IoT Solutions to a Telecom Paradigm Shift

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1. The IoT Context: Challenges – Paradox – Rational
2. The UNB Approach
3. Massively Parallel Cognitive SDR
4. Putting It All Together
5. Key Features & Performance
6. Future Evolutions

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The IoT Context:
Challenges – Paradoxes – Rational

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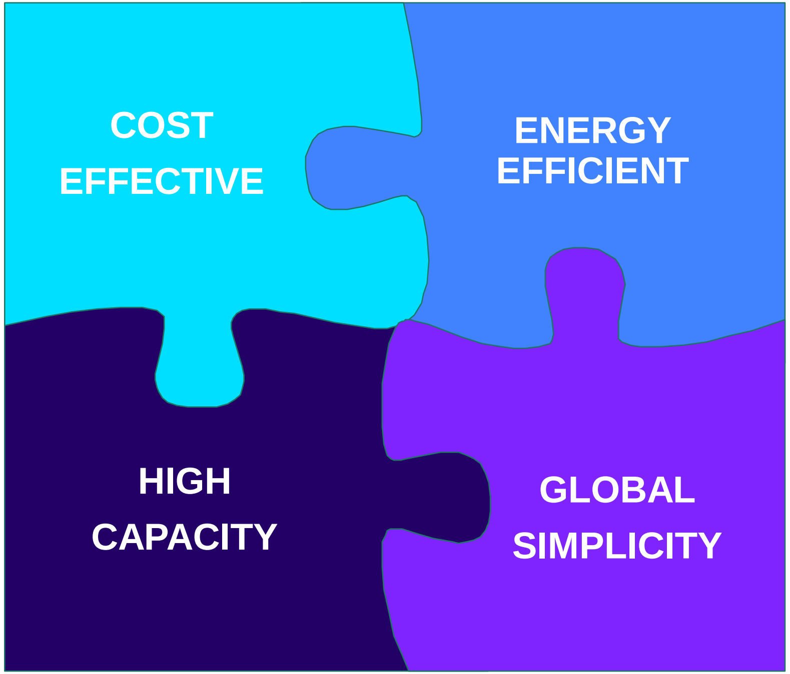
Key Goals for Massive IoT

- Ultra Low Cost (Devices and Network)
- Ultra Low Current Drain Ultra High
- Capacity – Scalability
- Global Simplicity



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Key Facts about Spectrum

- **Cellular** or Private Spectrum is and will remain **expensive**
- Usable **license-free** spectrum is **limited** and constrained (power, duty cycle, …)
- 60k devices / km^2 @ **100kB/day** leads to **15 – 50 MHz** additional spectrum
- 60k devices / km^2 @ **1kB/day** could be achieved with **0.2 MHz** of spectrum

➔ Make drastic Business Model / Resources Tradeoffs

➔ Be ready to Share your Spectrum (and live with interferers)

The Paradoxes

You need large cells for minimum CAPEX, thus long ranges…

… but you want low power

Despite large cells…

… you still want huge capacity on tiny spectrum

However…

… your devices are not disciplined for low power, complexity and cost

… you need to share the spectrum

➔ Network MUST be at the service of the Devices (not the opposite)

➔ Devices are Not Disciplined – they have a special DNA!

