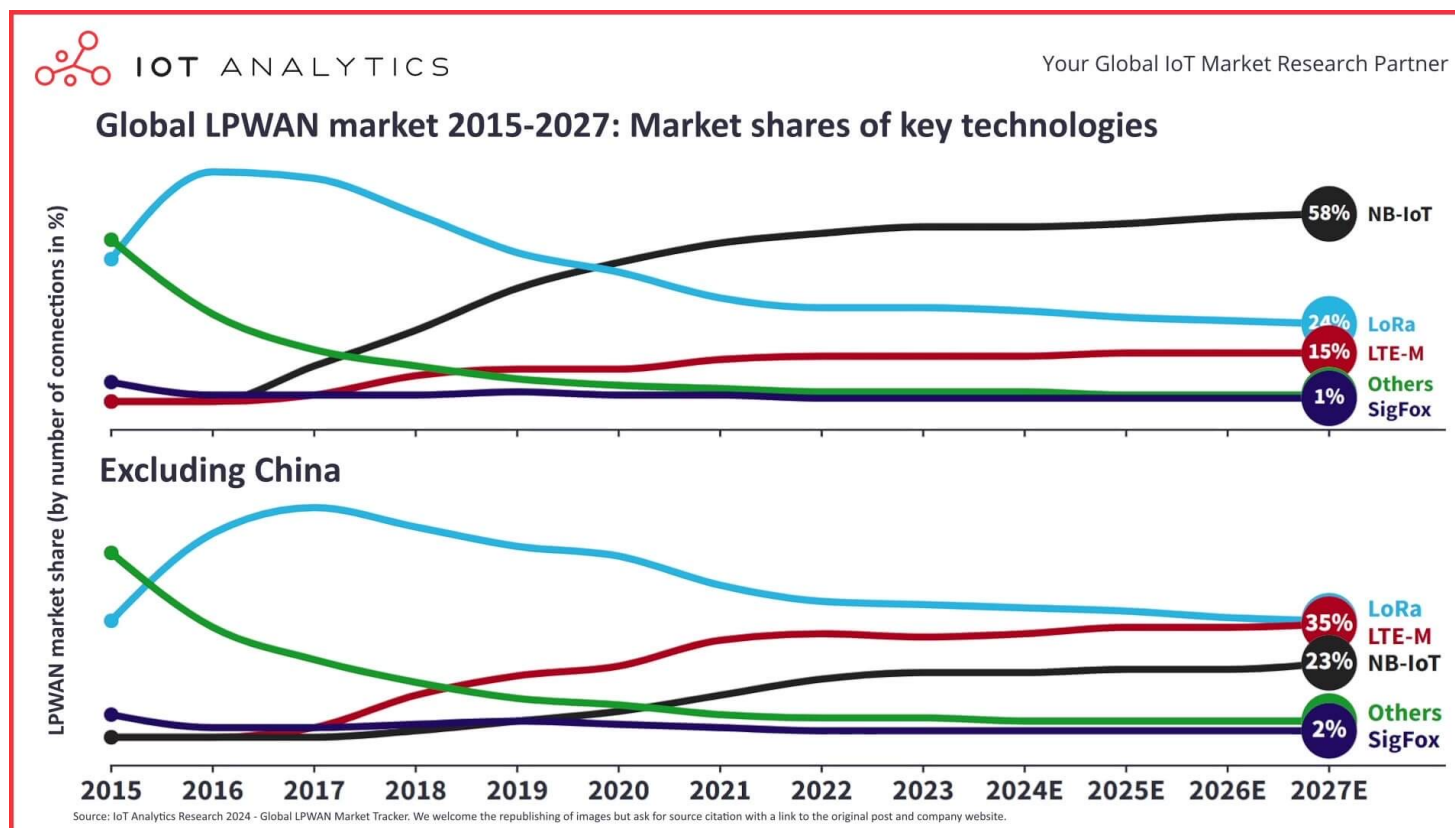
NB-IoT & LTE-M solutions

- ⦿ They both come from **mobile cellular** technologies
- ⦿ They operate in **licensed bands** assigned to operators
 - Can transmit at higher power, e.g. **200mW** instead of 25mW
- ⦿ They use **scheduled** channel access
 - Devices cannot transmit whenever they want
 - Base station assigns radio resources and transmission times
 - When, how long, and on which subcarriers (e.g. frequency)

LTE-M is optimized for mobile, higher-data, low-latency IoT with support for voice and handover → ~lightweight 4G for IoT

NB-IoT is optimized for massive, deep-coverage, low-power, low-data, static IoT → specifically designed for IoT

2026: the 4 (3?) that counts!



