

Low power IoT: an ongoing saga …no one has the full script

OLIVIER SELLER, SEPTEMBER 2026

AGENDA

01 Market surprises & mistakes

02 Technical challenges

03 Trends and current work

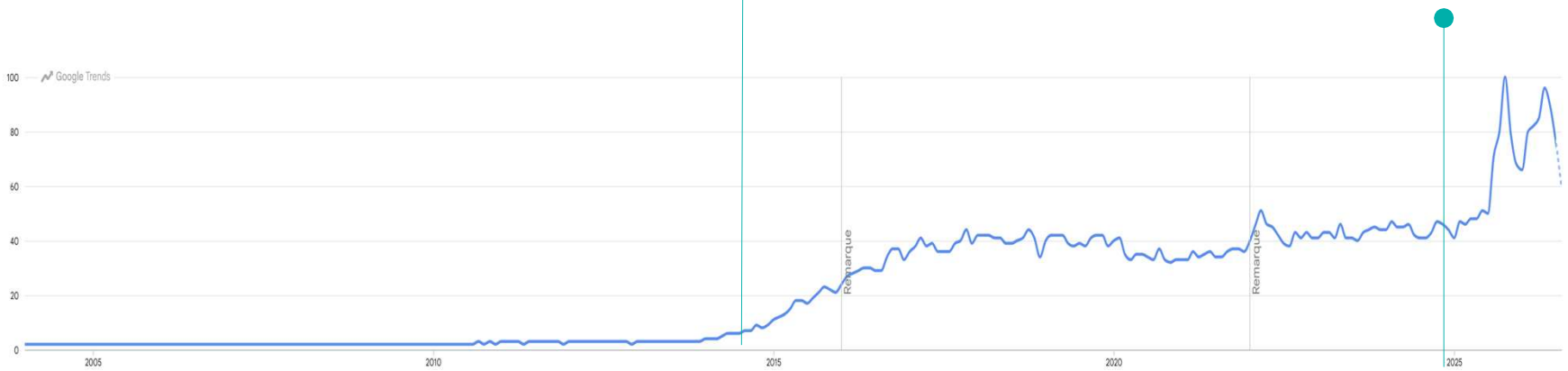
SEMTECH

The long road to the internet of things

« 5 years from ubiquitous » … for 15 years.

« IoT revolution is now »
100 billion devices by 2025
big start-up fundings

LPWAN market size
0.5~1 billion devices



Google trends for « IoT » search

SEMTECH

The myth of the overnight revolution

« creative destruction » requires more than a technology



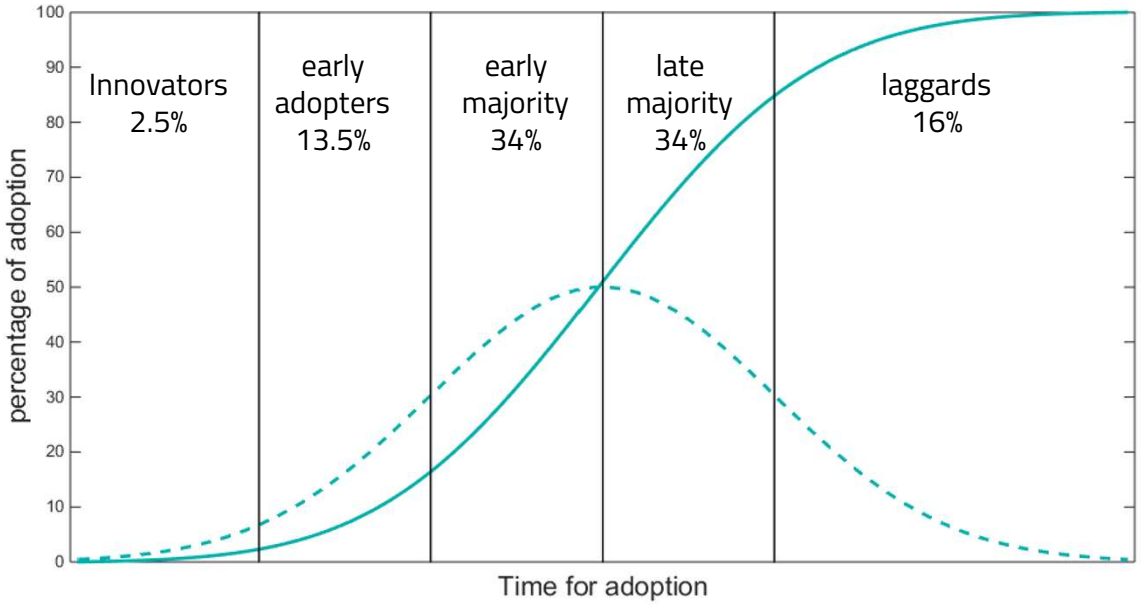
- Schumpeter's theory of creative destruction:
  - Innovation waves drive economic change
  - Old structures are destroyed
  - Economic growth emerges

- We *misinterpreted* the theory:
  - We have new technologies that can connect hundreds of billions of yet-unconnected devices
  - Digitalization of the world is a necessity

  ⇒ LPWANs should replace *quickly* the old technologies for data collection, and new applications will blossom.

Beyond the S-shaped adoption curve

If innovation adoption takes time, we, as technical people, just need to wait for marketing to work out…



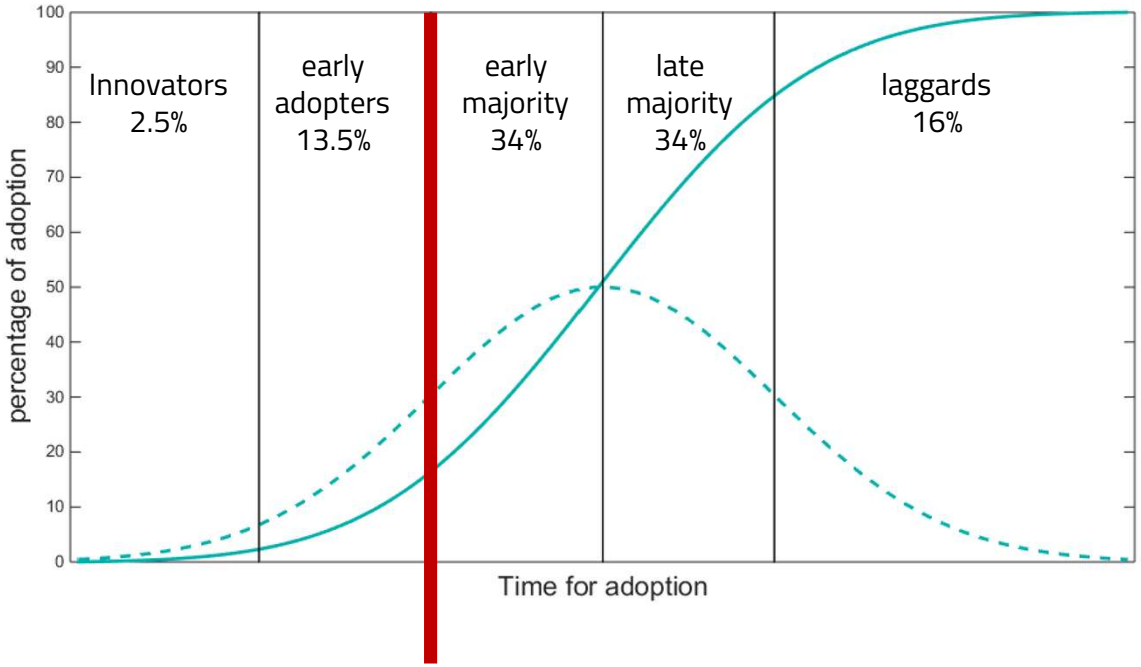
Everett Rogers' adoption curve

Advice to speed-up adoption:

Improve perception of the technology

SEMTECH

Beyond the S-shaped adoption curve



Geoffrey A. Moore: crossing the chasm

Advice to cross the chasm:

focus on specific application, package solution, make it simple.

