
I.O.T
ONLINE
IDEA
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WiFi
INNOVATIONS
BIG DATA
COMMUNITY
CHAT
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WAZIUP
DISRUPTIVE
INTERNET
OF THINGS
APPLICATIONS
IN AFRICA

Low-power, Long-range WAN for IoT: a technology overview

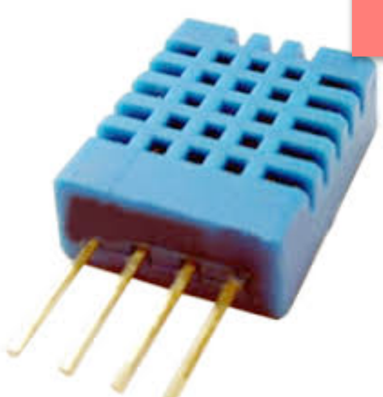
RESSACS'2016
IRD, Bondy

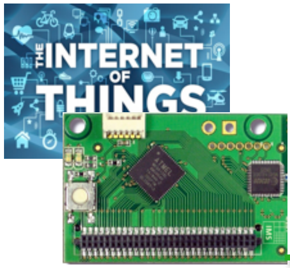
May 10 th, 2016

Prof. Congduc Pham
http://www.univ-pau.fr/~cpham
Université de Pau, France

Measuring the physical world

Sensing





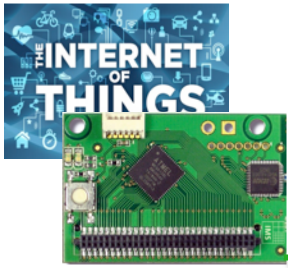
CONTROL, OPTIMIZE & INSTRUMENT !

DATA ANALYSIS, OPTIMIZATION & CONTROL

PERVASIVE SYSTEMS

SENSING

PEOPLES, INFRASTRUCTURES, BUILDINGS, VEHICULES



1ST ISSUE: COLLECT DATA

DATA ANALYSIS, OPTIMIZATION & CONTROL

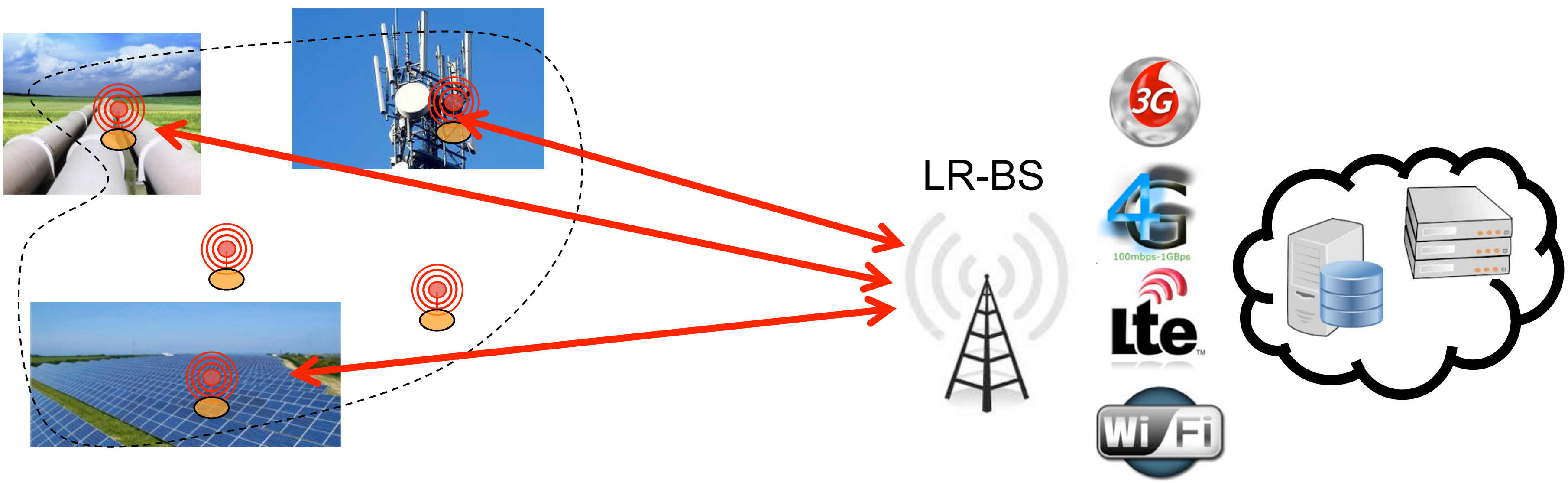
PERVASIVE SYSTEMS

SENSING

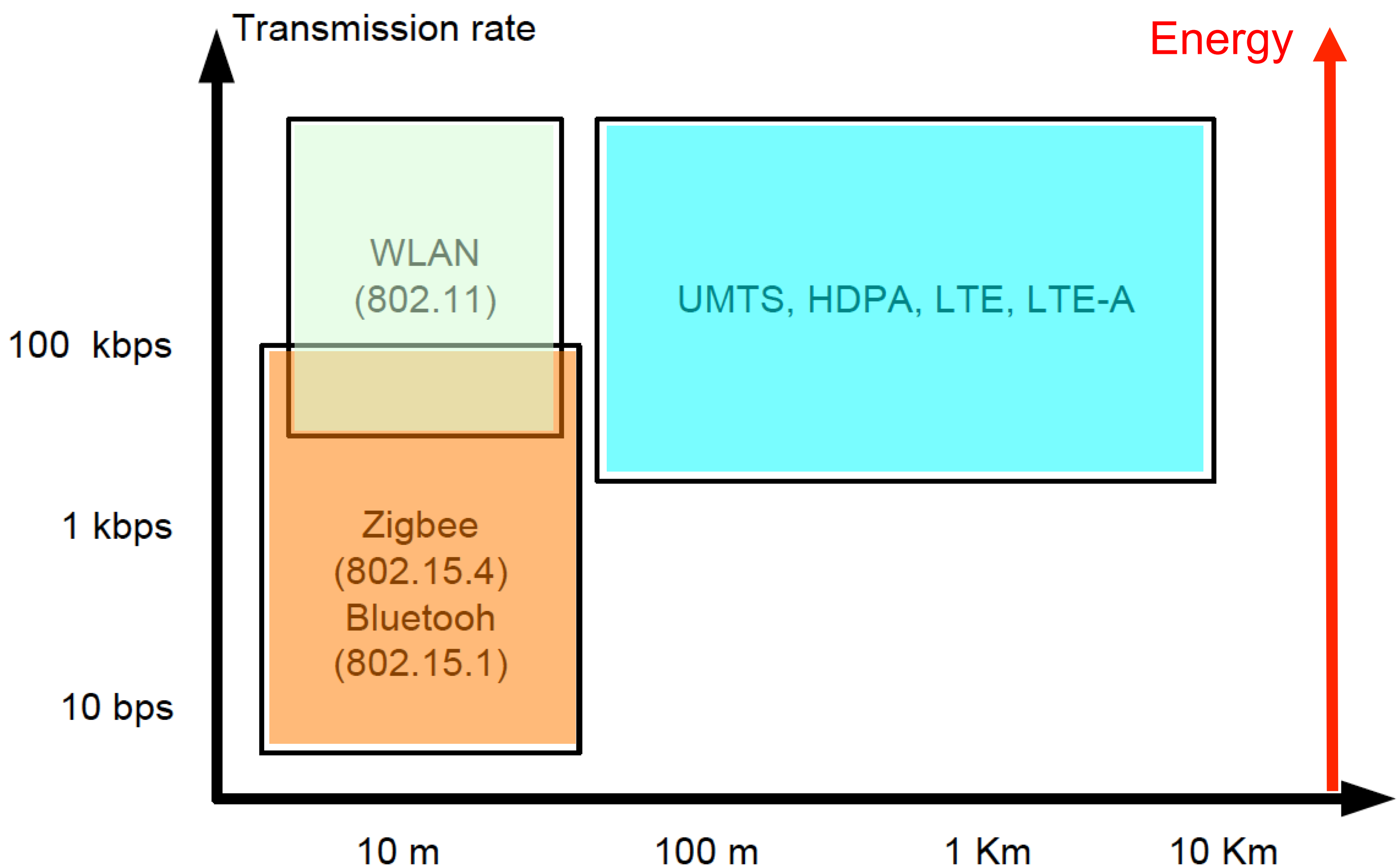
PEOPLES, INFRASTRUCTURES, BUILDINGS, VEHICULES

Deploying sensing systems

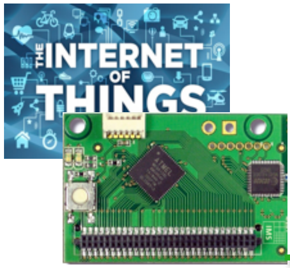
IoT/WSN deployment made easier in single-hop model !!!



Energy-Range dilemma



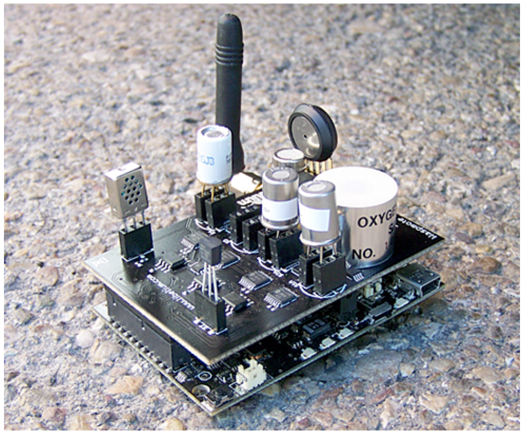
Enhanced from M. Dohler "M2M in SmartCities"



How costly is transmission?

Technology	2G	3G	LAN
Range (I=Indoor, O=Outdoor)	N/A	N/A	O: 300m I: 30m
Tx current consumption	200-500mA	500-1000mA	100-300mA
Standby current	2.3mA	3.5mA	NC

Energy consideration



18720 Joules

TX power: 500mA

P = I x V = 500 x 3.3 = 1650mW

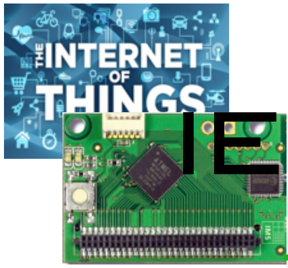
E = P x t -> t = E/P

11345s or 3h9mins

Technology	2G	3G	LAN
Range (I=Indoor, O=Outdoor)	N/A	N/A	O: 300m I: 30m
Tx current consumption	200mA-500mA	500mA – 1000mA	50mA
Standby current	2.3mA	3.5mA	NC

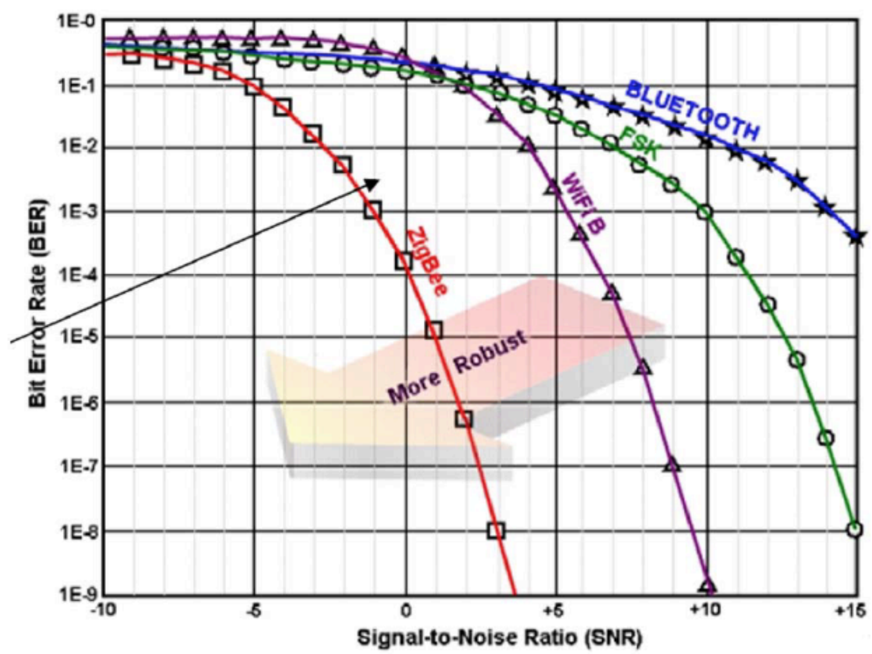
Haven't considered:

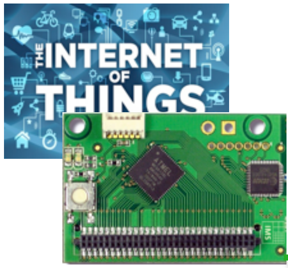
- Baseline power consumption of the sensor board
- RX consumption!
- Event capture consumption
- Event processing consumption



IEEE 802.15.4 in ISM 2.4GHz

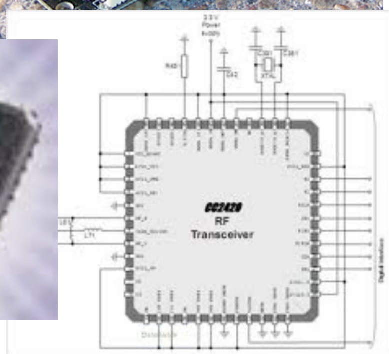
- Low-power radio in the 2.4GHz band offering 250kbps throughput at physical layer
- Power transmission from 1mW to 100mW for range from 100m to about 1km is LOS
- CSMA/CA
- BPSK, used as physical layer in ZigBee





Energy consideration

18720 Joules



Chipcon Products from Texas Instruments

CC2420

Parameter	Min.	Typ.	Max.	Unit	Condition / Note
Current Consumption, transmit mode:					
P = -25 dBm		8.5		mA	The output power is delivered differentially to a 50 Ω singled ended load through a balun, see also page 55.
P = -15 dBm		9.9		mA	
P = -10 dBm		11		mA	
P = −5 dBm		14		mA	
P = 0 dBm		17.4		mA	

TX power 0dbm: 17.4mA

P = I x V = 17.4 x 3.3 = 57.42mW

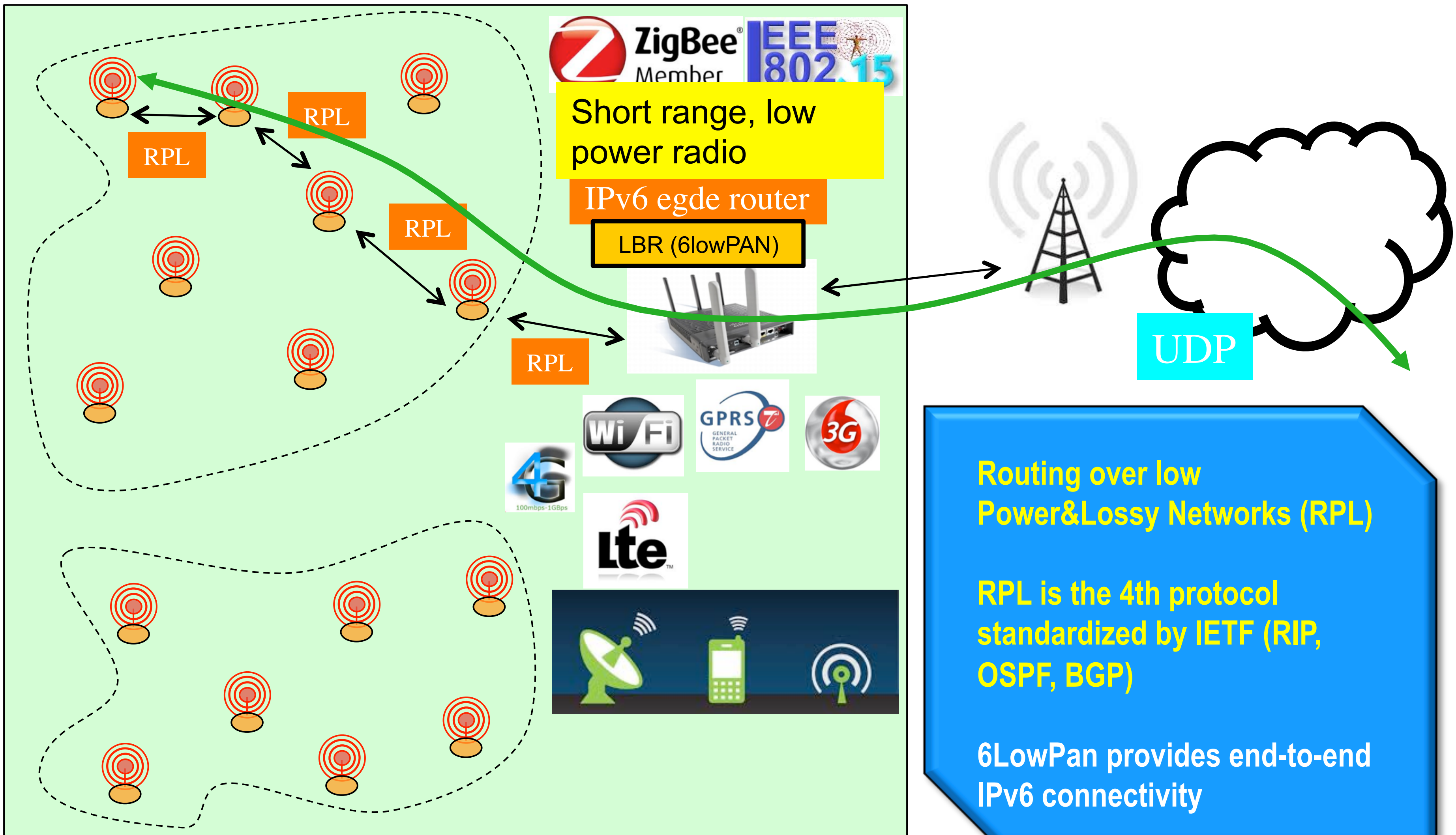
E = P x t -> t = E/P

326018s or 90.5h

Haven't considered:

- Baseline power consumption of the sensor board
- RX consumption: 18.8mA!
- Event capture consumption
- Event processing consumption

15 YEARS OF MULTI-HOP ROUTING?



Routing over low Power&Lossy Networks (RPL)

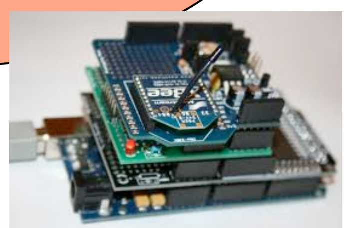
RPL is the 4th protocol standardized by IETF (RIP, OSPF, BGP)

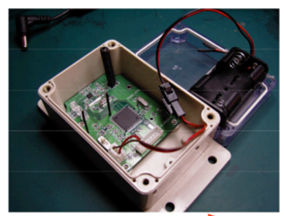
6LowPan provides end-to-end IPv6 connectivity

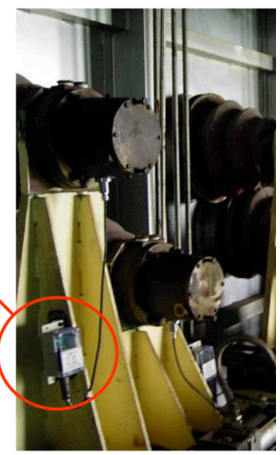
Academics vs Industries
Let's go back to reality!