LoRa

LTE-M
(Cat-M1)

NB-IOT

SigFox

aux Bahamas

What your mother never told you...

- ⦿ **Despite all these smart mechanisms, obtaining several kms range at low power is still very challenging!**

HIGH OVERHEAD, LOW TRANSFER EFFICIENCY!

REDUNDANCY & REPETITION FOR ROBUSTNESS

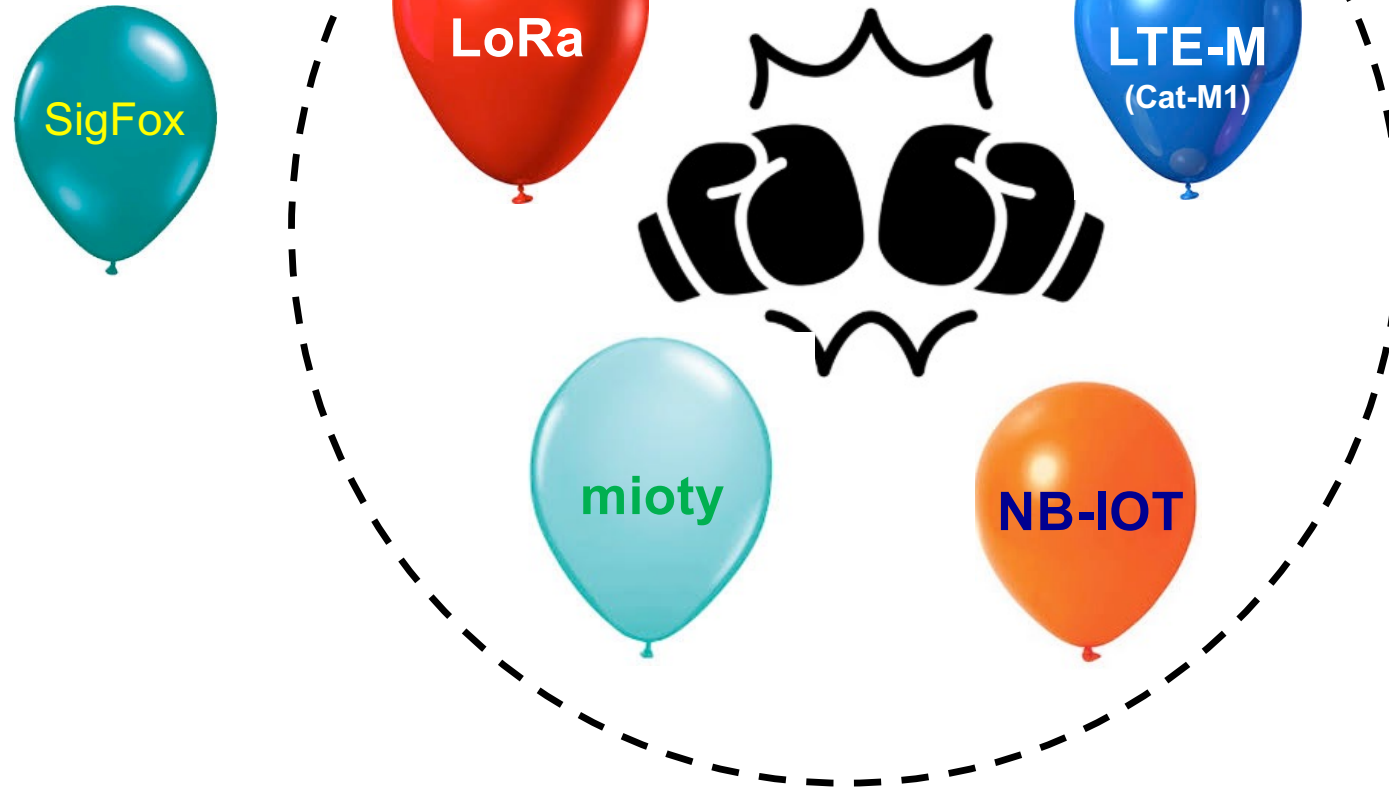
LORAWAN RECOMMENDS 2-3 REPETITIONS, SIGFOX USES 3