⇒ excellent advice for well defined applications, like water metering.

What about low-cost disruption strategy ?

another misinterpretation of theory…

Theoretized by Clayton M.Christensen in « the innovator's dilemna »:

> Disruptive innovations are simpler, cheaper, or more accessible, they reach overlooked or new customers



SEMTECH

What about low-cost disruption strategy ?

another misinterpretation of theory…

Theoretized by Clayton M.Christensen in « the innovator's dilemna »:

> Disruptive innovations are simpler, cheaper, or more accessible, they reach overlooked or new customers



However, IoT is for the most part a completely new market:

- low-cost products "waste" the premium early adopters are ready to pay
- The Minimum Viable Product is an integration with a limited feature set, which needs to be defined before applications exist ⇒ MVP misses target
- Per bit, LPWANs are much more expensive than 5G !

Innovation ecosystems

A model of distributed innovation, when vertical R&D does not work



"innovation ecosystem": the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize.

Adner, R. (2017). *Ecosystem as Structure: An Actionable Construct for Strategy.* Journal of Management, 43(1), 39-58.

Ecosystem as *affiliation* vs Ecosystem as *structure* (*)

Ecosystem as affiliation:

- Focal actor provides most of the innovation
- **Focal actor captures most of the value**
- Focal actor owns a platform, and its users
- Apple, Android, Tesla, Starlink, Sigfox (until Unabiz)

Proprietary technology platform, owned by focal actor, well integrated

Ecosystem as structure = **innovation ecosystems**

- A.k.a. innovation ecosystem
- Interdependent actors: shared responsibility for innovation & value
- **Value proposition is the focus. Combination of products from ecosystem actors**
- The ecosystem is the alignment structure to deliver the focal value proposition
- GSMA, WiFi, Bluetooth, LoRa Alliance

open technology platform, multiple options, integration challenges

(*) Adner, R. (2017). *Ecosystem as Structure: An Actionable Construct for Strategy.* Journal of Management, 43(1), 39-58.

Innovation ecosystems are required for IoT

Co-innovation with the users

With e.g., a 5G phone, there is no need to learn its use, nor to figure out what to do with it.

With IoT, users have to innovate to make good use of the new data:

- Change the way they work, change operations
- Change business model
- Invent application

IoT ecosystems include users and solution integrators

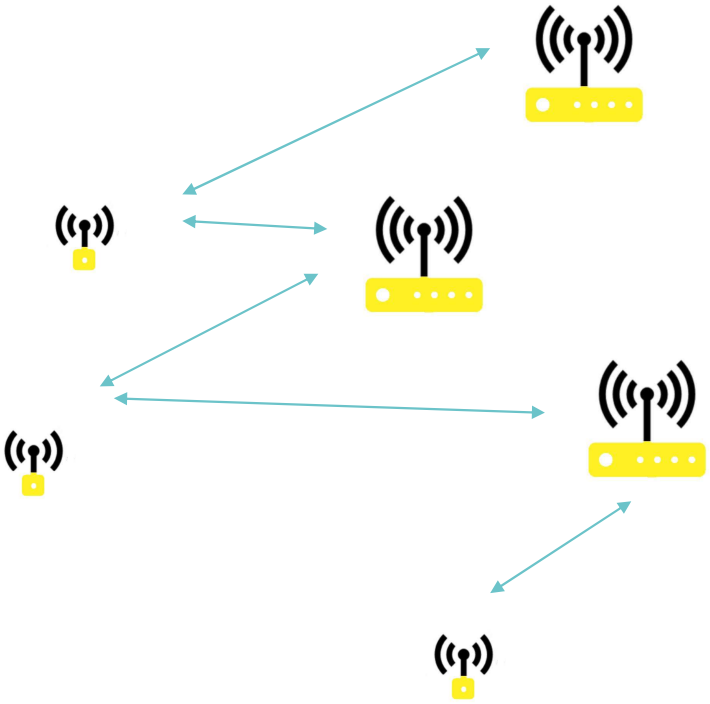
Why did it took so long ?

- Innovation adoption does not happen overnight, even when it is good
- There is no « killer app » that drag the others
- Low cost does not work for new markets
- Affiliation ecosystems did not work, as users need to invent their own product
- Technology platforms designed by open innovation ecosystems, have been adopted
  … they are slower initially

INTERNAL ONLY – Confidential Information – Property of Semtech Corporation

Innovation ecosystem example: LoRa Alliance

Interoperable networks over LoRa PHY



LoRaWAN is a radio network standard,
designed for low power devices and scalable and interoperable deployments

- LoRa range => Wide Area Networks
- Use of sub-GHz unlicensed spectrum
- Collaborative reception from gateways
- Very low protocol overhead
  - 13 bytes per message
  - Constant connection to a network
  - Devices transmit and receive instantly, without prior synchronization

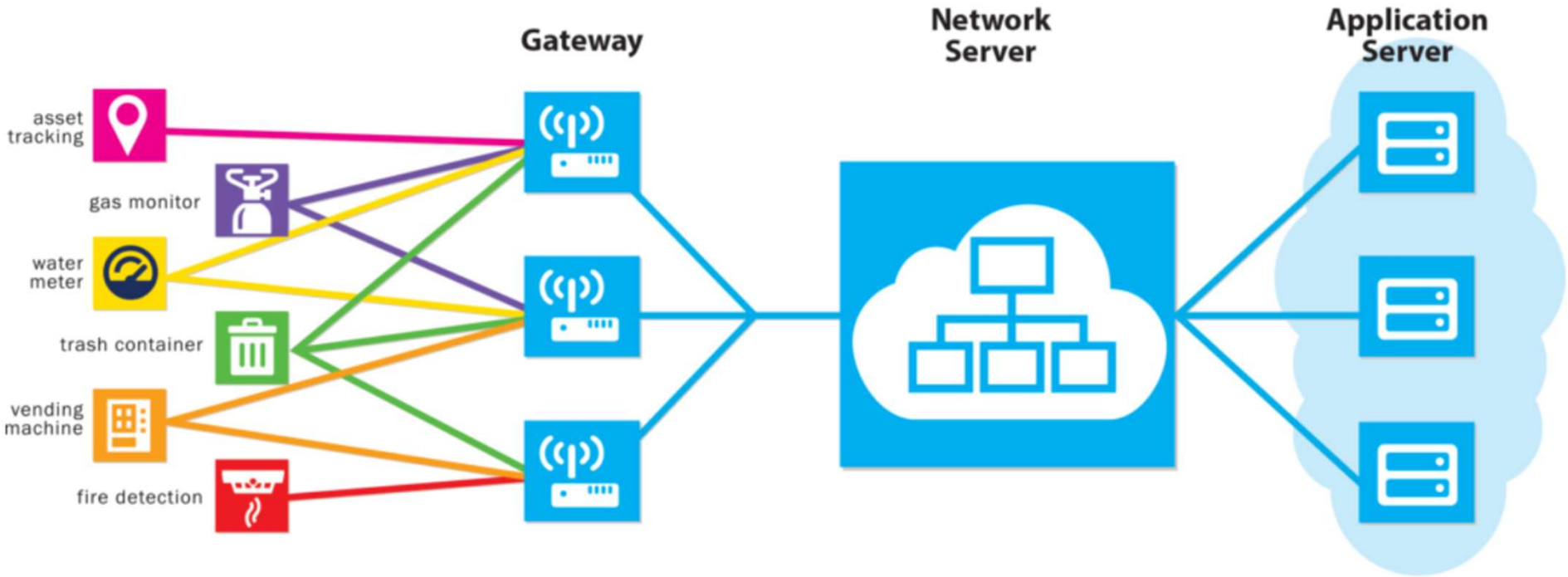
125 million end-devices deployed, 25% annual growth