Millions of sensors, self-organizing, self-configuring, with QoS-based multi-path routing, mobility, and …

500 sensors, STATIC deployment, but need to have RELIABILITY, GUARANTEED LATENCY for monitoring and alerting. MUST run for 3 YEARS. No fancy stuff! CAN I HAVE IT?

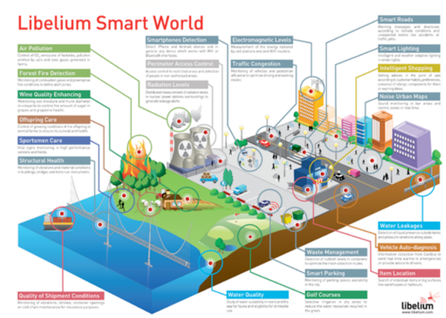




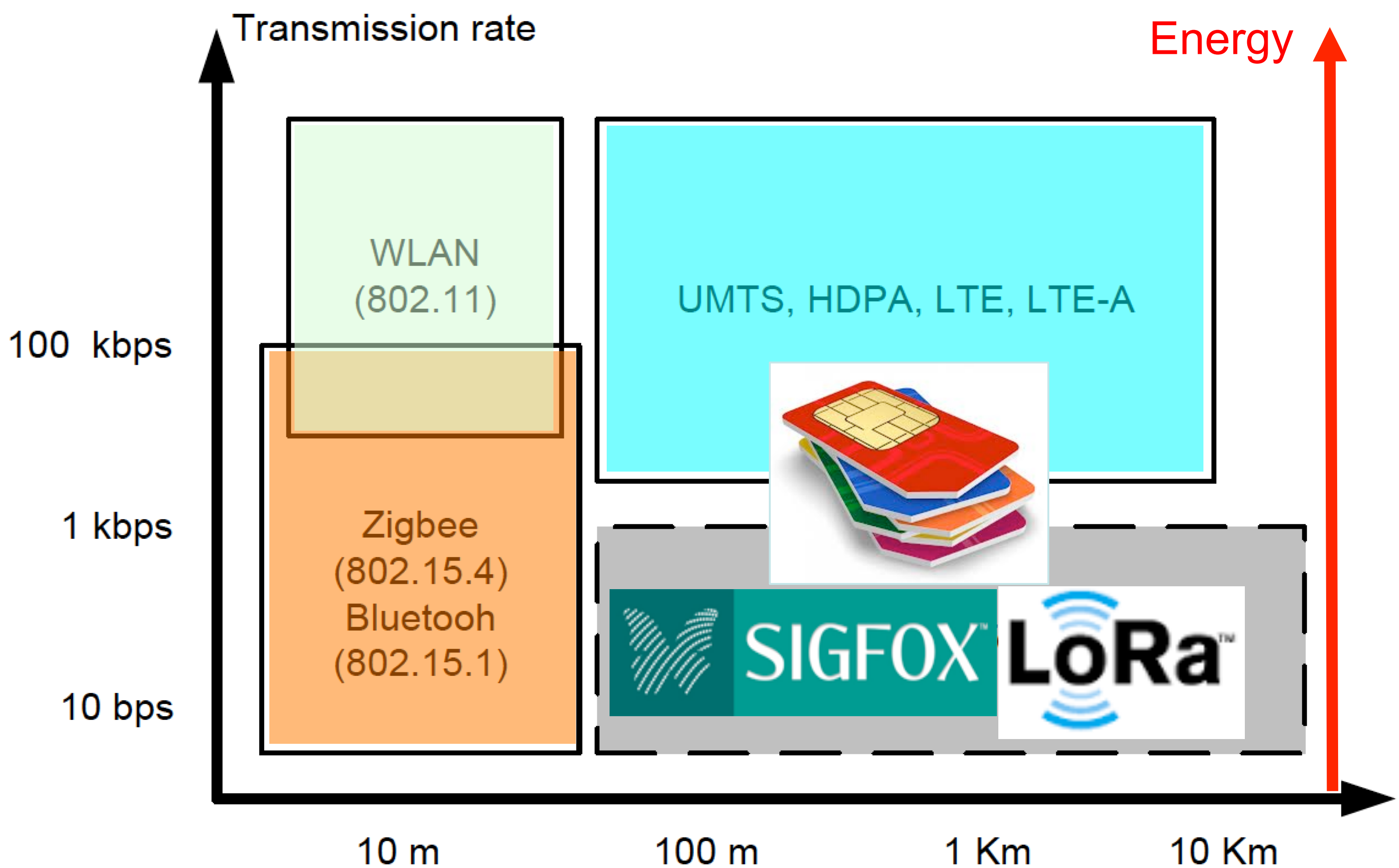


- Placement constraints
- Lifetime constraints

From Peng Zeng & Qin Wang



Low-power and long-range?



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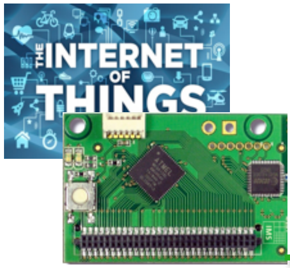
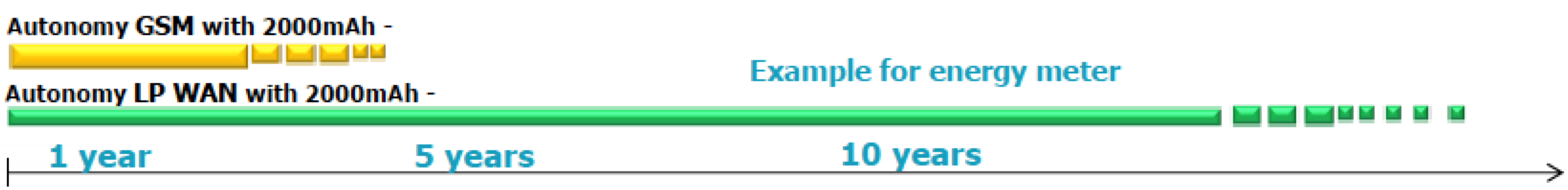


Low Power WAN ?

Tables from Semtech

Technology	2G	3G	LAN	ZigBee	Lo Power WAN
Range (I=Indoor, O=Outdoor)	N/A	N/A	O: 300m I: 30m	O: 90m I: 30m	Same as 2G/3G
Tx current consumption	200-500mA	500-1000mA	100-300mA	18mA	18mA
Standby current	2.3mA	3.5mA	NC	0.003mA	0.001mA
Energy harvesting (solar, other)	No	No	No	Possible	Possible
Battery 2000mAh (LR6 battery)	4-8 hours(com) 36 days(idle)	2-4 hours(com) X hours(idle)	50 hours(com) X hours(idle)	60hours (com)	120 hours(com) 10 year(idle)
Module Revenue Annually	12 $	20 $	4 $	$3	3 $



Typical scenarios

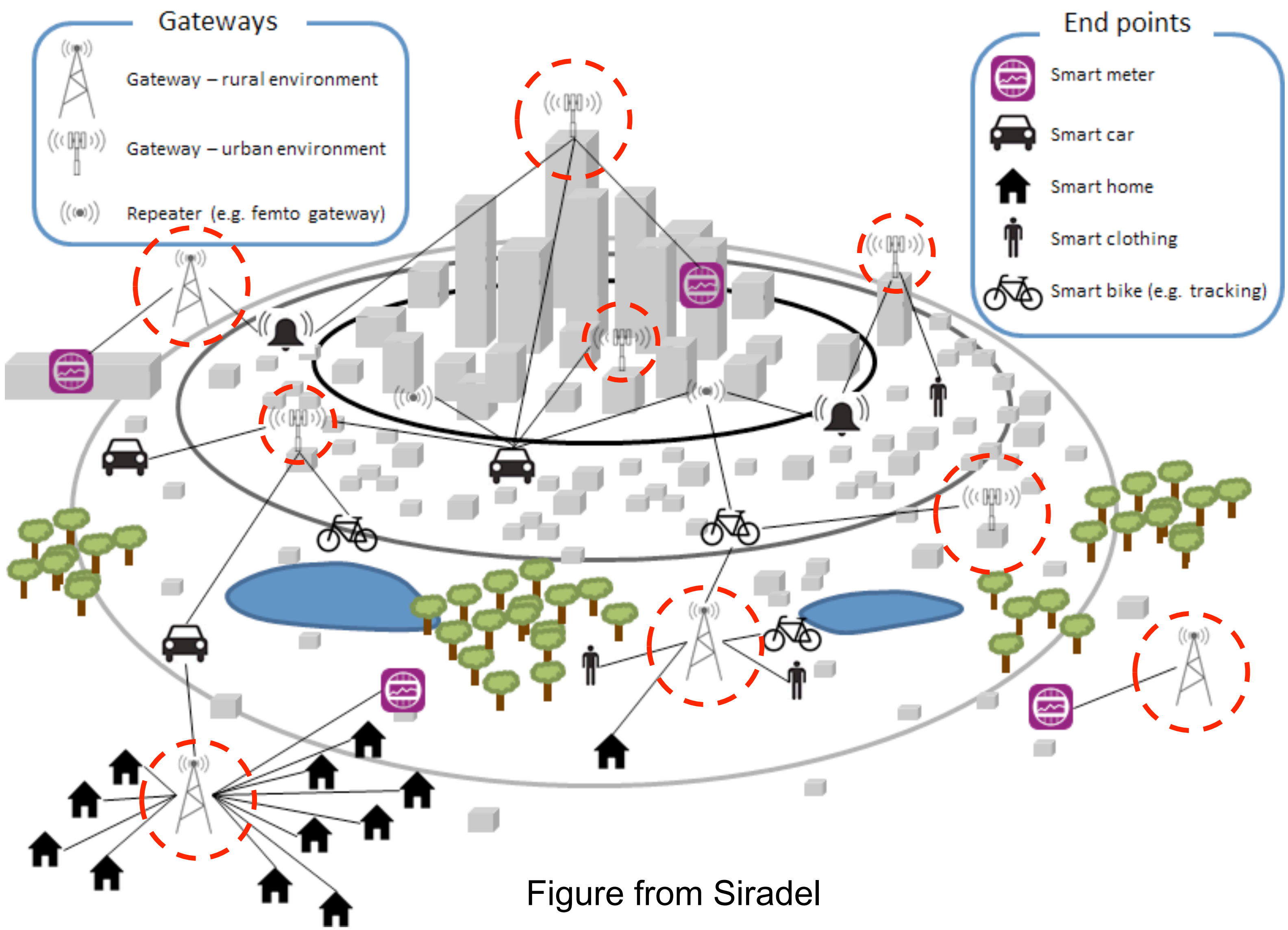
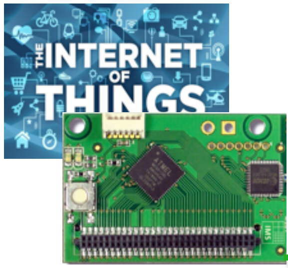
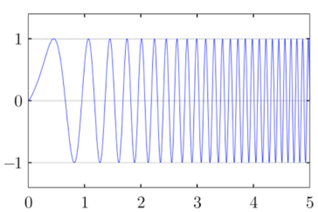


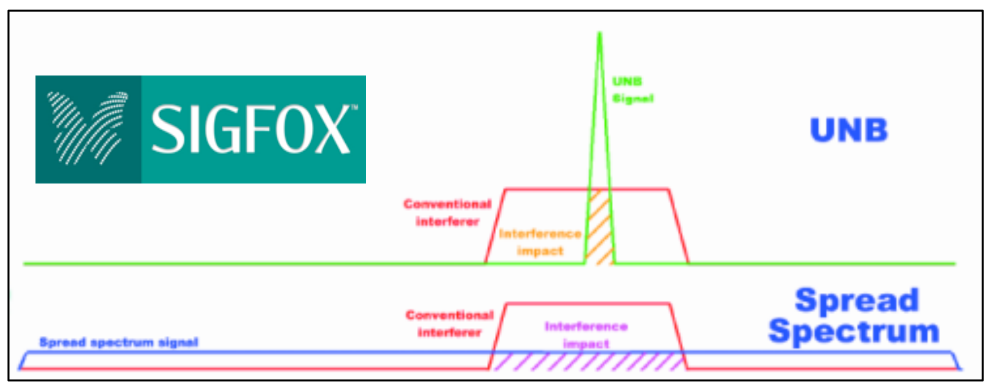
Figure from Siradel



INCREASING RANGE?