MIOTY'S OVERHEAD IS USUALLY 300-500%

NB-IoT CAN HAVE FROM 2 TO 128 REPETITIONS (DEEP)

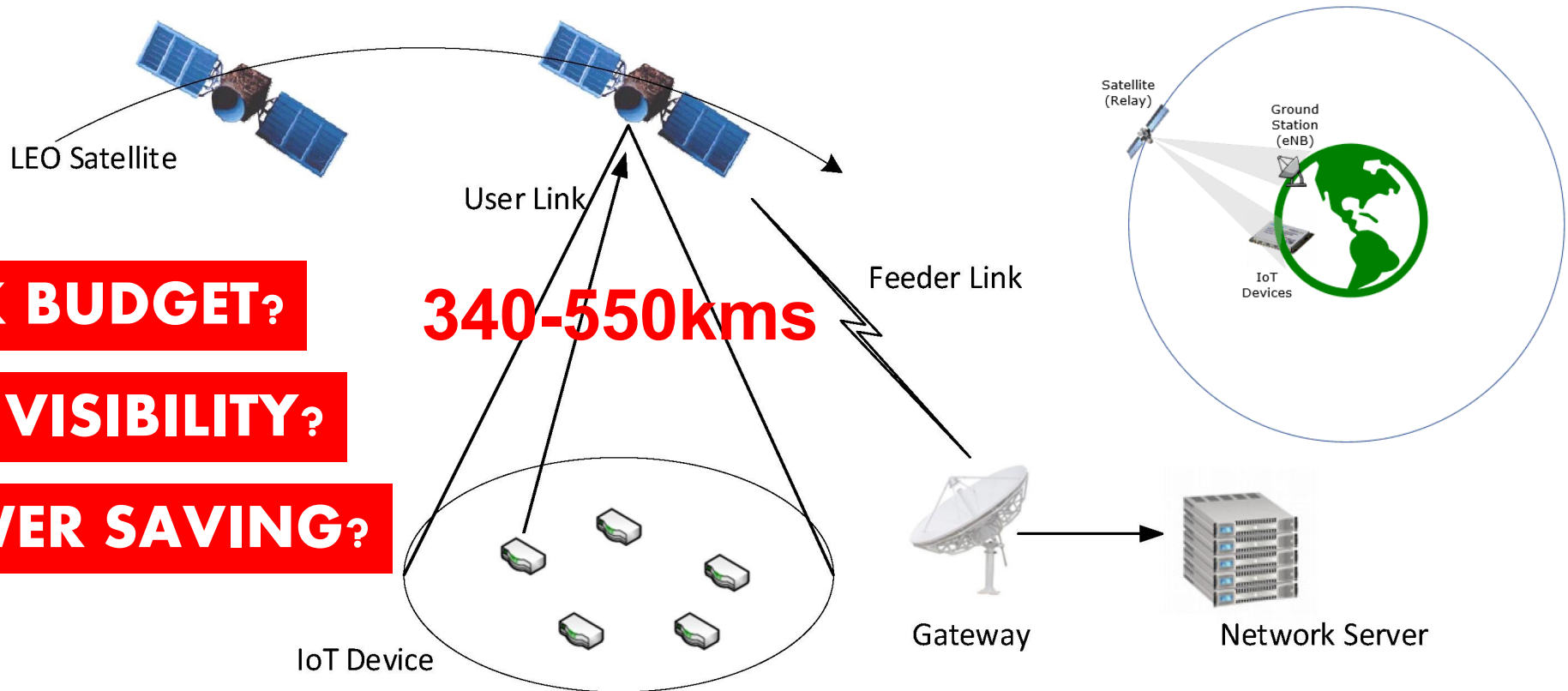
LTE-M CAN HAVE 2, 4 OR 8 REPETITIONS

What's ahead?



Really anywhere on Earth?

- Deployment of LEO satellite constellations make Satellite IoT a reality!



IoT connectivity battle going to space!