180 LoRaWAN public operators

670 LoRaWAN certified devices

LoRaWAN technical architecture

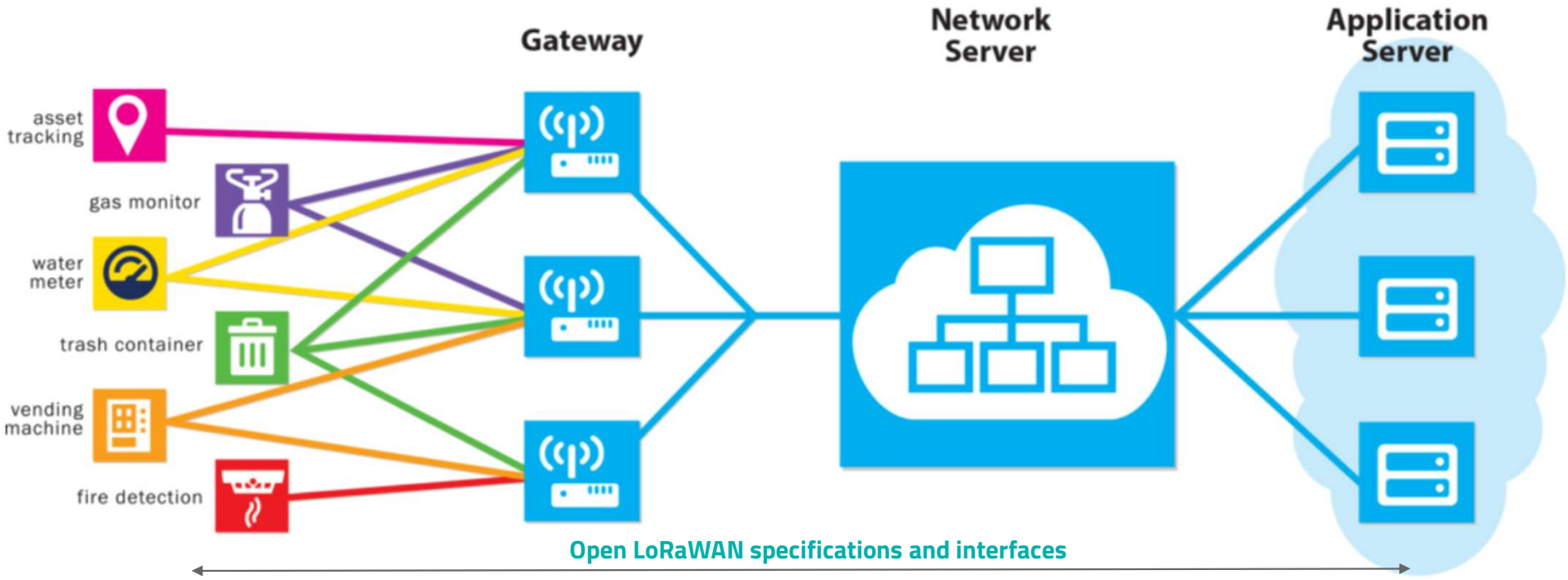
Technical architecture structures the ecosystem



SEMTECH

LoRaWAN technical architecture

Technical architecture structures the ecosystem: **align partners by defining roles**



Devices manufacturers
Module manufacturers
Certification

Gateways manufacturers

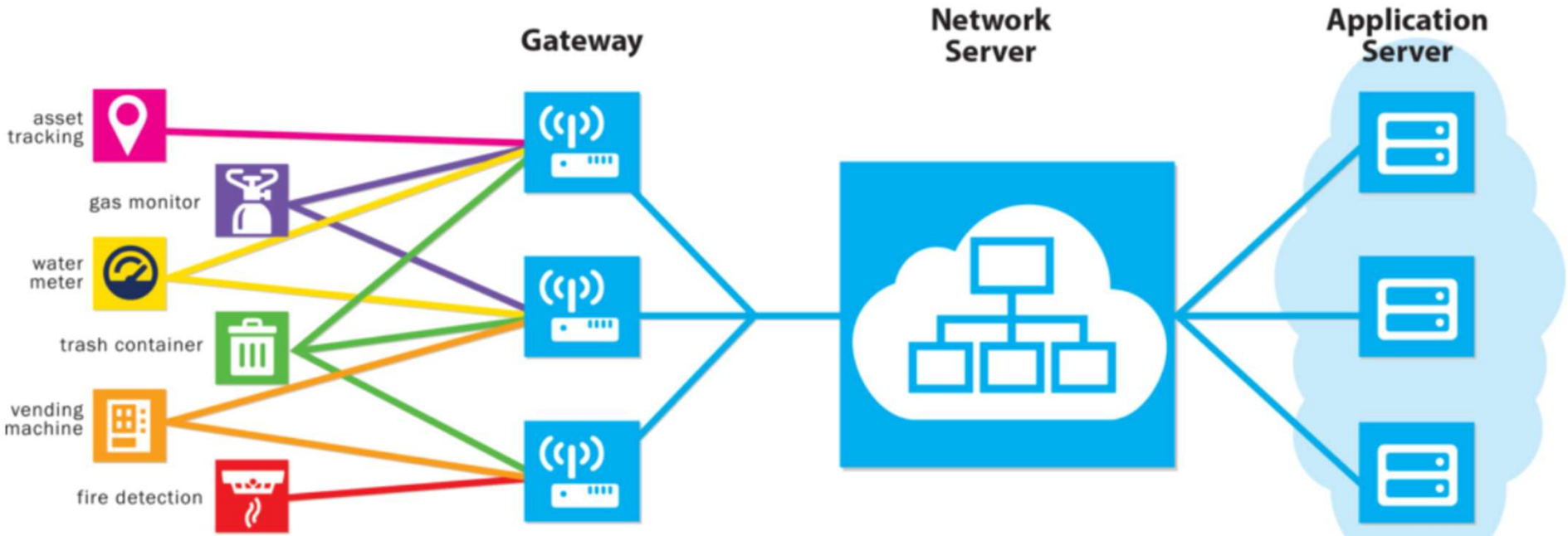
Unlicensed spectrum:
Public networks operators
Private networks operators

LoRaWAN users

SEMTECH

LoRaWAN technical architecture

Technical architecture structures the ecosystem: **multiple network deployment options**