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The UNB Approach

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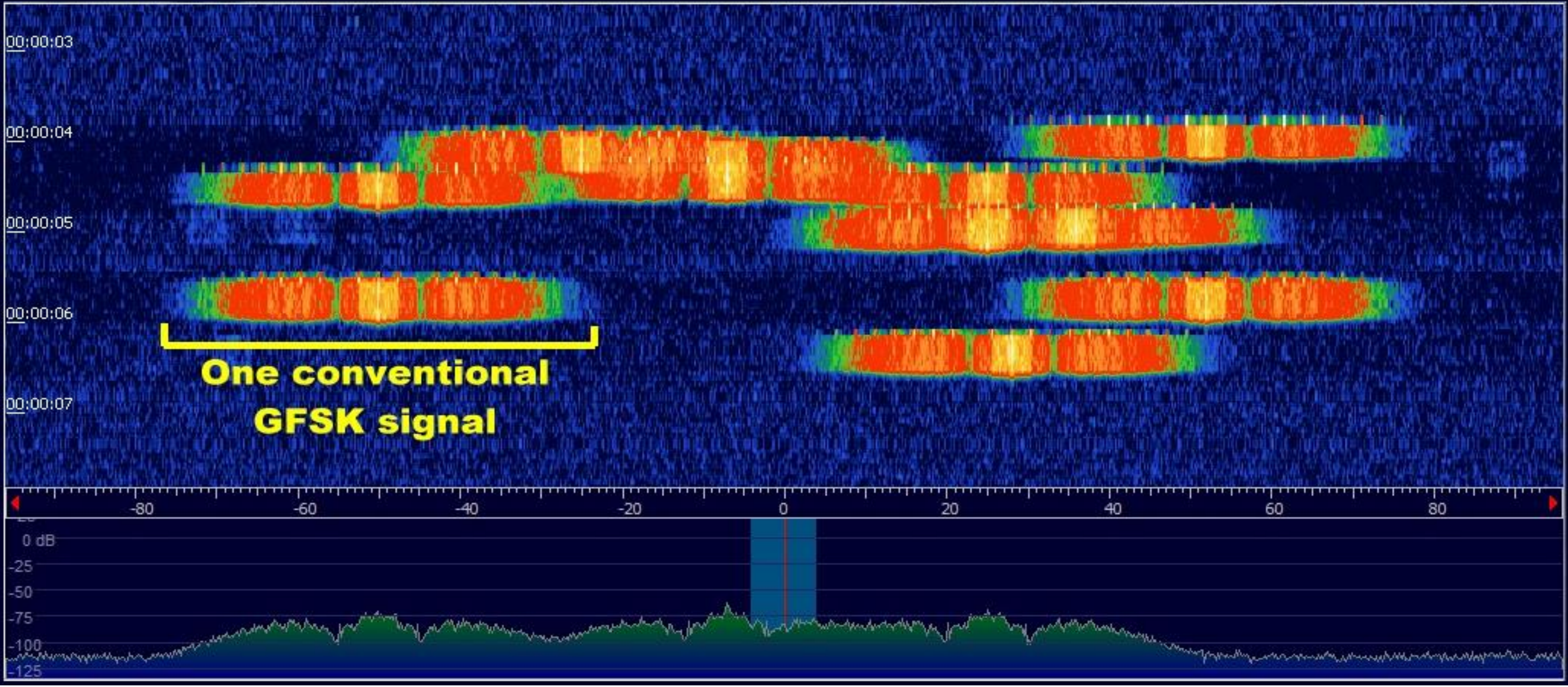
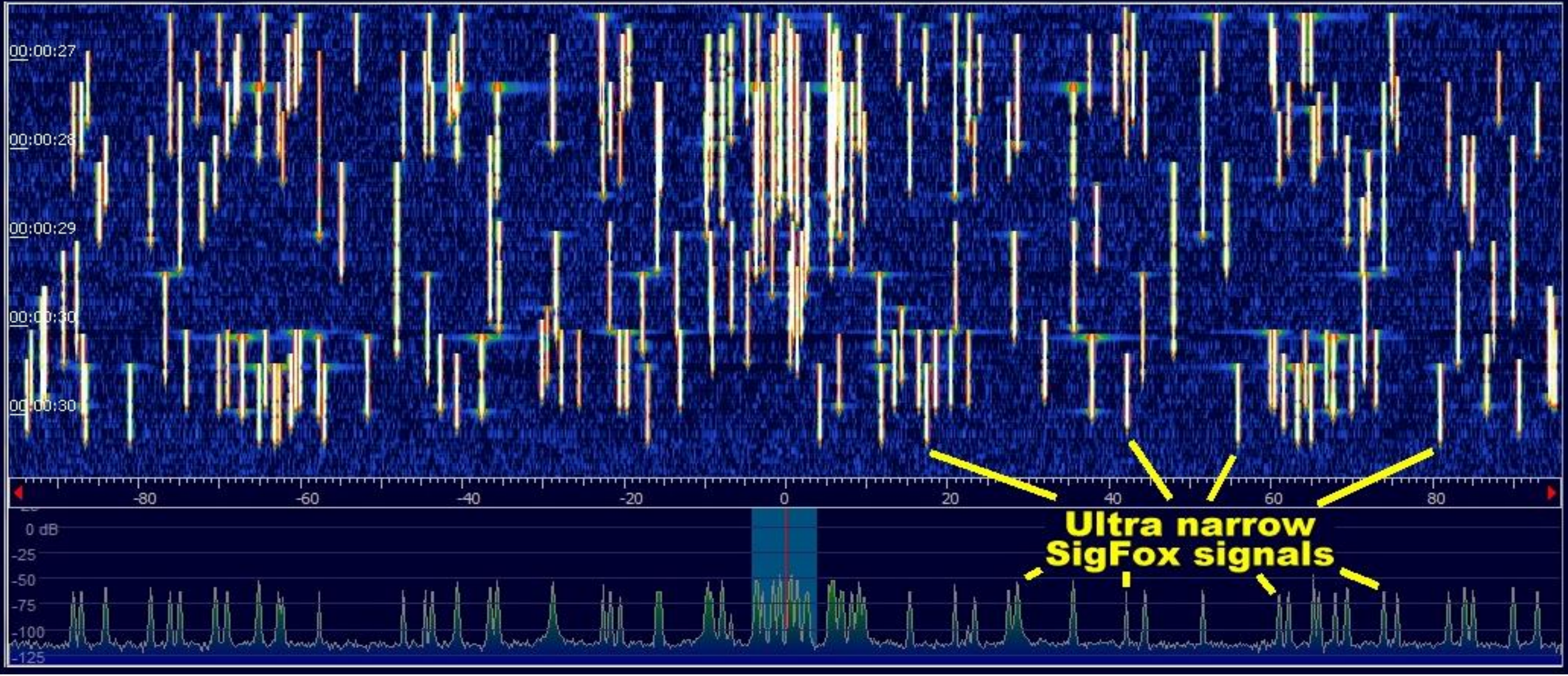
How Many Items Can Be Packed ?

vs.