- Generally, robustness and sensitivity can be increased when transmitting (much) slower
- A[Sigfox message is sent relatively slowly in a very narrow band of spectrum (hence ultra-narrow-band) using Gaussian Frequency-Shift Keying modulation]. Max throughput=~100bps
- LoRa also increases time-on-air when maximum range is needed. But LoRa uses spread spectrum instead of UNB.
  300bps-37.5kbps

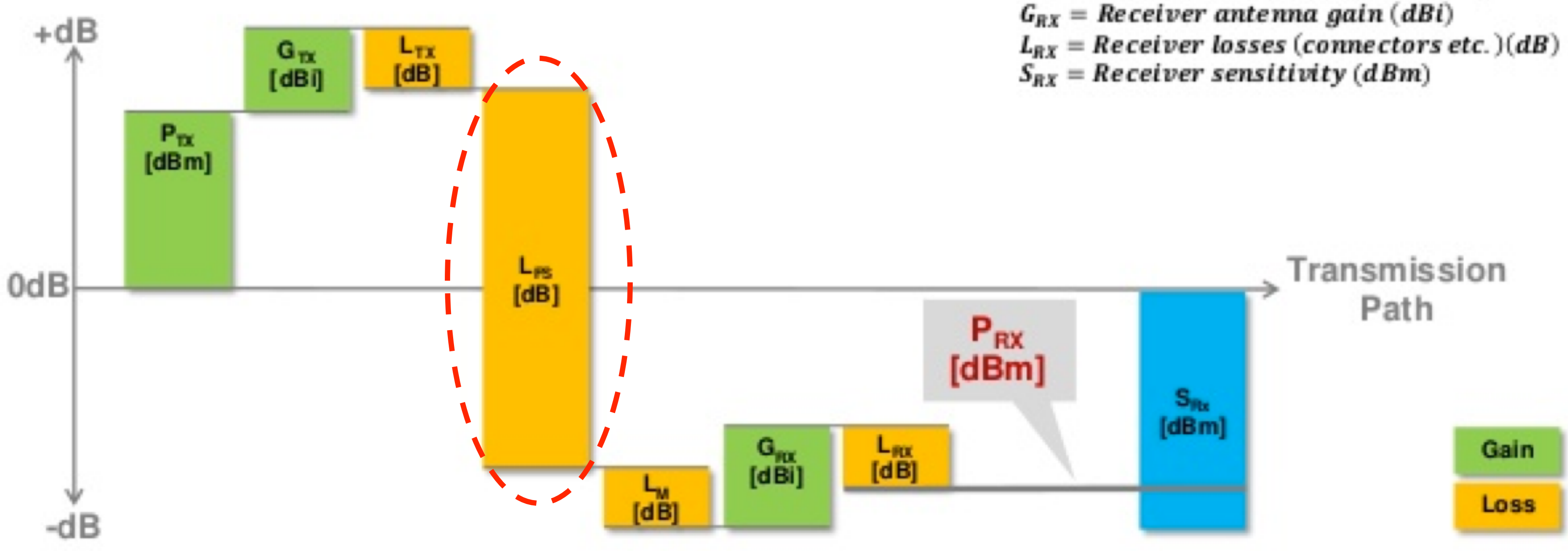




Link budget of LPWAN

$$P_{RX} = P_{TX} + G_{TX} - L_{TX} - L_{FS} - L_M + G_{RX} - L_{RX}$$

P_{RX} = Received power (dBm)
P_{TX} = Sender output power (dBm)
G_{TX} = Sender antenna gain (dBi)
L_{TX} = Sender losses (connectors etc.)(dB)
L_{FS} = Free space loss (dB)
L_M = Misc. losses (multipath etc.)(dB)
G_{RX} = Receiver antenna gain (dBi)
L_{RX} = Receiver losses (connectors etc.)(dB)
S_{RX} = Receiver sensitivity (dBm)



From Peter R. Egli, INDIGOO.COM

Simple loss in signal strength model

$$\text{FSPL} = \left(\frac{4\pi d}{\lambda}\right)^2 = \left(\frac{4\pi df}{c}\right)^2$$

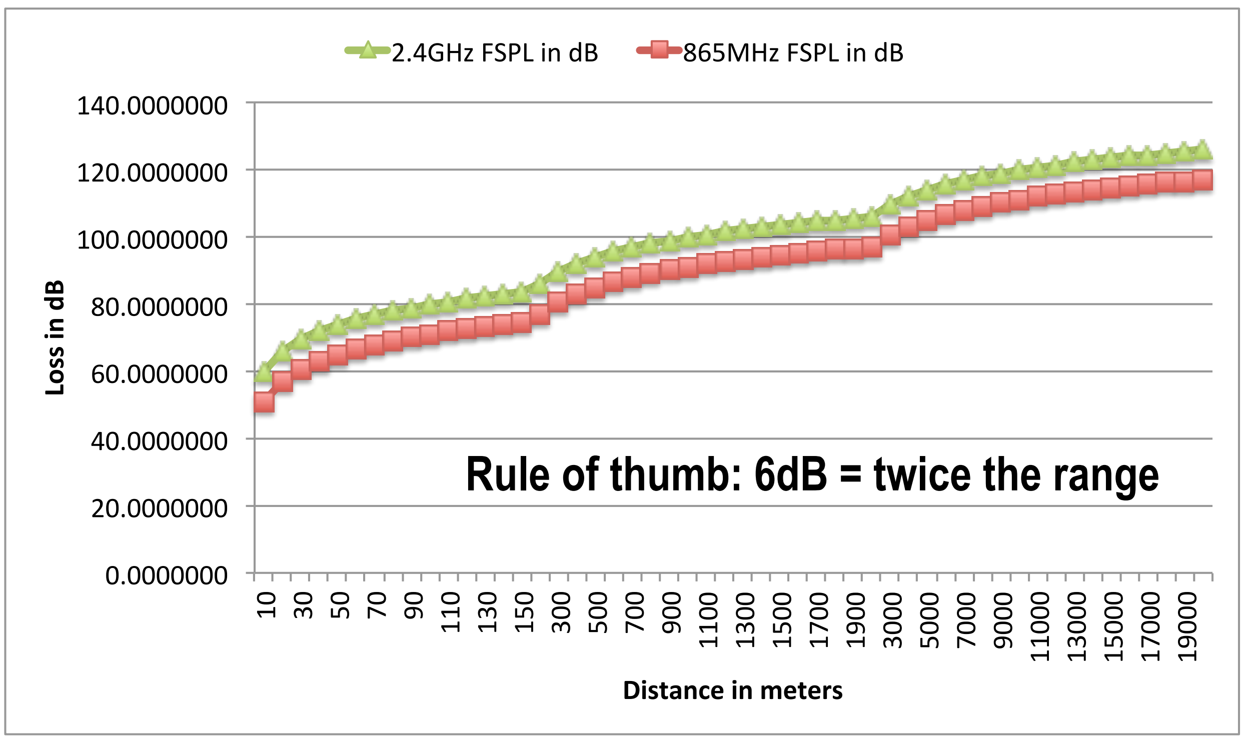
$$FSPL = \frac{P_t}{P_r} G_t G_r$$

- Free Space Path Loss model

$$L_{(dB)} = 10\log\left(\frac{P_t}{P_r}\right) = 20\log\left(\frac{4\pi d}{\lambda}\right) = 20\log\left(\frac{4\pi fd}{c}\right)$$

$$L_{(dB)} = 20\log(f) + 20\log(d) - 147{,}55\ dB$$

FSPL assume Gt=Gr=1



Link budget example

- Received Power (dBm) = Transmitted Power (dBm) + Gains (dB) – Losses (dB)
- Example
  - Transmitted power is +14dBm (25mw)
  - Losses (FSPL) is 120dB (received power is 10^{12} less than transmitted power)
  - Then Receiver Power (dBm) is -106dBm
- If you have a receiver sensitivity of -137dBm you can handle FSPL up to 151dB, i.e. 1.15×10^{15} less power than transmitted power!
- Rewriting the equation
  - Losses (dB) = Transmitted Power (dBm) - Received Power (dBm)
  - <u>Losses = link budget</u> & <u>Received Power = max receiver sensitivity</u>
  - Link budget = Transmitted Power - max receiver sensitivity
  - **151dB=14dBm - (-137dBm)**

dBm – power referred to 1 mW,

P_{dBm}=10log(P/1mW)

Link budget example

- Received Power (dBm) = Transmitted Power (dBm) + Gains (dB) – Losses (dB)
- Example
  - Transmitted power is +14dBm (25mw)
  - Losses (FSPL) is 1
    transmitted pow
  - Then Receiver P
- If you have a rece
  handle FSPL up to
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- Rewriting the equ
  - Losses (dB) = Trans
  - Losses = link budg
  - Link budget = Transmitted Power - max receiver sensitivity
  - **151dB=14dBm - (-137dBm)**

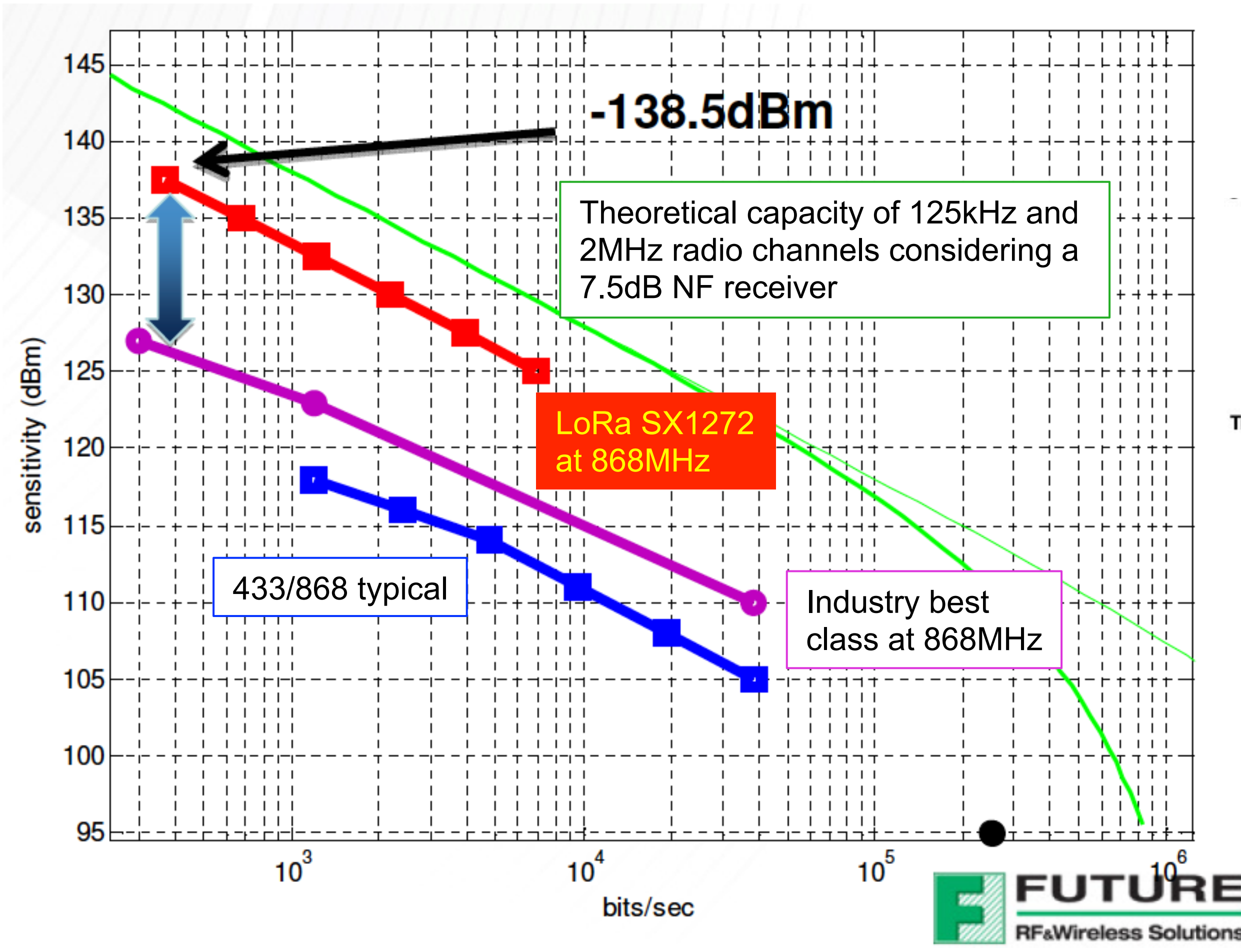
dBm – **power referred to 1 mW,**

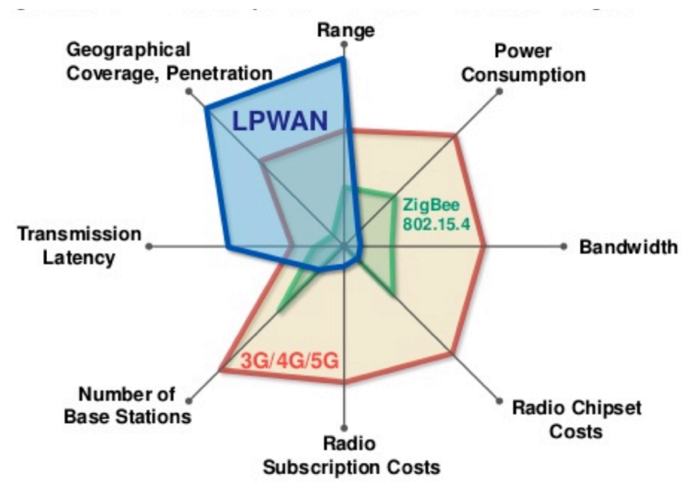
P_{dBm}**=10log(P/1mW)**

KEY PRODUCT FEATURES

- LoRa™ Modem
- 157 dB maximum link budget
- +20 dBm at 100 mW constant RF output vs. V supply
- +14 dBm high efficiency PA
- Programmable bit rate up to 300 kbps
- High sensitivity: down to -137 dBm

WHY THE LPWAN REVOLUTION?





From Peter R. Egli, INDIGOO.COM

Versatile LPWAN!

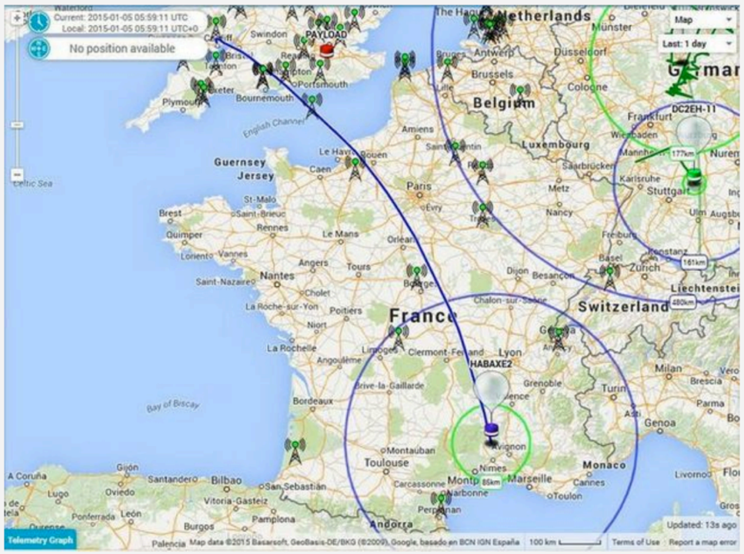
Dense urban areas

Rural areas

Indoor

Underground

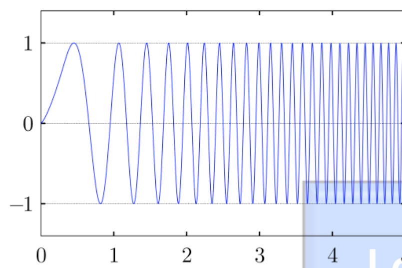
Extreme long-range!



UK HAB (High Altitude Ballooning) trials gave 2 way LoRa™ coverage at up to 240 km. Lowering the data rate from 1000bps to 100bps should allow coverage all the way to the radio horizon, which is perhaps 600 km at the typical 6000-8000m soaring altitude of these balloons. Balloon tracking can be made

Physical layer

SIGFOX



LoRa

Sigfox uses ultra-narrow band (UNB) of about
GMSK (~

Typical t
is about

Devices
typically send up to 140 messages of 12-bytes per day (operator limits)

EAI Endorsed Transactions
on the Internet of Things

Research Article ICST.ORG

Dedicated networks for IoT : PHY / MAC state of the art and challenges

C. Goursaud[1,*], J.M. Gorce[1]

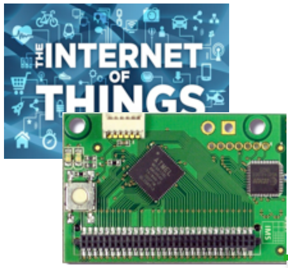
[1]Univ Lyon, INSA Lyon, Inria, CITI, F-69621 Villeurbanne, France

LoRa modulation is more versatile,

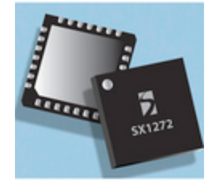
end

(coding rate) and SF (spreading factor)

Throughput range is 240bps to 37500bps



LoRa's parameters



$$R_b = SF * \frac{Rate\ Code}{\left[\frac{2^{SF}}{BW}\right]}\ bits/sec$$

- Parameters
  - Bandwidth: 62.5kHz, 125kHz, 250kHz, 500kHz
  - Rate code: 4/4+CR (CR=1, 2, 3, 4)
  - Spreading factor: 6 to 12

Sensitivity: lowest input power with acceptable link quality, typically 1% PER

SpreadingFactor (RegModemConfig2)	Spreading Factor (Chips / symbol)	LoRa Demodulator SNR
6	64	-5 dB
7	128	-7.5 dB
8	256	-10 dB
9	512	-12.5 dB
10	1024	-15 dB
11	2048	-17.5 dB
12	4096	-20 dB

Bandwidth (kHz)	Spreading Factor	Nominal Rb (bps)	Sensitivity (dBm)
125	6	9380	-122
125	12	293	$\boxed{-137}$
250	6	18750	-119
250	12	586	-134
500	6	37500	-116
500	12	1172	-131