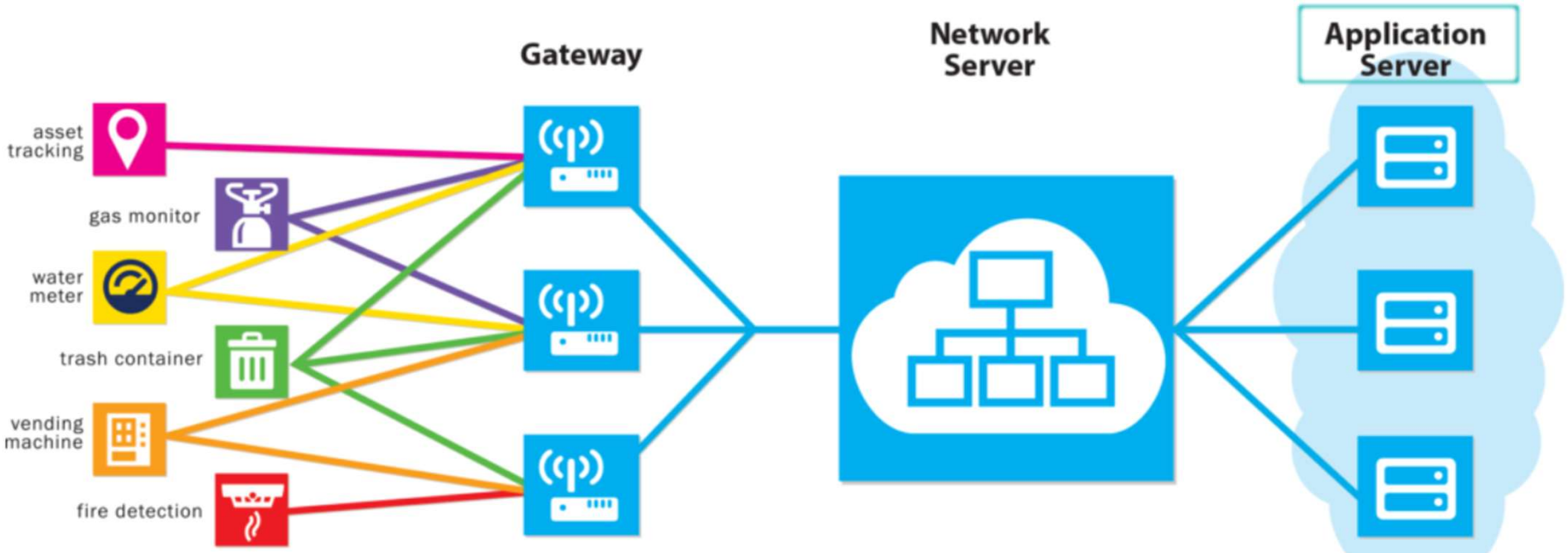
Simple network planning
Passive roaming
Collaborative networks: *TTN, Helium*

Private networks management services:
Actility, Netmore, TTI
Open source LNS: *chirpstack*

SEMTECH

LoRaWAN technical architecture

Technical architecture structures the ecosystem: **value materializes with integration**



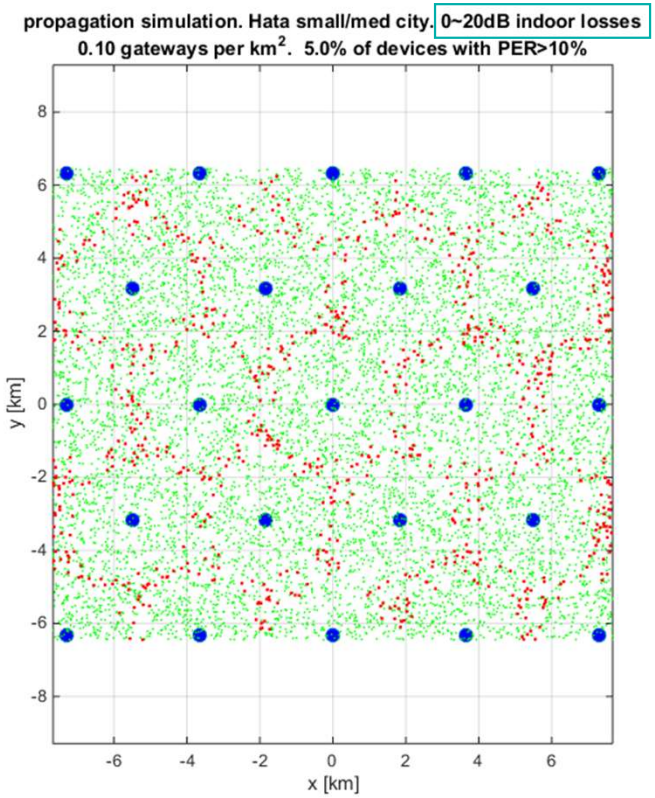
SEMTECH

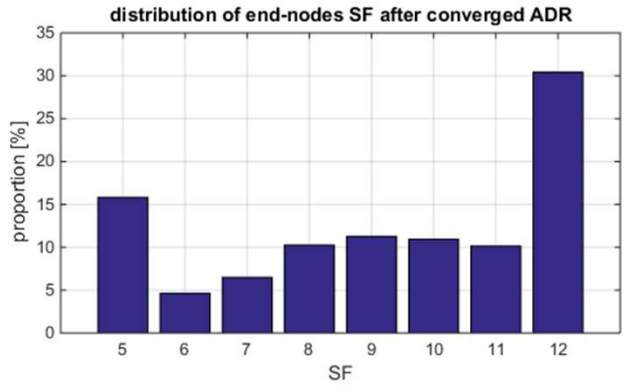
TECHNICAL CHALLENGES

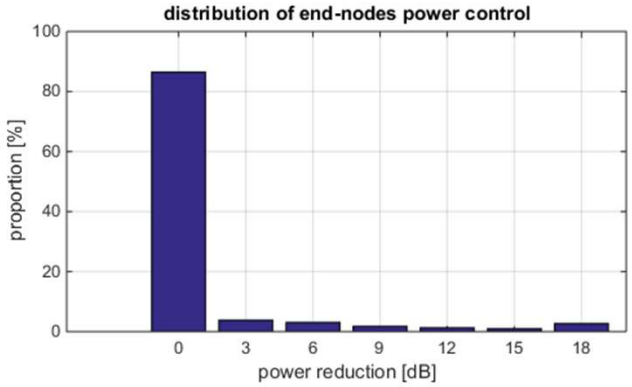


Coverage is the main technical challenge

The three rules of IoT are: coverage, coverage, coverage





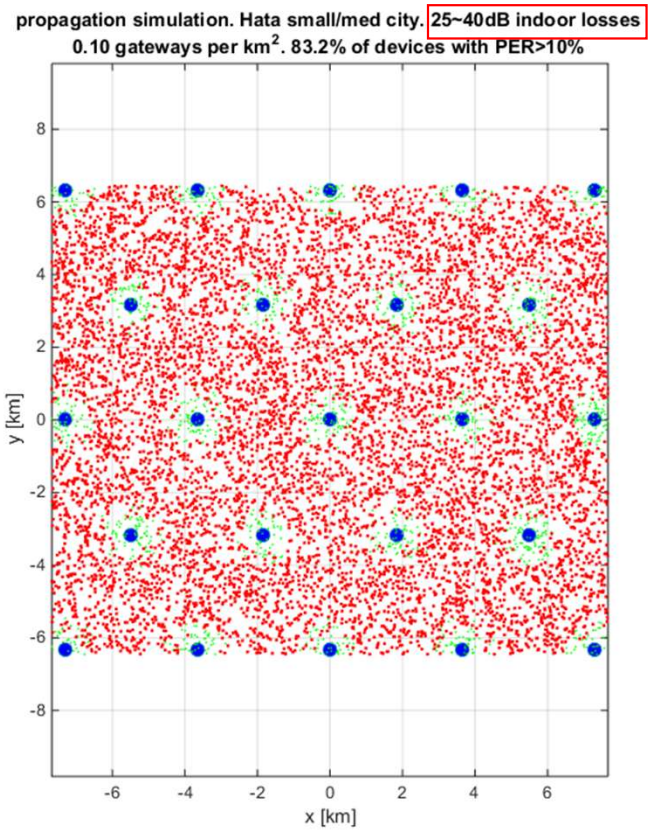


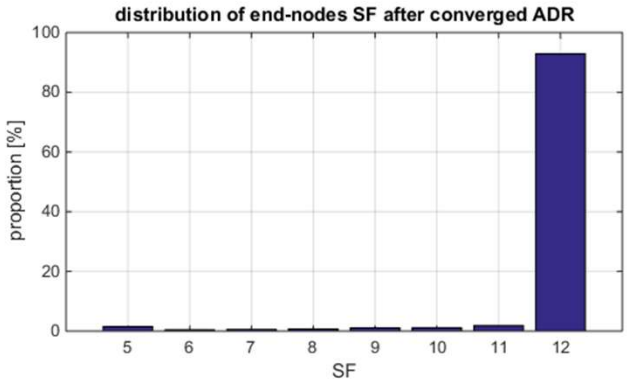
outdoor / light indoor is an easier case