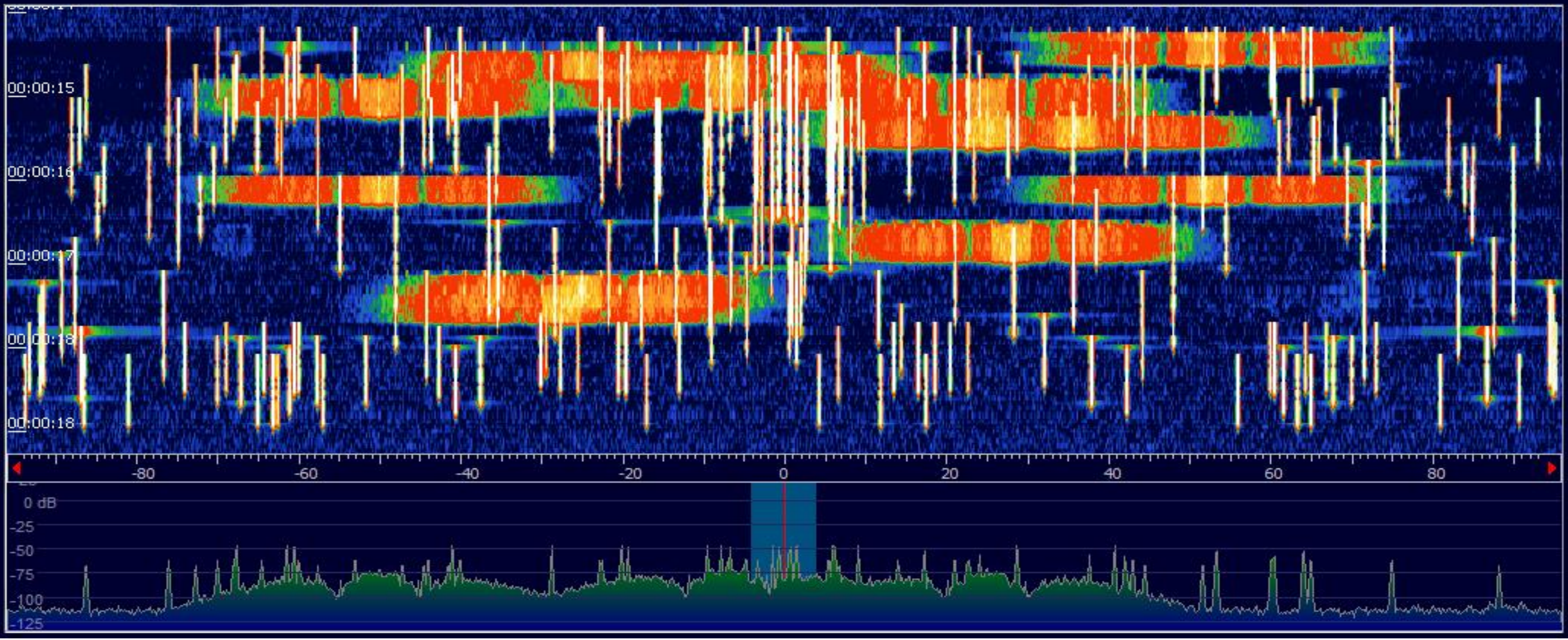
13 conventional GFSK signals, representing around 40% resource loading
3 collisions have occurred during this sequence



210 UNB SigFox signals, representing less than 4% resource loading
No collision occurred during this sequence



SigFox signals + conventional signals being transmitted on same spectrum at same power and same time. There was no loss of SigFox signals with a 25 dB protection margin relative to conventional "interferers"



YET …

Narrow Band Techniques have been essentially abandoned for more than 40 years

WHY ?

- Complex Tuning – Stability Issues – Expensive systems

Revisiting these conclusions

- Advanced techniques
- SDR

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Massively Parallel Cognitive SDR

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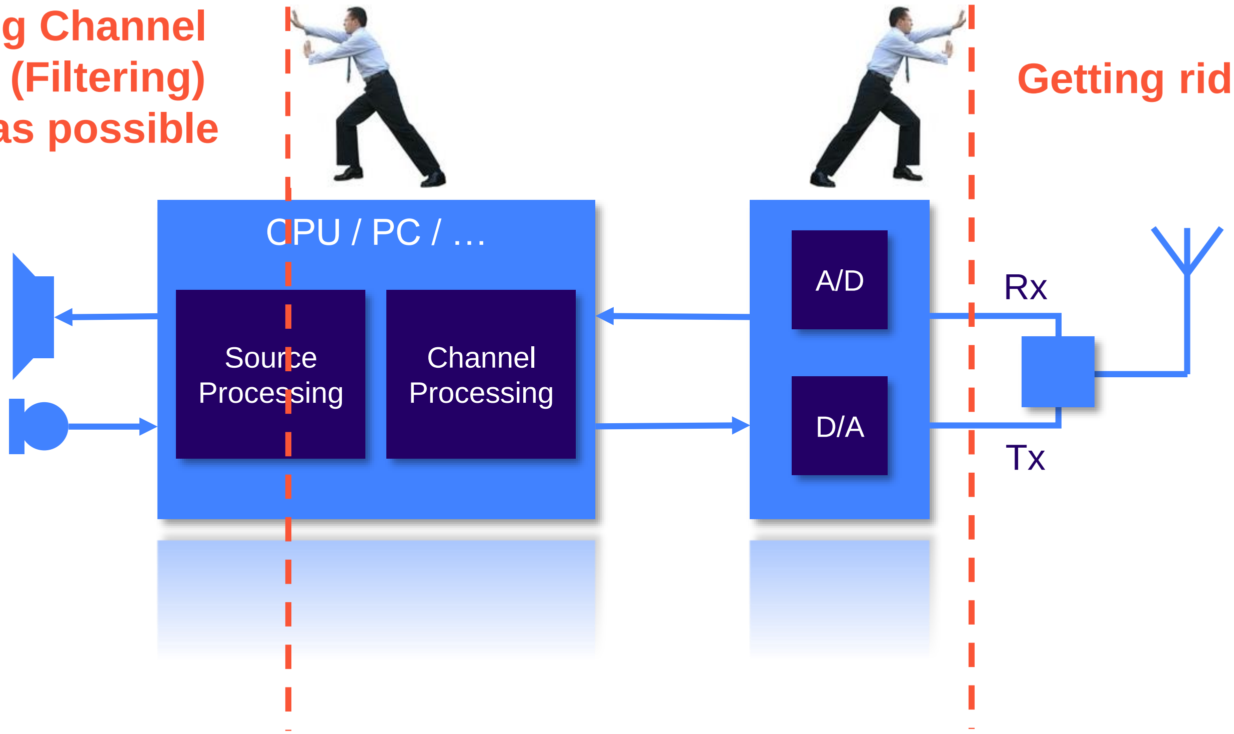
SDR or the search of the "Holy Grail"