Rule of thumb

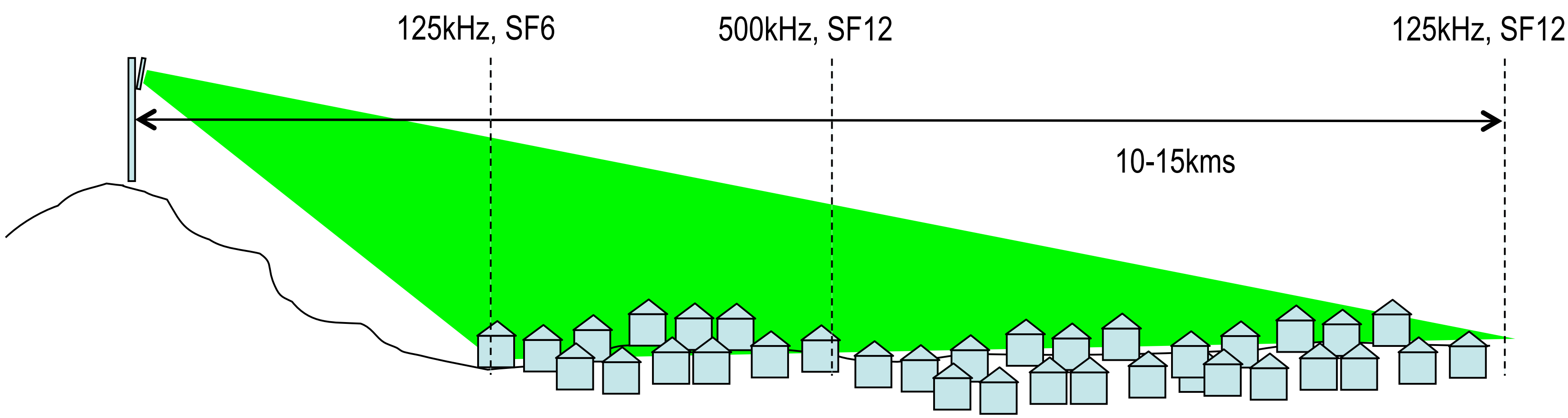
6dB increase = twice the range in LOS

12dB needed for urban areas

Bandwidth (kHz)	Spreading Factor	Coding rate	Nominal Rb (bps)	Sensitivity (dBm)
125	12	4/5	293	-136
250	12	4/5	586	-133
500	12	4/5	1172	-130

Tables from Semtech

Relation to range



Bandwidth (kHz)	Spreading Factor	Coding rate	Nominal Rb (bps)	Sensitivity (dBm)
125	12	4/5	293	-136
250	12	4/5	586	-133
500	12	4/5	1172	-130

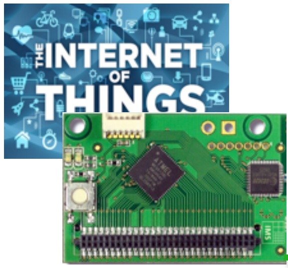
Time on air for various LoRa settings

Range

LoRa mode	BW	CR	SF	time on air in second for payload size of					
				5 bytes	55 bytes	105 bytes	155 Bytes	205 Bytes	255 Bytes
1	125	4/5	12	0.95846	2.59686	4.23526	5.87366	7.51206	9.15046
2	250	4/5	12	0.47923	1.21651	1.87187	2.52723	3.26451	3.91987
3	125	4/5	10	0.28058	0.69018	1.09978	1.50938	1.91898	2.32858
4	500	4/5	12	0.23962	0.60826	0.93594	1.26362	1.63226	1.95994
5	250	4/5	10	0.14029	0.34509	0.54989	0.75469	0.95949	1.16429
6	500	4/5	11	0.11981	0.30413	0.50893	0.69325	0.87757	1.06189
7	250	4/5	9	0.07014	0.18278	0.29542	0.40806	0.5207	0.63334
8	500	4/5	9	0.03507	0.09139	0.14771	0.20403	0.26035	0.31667
9	500	4/5	8	0.01754	0.05082	0.08154	0.11482	0.14554	0.17882
10	500	4/5	7	0.00877	0.02797	0.04589	0.06381	0.08301	0.10093

Throughput

From scoop.it (N. Ayu



Tata Communication
world's largest IoT n
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LoRa™ technology to be integrated into FLASHNET's street lighting management solution

From inteli

SIGFOX and Glen Canyon Corp. to Connect 1 Million Smart Meters to of Things

From www.businesswire.com

on, a
rt meters
ric

OTIO to Connect 1 Million Devices to SIGFOX

From www.businesswire.com - February 22, 4:59 PM

OTIO, a subsidiary of Groupe HBF specializ electrical equipment, lighting and home automation, has chosen the SIGFOX netwo deploy its new international offer of connec devices.

Semtech and STMicroelectronics Collaborate to Scale LoRa Technology to Meet High-Volume Demands of Internet of Things Applications

14,

of
systems
of
works by
s (MNOs)

Swisscom sets up a Swiss-wide network for the Internet of Things

From www.swisscom.ch - March 14, 7:49 PM

The Internet of Things has long connected millions of objects and devices to one another and to people. In the future, this number will reach into the billions worldwide. Swisscom is the first provider in Switzerland to set up an additional network dedicated to the Internet of Things: the Low Power Network, designed for the transmission of small amounts of data independently of the electrical network.

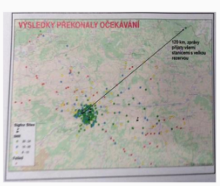
From www.sudo
16, 2015 2:24 PM

" Gestionnaire
les Landes, e
Dordogne, Sc
ondes radio de Sigfox pour relever les compteurs et surveiller l'état des canalisations
Le compteur..."

METERI
SMART

determine the

T-Mobile to cover Republic with the for the Internet of Things



From www.theinternetofthin
September 10, 4:41 PM

Following a pilot opera
Czech Republic that ex
expectations, T-Mobile
SimpleCell Networks w
SIGFOX's Internet of Th
network throughout the country.

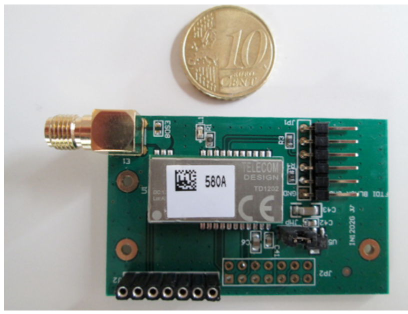
Rise from the Ashes?

" French
Telecom
LoRa radio technology for its own domestic IoT and M2M network."

From www.enevo.com - March 6, 4:12 PM

network, a narrow-band technology which guarantees connectivity at a reduced energy consumption rate and at a lower cost. Orange has chosen to rely on LoRa (Long Range) technology to deploy this network that will cover the whole of metropolitan France.

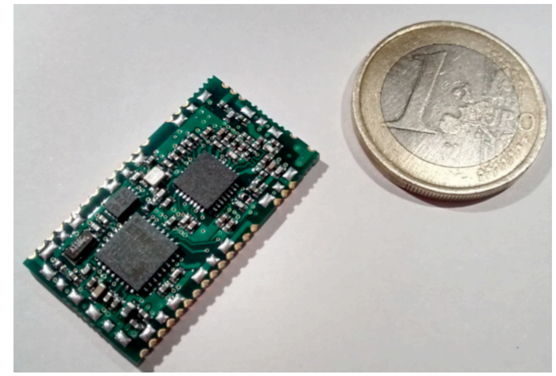
Some SigFox radio modules



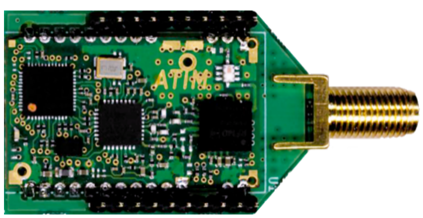
TD120x serie from Telecom Design

SigFox module from CookingHack (Libelium)

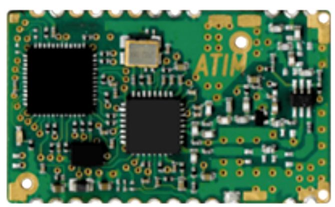
Adeunis SI868



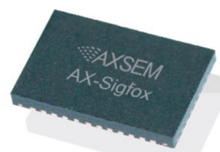
SIGT002 from CG-Wireless



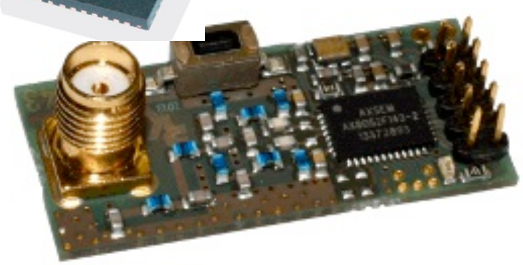
SigBee module from ATIM



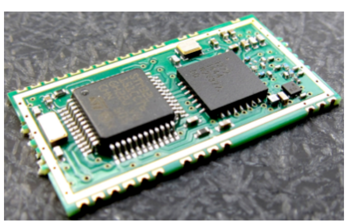
ARM-Nano N8 SigFox module from ATIM



AXSEM SigFox module



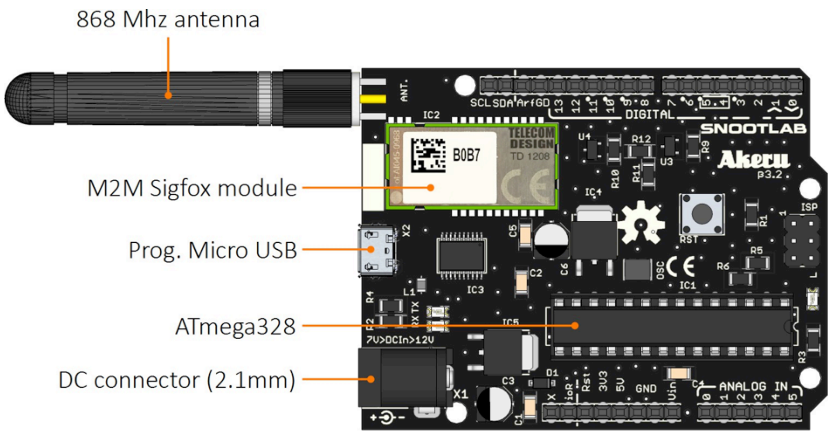
SigFox module from Snoc



Nemeus MM002-LS-EU LoRa/SigFox

RC1682-SIG from RadioCraft

Some ready-to-use SigFox devices



Snootlab Akeru is Arduino-like

SigFox demonstrator
by Adeunis

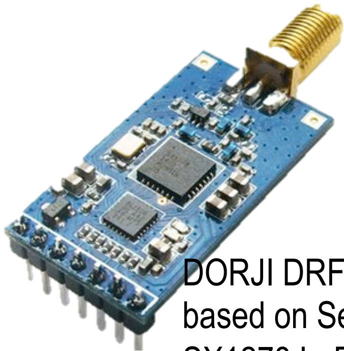
Universal push button
from Bttn Inc

SigFox ready sensor by ATIM

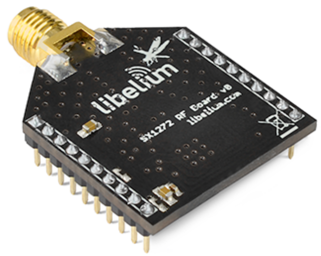
Sens'it from Axible Technologies

HidNSeek

LoRa modules from Semtech's SX127x chips



DORJI DRF1278DM is based on Semtech SX1278 LoRa 433MHz



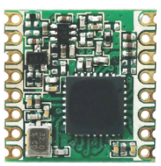
Libelium LoRa is based on Semtech SX1272 LoRa 863-870 MHz for Europe

inAir9/9B based on SX1276

Froggy Factory LoRa module (Arduino)

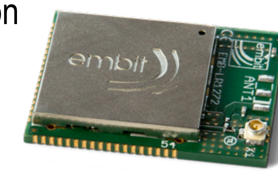
LinkLabs Symphony module

IMST IM880A-L is based on Semtech SX1272 LoRa 863-870 MHz for Europe

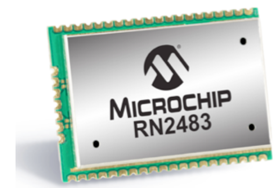


HopeRF RFM series

HopeRF HM-TRLR-D



Embit LoRa

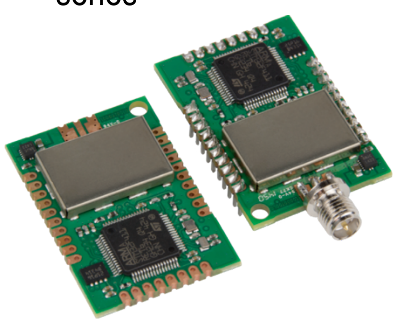


LoRa™ Long-Range Sub-GHz Module (Part # RN2483)