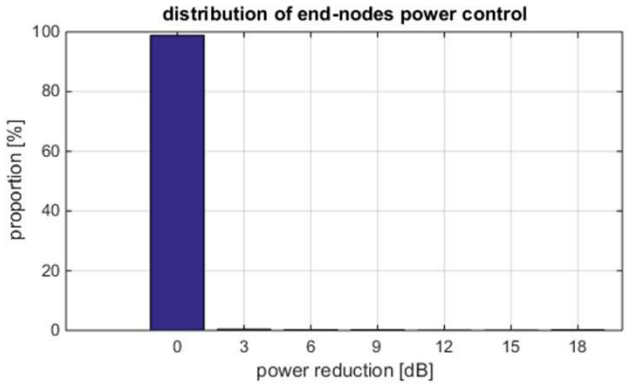
SEMTECH

Coverage is the main technical challenge

The three rules of IoT are: coverage, coverage, coverage





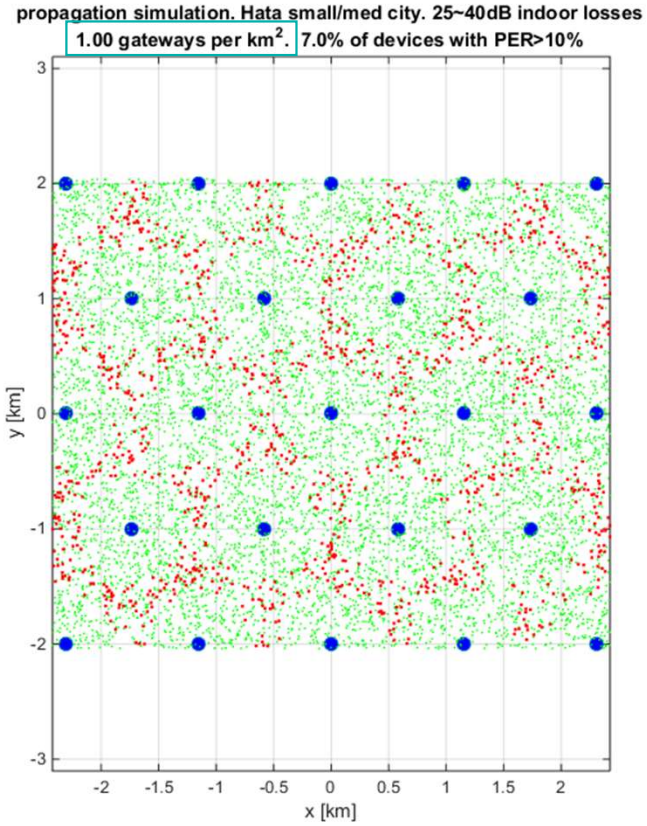


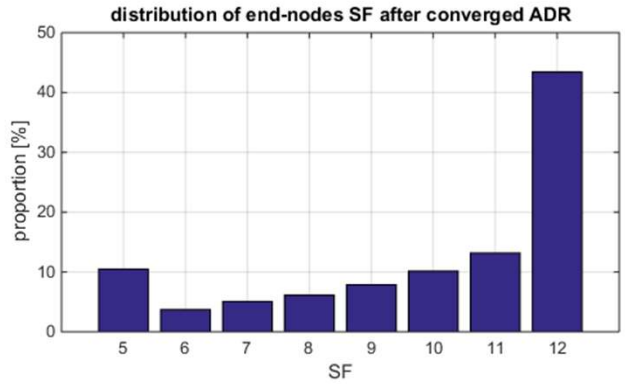
deep indoor is harder: it requires more gateways

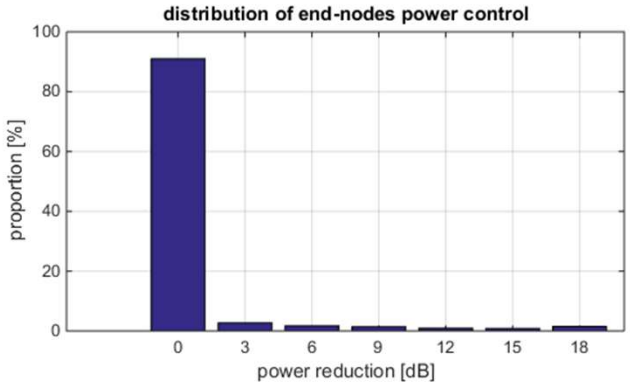
SEMTECH

Coverage is the main technical challenge

The three rules of IoT are: coverage, coverage, coverage





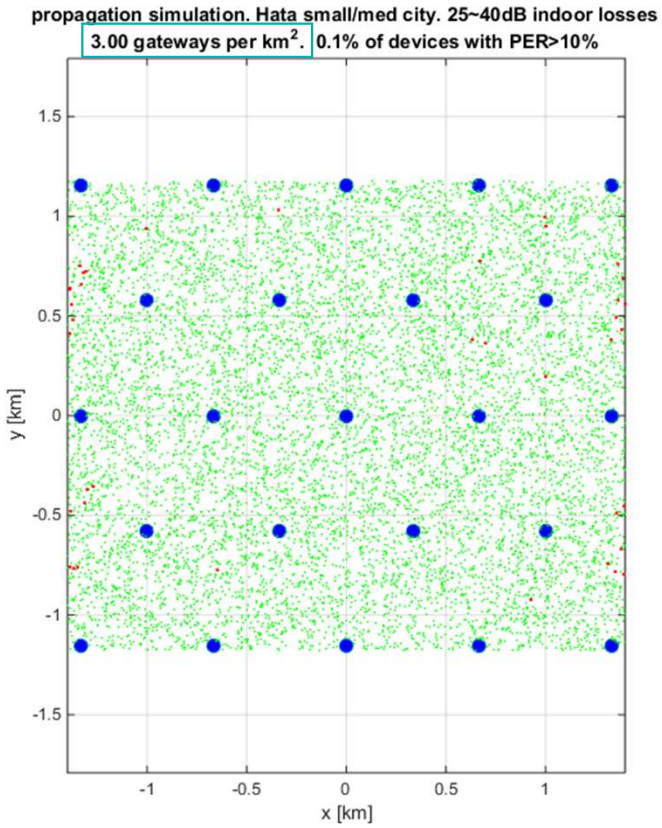


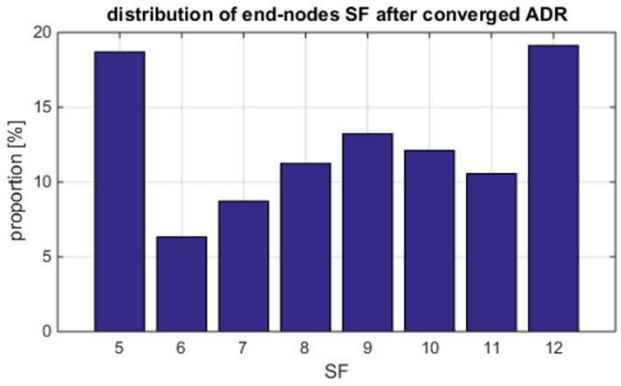
deep indoor is harder: it requires **10 times** more gateways