Pushing Channel Processing (Filtering) as far as possible

Getting rid of RF



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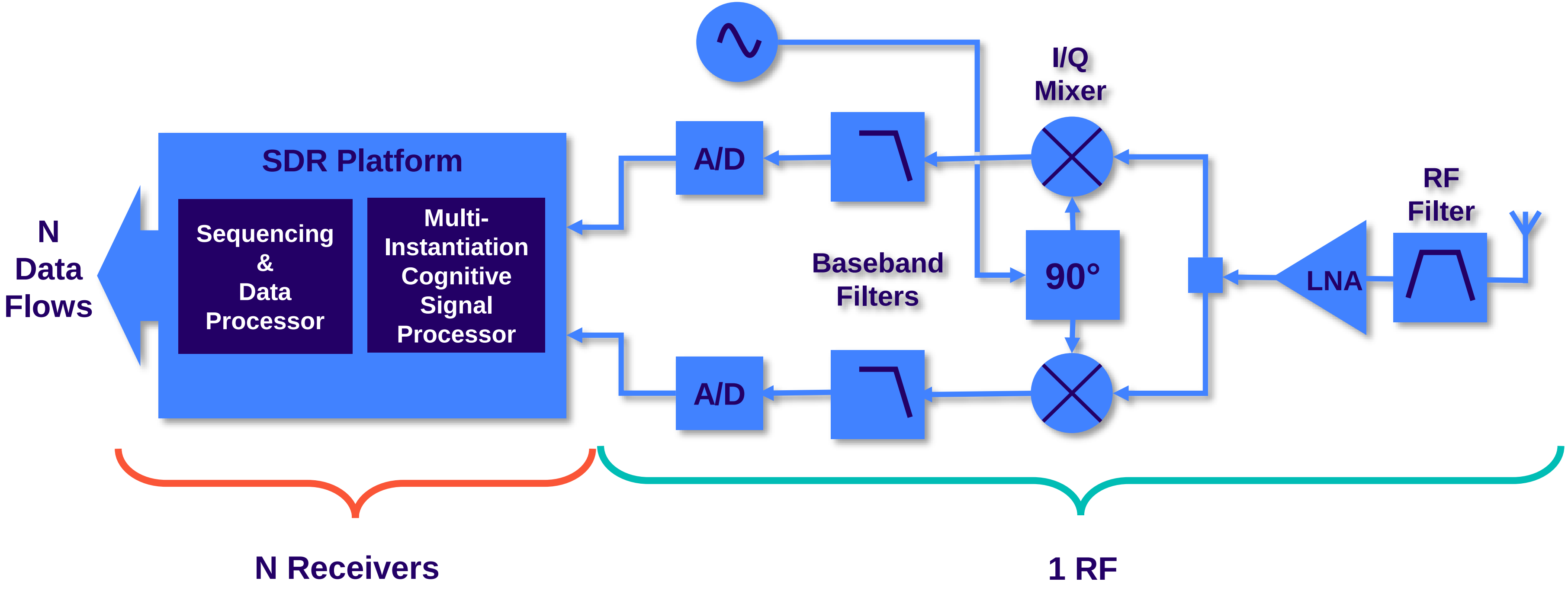
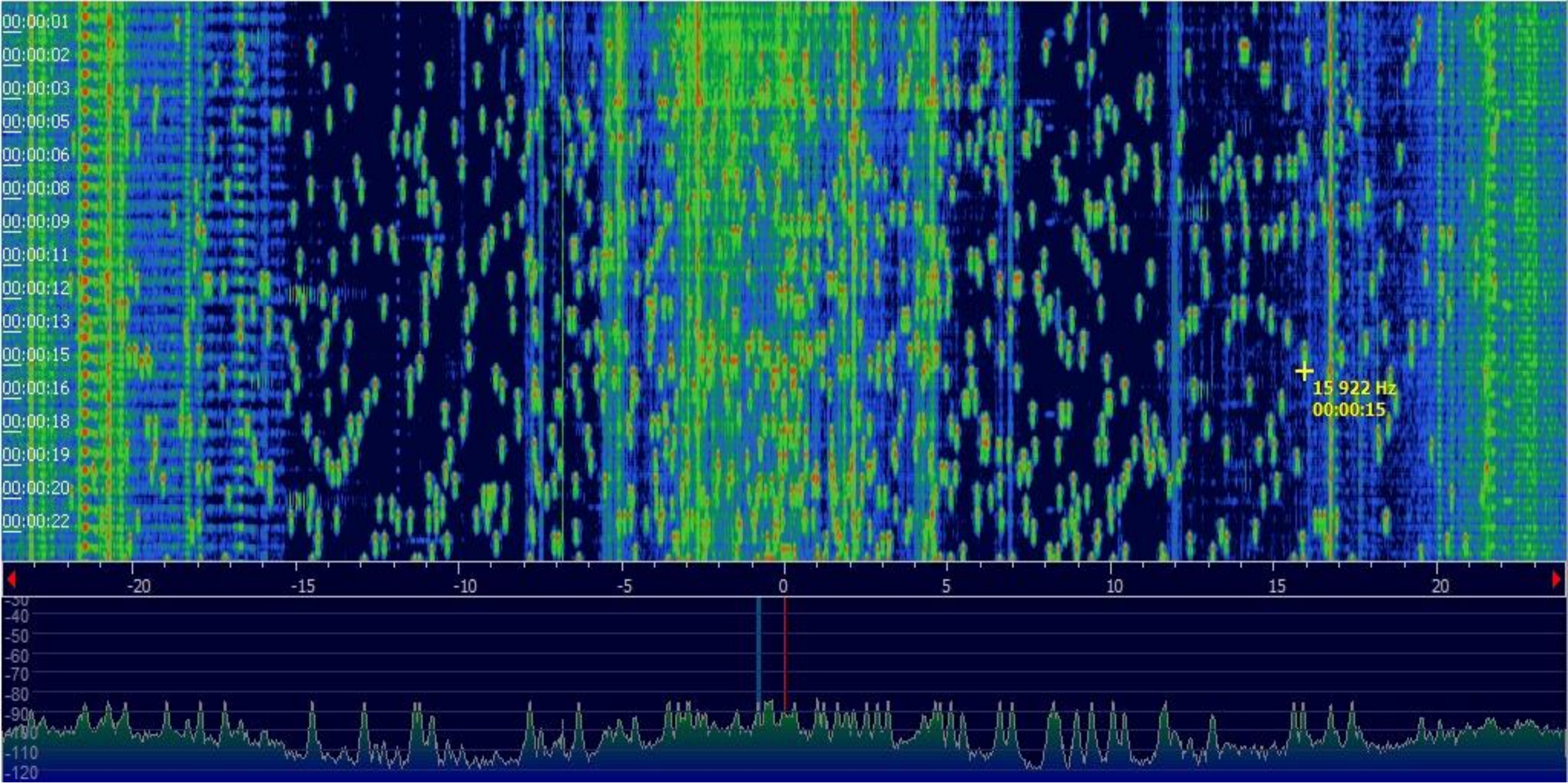
A Cognitive Multi-Instantiation SDR