Microship RN2483

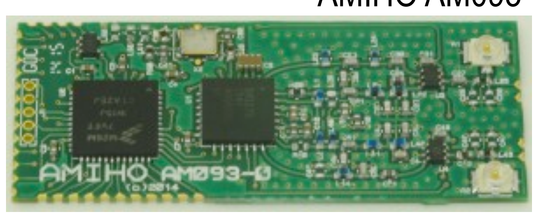
habSupplies

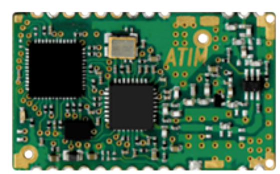
Adeunis ARF8030AA- Lo868



Multi-Tech MultiConnect mDot

AMIHO AM093





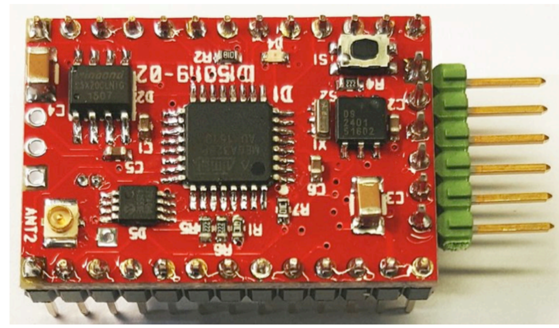
ARM-Nano N8 LoRa module from ATIM

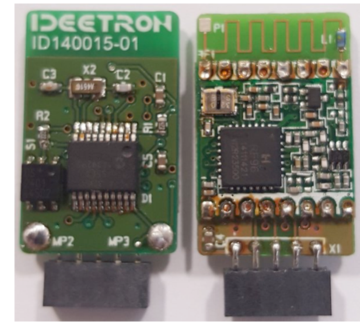
SODAQ LoRaBee Embit

SODAQ LoRaBee RN2483

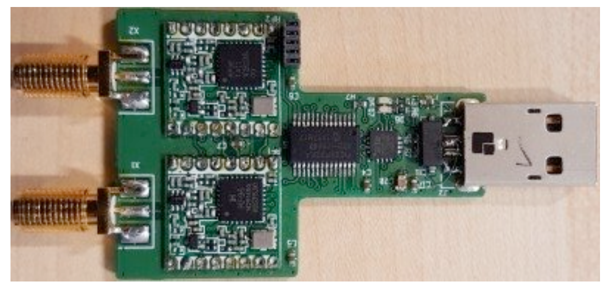
Some ready-to-use LoRa devices

LoRa Mote from Semtech

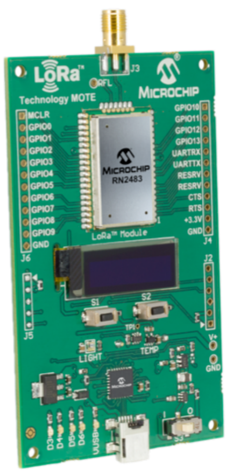




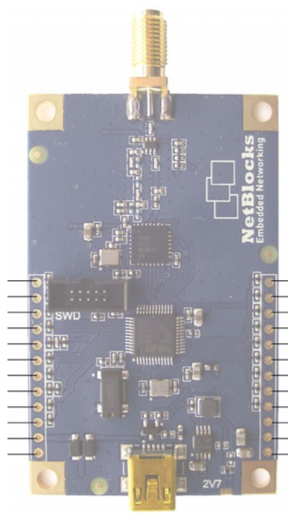
LoRa Alliance



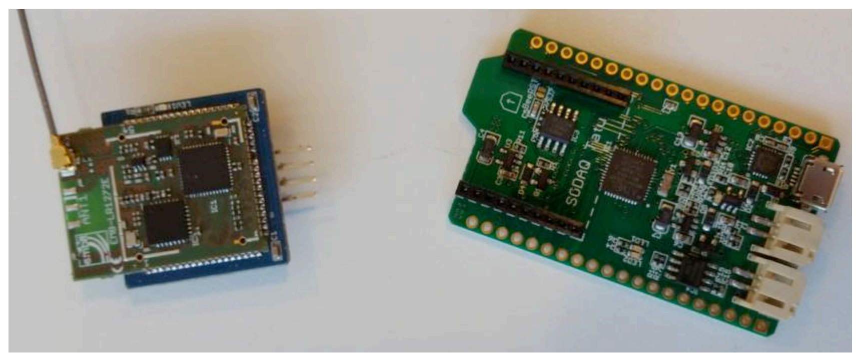
HopeRF/Ideetron motes



Microchip LoRa mote

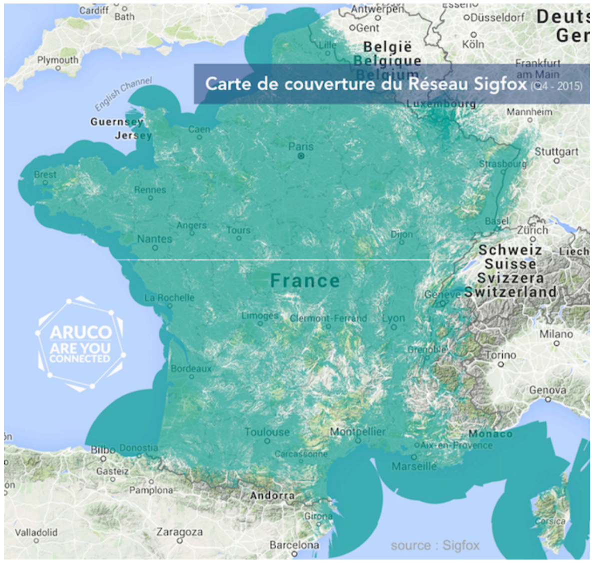


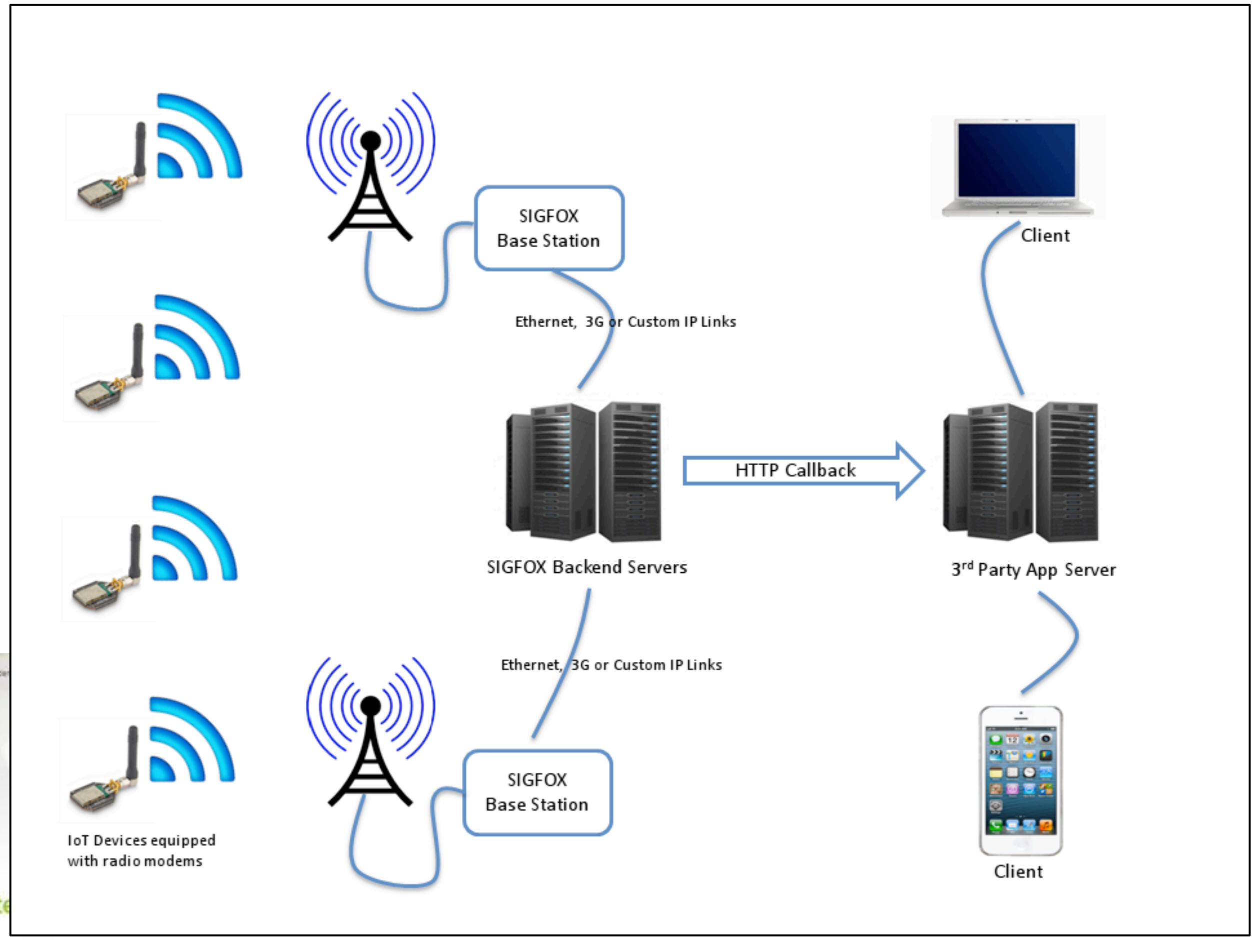
NetBlocks XRange



SODAQ Tatu with LoraBee (Embit)

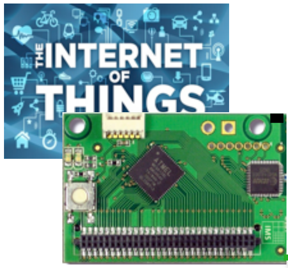
SIGFOX'S MODEL FOR M2M: THE « OPERATOR » (ALL-IN-ONE) APPROACH





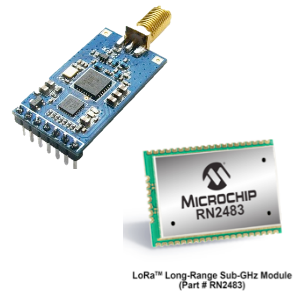
Figures from SigFox

http://www.scoop.it/t/toulouse-networks/?tag=SigFox



...vs Private Long Range Networks with LoRa

Add LoRa radio module to your preferred dev platform



Install a LoRa gateway and start collecting data

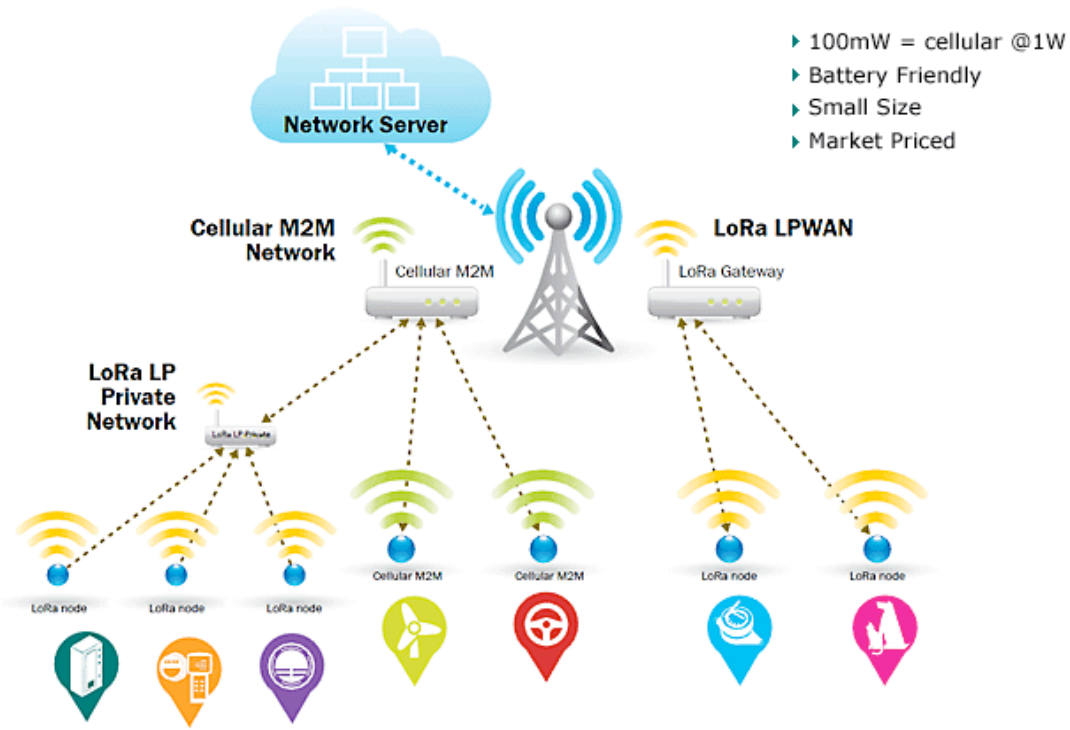


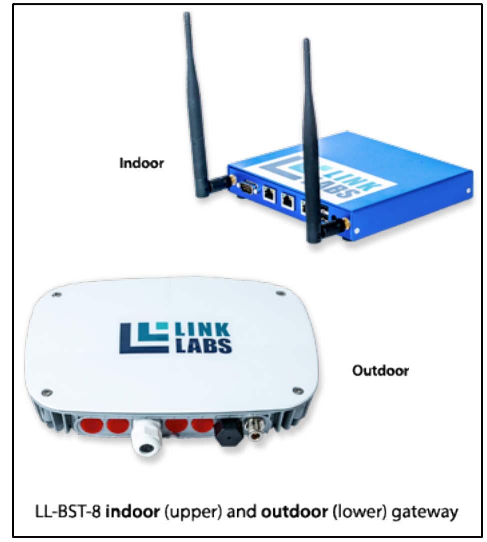
Figure from Semtech

LoRa Gateways
(non exhaustive list)

Multi-Tech Conduit

Embedded Planet
EP-M2M-LORA

Ideetron Lorank 8



LinkLabs Symphony

PicoWAN from
Archos

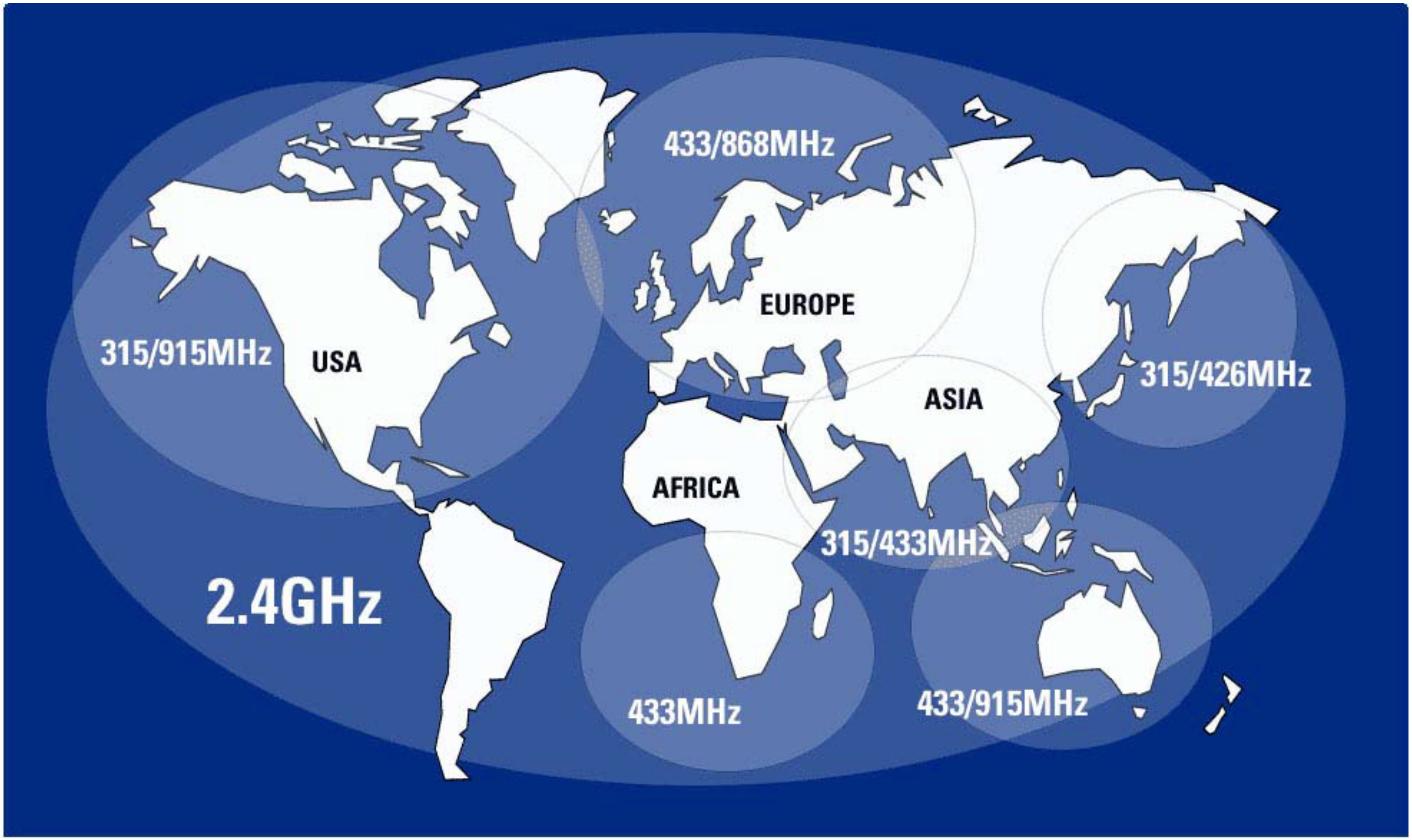
Kerlink IoT Station

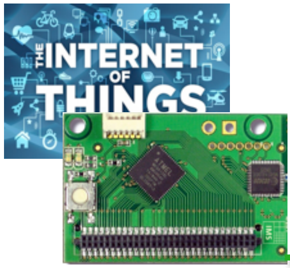
TheThingNetwork

Or build your own one:
Arduino, Rasperry PI, …

OTHER LONG-RANGE TECHNOLOGIES

The ISM/SRD License-Free Frequency Bands





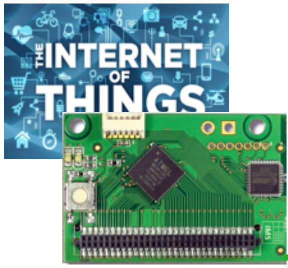
License-free Sub-GHz constraints

- Activity time is constrained from 0.1%, 1% 10% duty-cycle depending on frequency: 3.6s, 36s/hour to 360s/hour

Band	Edge Frequencies		Field / Power	Spectrum Access	Band Width
	Fe-	Fe+			
g(Note 7)	865 MHz	868 MHz	+6.2 dBm /100 kHz	1 % or LBT AFA	3 MHz
g(Note 7)	865 MHz	870 MHz	-0.8 dBm / 100 kHz	0.1% or LBT AFA	5 MHz
g1	868 MHz	868.6	14 dBm	1 % or LBT AFA	600 kHz
g2	868.7 MHz	869.2 MHz	14 dBm	0.1% or LBT AFA	500 kHz
g3	869.4 MHz	869.65 MHz	27 dBm	10 % or LBT AFA	250 kHz
g4	869.7 MHz	870 MHz	7 dBm	No requirement	300 kHz
g4	869.7 MHz	870 MHz	14 dBm	1 % or LBT AFA	300 kHz

				time on air in second for payload size of					
LoRa mode	BW	CR	SF	5 bytes	55 bytes	105 bytes	155 Bytes	205 Bytes	255 Bytes
1	125	4/5	12	0.95846	2.59686	4.23526	5.87366	7.51206	9.15046
2	250	4/5	12	0.47923	1.21651	1.87187	2.52723	3.26451	3.91987
[illegible]	[illegible]5	4/5	10	0.28058	0.69018	1.09978	1.50938	1.91898	2.32858