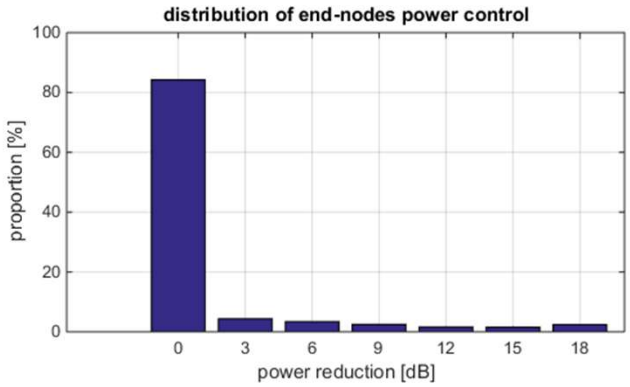
SEMTECH

Coverage is the main technical challenge

The three rules of IoT are: coverage, coverage, coverage





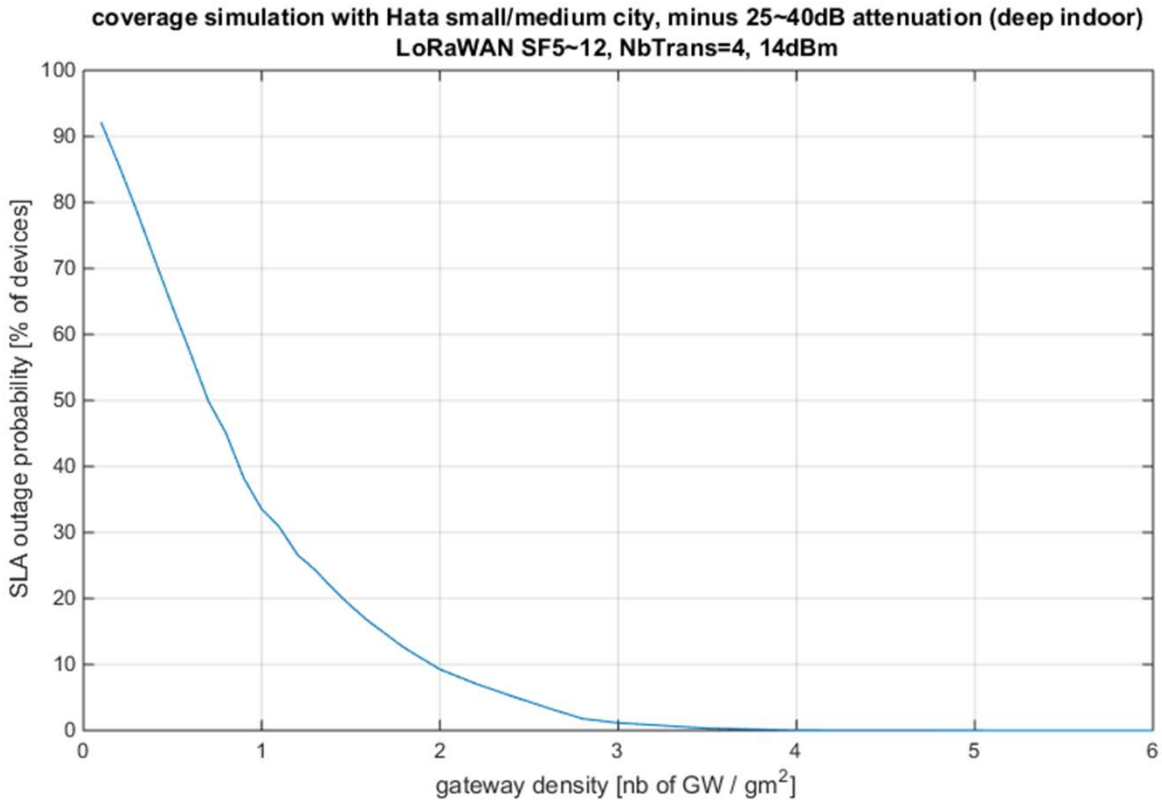


Healthy network requires further densification

SEMTECH

Coverage is the main technical challenge we face

The three rules of IoT are: coverage, coverage, coverage



Coverage is really hard ⇒ the hardest-to-reach nodes set the density of gateways.

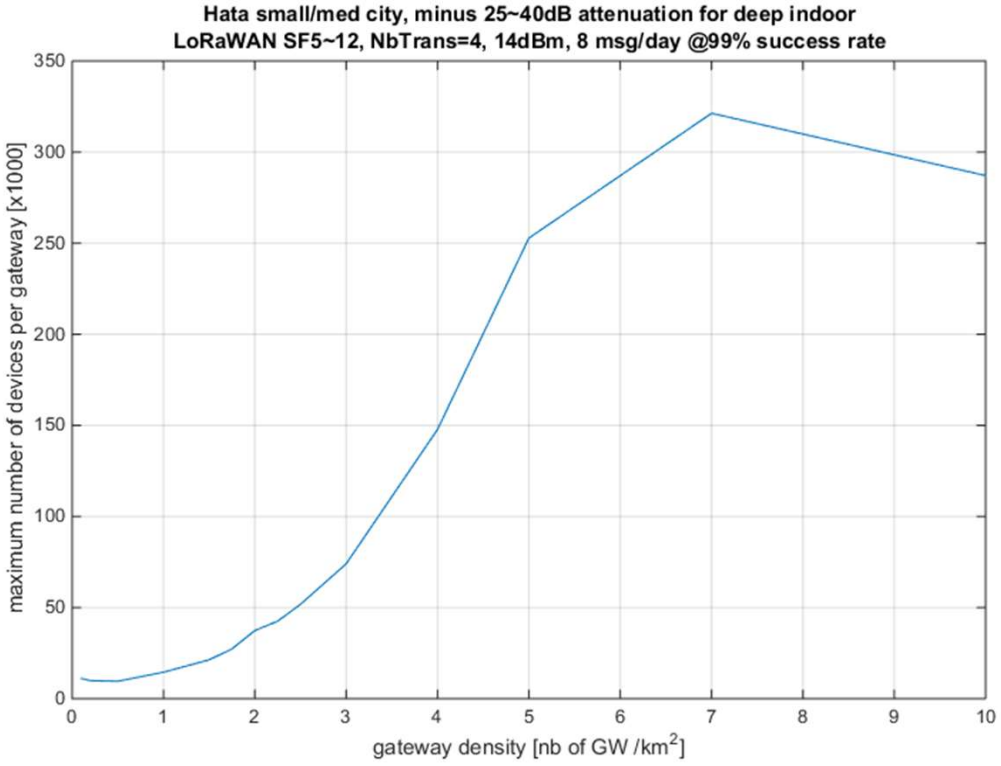
For deep indoor coverage, around 3 gateways per km^2, i.e., 100~1000 devices per gateway.

Despite 160dB link margin, and 4th order diversity.

SEMTECH

Network capacity is not a limitation

Once coverage is good, capacity is abundant



Capacity per gateway increases with gateway density, thanks to adaptive data rate

With 4 gateways per square kilometer, each gateway can handle 150000 devices.

⇒ There is plenty of uplink capacity !

⇒ There is plenty of downlink capacity, even with half-duplex gateways. ACKs can be generalized.

Time synchronization is a challenge

Low power time keeping, with low data rate communications



Applications transmit only a few times a day.

A low power crystal oscillator will drift by 0.5s per day (5PPM).

⇒ Between 2 frames, the timing drift can exceed the duration of a frame.

Transmitting frames dedicated to synchronization does not work: too high power

One solution is to have beacon from gateways. But this requires excellent coverage...

Other solution is to work around the problem, and use more asynchronous operations (no more planned transmissions) ⇒ Relay, CSMA, Drive-by, Network discovery, Unsynchonized mesh

Multiple data models add to fragmentation



Should temperature be in °C or °F ? Which resolution ? Which binary encoding ?