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-15
-10
-5
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5
10
15
20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120

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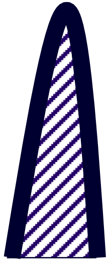
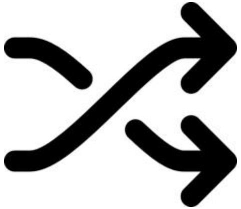
Putting It All Together

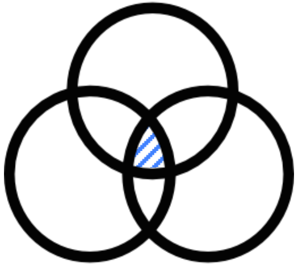
SIGFOX Solution for a Paradigm Shift



ULTRA NARROW BAND



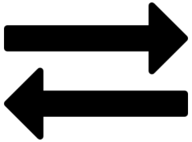
RANDOM ACCESS



COOPERATIVE RECEPTION

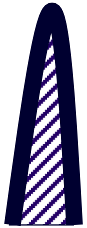
SMALL MESSAGES

SIGFOX CLOUD

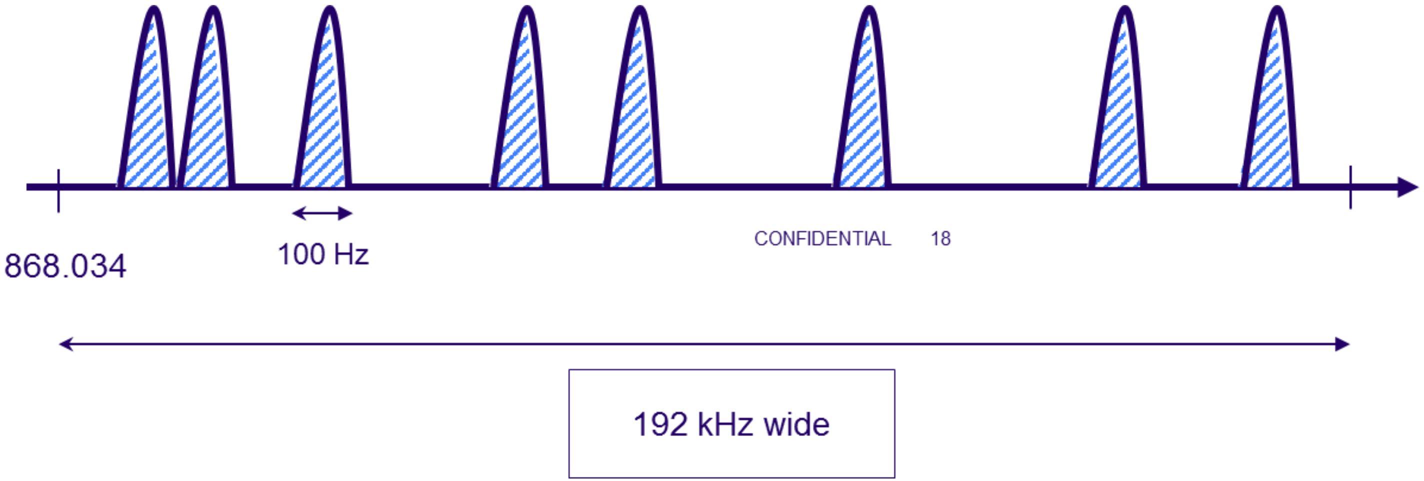


PIGGYBACK BI-DIR

ULTRA NARROW BAND



- 100Hz wide in a 200 kHz band
- DBPSK
- High spectrum efficiency 1bit/s = 1Hz of bandwidth



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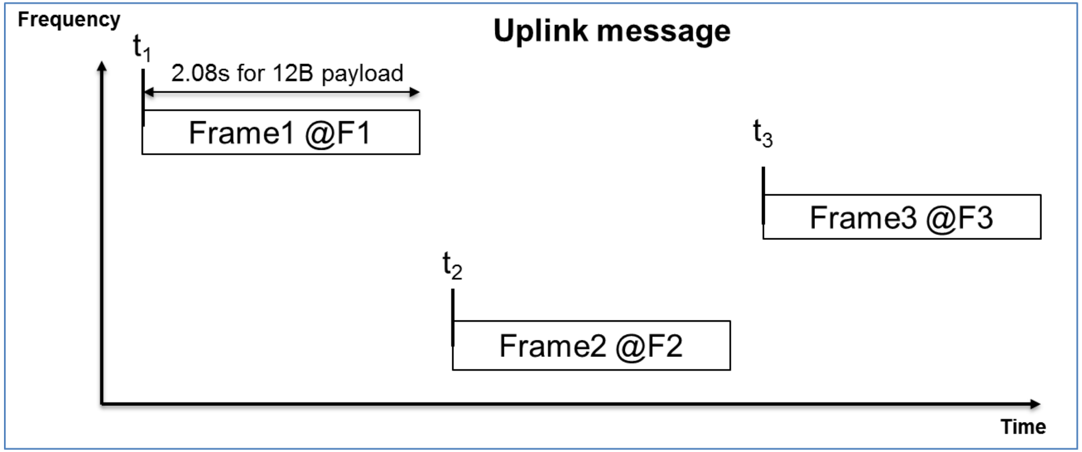
RANDOM ACCESS

- Unsynchronized transmission
- Random frequency
- SIGFOX Base stations permanently listen to the spectrum
- 3 replicas of the same frame @ 3 frequencies