TC/18.4/H/84/ every 10mins = 2s * 6 = 12s / hour



LoRa™ Alliance

Wide Area Networks for IoT

Sponsor members

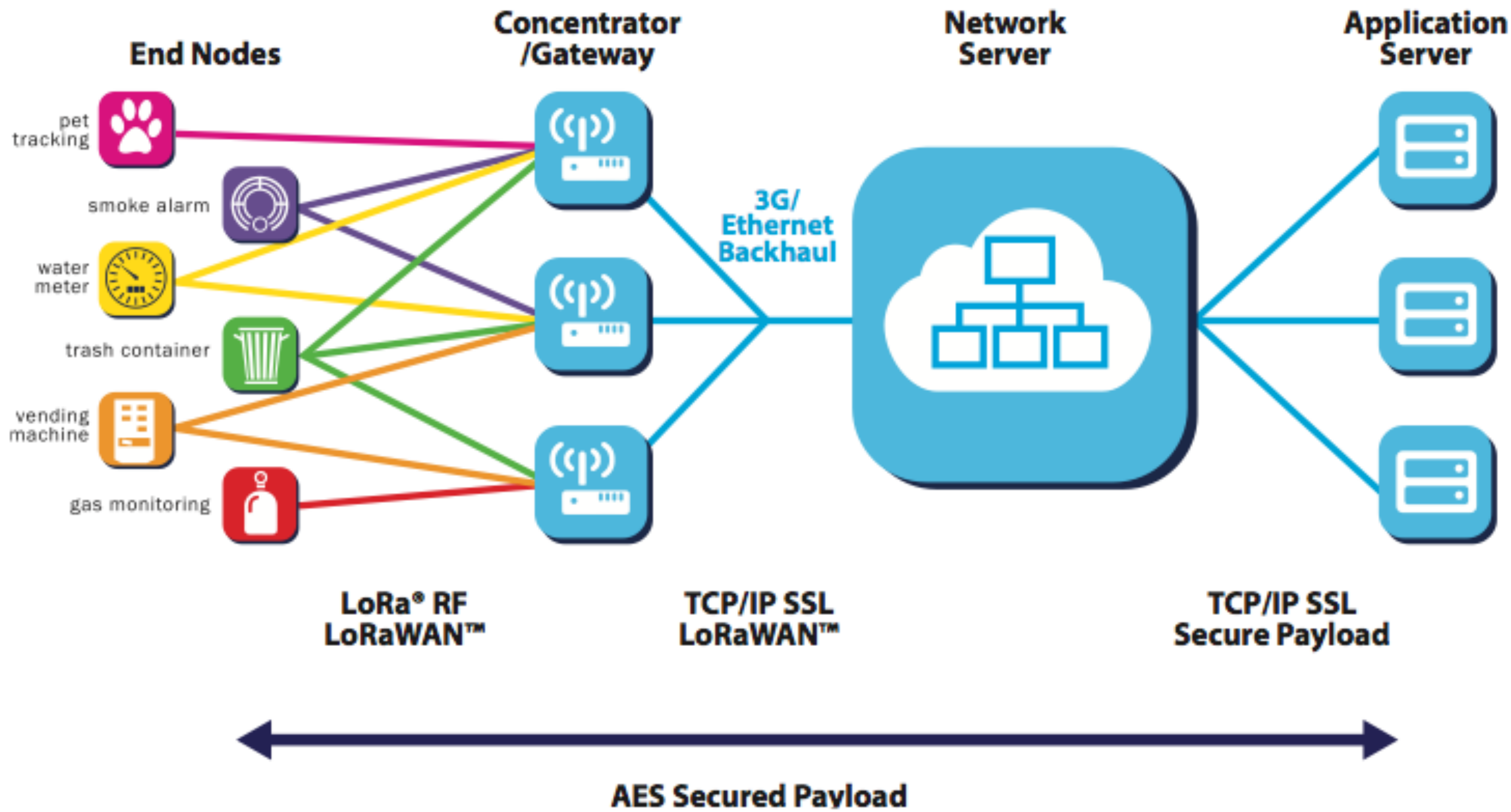
Actility, Augtek, Bouygues Telecom, Cisco, Endetec, IBM, Kerlink, KPN, ST, M2M Spectrum Networks, Proximus, Qowisio, Sagemcom, Semtech

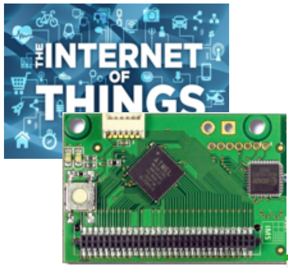
Contributor members

Adeunis RF, Espotel, FastNet, Flashnet, Gemalto, IMST, Inmarsat, Irdeto, La Poste, Lace, LinkLabs, M2B Communications Planning, Microchip, MultiTech, myDevices, OrbiWise, Senet, SK telecom, Stream, Swisscom, Vision Valley

Adopter members

LoRaWAN architecture

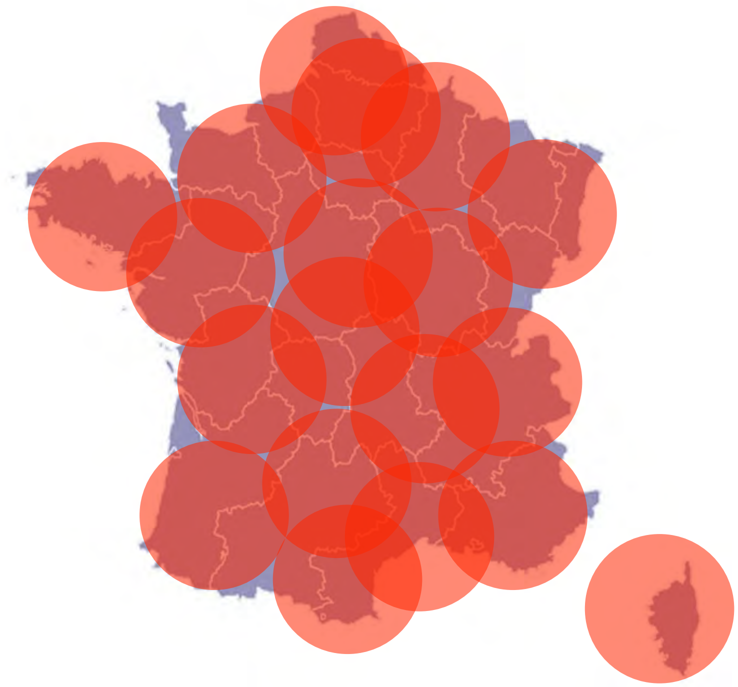




Will main market be operator based?

Long Range

- Greater than cellular
- Deep indoor coverage
- Star topology

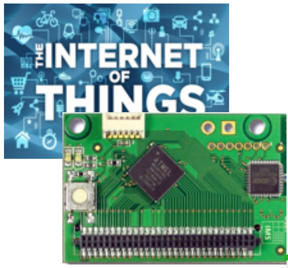


bouygues TELECOM

orange™

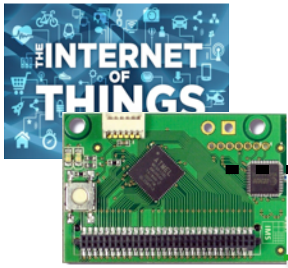
swisscom

kpn



...COMMUNITY BASED?

THE THINGS NETWORK



LOR FROM LOCAL ACTORS?

Irrigation

Livestock farming

Fish farming & aquaculture

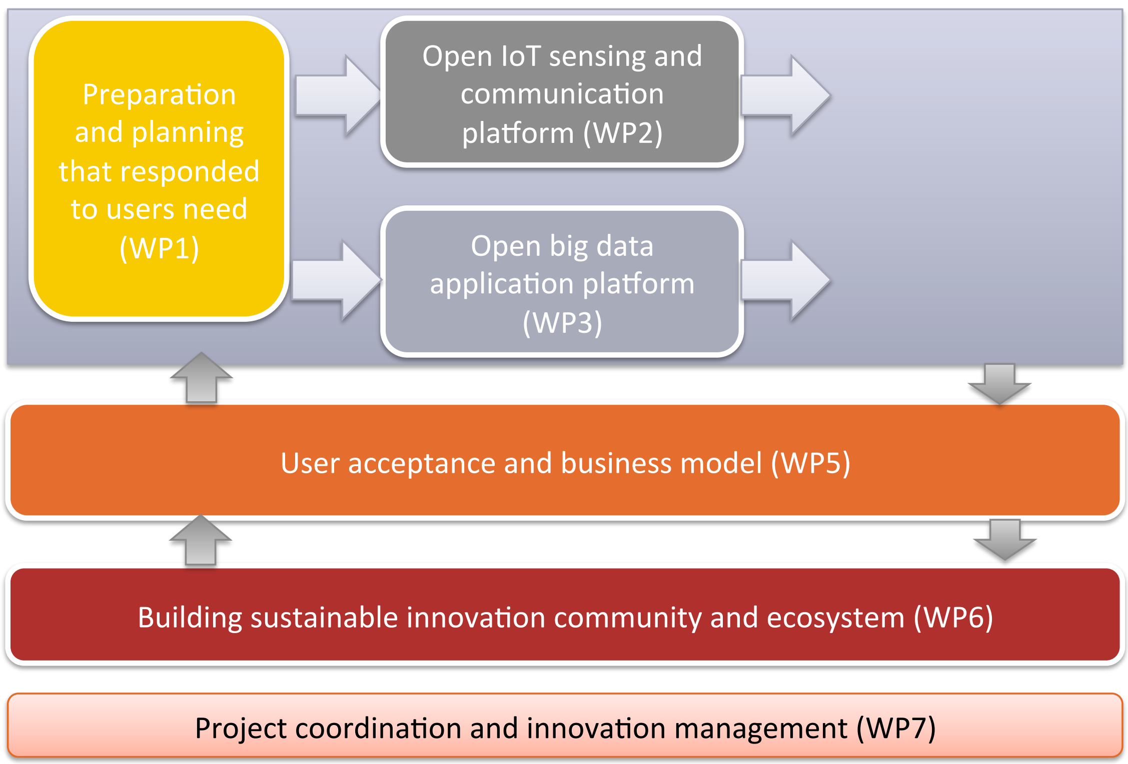
Storage & logistic

Agriculture

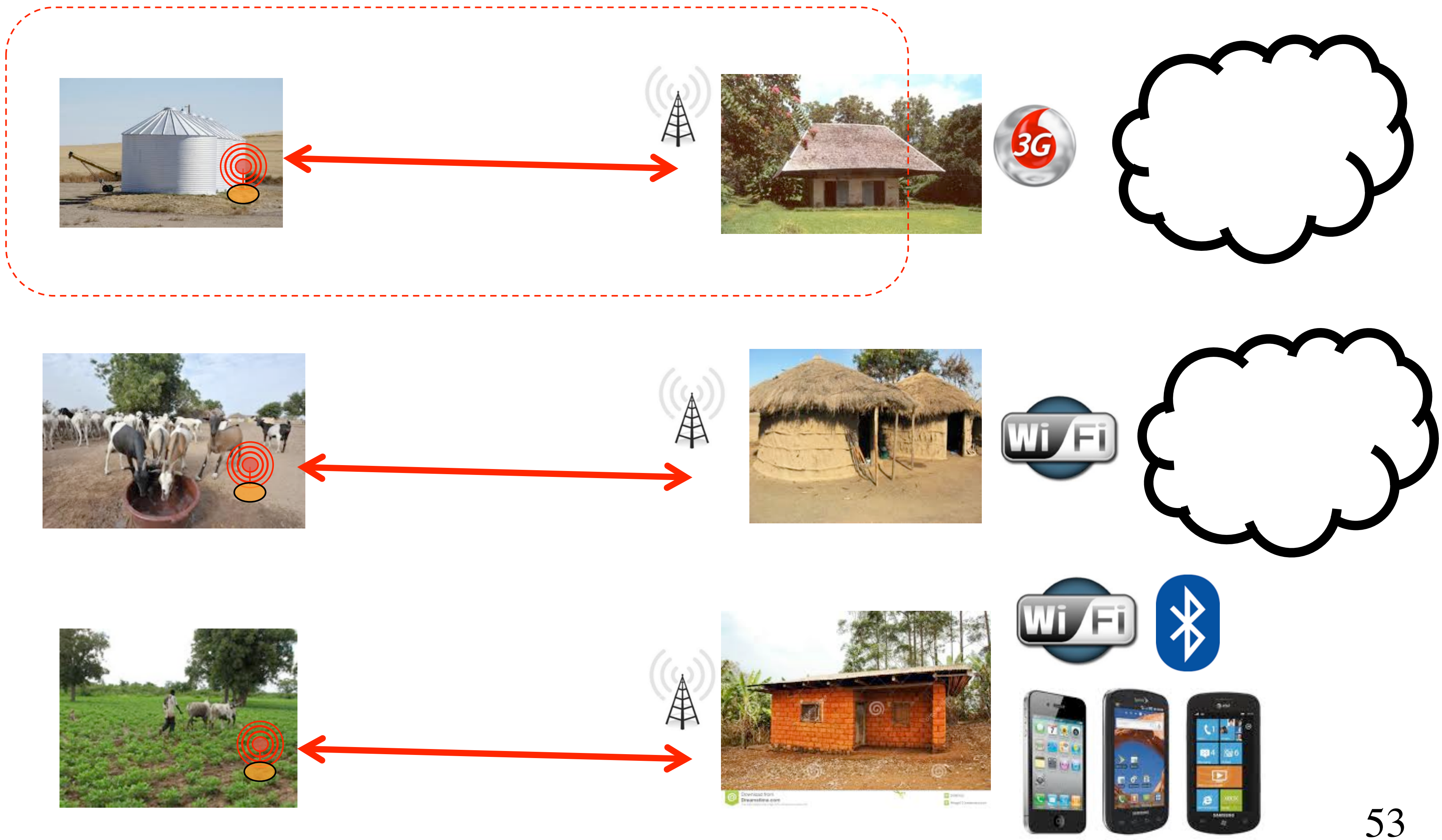
Fresh water

IoT FOR RURAL APPLICATIONS IN DEVELOPPING COUNTRIES

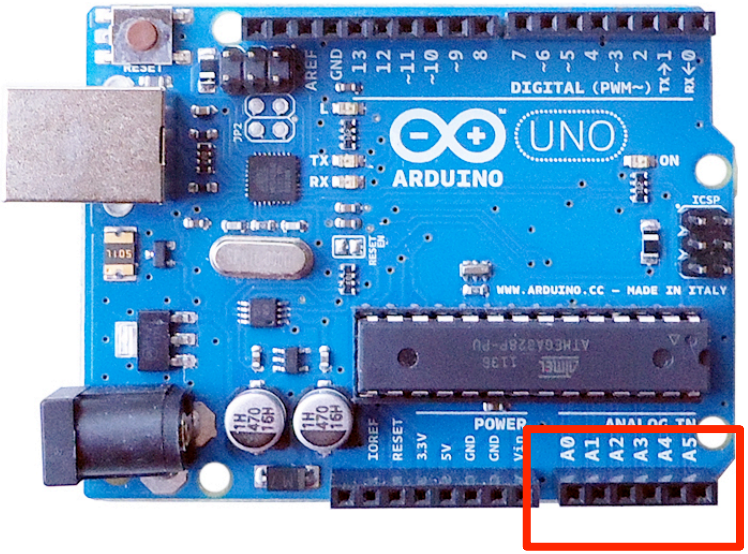
- WAZIUP is an EU H2020 project (2016-2019)
- contributes to long-range networks for rural applications with WP2



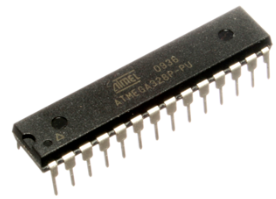
Typical scenarios

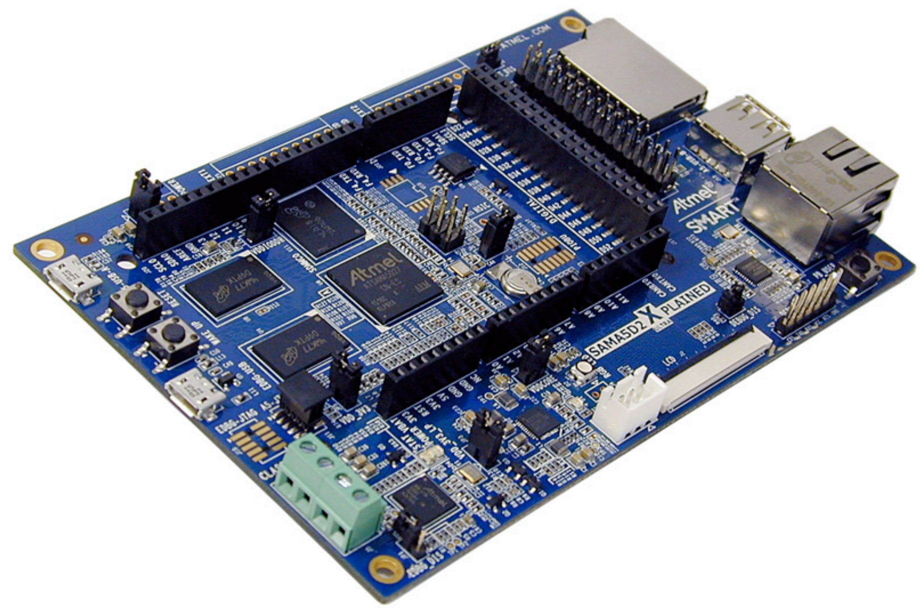


Powerfull micro-controller boards...



Analog pins





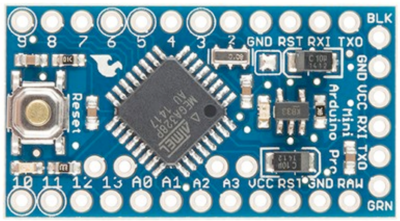
Atmel | SMART SAMA5D2

Come with build-in analog-to-digital converter (ADC) which usually have 10-bit resolution:

0V means 0
3.3V or 5V means 1024 = 2^{10}

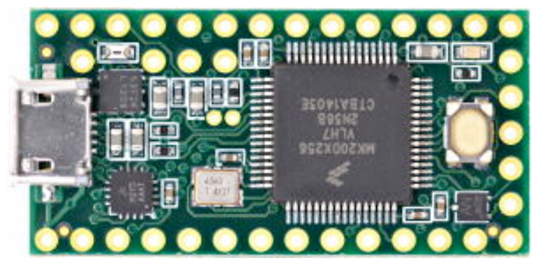
…GETTING SMALLER AND SMALLER !!