All IoT protocols tend to have their own data models, profiles, ontology, leading to data interoperability challenges !

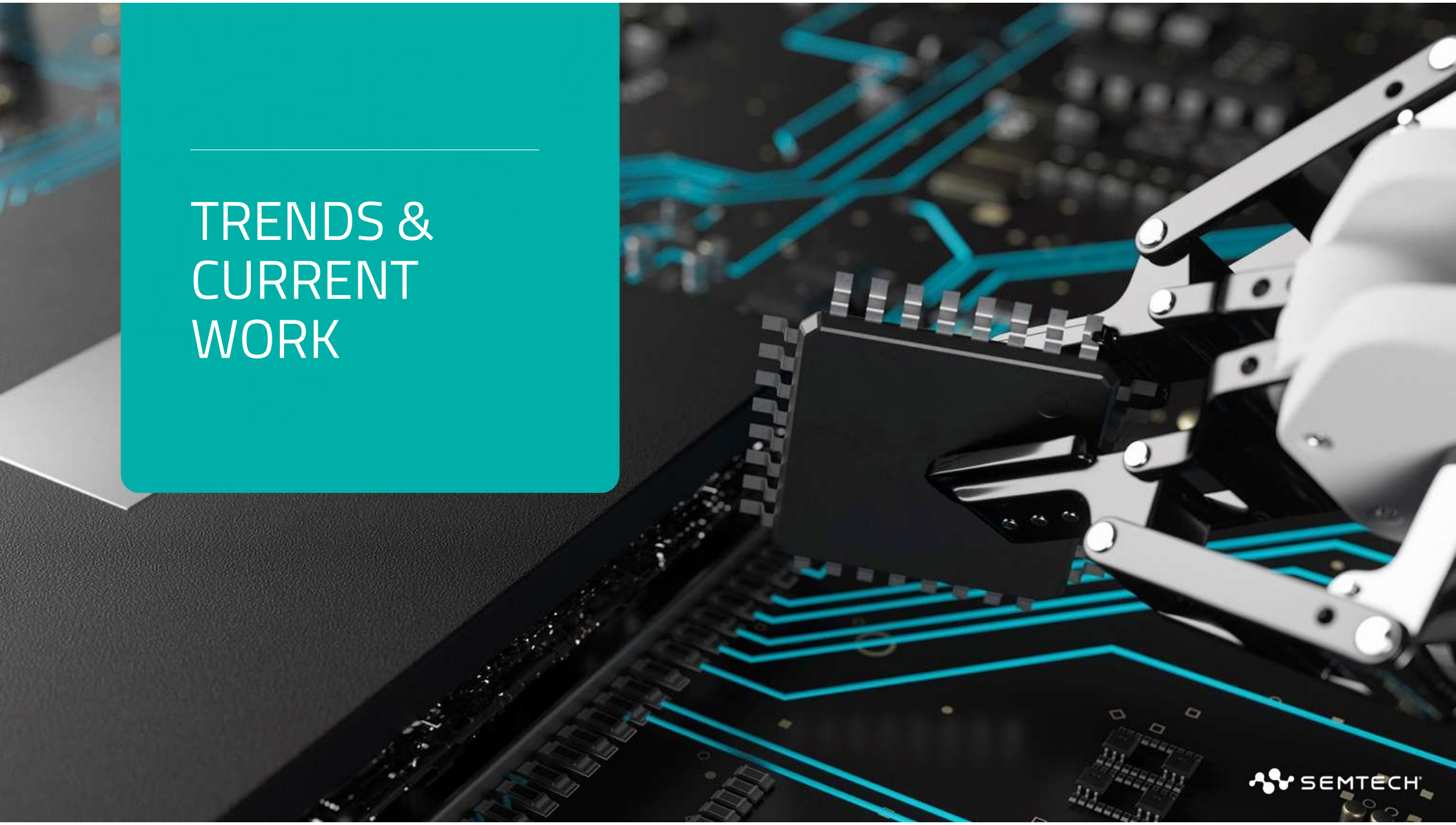
LoRaWAN responses:

1. For each target application, define a dedicated adaptation layer
2. Many protocols are IP based, so use SCHC to transport IP over LoRaWAN
3. Let end-device developpers use whatever encoding they need, and standardize the codec that makes the binary ↔ json conversion.

3 bis. Provide a repository for codecs

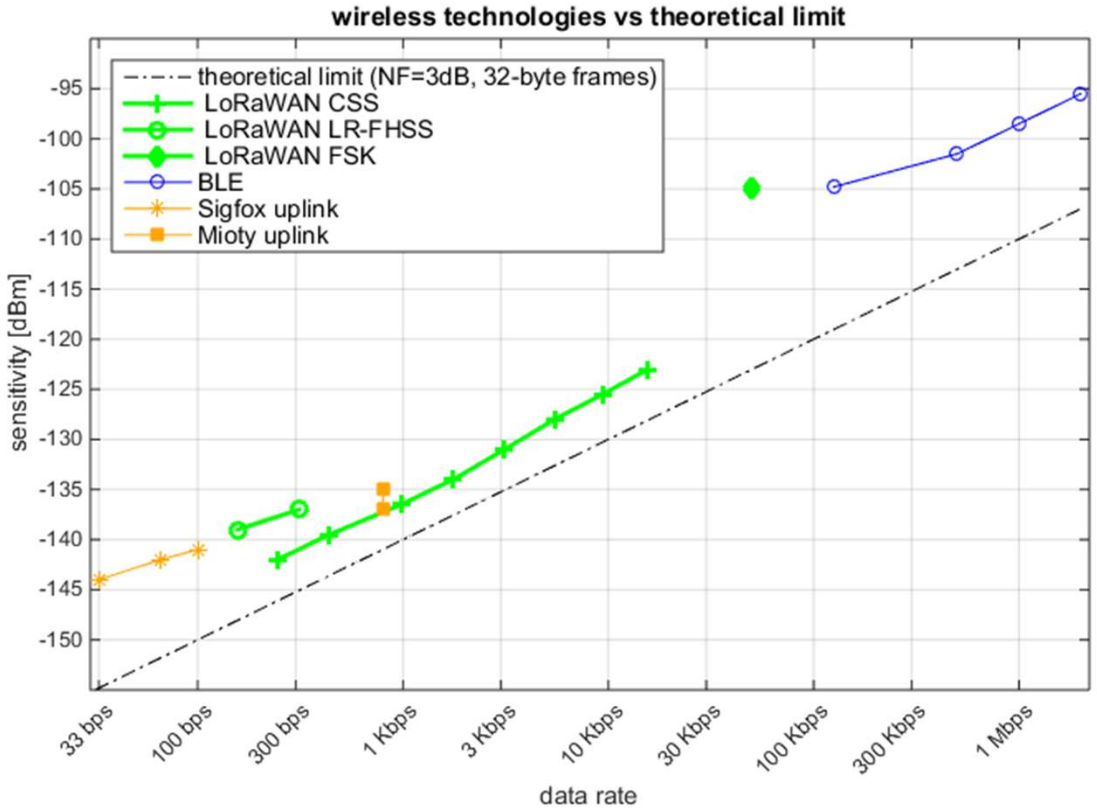
4. Work in progress: define schemas, i.e., the format rather than the function

   ⇒ from the format, LLM ingestion and translation to other formats are straightforward