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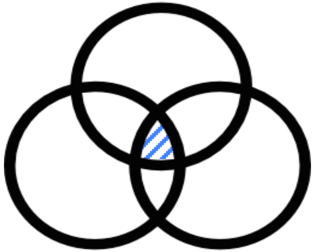
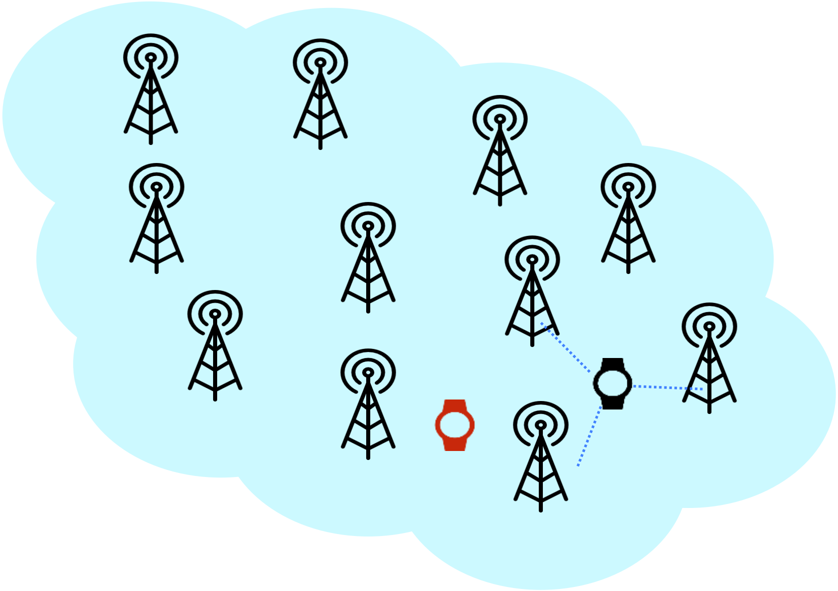
COOPERATIVE RECEPTION



- Message received by 3 Base Stations in average
- Spatial diversity decreases collision probability
- MIMO like Approach

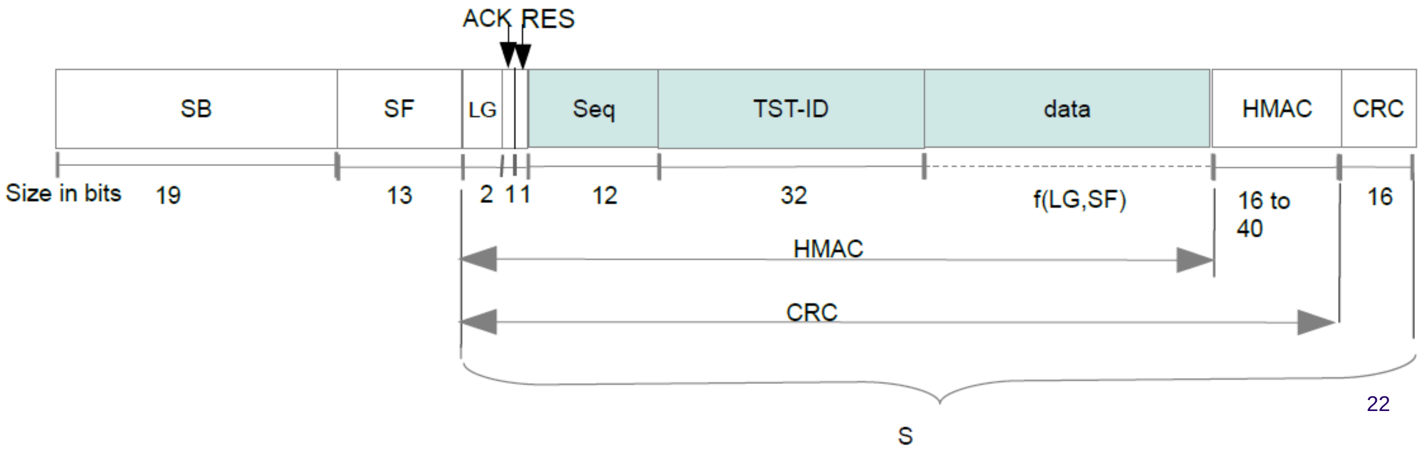


SMALL MESSAGES

- Payload size from 0 to 12 Bytes
- Message Size from 120 to 208 bit
- 1 % duty cycle for Objects – Up to 6 messages/hour

Payload size examples

- 6 bytes: GPS coordinates
- 2 bytes: temperature reporting
- 1 byte: speed reporting
- 1 byte: object state reporting
- 0 byte: heartbeat (demonstrate when an object is alive)