Arduino Pro Mini



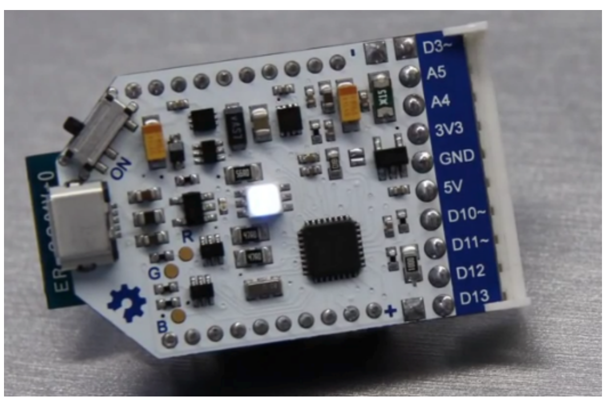
http://blog.atmel.com/2015/12/16/rewind-50-of-the-best-boards-from-2015/

http://blog.atmel.com/2015/04/09/25-dev-boards-to-help-you-get-started-on-your-next-iot-project/



Teensy 3.2

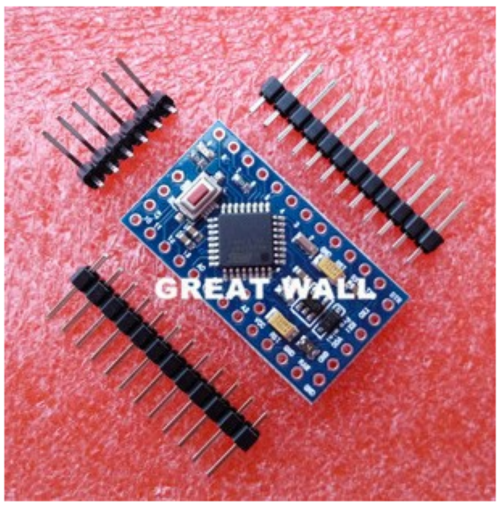
STM32 Nucleo-32



Theairboard on kickstarter

Tinyduino

...AND CHEAPER !!!



Avec la bootloader 1 pcs Pro Mini ATMEGA328 Pro Mini 328 Mini ATMEGA328 3.3 V / 8 MHz pour Arduino

View original title in English

★★★★★ 4.9 (417 Votes) | 434 Commandes

Prix : **€ 1,49** / Kit

Trouvez plus de deals sur l'App

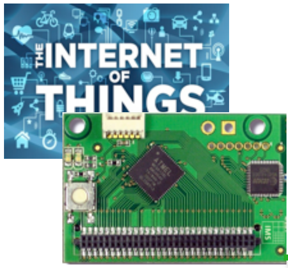
Livraison : **€ 0,29 vers France via China Post Ordinary Small Packet Plus**

Livraison : 15-34 jours (envoyé en 7 jours ouvrables)

Quantité : – 1 + Kit (55350 Kits available)

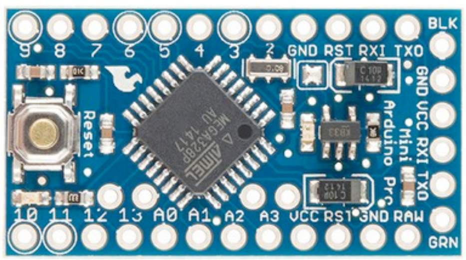
Montant total : **€ 1,78**

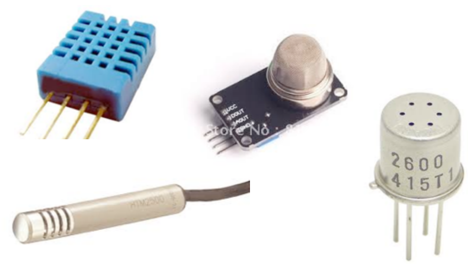
Acheter maintenant | Ajouter au panier

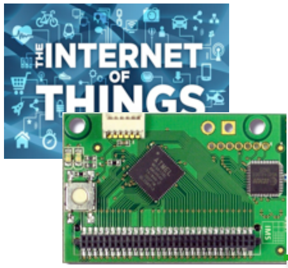


Design and adaptation

- Build low-cost, low-power, Long-range enabled generic platform
- Methodology for low-cost platform design
- Technology transfers to user communities, economic actors, stakeholders,…







Design and adaptation

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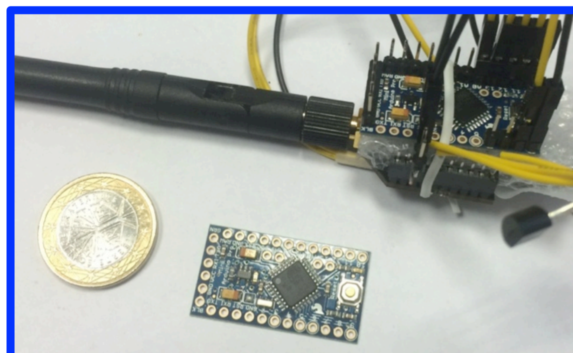
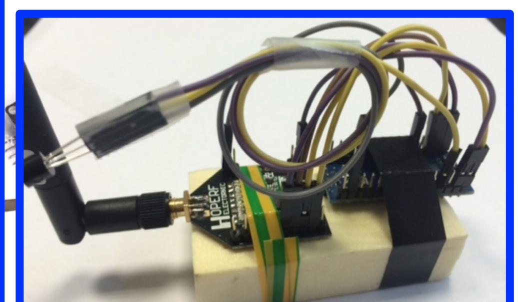
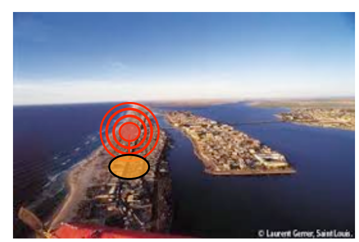
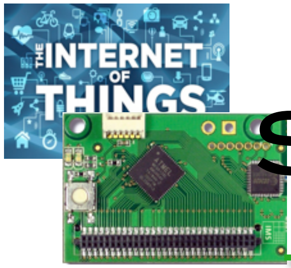
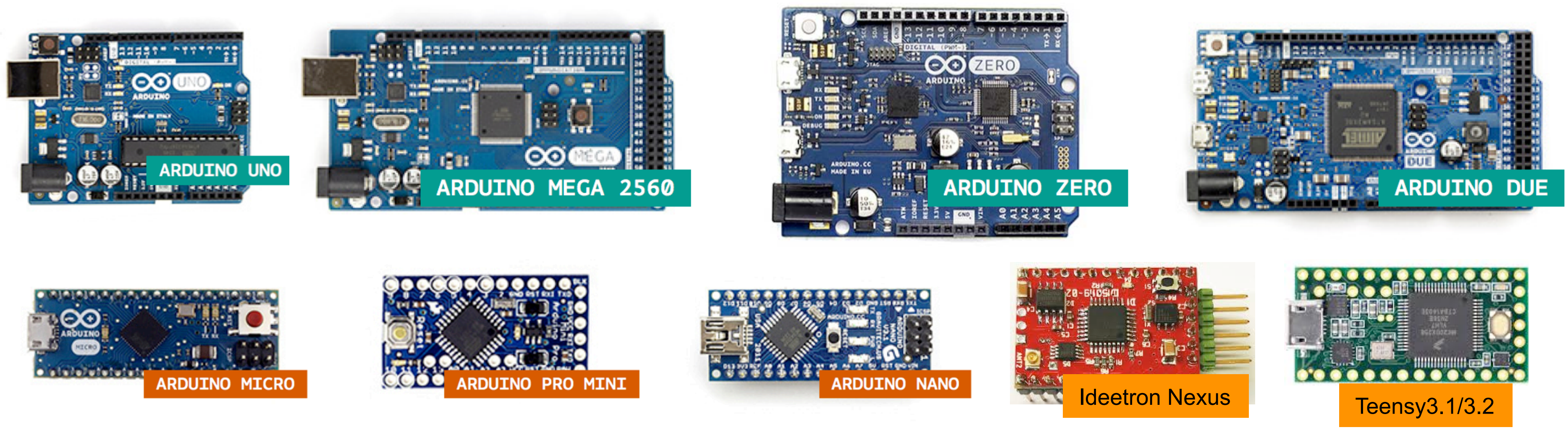






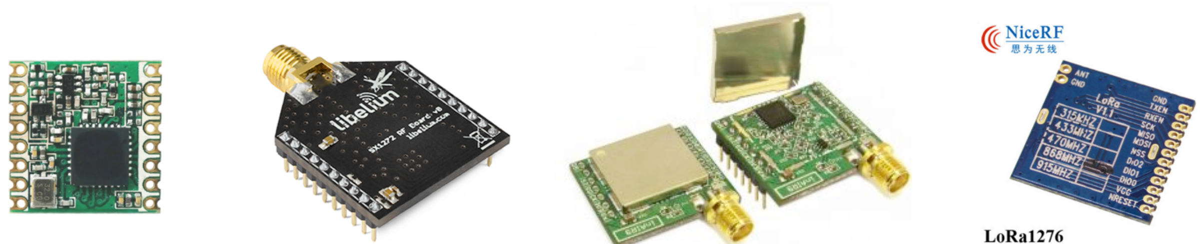


SW/HW building blocks



LoRa™

LoRa radios that our library already supports



HopeRF RFM92W/95W

Libelium LoRa

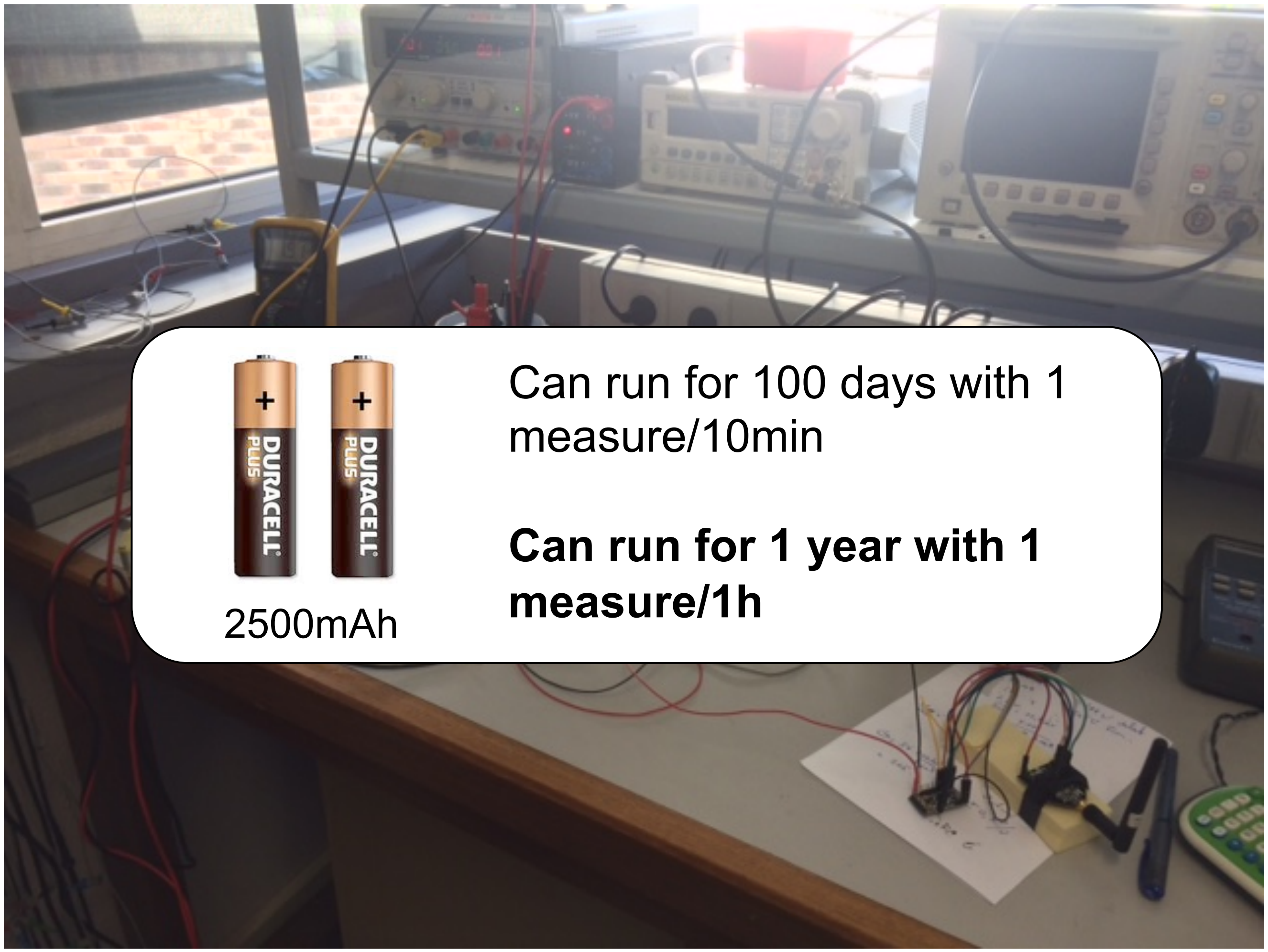
Modtronix inAir9/9B

NiceRF LoRa1276

Long-Range communication library

Running for 1 year

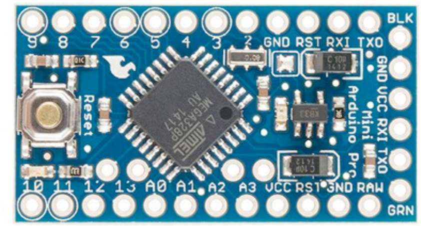
Low-Power library from RocketScream



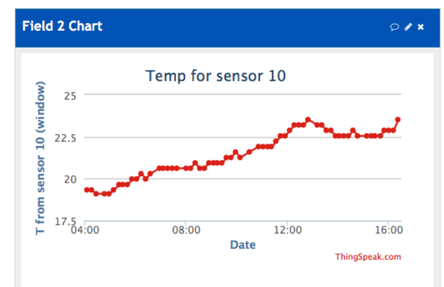
Can run for 100 days with 1 measure/10min

Can run for 1 year with 1 measure/1h

2500mAh



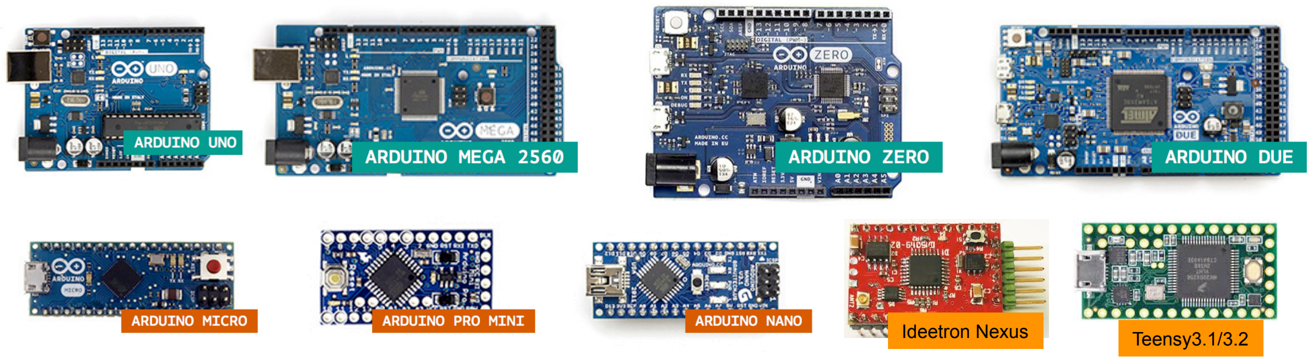
Wakes-up every 10min, take a measure (temp) and send to GW



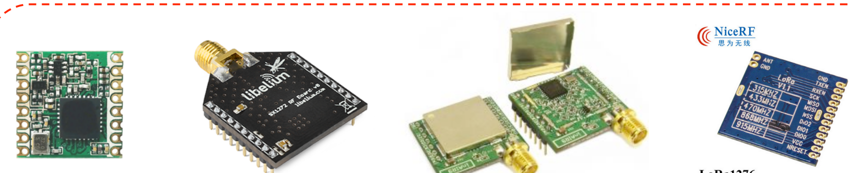
146µA in deep sleep mode, 93mA when active and sending

Thanks to T. Mesplou and P. Plouraboué for their help

Communication to gateway is straightforward for developers



LoRa radios that our library already supports



HopeRF RFM92W/95W

Libelium LoRa

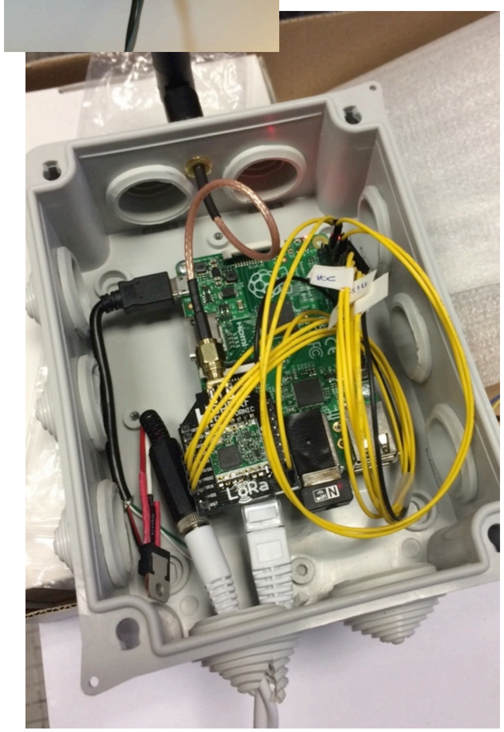
Modtronix inAir9/9B

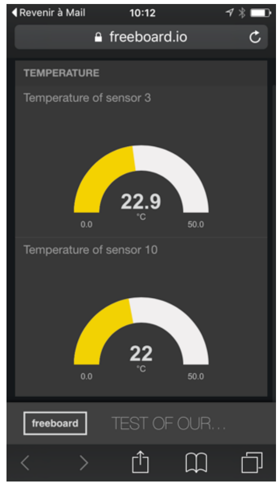
NiceRF LoRa1276

```
sendPacketTimeout(1, "18.5", 4);
// 1: sends to gateway
// 18.5 : temperature message
// 4 : message size
```

1 send function!