TRENDS &
CURRENT
WORK
SEMTECH

Expand the set of data rates

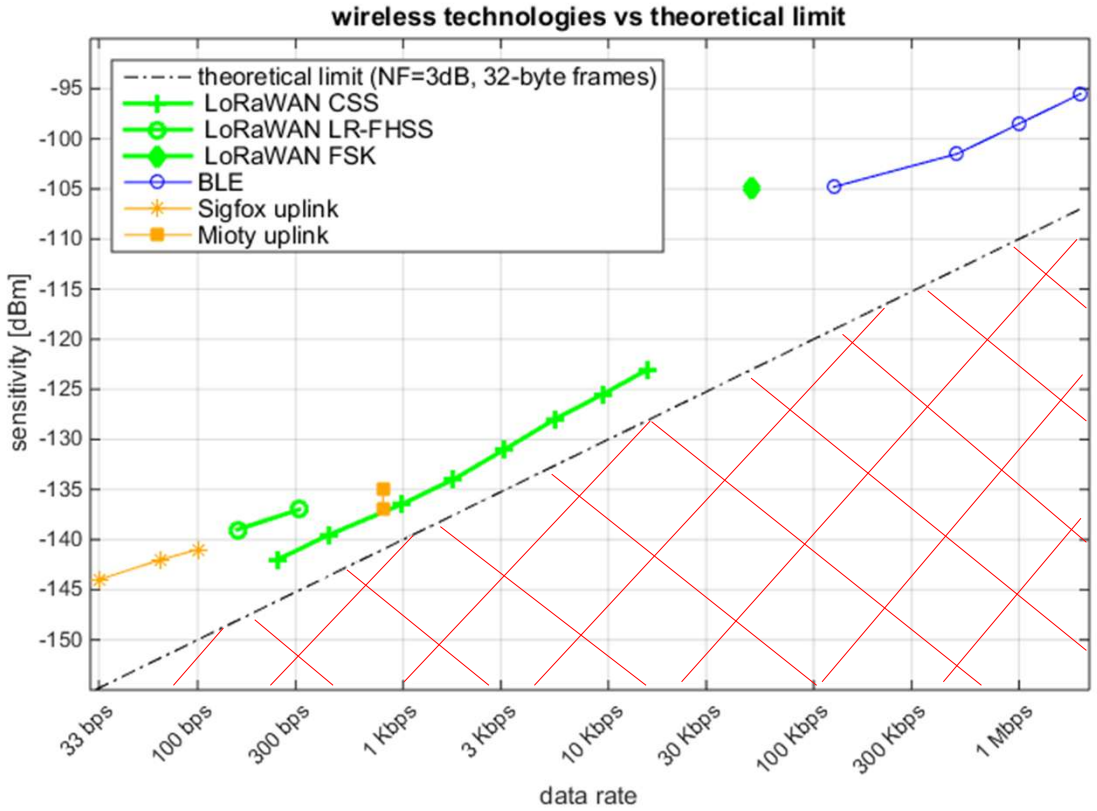
long range & low power operations



long range ⇒ high sensitivity ⇒ low data rate

Expand the set of data rates

long range & low power operations

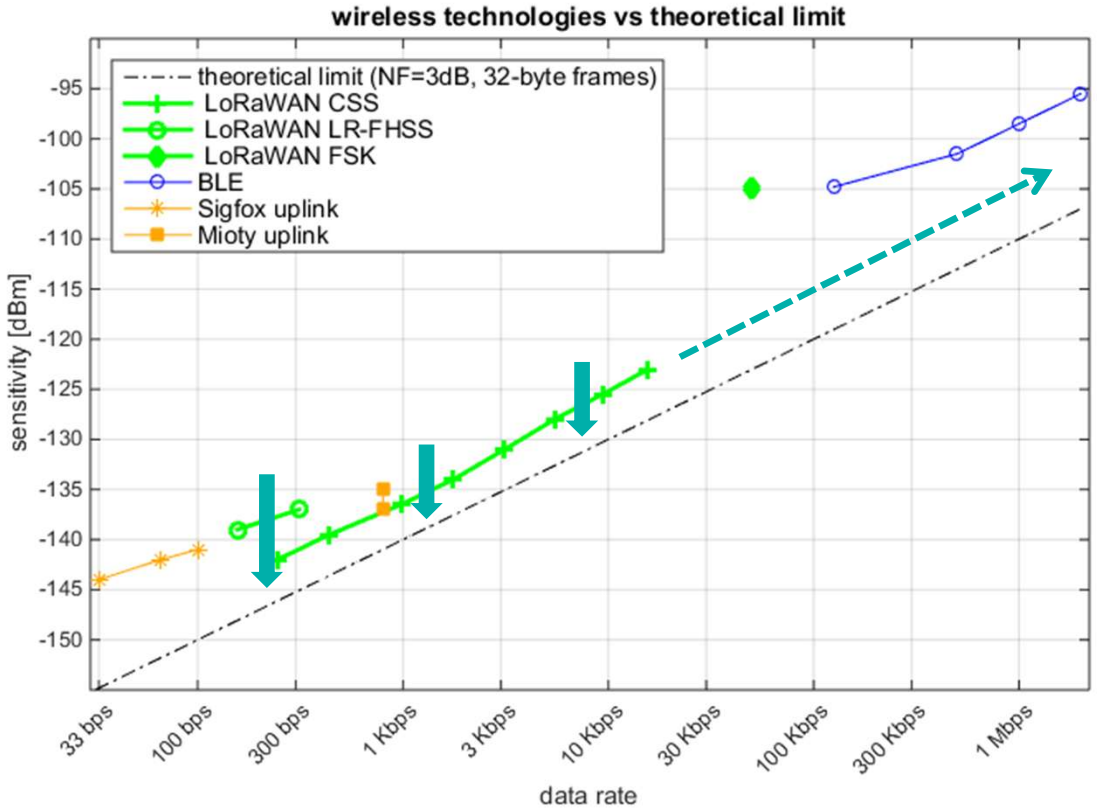


long range ⇒ high sensitivity ⇒ low data rate

Here theoretical limit is « sphere packing bound », it takes into account the limited payload length

Expand the set of data rates

long range & low power operations



long range ⇒ high sensitivity ⇒ low data rate

Expand connectivity

Connectivity everywhere, so we don't even notice it

Expand the range of data rates

Combine various network topologies

- Cellular
- Star
- Relays
- Mesh
- Satellites
- Walk-by / Drive-by / Fly-by
- Backscattering



Expand connectivity: drive-by

Pervasive coverage… but not always



LoRa Alliance is working on low power network discovery

- If device is moving, intermittent coverage, this is network discovery
- If device is static, this is walk-by, drive-by, fly-by, or satellites
- *Opportunistic* drive-by can provide very low connectivity costs (garbage collection or deliveries)

Technical solution is a beacon

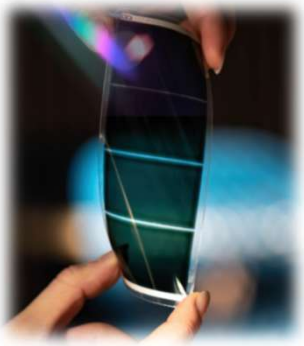
- End-device can detect the beacon in a low power fashion (long preamble / low rx duty cycle)
- Beacon is authenticated with a signature (ECC for now, as beacon validity is ephemeral)
- Beacon includes selection of end-device (ID, group of IDs, manufacturer, distance, signal level)
- « Plug & play »: beacon includes channel plan, ephemeris for LEO satellites, supported features, and recommended actions

From low power, to no power

Smaller devices, little maintenance

Efficient energy management, on chip/PMIC: DC-DC converters, chargers, MPPT.

Recent progress in energy harvesting: PV, OPV, piezoelectric, temp. difference, induction, RF.






Energy harvesting devices require protocol adaptations / restrictions, or dedicated procotols.

Batteries replacement is costly, and bad enough to the environment to deserve regulation

THANK YOU