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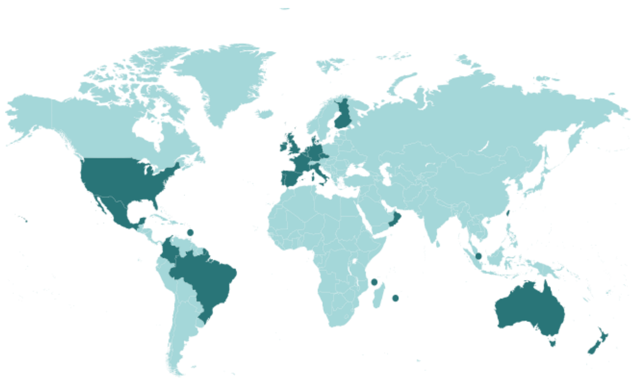
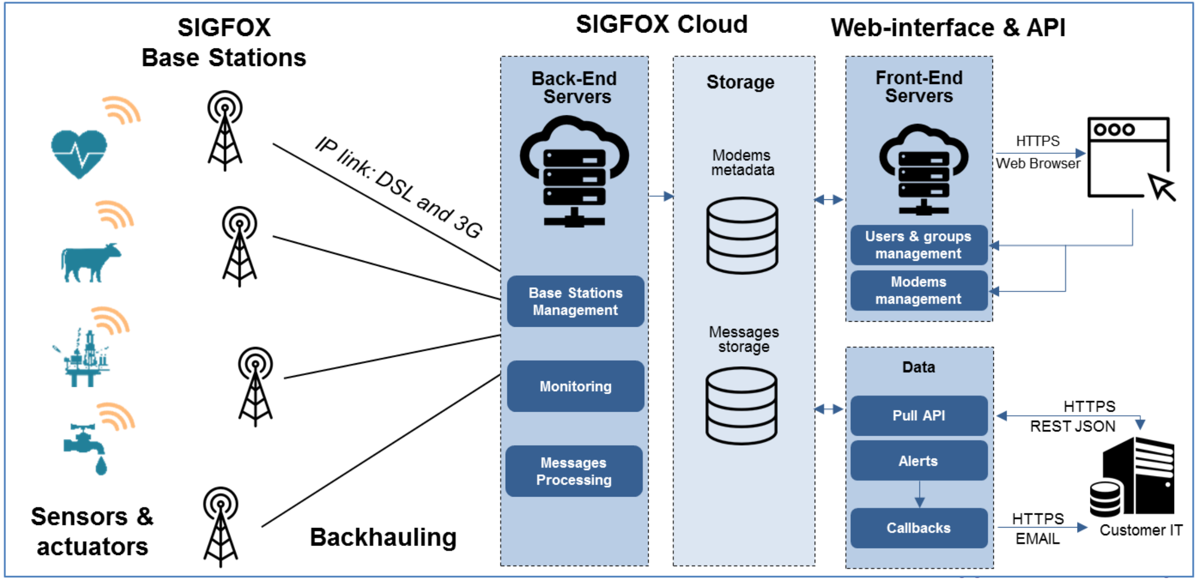
SIGFOX CLOUD

- ✓ Flat Architecture
- ✓ Centralized Authentication & Routing of Messages





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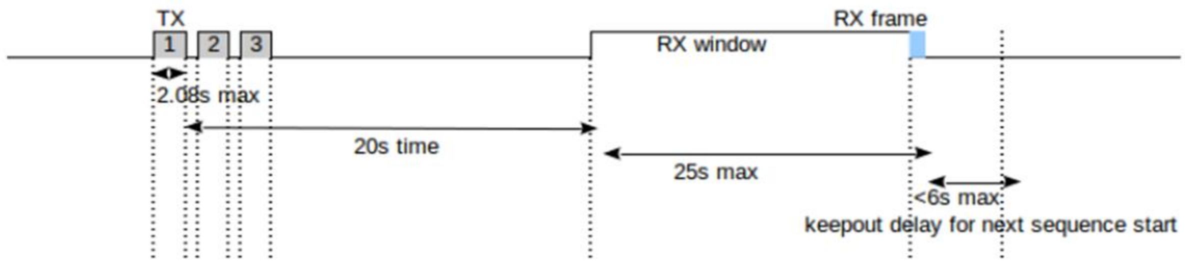
PIGGYBACK BI-DIR

- Requested by the device to the network
- Delay of 20 seconds – 25 seconds Downlink Window
- Downlink Frequency Derived from Uplink Frequency
- SDR Tx Mode : 1 RF – N Transmitters



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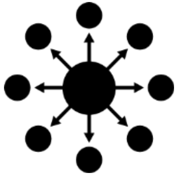
Key Features & Performance