- ⦿ Satellites belong to so-called **Non-Terrestrial Networks** (NTN)
- ⦿ **3 approaches** for Satellite IoT connectivity (mostly to LEO satellites)

1/ Use terrestrial LPWAN technologies: adaptations of terrestrial LPWAN technologies to satellite links

Direct-to-Satellite (DtS) means device → satellite

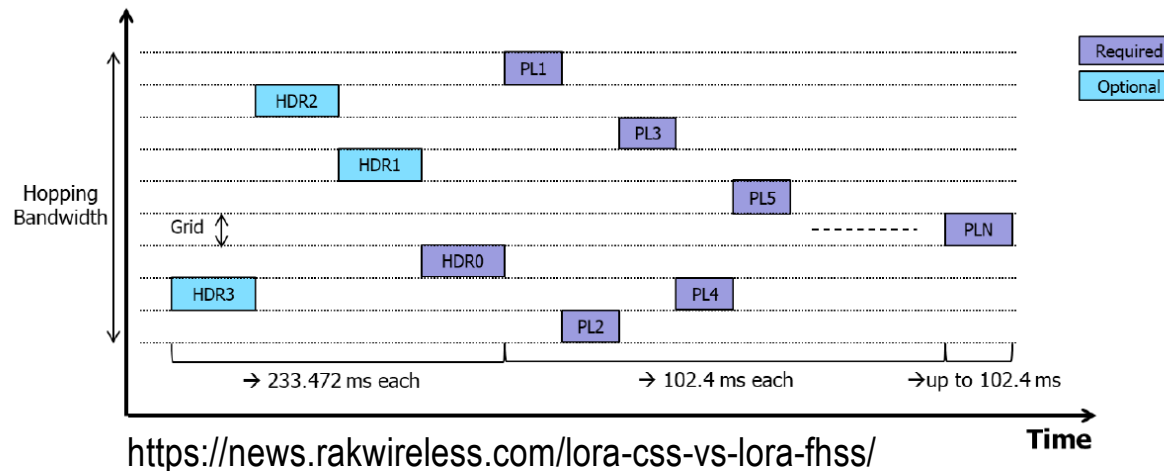
Indirect access means device → gateway → satellite

2/ Extending cellular technologies for NTN: satellites provide connectivity to ordinary or adapted cellular devices using spectrum traditionally associated with terrestrial cellular mobile networks

3/ Use satellite-native LPWAN: low-power devices communicate with satellites using protocols or waveforms specifically designed for satellite IoT

1/ Terrestrial LPWAN technologies

- Direct-to-Satellite (DtS) device → satellite
- DtS version of LoRa CSS for more robustness → Semtech **LR-FHSS**
Long-Range Frequency Hopping Spread Spectrum



10dB link budget improvement results in 3X free-space and 1.5X terrestrial range improvement

- mioty** can be more easily extended to DtS communications due to its native FHSS-like operating mode

2/ Cellular technologies for NTN

- ⦿ Extending 3GPP cellular technologies
→ NB-IoT NTN & LTE-M NTN
- ⦿ **Advantage** → Can leverage compatible cellular IoT chipsets and standards
- ⦿ **Main challenge** → Adapting cellular procedures and devices to NTN conditions
- ⦿ **Adoption** → Utilities and governments prefer licensed spectrum, national operator coverage, and long-term standardization

NB-IoT NTN is optimized for low-rate IoT communications

LTE-M NTN supports IoT applications requiring greater mobility or throughput

3/ Satellite-native LPWAN

- LEO constellations from Kinéis, Astrocast, Iridium, ...
- **Kinéis** (France): 25 LEO nanosatellites
- **Astrocast** (Switzerland): 100 LEO nanosatellites
- **Iridium** (US); 66 LEO satellites, Short Burst Data (340 bytes) service
- **Globalstar** (US): 48 LEO satellites, with expanding plan!
- **Swarm**: 150 picosatellites. Bought by SpaceX in 2021. Now has ceased activity → included in Starlink
- **Starlink** (US): originally not really adapted for IoT, more oriented towards broadband residential Internet connectivity. Now jumps into satellite IoT but rather with LTE Direct-to-Device approach



Conclusions

- **~1999: Smart Objects and Internet-of-Things**
- **2026:** Technology maturation is here!
- From application perspective, it is great!
- From research perspective, well... **we can study, evaluate, propose...**
- ... but probably marginal change to "standards"
- **Can contribute** to innovative applications with **more open technologies**
 - Collaboration between devices in P2P & mesh
 - Hybrid and continuity of access: multi-radio, terrestrial, non-terrestrial, ...
- **Ad-hoc** deployments with **application-specific mechanisms** in **agriculture, agroecology, environment, wildlife, ...**

STILL A LOT OF EXCITING RESEARCH BEFORE I RETIRE!