Low-cost LoRa gateway: less than 50€



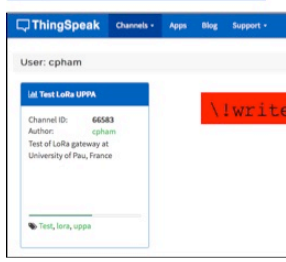


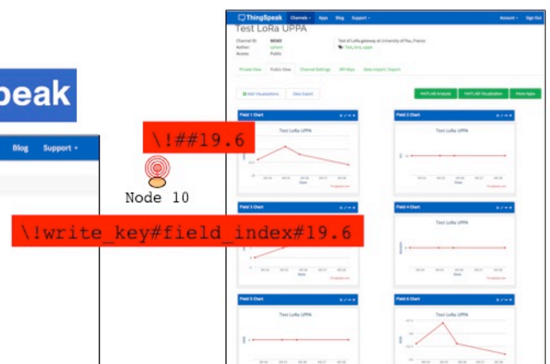
Dropbox

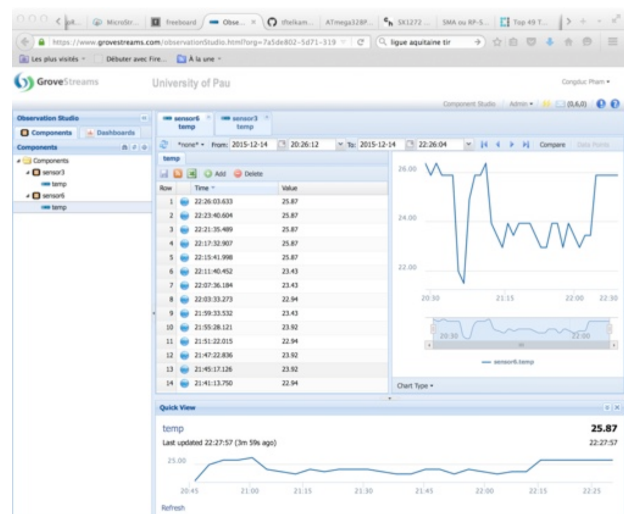
freeboard

FIWARE

ThingSpeak





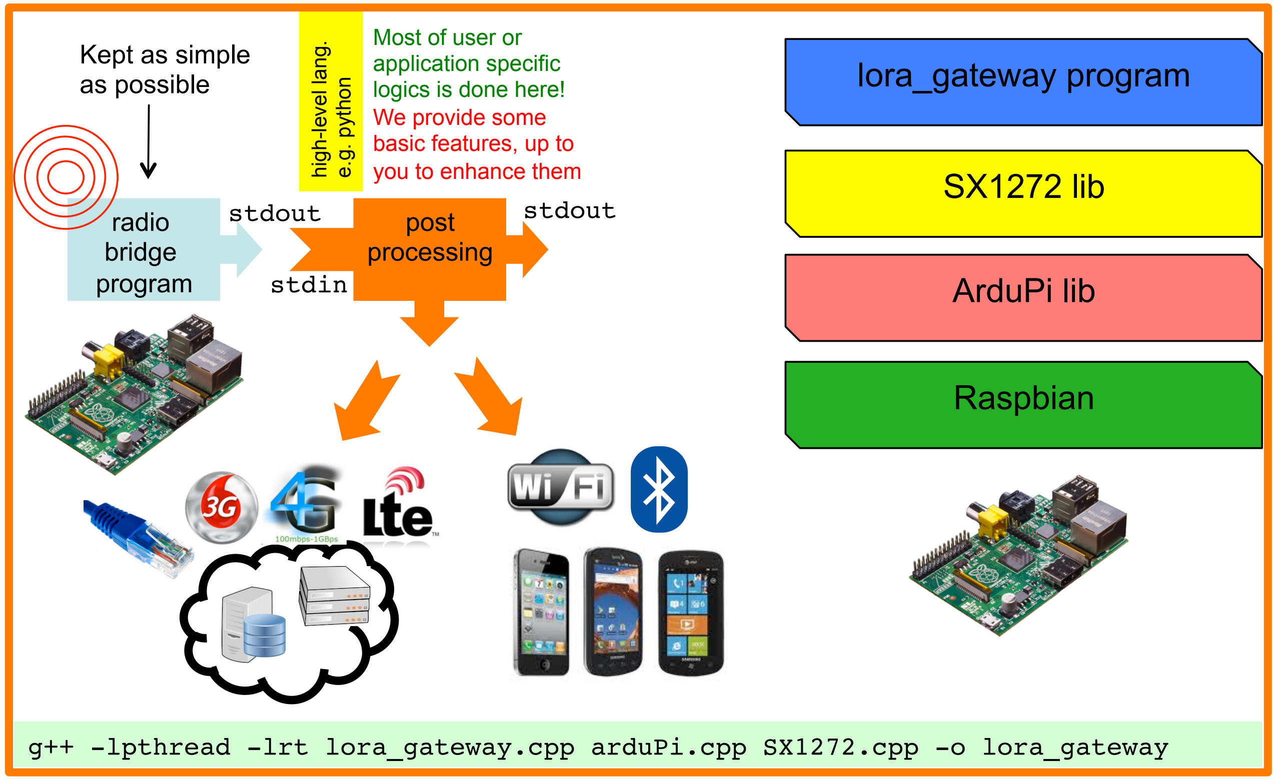


GroveStreams

SensorCloud™

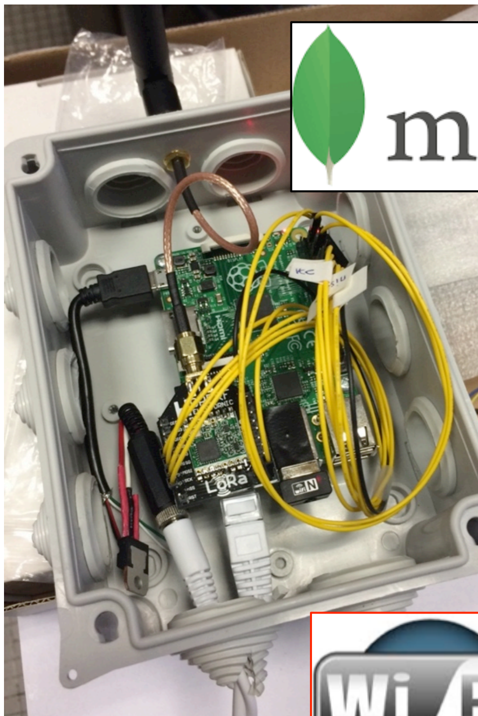
From GW to Cloud platforms

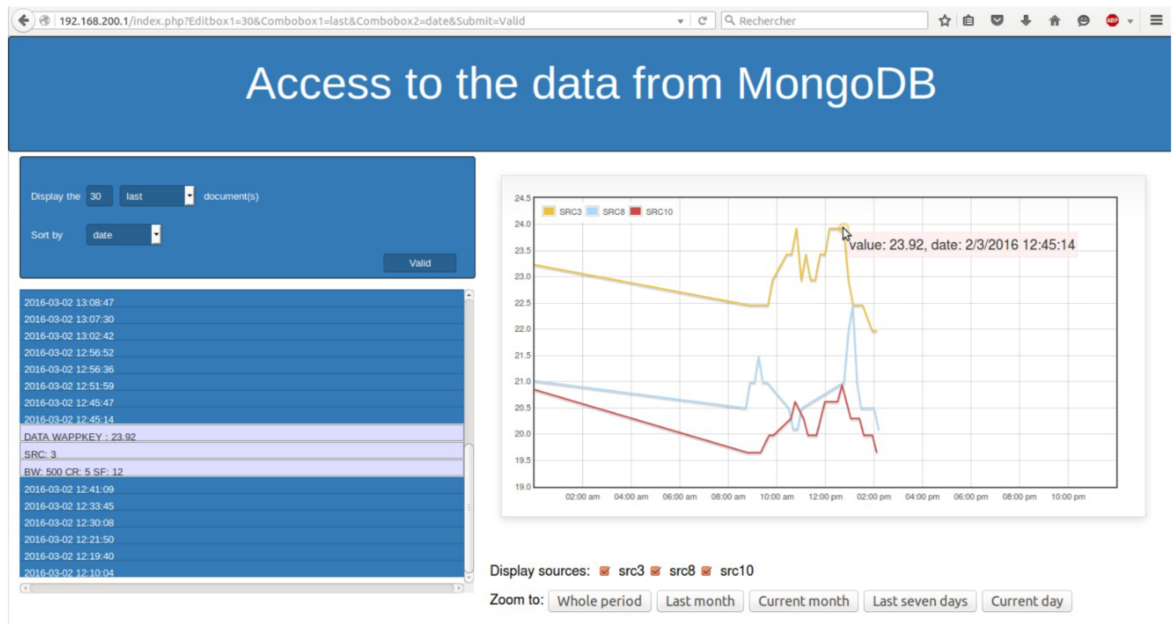
Once data is received at gateway, traditional Internet tools can be used to push data to cloud



- High-level scripting language provides connectivity to any cloud platforms depending on end-user needs

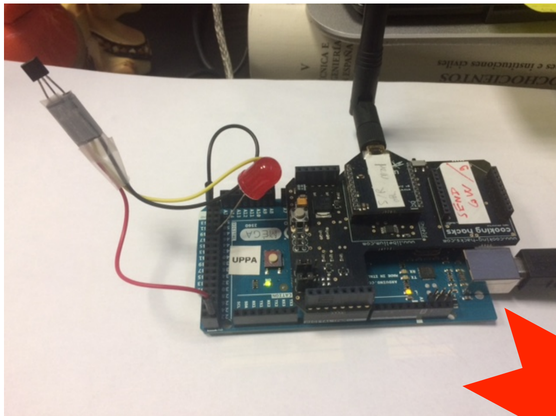
Running without Internet access





Internship of N. Bertuol, collaboration with ConnectingNature (F. Duvignac)

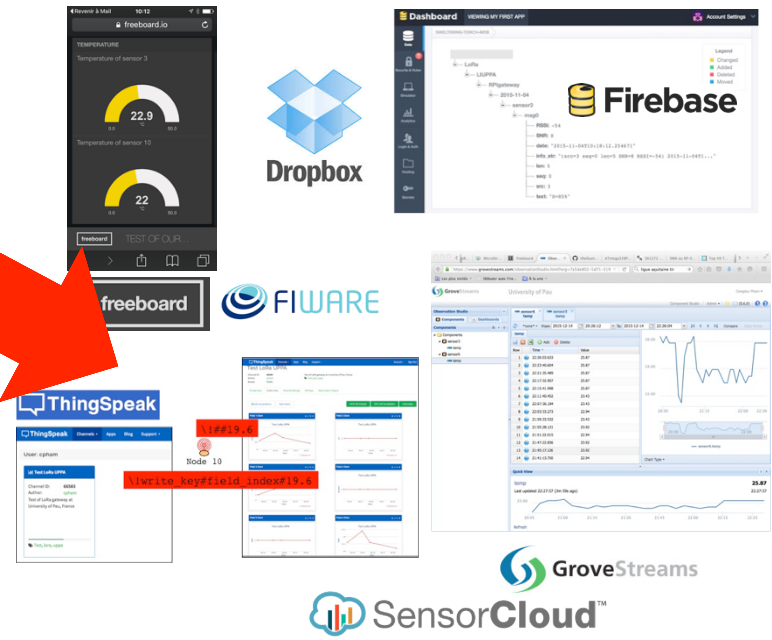
FULL EXAMPLE IS PROVIDED



Source code available

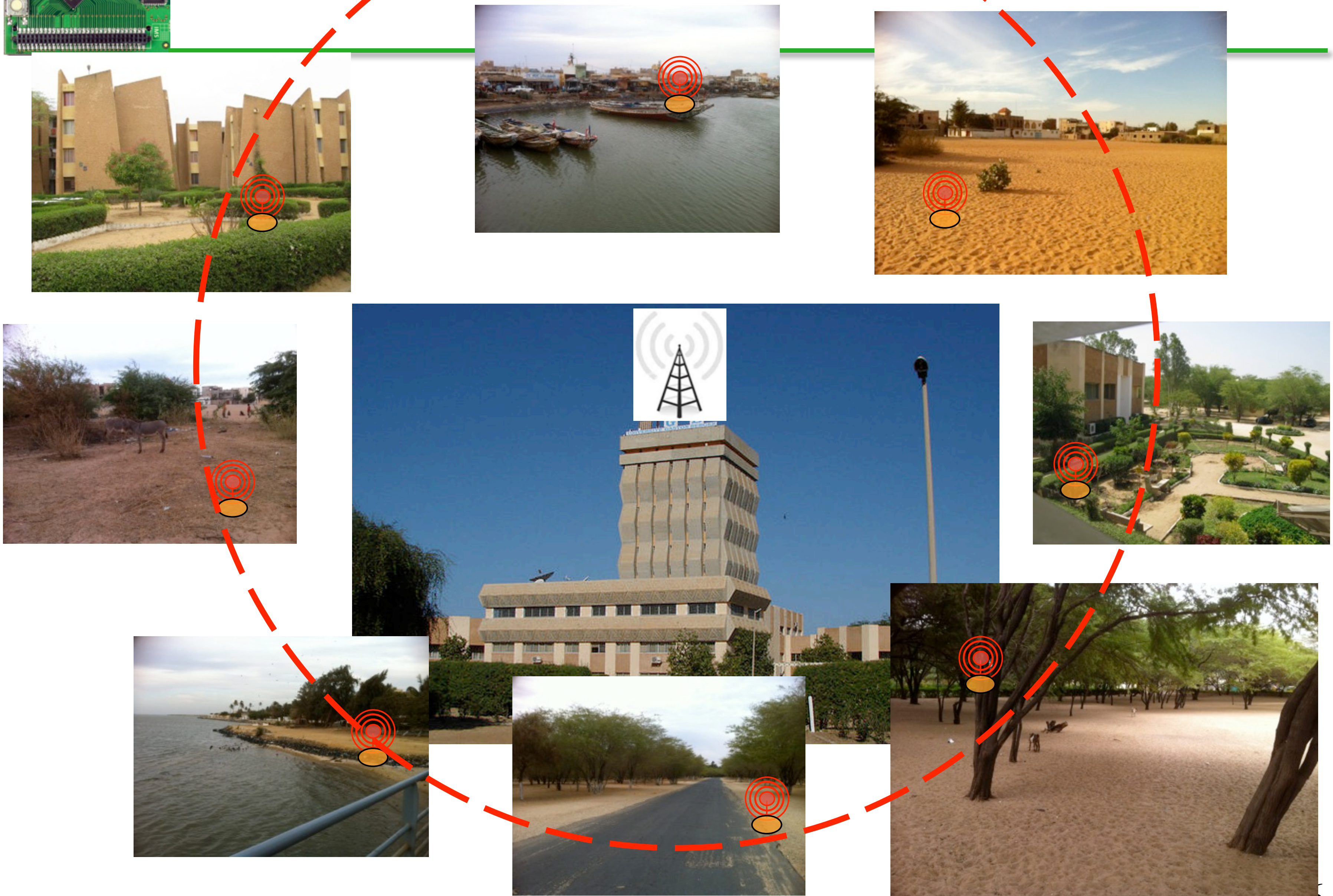
Source code available

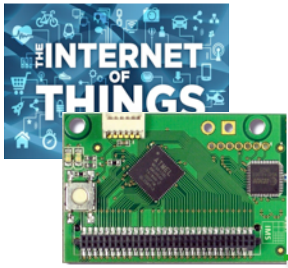
Python scripts available



https://github.com/CongducPham/LowCostLoRaGw

LONG-RANGE TEST-BED & BENCHMARK





Conclusions

- Low-power, long-range (LR) transmission is a break-through technology for IoT and large-scale deployment of wireless (sensor) devices
- With a large variety of applications, products & actors the low-power WAN (LPWAN) eco-system is becoming mature
- New technologies will certainly emerge but the LPWAN « philosophy » is now settled firmly: out-of-the-box connectivity is now the standard and multi-hop scenarios based on short-range technologies is questionable.