HIGH NETWORK CAPACITY



ABILITY TO SCALE TO THE BILLIONS OF OBJECTS TO COME

UNB + **Frequency & Time diversity** + **Spatial diversity**

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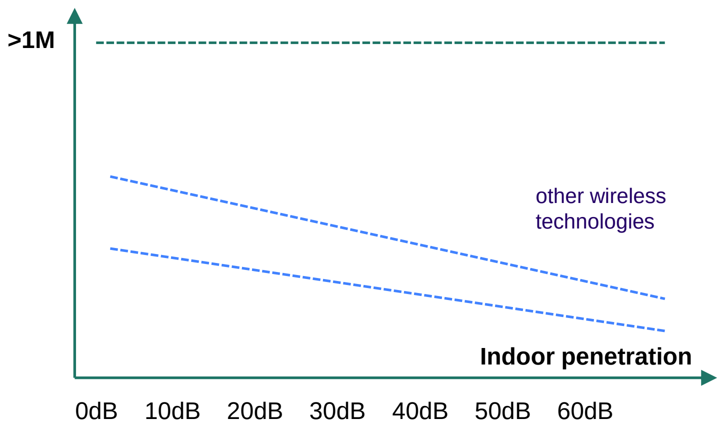
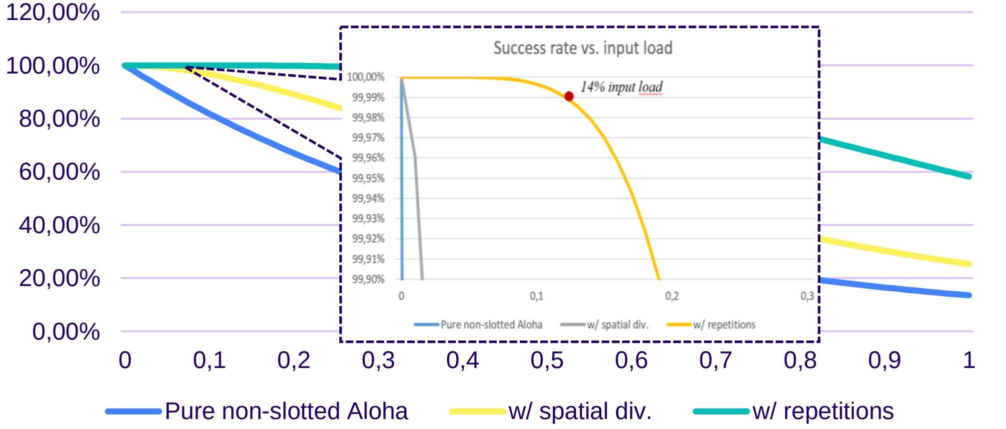
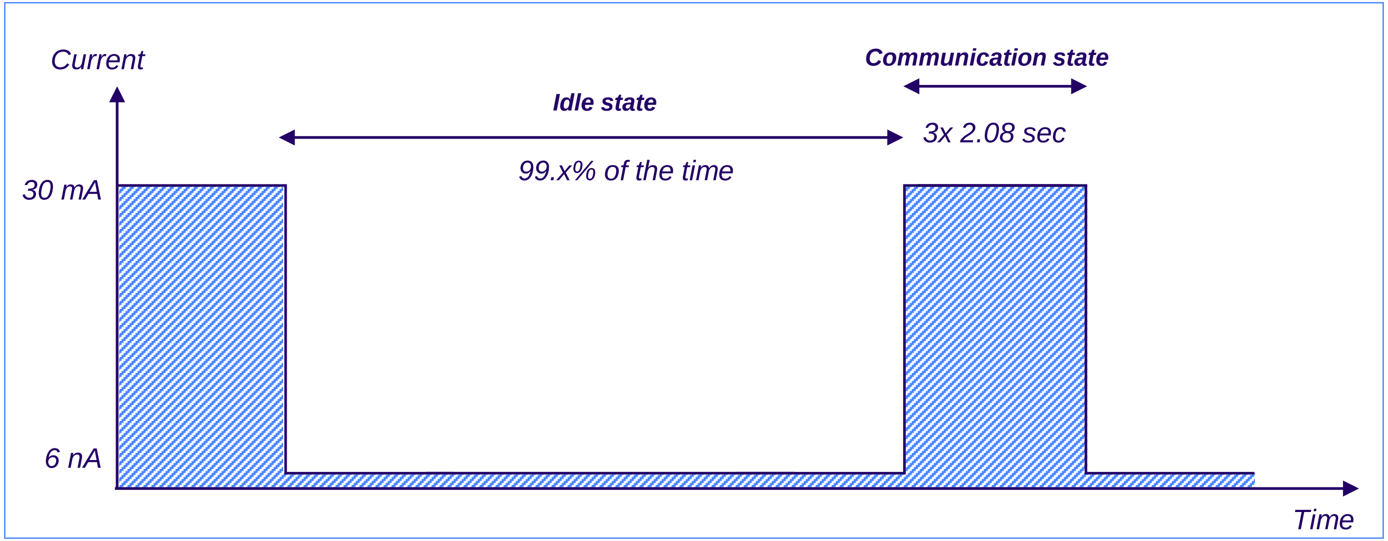
Massive capacity &
High Quality of Service





HIGH ENERGY EFFICIENCY

- No pairing – No Discipline – No Listening
- 15 to 45 mA during Tx (few seconds)
- Negligible Idle consumption



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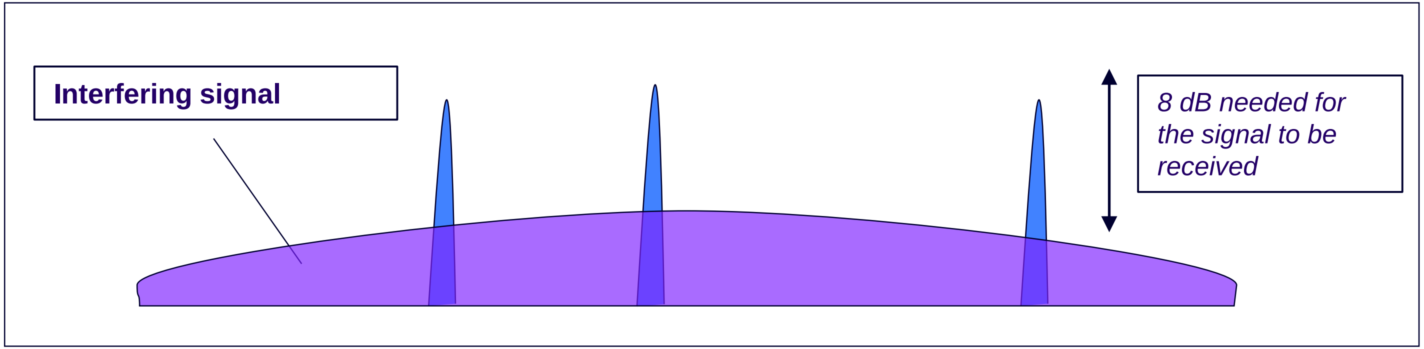
VERY LONG RANGE

- ✓ Very small Data Rate
- ✓ Comfortable Link Budget
- ✓ Sub GHz

	Modulation	Data-rate (bps)	Tx Power	CompoundTX Antenna Gain	CompoundRX Antenna Gain	RX sensitivity	Link Budget
Uplink (ETSI)	BPSK	100	+14 dBm	*0dB*	*+6dB*	-142dBm	***+162dB***
Downlink (ETSI	GFSK	600	+27 dBm	*+6dB*	*0dB*	*-130dBm*	***+163dB***
Uplink (FCC)	BPSK	600	*+22 dBm*	*0dB*	*0dB*	-134 dBm	***+156dB***
Downlink (FCC)	GFSK	600	*+30 dBm*	*0dB*	*0dB*	*-129 dBm*	***+159dB***

HIGH RESILIENCE TO INTERFERERS

- Intrinsic Ruggedness of UNB
- Spatial Diversity
- No Discipline



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Future Evolutions

Towards a Large Array Radio Telescope

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Towards Massive MIMO Processing

Today:

- Multiple sites having 1 RF – N Receivers
- Site Diversity – Not real Diversity Processing

Options:

- One Site Time/Frequency Diversity – Recombine replicas ➔ Low Cost
- On Site Diversity – Independent SDR processing ➔ Cost / Benefit is limited
- On Site Diversity – Joint SDR Processing ➔ Not enough (antenna decorrelation)

Better Option:

- Large Array – Multi Site Diversity

Thank You

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